more than
300
reactions!

Jie Jack Li

Name Reactions

A Collection of Detailed Reaction Mechanisms

Danheiser annulation

Third Edition

Corey-Kim oxidation

Swern oxidation

Heck reaction

Chan-Lam coupling

Springer

Kurt Alder
1902–1958
Nobel Prize, 1950

Eduard Buchner
1860–1917
Nobel Prize, 1907

Adolf von Baeyer
1835–1917
Nobel Prize, 1905

Elias James Corey
1928–
Nobel Prize, 1990

Derek H. R. Barton
1918–1999
Nobel Prize, 1969

Otto Paul Hermann Diels
1876–1954
Nobel Prize, 1950

Name Reactions

Jie Jack Li

Name Reactions

A Collection of Detailed Reaction Mechanisms

Third Expanded Edition

Springer

Jie Jack Li, Ph.D.

Pfizer Global Research and Development
Chemistry Department
2800 Plymouth Road
Ann Arbor, MI 48105
USA
e-mail: jack.li@pfizer.com

3rd. expanded ed.

ISBN-10 3-540-30030-9 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-30030-4 Springer Berlin Heidelberg New York
e-ISBN 3-540-30031-7
ISBN-10 3-540-40203-9 2nd ed. Springer Berlin Heidelberg New York

Library of Congress Control Number: 2006925628

Springer is a part of Springer Science+Business Media
springer.com

Printed in Germany

Typesetting: By the Author
Production: LE-TEX, Jelonek, Schmidt & Vöckler GbR, Leipzig
Coverdesign: KünkelLopka, Heidelberg

Printed on acid-free paper 2/3100 YL – 5 4 3 2 1 0

Dedicated to

Professor E. J. Corey

Foreword

I don't have my name on anything that I don't really do.
–Heidi Klum

Can the organic chemists associated with so-called “Named Reactions” make the same claim as supermodel Heidi Klum? Many scholars of chemistry do not hesitate to point out that the names associated with “name reactions” are often not the actual inventors. For instance, the Arndt-Eistert reaction has nothing to do with either Arndt or Eistert, Pummerer did not discover the “Pummerer” rearrangement, and even the famous Birch reduction owes its initial discovery to someone named Charles Wooster (first reported in a DuPont patent). The list goes on and on…

But does that mean we should ignore, boycott, or outlaw “named reactions”? Absolutely not. The above examples are merely exceptions to the rule. In fact, the chemists associated with name reactions are typically the original discoverers, contribute greatly to its general use, and/or are the first to popularize the transformation. Regardless of the controversial history underlying certain named reactions, it is the students of organic chemistry who benefit the most from the cataloging of reactions by name. Indeed, it is with **education** in mind that Dr. Jack Li has masterfully brought the chemical community the latest edition of *Name Reactions*.

It is clear why this beautiful treatise has rapidly become a bestseller within the chemical community. The quintessence of hundreds of named reactions is encapsulated in a concise format that is ideal for students and seasoned chemists alike. Detailed mechanistic and occasionally even historical details are given for hundreds of reactions along with key references. This “must-have” book will undoubtedly find a place on the bookshelves of all serious practitioners and students of the art and science of synthesis.

Phil S. Baran
La Jolla, March 2006

Preface

Confucius said: "*Reviewing old knowledge while learning new old knowledge, is that not, after all, a pleasure?*" Indeed, name reactions are not only the fruit of pioneering organic chemists, but also our contemporaries whose combined discoveries have resulted in organic chemistry today. Since publication of this book, Barry Sharpless and Ryoji Noyori, whose name reactions have been included since the first edition, went on to win the Nobel Prizes in 2001. Recently, Richard Schrock, Robert Grubbs, and Yves Chauvin shared the 2005 Nobel Prize in chemistry for their contributions to metathesis, a name reaction that has been also included since the first edition. Therefore, I intend to keep up with the new developments in the field of organic chemistry while retaining the collection of name reactions that have withheld test of time.

The third edition contains major improvements over the previous two editions. I have updated references. Each reaction is now supplemented with two to three representative examples in synthesis to showcase its synthetic utility. As Emil Fischer stated: "*Science is not an abstraction; but as a product of human endeavor it is inseparably bound up in its development with the personalities and fortunes of those who dedicate themselves to it.*" To that end, I added biographical sketches for most of the chemists who discovered or developed those name reactions. Furthemore, I have significantly beefed up the subject index to help the reader navigate the book more easily.

In preparing this manuscript, I have incurred many debts of gratitude to Prof. Reto Mueller of Switzerland, Prof. Robin Ferrier of New Zealand, and Prof. James M. Cook of the University of Wisconsin, Milwaukee; Dr. Yike Ni of California Institute of Technology, and Dr. Shengping Zheng of Columbia University for invaluable suggestions. I also wish to thank Dr. Gilles Chambournier, Prof. Phil S. Baran of Scripps Research Institute and his students, Narendra Ambhaikar, Ben Hafensteiner, Carlos Guerrero, and Dan O'Malley, Prof. Brian M. Stoltz of California Institute of Technology and his students, Kevin Allan, Daniel Caspi, David Ebner, Andrew Harned, Shyam Krishnan, Michael Krout, Qi Charles Liu, Sandy Ma, Justin Mohr, John Phillips, Jennifer Roizen, Brinton Seashore-Ludlow, Nathaniel Sherden, Jennifer Stockdill, and Carolyn Woodroofe for proofreading the final draft of the manuscript. Their knowledge and time have tremendously enhanced the quality of this book. Any remaining errors are, of course, solely my own responsibility.

I welcome your critique.

Jack Li

Jack Li
Ann Arbor, Michigan, March 2006

Table of Contents

Abbreviations and Acronyms

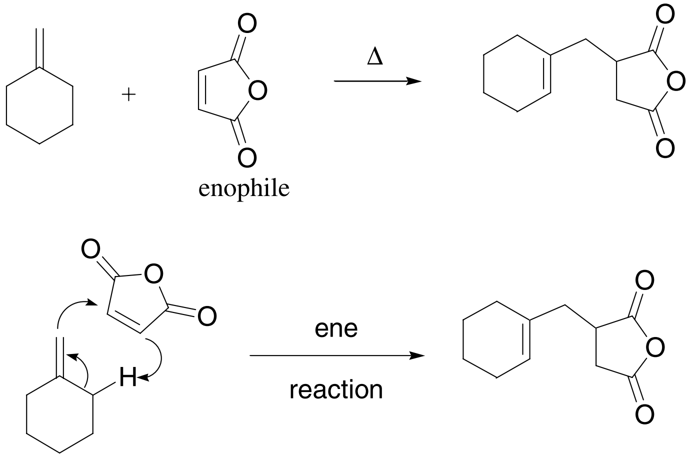
 polymer support	
A	adenosine
Ac	acetyl
AIBN	2,2'-azobisisobutyronitrile
Alpine-borane®	*B*-isopinocampheyl-9-borabicyclo[3.3.1]-nonane
Ar	aryl
B**:**	generic base
9-BBN	9-borabicyclo[3.3.1]nonane
[bimim]Cl•2AlCl$_3$	1-butyl-3-methylimidazolium chloroaluminuminate (a Lewis acid ionic liquid)
BINAP	2,2'-bis(diphenylphosphino)-1,1'-binaphthyl
Bn	benzyl
Boc	*tert*-butyloxycarbonyl
t-Bu	*tert*-butyl
Bz	benzoyl
Cbz	benzyloxycarbonyl
m-CPBA	*m*-chloroperoxybenzoic acid
CuTC	copper thiophene-2-carboxylate
DABCO	1,4-diazabicyclo[2.2.2]octane
dba	dibenzylideneacetone
DBU	1,8-diazabicyclo[5.4.0]undec-7-ene
DCC	1,3-dicyclohexylcarbodiimide
DDQ	2,3-dichloro-5,6-dicyano-1,4-benzoquinone
DEAD	diethyl azodicarboxylate
Δ	solvent heated under reflux
(DHQ)$_2$-PHAL	1,4-bis(9-*O*-dihydroquinine)-phthalazine
(DHQD)$_2$-PHAL	1,4-bis(9-*O*-dihydroquinidine)-phthalazine
DIAD	diisopropyl azodidicarboxylate
DIBAL	diisobutylaluminum hydride
DIPEA	diisopropylethylamine
DMA	*N,N*-dimethylacetamide
DMAP	4-*N,N*-dimethylaminopyridine
DME	1,2-dimethoxyethane
DMF	*N,N*-dimethylformamide
DMFDMA	*N,N*-dimethylformamide dimethyl acetal
DMS	dimethylsulfide
DMSO	dimethylsulfoxide
DMSY	dimethylsulfoxonium methylide
DMT	dimethoxytrityl
dppb	1,4-bis(diphenylphosphino)butane
dppe	1,2-bis(diphenylphosphino)ethane
dppf	1,1'-bis(diphenylphosphino)ferrocene
dppp	1,3-bis(diphenylphosphino)propane

DTBAD	di-*tert*-butylazodicarbonate
DTBMP	2,6-di-*tert*-butyl-4-methylpyridine
E1	unimolecular elimination
E2	bimolecular elimination
E1cB	2-step, base-induced β-elimination *via* carbanion
EAN	ethylammonium nitrate
EDDA	ethylenediamine diacetate
ee	enantiomeric excess
Ei	two groups leave at about the same time and bond to each other as they are doing so.
Eq	equivalent
Et	ethyl
EtOAc	ethyl acetate
HMDS	hexamethyldisilazane
HMPA	hexamethylphosphoramide
HMTTA	1,1,4,7,10,10-hexamethyltriethylenetetramine
Imd	imidazole
KHMDS	potassium hexamethyldisilazide
LAH	lithium aluminum hydride
LDA	lithium diisopropylamide
LHMDS	lithium hexamethyldisilazide
LTMP	lithium 2,2,6,6-tetramethylpiperidide
M	metal
Mes	mesityl
Ms	methanesulfonyl
MVK	methyl vinyl ketone
NBS	*N*-bromosuccinimide
NCS	*N*-chlorosuccinimide
NIS	*N*-iodosuccinimide
NMP	1-methyl-2-pyrrolidinone
Nos	nosylate (4-nitrobenzenesulfonyl)
Nu	nucleophile
N-PSP	*N*-phenylselenophthalimide
N-PSS	*N*-phenylselenosuccinimide
PCC	pyridinium chlorochromate
PDC	pyridinium dichromate
Piv	pivaloyl
PMB	para-methoxybenzyl
PPA	polyphosphoric acid
PPTS	pyridinium *p*-toluenesulfonate
$PyPh_2P$	diphenyl 2-pyridylphosphine
Pyr	pyridine
Red-Al	sodium bis(methoxy-ethoxy)aluminum hydride (SMEAH)
Salen	*N,N´*-disalicylidene-ethylenediamine
SET	single electron transfer
SM	starting material

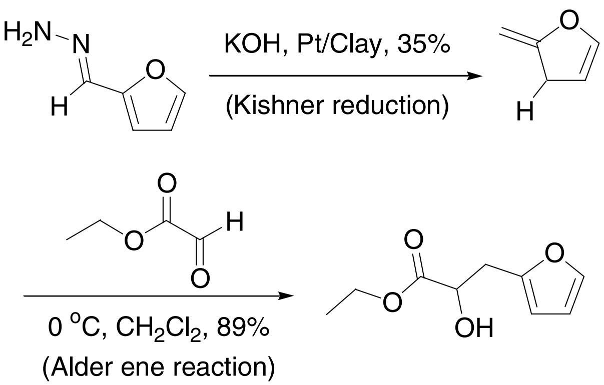
SMEAH	sodium bis(methoxy-ethoxy)aluminum hydride (Red-Al)
S_N1	unimolecular nucleophilic substitution
S_N2	bimolecular nucleophilic substitution
S_NAr	nucleophilic substitution on an aromatic ring
TBABB	tetra-*n*-butylammonium bibenzoate
TBAF	tetra-*n*-butylammonium fluoride
TBDMS	*tert*-butyldimethylsilyl
TBDPS	*tert*-butyldiphenylsilyl
TBS	*tert*-butyldimethylsilyl
TEA	triethylamine
TEOC	trimethysilylethoxycarbonyl
Tf	trifluoromethanesulfonyl (triflyl)
TFA	trifluoroacetic acid
TFAA	trifluoroacetic anhydride
TFP	tri-2-furylphosphine
THF	tetrahydrofuran
TIPS	triisopropylsilyl
TMEDA	*N,N,N',N'*-tetramethylethylenediamine
TMG	tetramethylguanidine
TMP	tetramethylpiperidine
TMS	trimethylsilyl
TMSCl	trimethylsilyl chloride
TMSCN	trimethylsilyl cyanide
TMSI	trimethylsilyl iodide
TMSOTf	trimethylsilyl triflate
Tol	toluene or tolyl
Tol-BINAP	2,2'-bis(di-*p*-tolylphosphino)-1,1'-binaphthyl
TosMIC	(*p*-tolylsulfonyl)methyl isocyanide
Ts	tosyl
TsO	tosylate
UHP	urea-hydrogen peroxide

Alder ene reaction

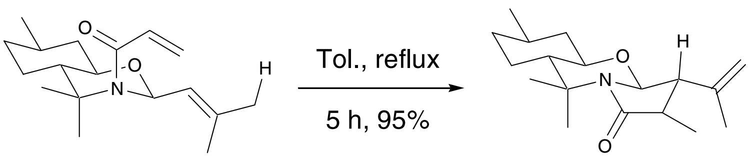
Addition of an enophile to an alkene *via* allylic transposition. Also known as hydroallyl addition.



Example 1[13]



Example 2[14]

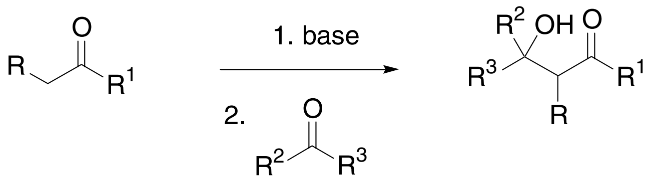


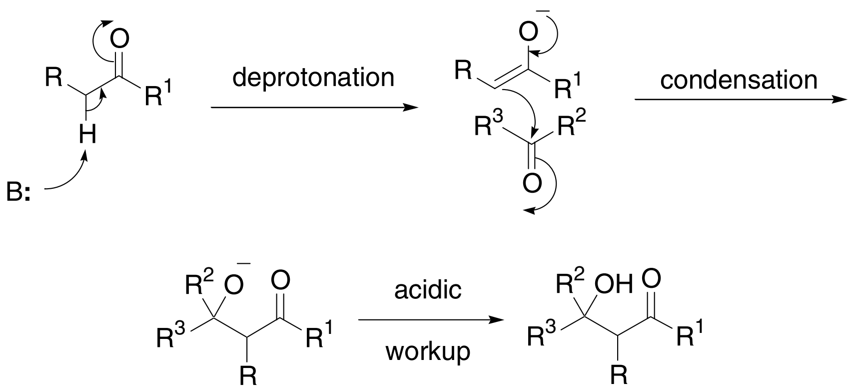
References

1. Alder, K.; Pascher, F.; Schmitz, A. *Ber. Dtsch. Chem. Ges.* **1943**, *76*, 27. Kurt Alder (Germany, 1902−1958) shared the Nobel Prize in Chemistry in 1950 with his teacher Otto Diels (Germany, 1876−1954) for development of the diene synthesis.
2. Oppolzer, W. *Pure Appl. Chem.* **1981**, *53*, 1181. (Review).
3. Oppolzer, W. *Angew. Chem.* **1984**, *96*, 840.
4. Mackewitz, T. W.; Regitz, M. *Synthesis* **1998**, 125−138.
5. Johnson, J. S.; Evans, D. A. *Acc. Chem. Res.* **2000**, *33*, 325−335. (Review).
6. Stratakis, M.; Orfanopoulos, M. *Tetrahedron* **2000**, *56*, 1595−1615.
7. Mikami, K.; Nakai, T. In *Catalytic Asymmetric Synthesis;* 2nd edn.; Ojima, I., ed.; Wiley−VCH: New York, **2000**, 543−568. (Review).
8. Leach, A. G.; Houk, K. N. *Chem. Commun.* **2002**, 1243.
9. Lei, A.; He, M.; Zhang, X. *J. Am. Chem. Soc.* **2002**, *124*, 8198.
10. Shibata, T.; Takesue, Y.; Kadowaki, S.; Takagi, K. *Synlett* **2003**, 268.
11. Suzuki, K.; Inomata, K.; Endo, Y. *Org. Lett*. **2004**, *6*, 409.
12. Brummond, K. M.; McCabe, J. M. *The Rhodium(I)-catalyzed Alder-ene Reaction.* In *Modern Rhodium-Catalyzed Organic Reactions* **2005**, 151−172. (Book chapter).
13. Miles, W. H.; Dethoff, E. A.; Tuson, H. H.; Ulas, G. *J. Org. Chem.* **2005**, *70*, 2862.
14. Pedrosa, R.; Andres, C.; Martin, L.; Nieto, J.; Roson, C. *J. Org. Chem.* **2005**, *70*, 4332.

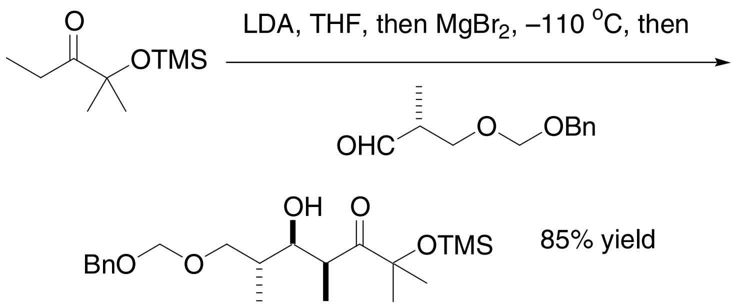
Aldol condensation

Condensation of a carbonyl with an enolate or an enol. A simple case is addition of an enolate to an **ald**ehyde to afford an alcoh**ol**, thus the name **aldol**.

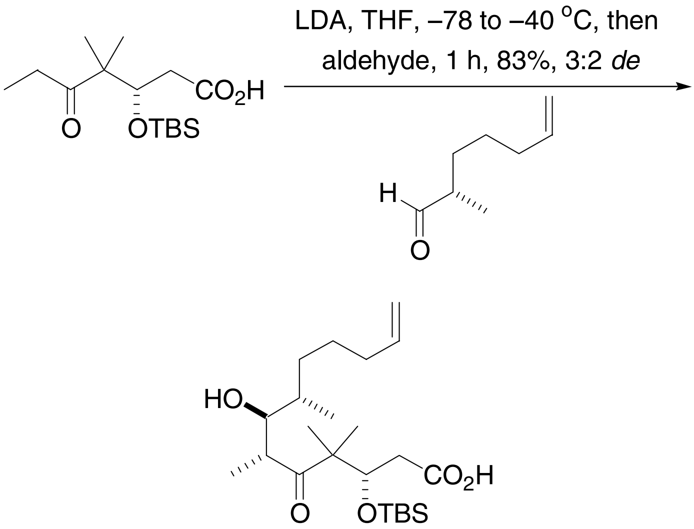




Example 1[3]



Example 2[12]

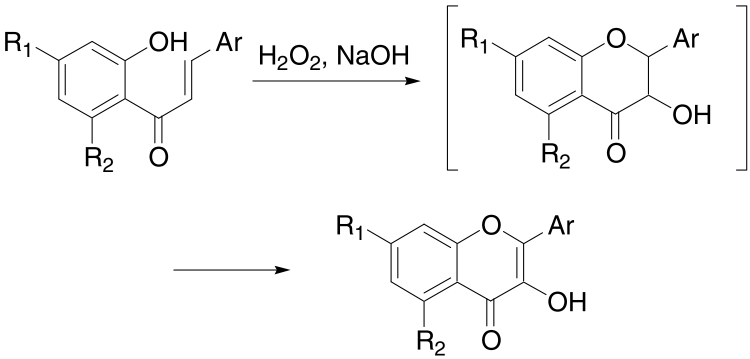


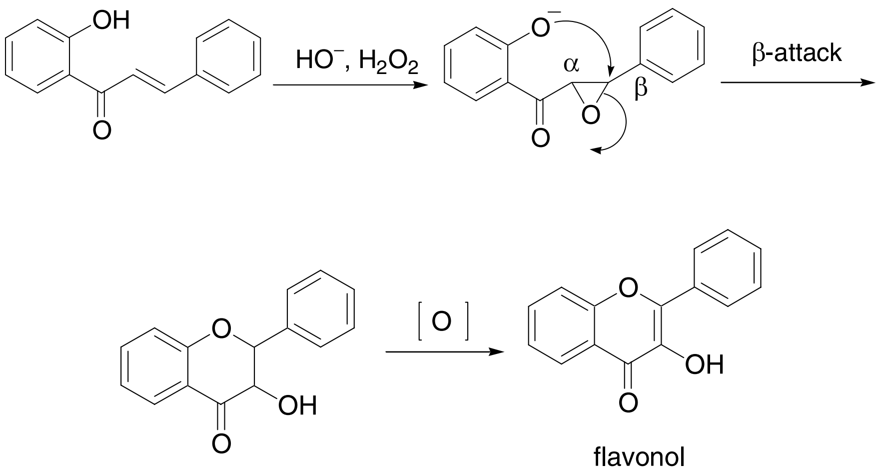
References

1. Wurtz, C. A. *Bull. Soc. Chim. Fr.* **1872**, *17,* 436. Charles Adolphe Wurtz (1817–1884) was born in Strasbourg, France. After his doctoral training, he spent a year under Liebig in 1843. In 1874, Wurtz became a chair of organic chemistry at the Sorbonne, where he educated many illustrous chemists such as Crafts, Fittig, Friedel, and van't Hoff. The Wurtz reaction is no longer considered synthetically useful, although *the aldol reaction* that Wurtz discovered in 1872 has become a staple in organic synthesis.
2. Nielsen, A. T.; Houlihan, W. J. *Org. React.* **1968**, *16*, 1–438. (Review).
3. Still, W. C.; McDonald, J. H., III. *Tetrahedron Lett.* **1980**, *21*, 1031, 1035.
4. Mukayama, T. *Org. React.* **1982**, *28*, 203–331. (Review).
5. Mukayama, T.; Kobayashi, S. *Org. React.* **1994**, *46*, 1–103. (Review on Tin(II) enolates).
6. Saito, S.; Yamamoto, H. *Chem. Eur. J.* **1999**, *5*, 1959–1962. (Review).
7. Johnson, J. S.; Evans, D. A. *Acc. Chem. Res.* **2000**, *33*, 325–335. (Review).
8. Denmark, S. E.; Stavenger, R. A. *Acc. Chem. Res.* **2000**, *33*, 432–440. (Review).
9. Nicolaou, K. C.; Ritzén, A.; Namoto, K. *Chem. Commun.* **2001**, 1523.
10. Palomo, C.; Oiarbide, M.; García, J. M. *Chem. Eur. J.* **2002**, *8*, 36–44. (Review).
11. Alcaide, B.; Almendros, P. *Eur. J. Org. Chem.* **2002**, 1595–1601. (Review).
12. Wei, H.-X.; Hu, J.; Purkiss, D. W.; Paré, P. W. *Tetrahedron Lett.* **2003**, *44*, 949.
13. Bravin, F. M.; Busnelli, G.; Colombo, M.; Gatti, F.; Manzoni, L.; Scolastico, C. *Synthesis* **2004**, 353.
14. Mahrwald, R. (ed.) *Modern Aldol Reactions,* Wiley–VCH: Weinheim, Germany, **2004**. (Book).

Algar–Flynn–Oyamada Reaction

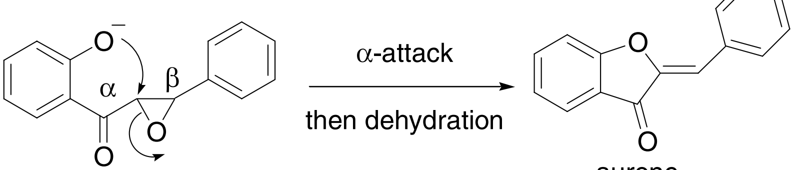
Conversion of 2’-hydroxychalcones to 2-aryl-3-hydroxy-4*H*-1benzopyran-4-ones (flavonols) by alkaline hydrogen peroxide oxidation.





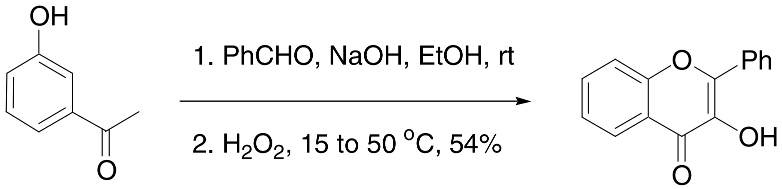
flavonol

A side reaction:

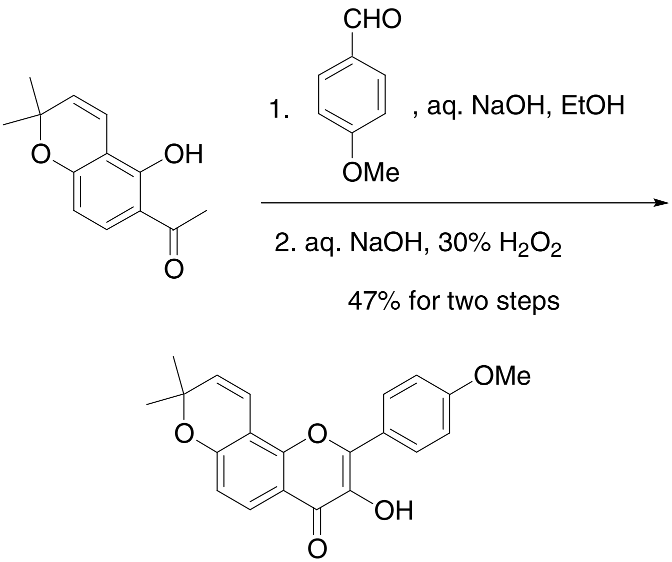


aurone

Example 1[5]



Example 2[5]



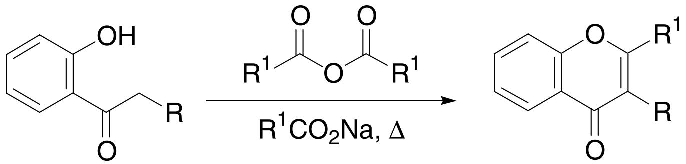
References

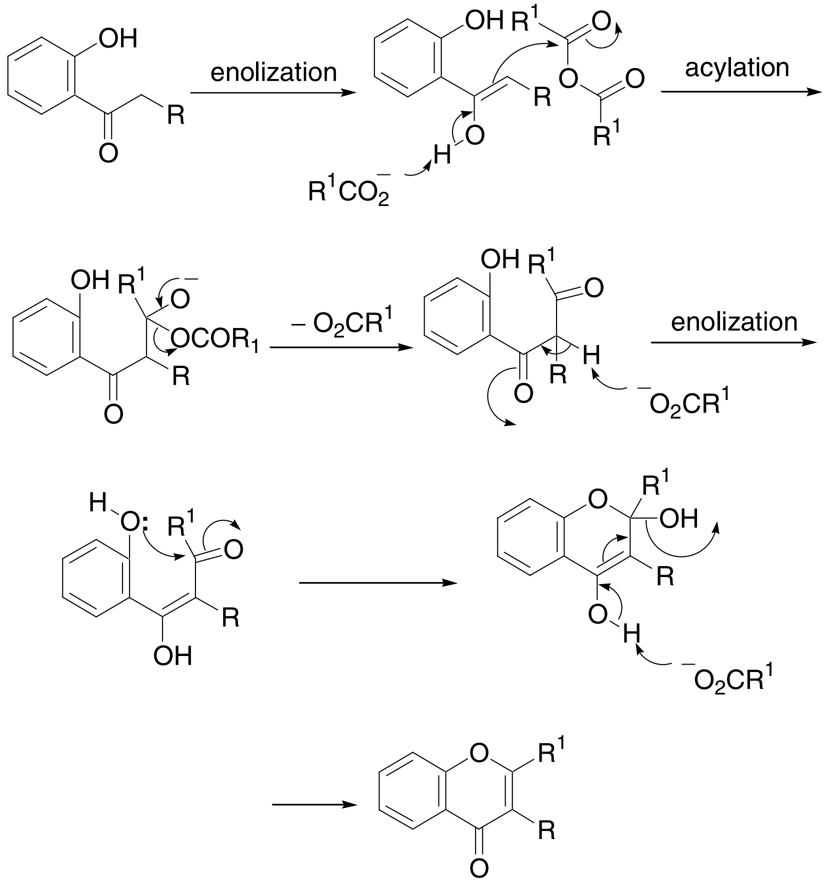
1. Algar, J.; Flynn, J. P. *Proc. Roy. Irish. Acad.* **1934**, *42B*, 1.
2. Oyamada, T. *J. Chem. Soc. Japan* **1934**, *55*, 1256.
3. Oyamada, T. *Bull. Chem. Soc. Jpn.* **1935**, *10*, 182.
4. Wheeler, T.S. *Rec. of Chem. Prog.* **1957**, *18*, 133. (Review)
5. Smith, M. A.; Neumann, R. M.; Webb, R. A. *J. Heterocycl. Chem.* **1968**, *5*, 425.
6. Rao, A. V. S.; Rao, N. V. S. *Current Science* **1974**, *43*, 477.
7. Cullen, W. P.; Donnelly, D. M. X.; Keenan, A. K.; Kennan, P. J.; Ramdas, K. *J. Chem. Soc., Perkin Trans. 1* **1975**, 1671.
8. Wagner, H.; Farkas, L. In *The Flavonoids*; Harborne, J. B.; Mabry, T. J.; Mabry H., Eds.; Academic Press: New York, **1975**; p 127. (Review).
9. Wollenweber, E. In *The Flavonoids: Advances in Research*; Harborne, J. B.; Mabry, T. J., Eds; Chapman and Hall: New York, **1982**; p 189. (Review).
10. Jain, A. C.; Gupta, S. M.; Sharma, A. *Bull. Chem. Soc. Jpn.* **1983**, *56*, 1267.
11. Prasad, K. J. Rajendra; Iyer, C. S. Rukmani; Iyer, P. R. *Indian J. Chem., Sect. B* **1983**, *22B*, 693.

12. Wollenweber, E. In *The Flavonoids: Advances in Research since 1986*; Harborne, J. B., Ed.; Chapman and Hall: New York, **1994**, p 259. (Review).
13. Bennett, M.; Burke, A. J.; O'Sullivan, W. I. *Tetrahedron* **1996**, *52*, 7163.
14. Sobottka, A. M.; Werner, W.; Blaschke, G.; Kiefer, W.; Nowe, U.; Dannhardt, G.; Schapoval, E. E. S.; Schenkel, E. P.; Scriba, G. K. E. *Arch. Pharm.* **2000**, *333*, 205.
15. Bohm, B. A.; Stuessy, T. F. *Flavonoids of the Sunflower Family (Asteraceae)*; Springer-Verlag: New York, **2001**. (Review).

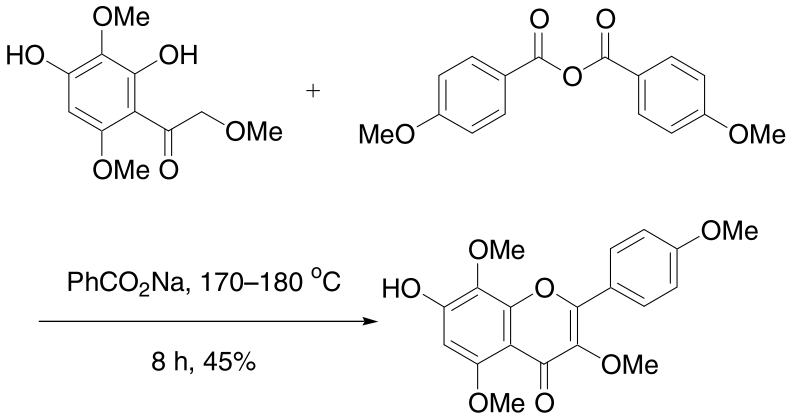
Allan–Robinson reaction

Synthesis of flavones or isoflavones.





Example 1[6]

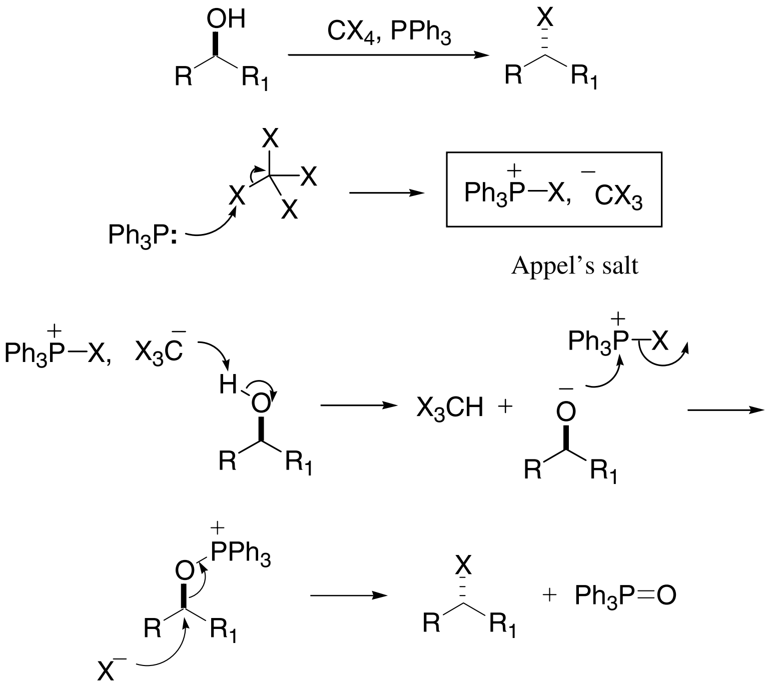


References

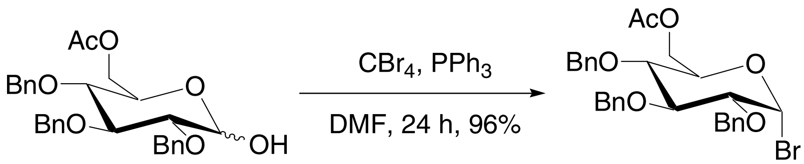
1. Allan, J.; Robinson, R. *J. Chem. Soc.* **1924**, *125*, 2192. Robert Robinson (United Kingdom, 1886–1975) won the Nobel Prize in Chemistry in 1947 for his studies on alkaloids. However, Robinson himself considered his greatest contribution to science was that he founded the qualitative theory of electronic mechanisms in organic chemistry. Robinson, along with Lapworth (a friend) and Ingold (a rival), pioneered the arrow pushing approach to organic reaction mechanism. Robinson was also an accomplished pianist. J. Allan, his student, also coauthored another important paper with Robinson on the relative directive powers of groups for aromatic substitution.
2. Széll, T.; Dózsai, L.; Zarándy, M.; Menyhárth, K. *Tetrahedron* **1969**, *25*, 715.
3. Wagner, H.; Maurer, I.; Farkas, L.; Strelisky, J. *Tetrahedron* **1977**, *33*, 1405.
4. Dutta, P. K.; Bagchi, D.; Pakrashi, S. C. *Indian J. Chem., Sect. B* **1982**, *21B*, 1037.
5. Patwardhan, S. A.; Gupta, A. S. *J. Chem. Res., (S)* **1984**, 395.
6. Horie, T.; Tsukayama, M.; Kawamura, Y.; Seno, M. *J. Org. Chem.* **1987**, *52*, 4702.
7. Horie, T.; Tsukayama, M.; Kawamura, Y.; Yamamoto, S. *Chem. Pharm. Bull.* **1987**, *35*, 4465.
8. Horie, T.; Kawamura, Y.; Tsukayama, M.; Yoshizaki, S. *Chem. Pharm. Bull.* **1989**, *37*, 1216.

Appel reaction

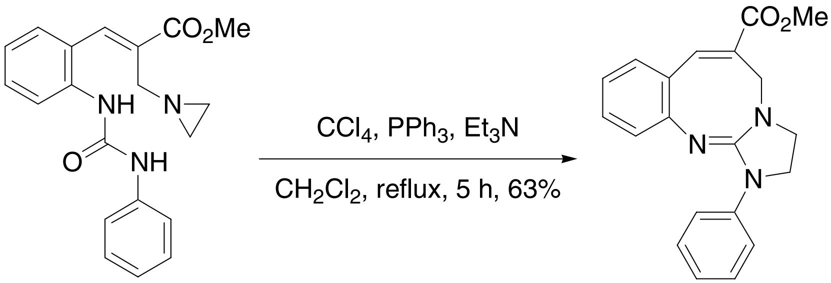
The reaction between triphenylphosphine and tetrahalomethane (CCl_4, CBr_4) forms a salt known as Appel's salt. Treatment of alcohols with Appel's salt gives rise to the corresponding halides.



Example 1[7]



Example 2, Appel's salt is often used as a dehydrating agent[8]

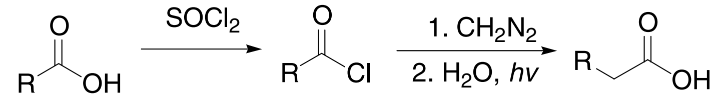


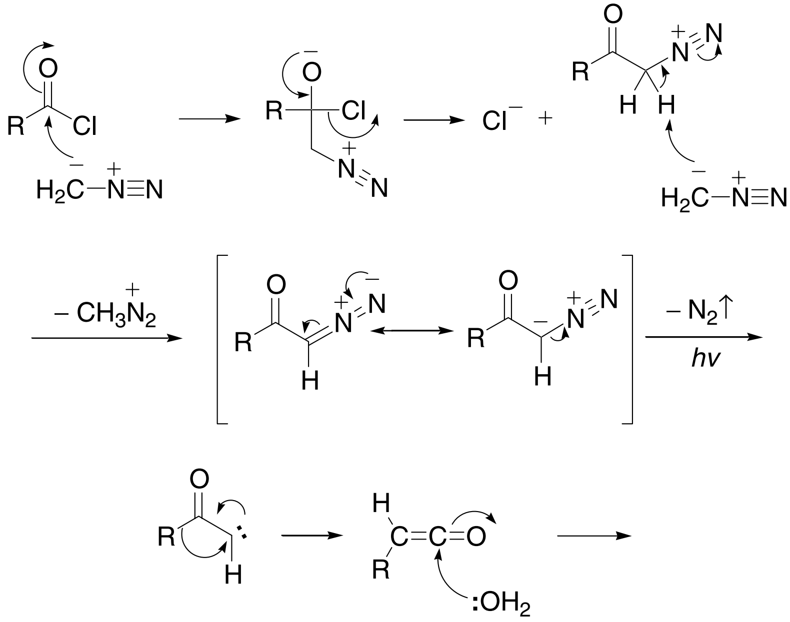
References

1. Appel, R.; Kleinstueck, R.; Ziehn, K. D. *Angew. Chem., Int. Ed. Engl.* **1971**, *10*, 132. Rolf Appel was a professor at Anorganisch-Chemisches Institut der Universität in Bonn, Germany.
2. Appel, R.; Kleinstück, R.; Ziehn, K.-D. *Chem. Ber.* **1971**, *104*, 1335.
3. Appel, R. *Angew. Chem., Int. Ed. Engl.* **1975**, *14*, 801. (Review).
4. Beres, J.; Bentrude, W. G.; Parkanji, L.; Kalman, A.; Sopchik, A. E. *J. Org. Chem.* **1995**, *50*, 1271.
5. Lee, K. J.; Kim, S. Heon; K., Jong H. *Synthesis* **1997**, 1461.
6. Lee, K.-J.; Kwon, H.-T.; Kim, B.-G. *J. Heterocycl. Chem.* **1997**, *34*, 1795.
7. Lim, J.-S.; Lee, K.-J. *J. Heterocycl. Chem.* **2002**, *39*, 975.
8. Nishida, Y.; Shingu, Y.; Dohi, H.; Kobayashi, K. *Org. Lett.* **2003**, *5*, 2377.
9. Cho, H. I.; Lee, S. W.; Lee, K.-J. *J. Heterocycl. Chem.* **2004**, *41*, 799.

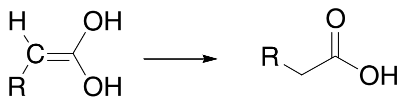
Arndt–Eistert homologation

One carbon homologation of carboxylic acids using diazomethane.

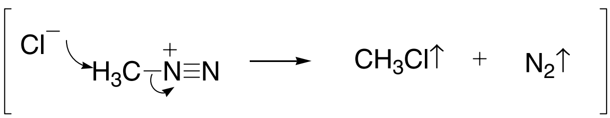




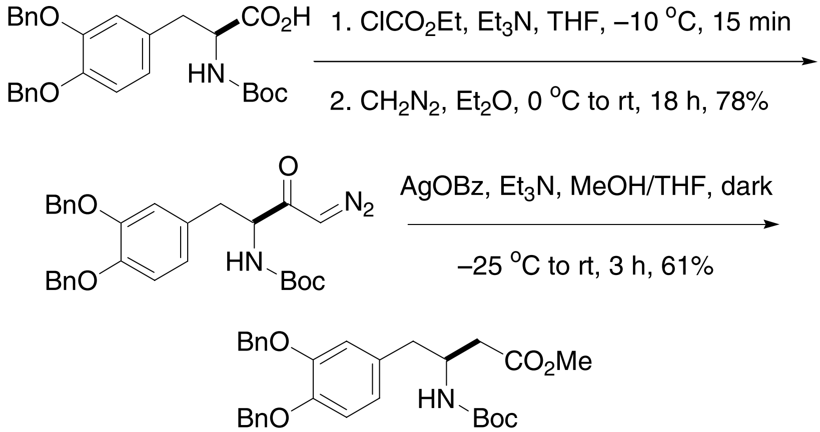
α-ketocarbene intermediate ketene intermediate



side reaction:



Example 1[10]

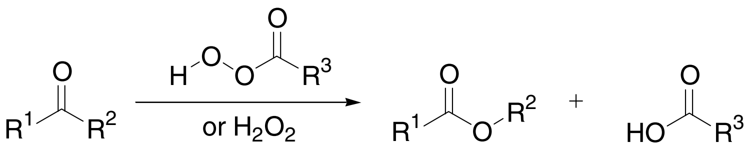


References

1. Arndt, F.; Eistert, B. *Ber. Dtsch. Chem. Ges.* **1935**, *68*, 200. Fritz Arndt (1885–1969) was born in Hamburg, Germany. He discovered the Arndt–Eistert homologation at the University of Breslau where he extensively investigated the synthesis of diazomethane and its reactions with aldehydes, ketones, and acid chlorides. Fritz Arndt's chain-smoking of cigars ensured that his presence in the laboratories was always well advertised. Bernd Eistert (1902–1978), born in Ohlau, Silesia, was Arndt's Ph.D. student. Eistert later joined I. G. Farbenindustrie, which became BASF after the Allies broke the conglomerate up after WWII.
2. Kuo, Y. C.; Aoyama, T.; Shioiri, T. *Chem. Pharm. Bull.* **1982**, *30*, 899.
3. Podlech, J.; Seebach, D. *Angew. Chem., Int. Ed. Engl.* **1995**, *34*, 471.
4. Matthews, J. L.; Braun, C.; Guibourdenche, C.; Overhand, M.; Seebach, D. in *Enantioselective Synthesis of β-Amino Acids* Juaristi, E. ed. Wiley-VCH, New York, N. Y. **1997**, pp 105–126. (Review).
5. Katritzky, A. R.; Zhang, S.; Fang, Y. *Org. Lett.* **2000**, *2*, 3789.
6. Cesar, J.; Sollner Dolenc, M. *Tetrahedron Lett.* **2001**, *42*, 7099.
7. Katritzky, A. R.; Zhang, S.; Hussein, A. H. M.; Fang, Y.; Steel, P. J. *J. Org. Chem.* **2001**, *66*, 5606.
8. Vasanthakumar, G.-R.; Babu, V. V. S. *Synth. Commun.* **2002**, *32*, 651.
9. Chakravarty, P. K.; Shih, T. L.; Colletti, S. L.; Ayer, M. B.; Snedden, C.; Kuo, H.; Tyagarajan, S.; Gregory, L.; Zakson-Aiken, M.; Shoop, W. L.; Schmatz, D. M.; Wyvratt, M.J.; Fisher, M. H.; Meinke, P. T. *Bioorg. Med. Chem. Lett.* **2003**, *13*, 147.
10. Gaucher, A.; Dutot, L.; Barbeau, O.; Hamchaoui, W.; Wakselman, M.; Mazaleyrat, J.-P. *Tetrahedron: Asymmetry* **2005**, *16*, 857.

Baeyer–Villiger oxidation

General scheme:



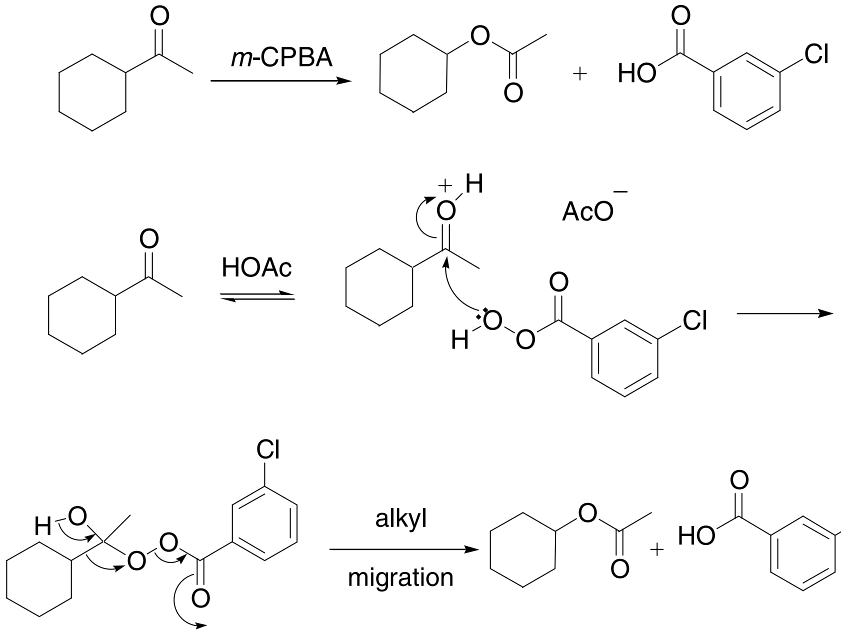
The most electron-rich alkyl group (more substituted carbon) migrates first. The general migration order:

tertiary alkyl > cyclohexyl > secondary alkyl > benzyl > phenyl > primary alkyl > methyl >> H.

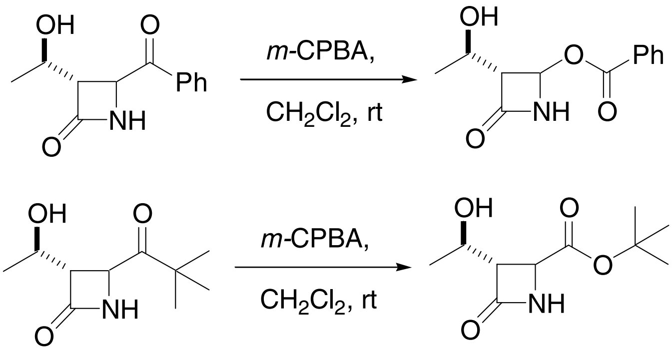
For substituted aryls:

p-MeO-Ar > *p*-Me-Ar > *p*-Cl-Ar > *p*-Br-Ar > *p*-MeOAr > *p*-O_2N-Ar

Example 1:



Example 2[10]

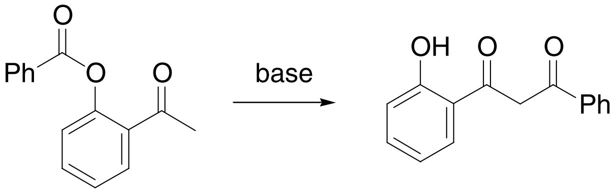


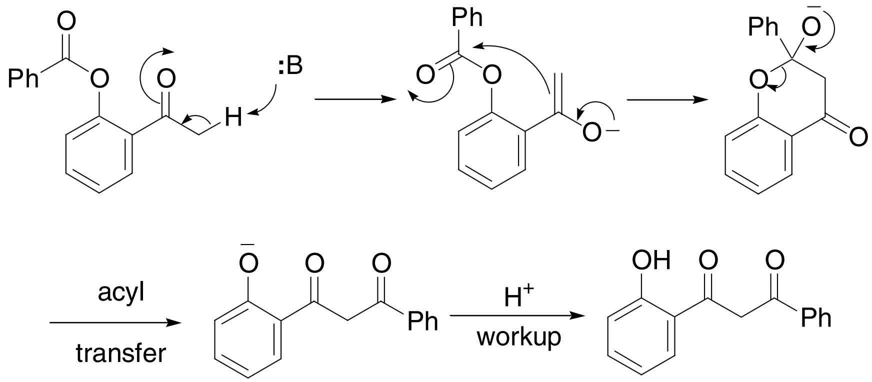
References

1. v. Baeyer, A.; Villiger, V. *Ber. Dtsch. Chem. Ges.* **1899**, *32*, 3625. Adolf von Baeyer (1835–1917) was one of the most illustrious organic chemists in history. He contributed in many areas of the field. The Baeyer-Drewson indigo synthesis made possible the commercialization of synthetic indigo. Baeyer's other claim of fame is his synthesis of barbituric acid, named after his girlfriend, Barbara. Baeyer's real joy was in his laboratory and he deplored any outside work that took him away from his bench. When a visitor expressed envy that fortune had blessed so much of Baeyer's work with success, Baeyer retorted dryly: "Herr Kollege, I experiment more than you." As a scientist, Baeyer was free of vanity. Unlike other scholastic masters of his time (Liebig for instance), he was always ready to acknowledge ungrudgingly the merits of others. Baeyer's famous greenish-black hat was a part of his perpetual wardrobe and he had a ritual of tipping his hat when he admired novel compounds. Adolf von Baeyer received the Nobel Prize in Chemistry in 1905 at age seventy. His apprentice, Emil Fischer, won it in 1902 when he was fifty, three years before his teacher. Victor Villiger (1868–1934), born in Switzerland, went to Munich to work with Adolf von Baeyer for eleven years.
2. Krow, G. R. *Tetrahedron* **1981**, *37*, 2697.
3. Krow, G. R. *Org. React.* **1993**, *43*, 251–798. (Review).
4. Renz, M.; Meunier, B. *Eur. J. Org. Chem.* **1999**, *4*, 737. (Review).
5. Bolm, C.; Beckmann, O. *Compr. Asymmetric Catal. I-III* **1999**, *2*, 803. (Review).
6. Crudden, C. M.; Chen, A. C.; Calhoun, L. A. *Angew. Chem., Int. Ed.* **2000**, *39*, 2851.
7. Fukuda, O.; Sakaguchi, S.; Ishii, Y. *Tetrahedron Lett.* **2001**, *42*, 3479.
8. Watanabe, A.; Uchida, T.; Ito, K.; Katsuki, T. *Tetrahedron Lett.* **2002**, *43*, 4481.
9. Kobayashi, S.; Tanaka, H.; Amii, H.; Uneyama, K. *Tetrahedron* **2003**, *59*, 1547.
10. Laurent, M.; Ceresiat, M.; Marchand-Brynaert, J. *J. Org. Chem.* **2004**, *69*, 3194.
11. Reetz, M. T.; Brunner, B.; Schneider, T.; Schulz, F.; Clouthier, C. M.; Kayser, M. M. *Angew. Chem., Int. Ed.* **2004**, *43*, 4075.

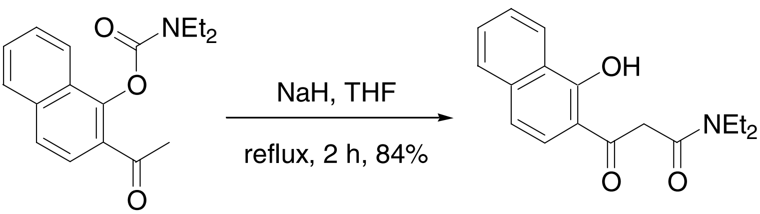
Baker–Venkataraman rearrangement

Base-catalyzed acyl transfer reaction that converts α-acyloxyketones to β-diketones.

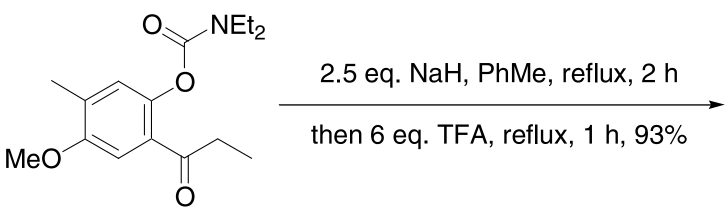


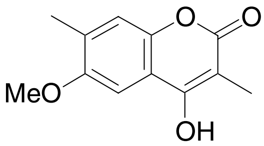


Example 1[7]



Example 2[8]



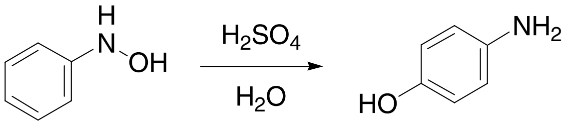


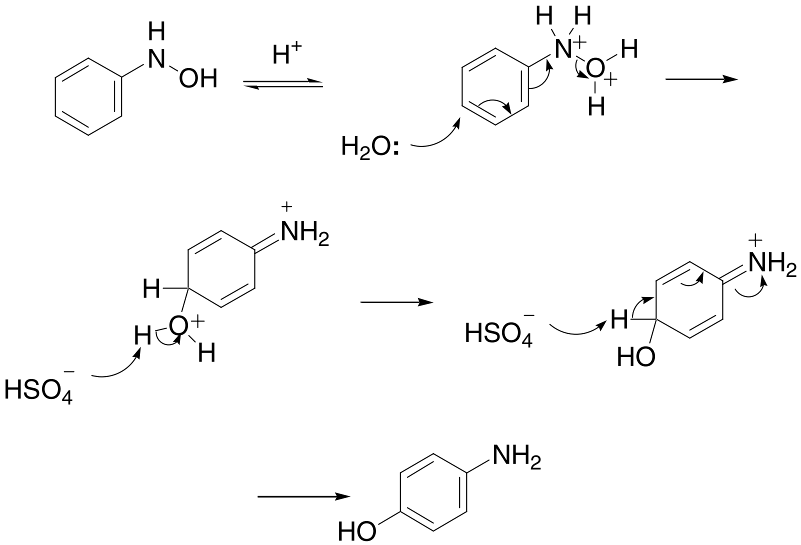
References

1. Baker, W. *J. Chem. Soc.* **1933**, 1381. Wilson Baker (1900–2002) was born in Runcorn, England. He studied chemistry at Manchester under Arthur Lapworth and at Oxford under Robinson. In 1943, Baker was the first one who confirmed that penicillin contained sulfur, of which Robinson commented: "This is a feather in your cap, Baker." Baker began his independent academic career at University of Bristol. He retired in 1965 as the head of the School of Chemistry. Baker was a well-known chemist centenarian, spending 47 years in retirement!
2. Mahal, H. S.; Venkataraman, K. *J. Chem. Soc.* **1934**, 1767. K. Venkataraman studied under Robert Robinson Manchester. He returned to India and later arose to be the director of the National Chemical Laboratory at Poona.
3. Kraus, G. A.; Fulton, B. S.; Wood, S. H. *J. Org. Chem.* **1984**, *49*, 3212.
4. Bowden, K.; Chehel-Amiran, M. *J. Chem. Soc., Perkin Trans. 2* **1986**, 2039.
5. Makrandi, J. K.; Kumari, V. *Synth. Commun.* **1989**, *19*, 1919.
6. Reddy, B. P.; Krupadanam, G. L. D. *J. Heterocycl. Chem.* **1996**, *33*, 1561.
7. Kalinin, A. V.; da Silva, A. J. M.; Lopes, C. C.; Lopes, R. S. C.; Snieckus, V. *Tetrahedron Lett.* **1998**, *39*, 4995.
8. Kalinin, A. V.; Snieckus, V. *Tetrahedron Lett.* **1998**, *39*, 4999.
9. Thasana, N.; Ruchirawat, S. *Tetrahedron Lett.* **2002**, *43*, 4515.
10. Santos, C. M. M.; Silva, A. M. S.; Cavaleiro, J. A. S. *Eur. J. Org. Chem.* **2003**, 4575.

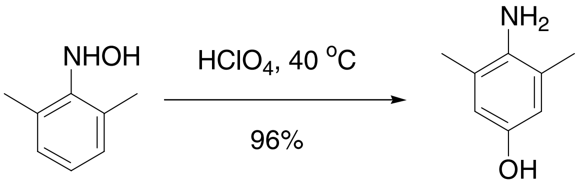
Bamberger rearrangement

Acid-mediated rearrangement of *N*-phenylhydroxylamines to 4-aminophenols.





Example 1[5]



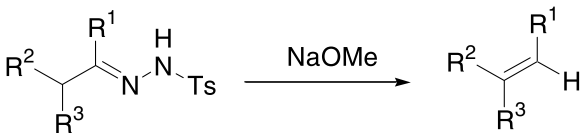
References

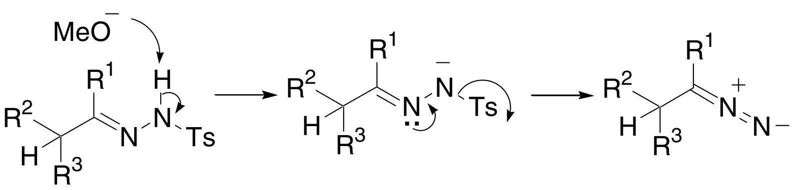
1. Bamberger, E. *Ber. Dtsch. Chem. Ges.* **1894**, *27*, 1548. Eugen Bamberger (1857−1932) was born in Berlin. He taught in Munich and at ETH in Zurich. He introduced sodium and amyl alcohol as a reducing agent. Bamberger also engaged in a long (1894−1900) and acrimonious controversy with Arthur Hantzsch on the structure of diazo-compounds.
2. Shine, H. J. in *Aromatic Rearrangement* Elsevier: New York, **1967**, pp 182−190. (Review).
3. Buckingham, J. *Tetrahedron Lett.* **1970**, *11*, 2341.

4. Sone, T.; Tokuda, Y.; Sakai, T.; Shinkai, S.; Manabe, O. *J. Chem. Soc., Perkin Trans. 2* **1981**, 298.
5. Fishbein, J. C.; McClelland, R. A. *J. Am. Chem. Soc.* **1987**, *109*, 2824.
6. Zoran, A.; Khodzhaev, O.; Sasson, Y. *J. Chem. Soc., Chem. Commun.* **1994**, 2239.
7. Tordeux, M.; Wakselman, C. *J. Fluorine Chem*. **1995**, *74*, 251.
8. Fishbein, J. C.; McClelland, R. A. *Can. J. Chem*. **1996**, *74*, 1321.
9. Naicker, K. P.; Pitchumani, K.; Varma, R. S. *Catal. Lett*. **1999**, *58*, 167.
10. Pirrung, M. C.; Wedel, M.; Zhao, Y. *Synlett* **2002**, 143.
11. Qiu, X.; Jiang, J.-J.; Wang, X.-Y.; Shen, Y.-J. *Youji Huaxue* **2005**, *25*, 561.

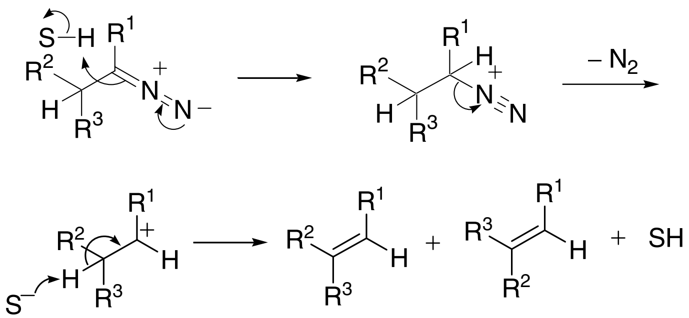
Bamford–Stevens reaction

The Bamford−Stevens reaction and the Shapiro reaction share a similar mechanistic pathway. The former uses a base such as Na, NaOMe, LiH, NaH, $NaNH_2$, heat, *etc.*, whereas the latter employs bases such as alkyllithiums and Grignard reagents. As a result, the Bamford−Stevens reaction furnishes more-substituted olefins as the thermodynamic products, while the Shapiro reaction generally affords less-substituted olefins as the kinetic products.

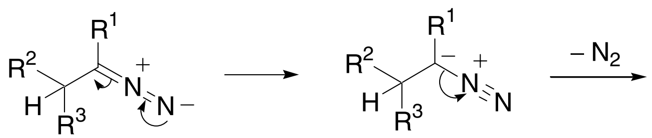


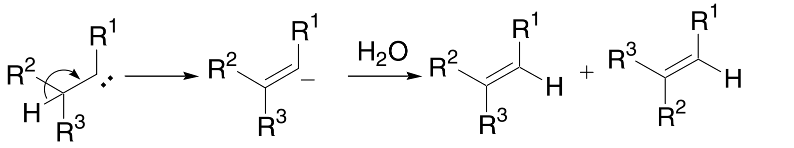


In protic solvent:

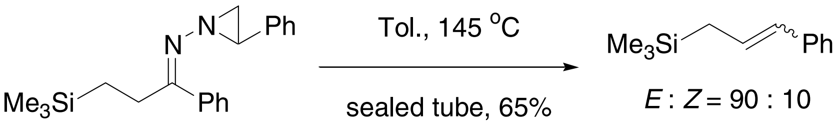


In aprotic solvent:

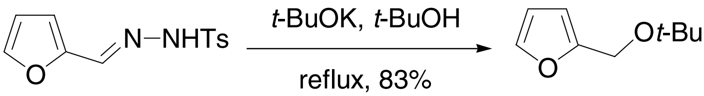




Example 1, thermal Bamford–Stevens[5]



Example 2[9]

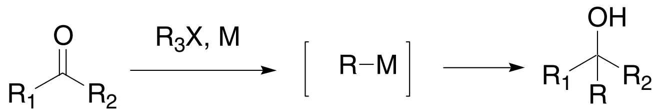


References

1. Bamford, W. R.; Stevens, T. S. M. *J. Chem. Soc.* **1952**, 4735. Thomas Stevens (1900–2000), a chemist centenarian, was born in Renfrew, Scotland. He and his student W. R. Bamford published this paper at the University of Sheffield, UK. Stevens also contributed to another name reaction, the McFadyen–Stevens reaction (page 354).
2. Shapiro, R. H. *Org. React.* **1976**, *23*, 405–507. (Review).
3. Adlington, R. M.; Barrett, A. G. M. *Acc. Chem. Res.* **1983**, *16*, 55–59. (Review on the Shapiro reaction).
4. Chamberlin, A. R.; Bloom, S. H. *Org. React.* **1990**, *39*, 1–83. (Review).
5. Sarkar, T. K.; Ghorai, B. K. *J. Chem. Soc., Chem. Commun*. **1992**, *17,* 1184.
6. Nickon, A.; Stern, A. G.; Ilao, M. C. *Tetrahedron Lett*. **1993**, *34*, 1391.
7. Olmstead, K. K.; Nickon, A. *Tetrahedron* **1998**, *54*, 12161.
8. Olmstead, K. K.; Nickon, A. *Tetrahedron* **1999**, *55*, 7389.
9. Chandrasekhar, S.; Rajaiah, G.; Chandraiah, L.; Swamy, D. N. *Synlett* **2001**, 1779.
10. May, J. A.; Stoltz, B. M. *J. Am. Chem. Soc.* **2002**, *124*, 12426.
11. Zhu, S.; Liao, Y.; Zhu, S. *Org. Lett.* **2004**, *6*, 377.

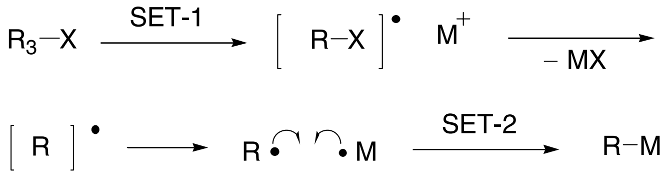
Barbier coupling reaction

In essence, the Barbier coupling reaction is a Grignard reaction carried out *in situ*, although its discovery preceded that of the Grignard reaction by a year. *Cf.* Grignard reaction.

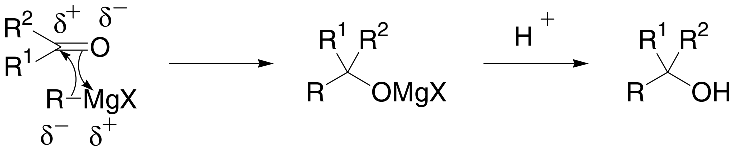


According to conventional wisdom,[3] the organometallic intermediate (M = Mg, Li, Sm, Zn, La, *etc.*) is generated *in situ*, which is intermediately trapped by the carbonyl compound. However, recent experimental and theoretical studies seem to suggest that the Barbier coupling reaction goes through a single electron transfer pathway.

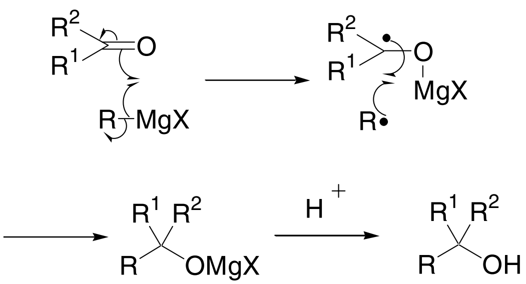
Generation of the Grignard reagent,



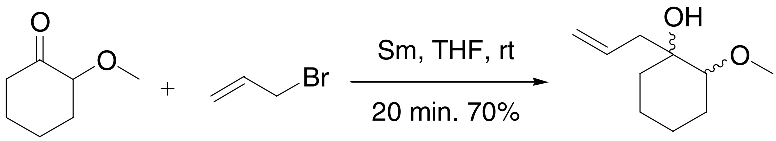
Ionic mechanism,



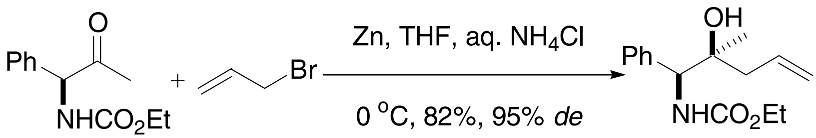
Single electron transfer mechanism,



Example 1[8]



Example 2[11]

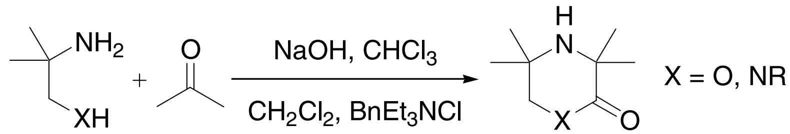


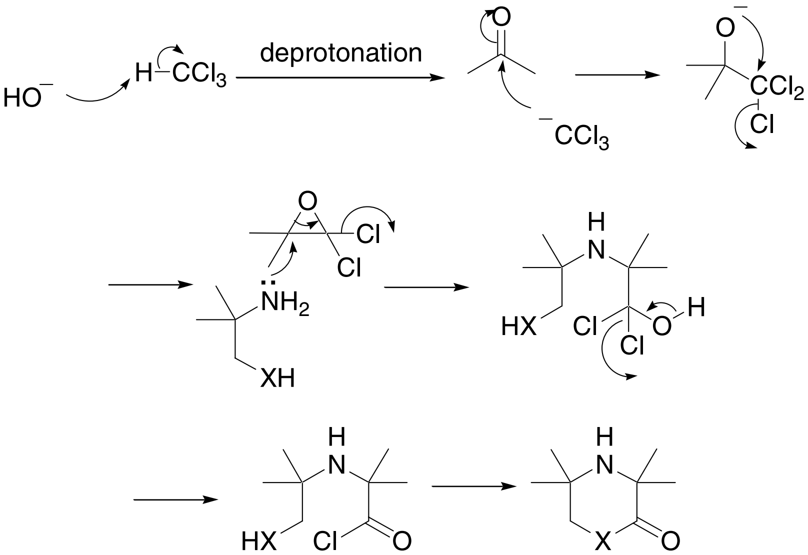
References

1. Barbier, P. *C. R. Hebd. Séances Acad. Sci.* **1899**, *128,* 110. Phillippe Barbier (1848–1922) was born in Luzy, Nièvre, France. He studied terpenoids using zinc and magnesium. Barbier suggested the use of magnesium to his student, Victor Grignard, who later discovered the Grignard reagent and won the Nobel Prize in 1912.
2. Grignard, V. *C. R. Hebd. Seanes Acad. Sci.* **1900**, *130,* 1322.
3. Molle, G.; Bauer, P. *J. Am. Chem. Soc.* **1982**, *104,* 3481.
4. Moyano, A.; Pericás, M. A.; Riera, A.; Luche, J.-L. *Tetrahedron Lett.* **1990**, *31*, 7619. (Theoretical study).
5. Alonso, F.; Yus, M. *Rec. Res. Dev. Org. Chem.* **1997**, *1*, 397. (Review).
6. Russo, D. A. *Chem. Ind.* **1996**, *64*, 405. (Review).
7. Curran, D. P.; Gu, X.; Zhang, W.; Dowd, P. *Tetrahedron* **1997**, *53*, 9023.
8. Basu, M. K.; Banik, B. *Tetrahedron Lett.* **2001**, *42*, 187.
9. Sinha, P.; Roy, S. *Chem. Commun.* **2001**, 1798.
10. Lambardo, M.; Gianotti, K.; Licciulli, S.; Trombini, C. *Tetrahedron* **2004**, *60*, 11725.
11. Resende, G. O.; Aguiar, L. C. S.; Antunes, O. A. C. *Synlett* **2005**, 119.

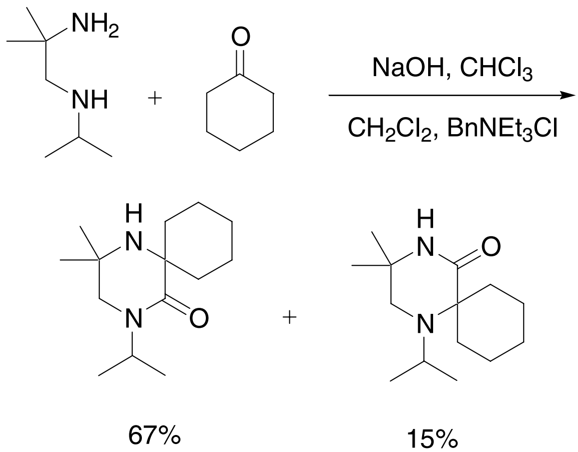
Bargellini reaction

Synthesis of hindered morpholinones or piperazinones from ketones (such as acetone) and 2-amino-2-methyl-1-propanol or 1,2-diaminopropanes.

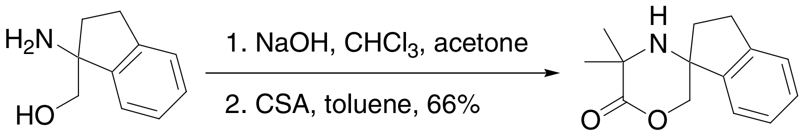




Example 1[2]



Example 2[6]

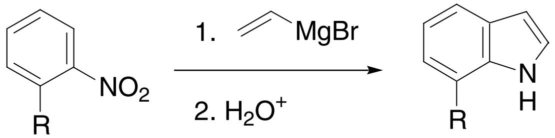


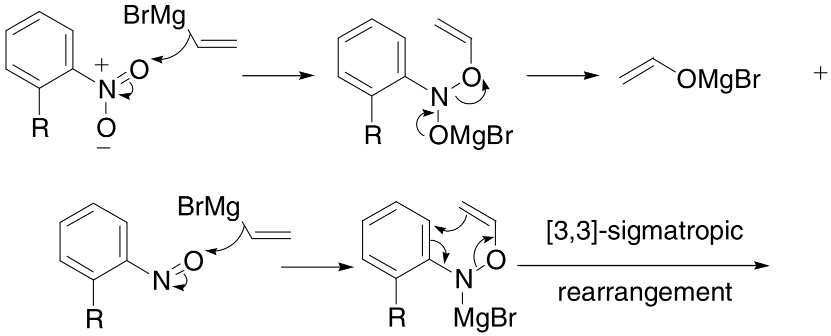
References

1. Bargellini, G. *Gazz. Chim. Ital.* **1906**, *36*, 329.
2. Lai, J. T. *J. Org. Chem.* **1980**, *45*, 754.
3. Lai, J. T. *Synthesis* **1981**, 754.
4. Lai, J. T. *Synthesis* **1984**, 122.
5. Lai, J. T. *Synthesis* **1984**, 124.
6. Rychnovsky, S. D.; Beauchamp, T.; Vaidyanathan, R.; Kwan, T. *J. Org. Chem.* **1998**, *63*, 6363.
7. Cvetovich, R. J.; Chung, J. Y. L.; Kress, M. H.; Amato, J. S.; Zhou, G.; Matty, L.; Tsay, F. R.; Li, Z. *Abstracts of Papers, 226th ACS National Meeting, New York, NY, United States, September 7–11, 2003 (***2003***), ORGN-078.*

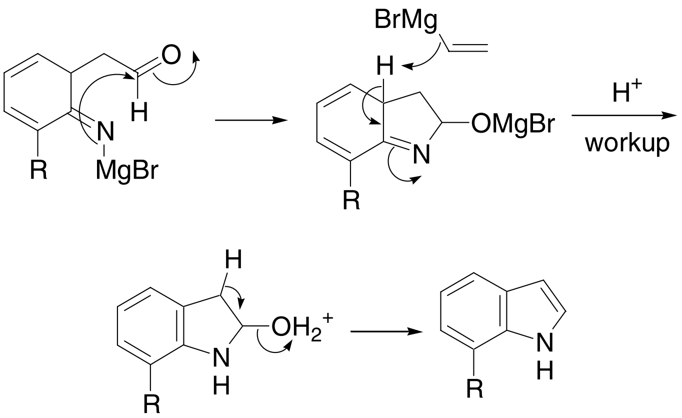
Bartoli indole synthesis

7-Substituted indoles from the reaction of *ortho*-substituted nitroarenes and vinyl Grignard reagents.

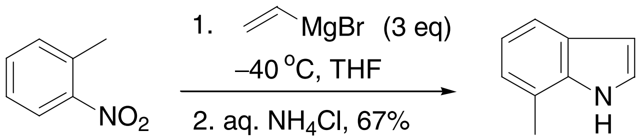




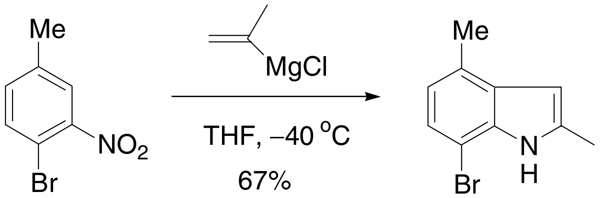
nitroso intermediate



Example 1[3]



Example 2[8]

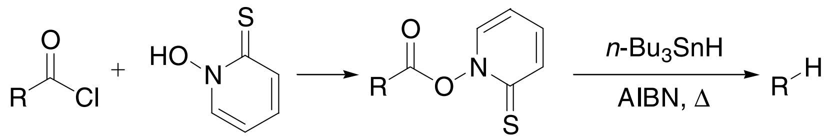


References

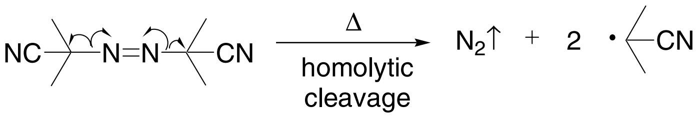
1. Bartoli, G.; Leardini, R.; Medici, A.; Rosini, G. *J. Chem. Soc., Perkin Trans. 1* **1978**, 892. Giuseppe Bartoli is a professor at the Università di Bologna, Italy.
2. Bartoli, G.; Bosco, M.; Dalpozzo, R.; Todesco, P. E. *J. Chem. Soc., Chem. Commun.* **1988**, 807.
3. Bartoli, G.; Palmieri, G.; Bosco, M.; Dalpozzo, R. *Tetrahedron Lett.* **1989**, *30*, 2129.
4. Bosco, M.; Dalpozzo, R.; Bartoli, G.; Palmieri, G.; Petrini, M. *J. Chem. Soc., Perkin Trans. 2* **1991**, 657. Mechanistic studies.
5. Bartoli, G.; Bosco, M.; Dalpozzo, R.; Palmieri, G.; Marcantoni, E. *J. Chem. Soc., Perkin Trans. 1* **1991**, 2757.
6. Dobson, D. R.; Gilmore, J.; Long, D. A. *Synlett* **1992**, 79.
7. Dobbs, A. P.; Voyle, M.; Whittall, N. *Synlett* **1999**, 1594.
8. Dobbs, A. *J. Org. Chem.* **2001**, *66*, 638.
9. Pirrung, M. C.; Wedel, M.; Zhao, Y. *Synlett* **2002**, 143.
10. Garg, N. K.; Sarpong, R.; Stoltz, B. M. *J. Am. Chem. Soc.* **2002**, *124,* 13179.
11. Knepper, K.; Braese, S. *Org. Lett.* **2003**, *5*, 2829.
12. Li, J.; Cook, J. M. *Bartoli indole synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 100–103. (Review).
13. Dalpozzo, R.; Bartoli, G. *Current Org. Chem.* **2005**, *9*, 163–178. (Review).

Barton radical decarboxylation

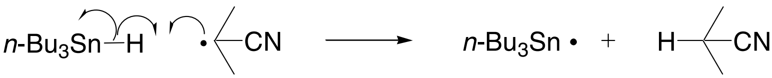
Radical decarboxylation *via* the corresponding thiocarbonyl derivatives of the carboxylic acids.

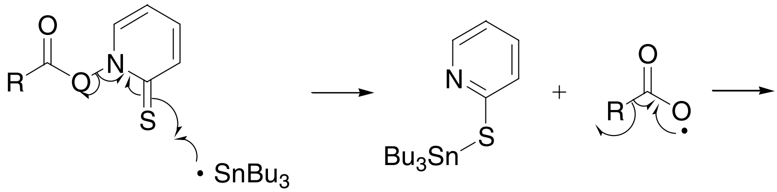


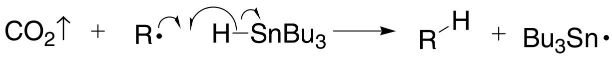
Barton ester



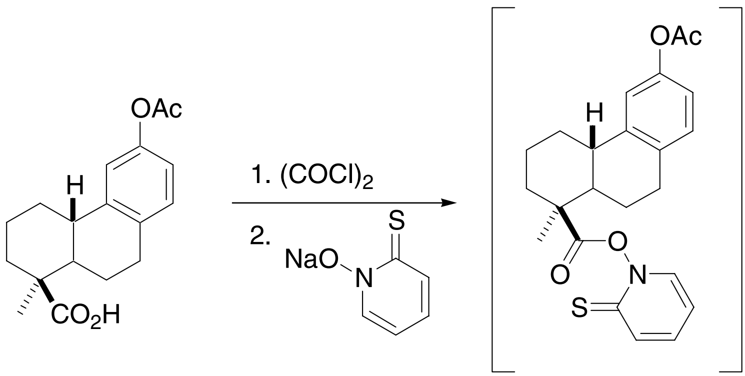
2,2'-azobisisobutyronitrile (AIBN)

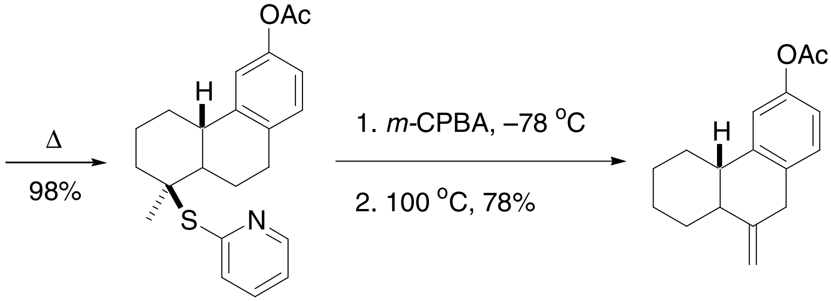




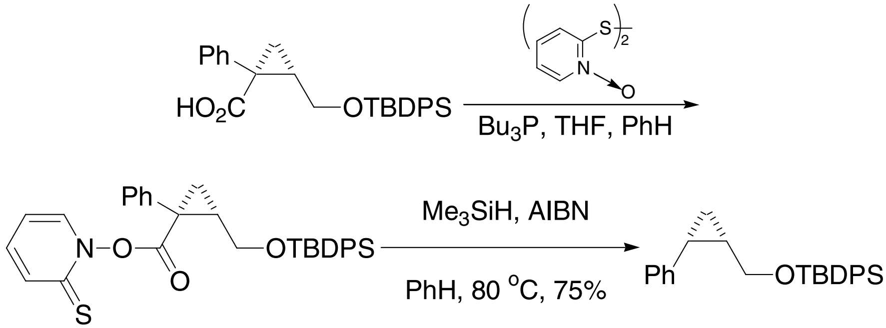


Example 1[3]





Example 2[11]

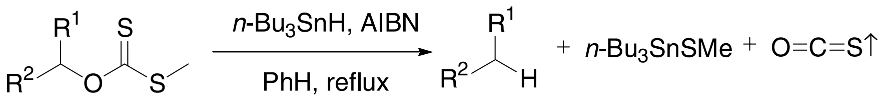


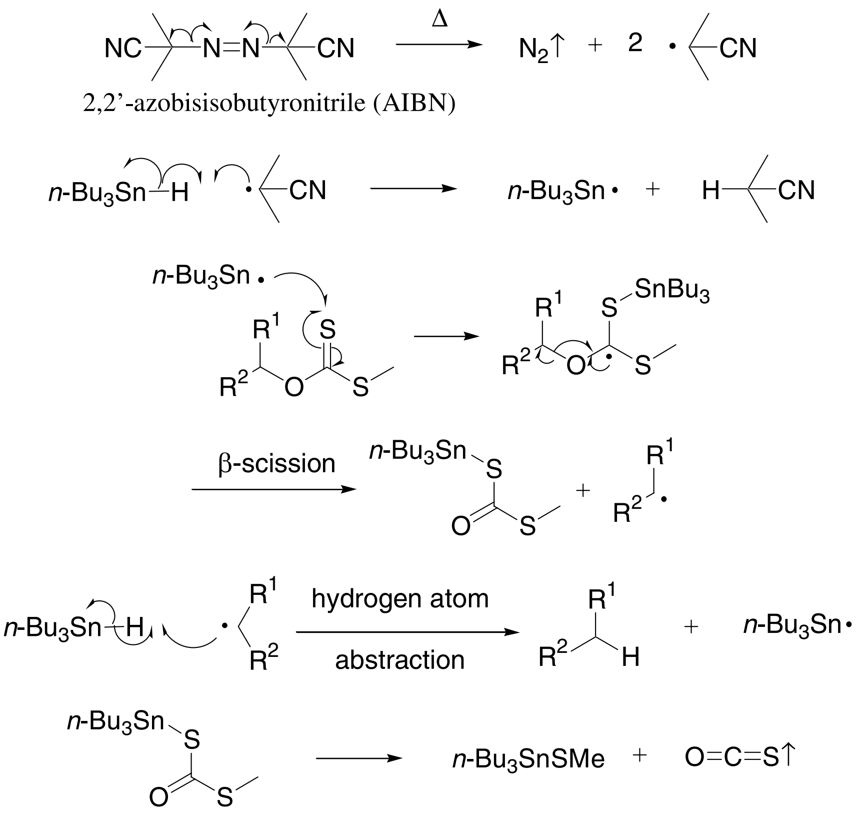
References

1. Barton, D. H. R.; Crich, D.; Motherwell, W. B. *J. Chem. Soc., Chem. Commun.* **1983**, 939. Derek Barton (United Kingdom, 1918–1998) studied under Ian Heilbron at Imperial College in his youth. He taught in England, France and the US. Barton won the Nobel Prize in Chemistry in 1969 for development of the concept of conformation. He passed away in his office at the University of Texas at Austin.
2. Barton, D. H. R.; Zard, S. Z. *Pure Appl. Chem.* **1986**, *58*, 675.
3. Barton, D. H. R.; Bridon, D.; Zard, S. Z.; Fernandaz-Picot, I. *Tetrahedron* **1987**, *43*, 2733.
4. Cochane, E. J.; Lazer, S. W.; Pinhey, J. T.; Whitby, J. D. *Tetrahedron Lett.* **1989**, *30*, 7111.
5. Barton, D. H. R. *Aldrichimica Acta* **1990**, *23*, 3. (Review).
6. Gawronska, K.; Gawronski, J.; Walborsky, H. M. *J. Org. Chem.* **1991**, *56*, 2193.
7. Eaton, P. E.; Nordari, N.; Tsanaktsidis, J.; Upadhyaya, S. P. *Synthesis* **1995**, 501.
8. Crich, D.; Hwang, J.-T.; Yuan, H. *J. Org. Chem.* **1996**, *61*, 6189.
9. Attardi, M. E.; Taddei, M. *Tetrahedron Lett.* **2001**, *42*, 3519.
10. Materson, D. S.; Porter, N. A. *Org. Lett.* **2002**, *4*, 4253.
11. Yamaguchi, K.; Kazuta, Y.; Abe, H.; Matsuda, A.; Shuto, S. *J. Org. Chem.* **2003**, *68*, 9255.
12. Zard, S. Z. *Radical Reactions in Organic Synthesis* Oxford University Press: Oxford, UK, **2003**. (Book).
13. Carry, J.-C.; Evers, M.; Barriere, J.-C.; Bashiardes, G.; Bensoussan, C.; Gueguen, J.-C.; Dereu, N.; Filoche, B.; Sable, S.; Vuilhorgne, M.; Mignani, S. *Synlett* **2004**, 316.

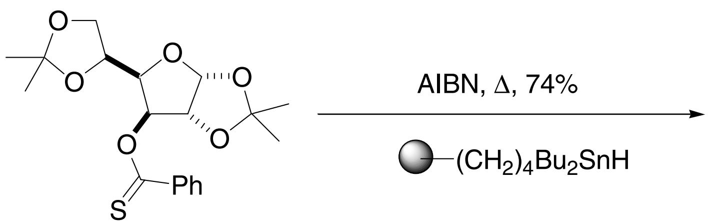
Barton–McCombie deoxygenation

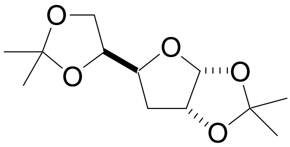
Deoxygenation of alcohols by means of radical scission of their corresponding thiocarbonyl derivatives.



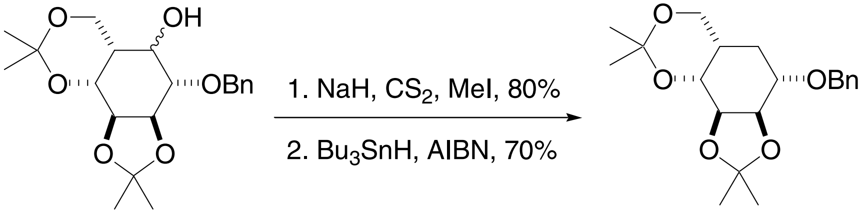


Example 1[5]





Example 2[9]

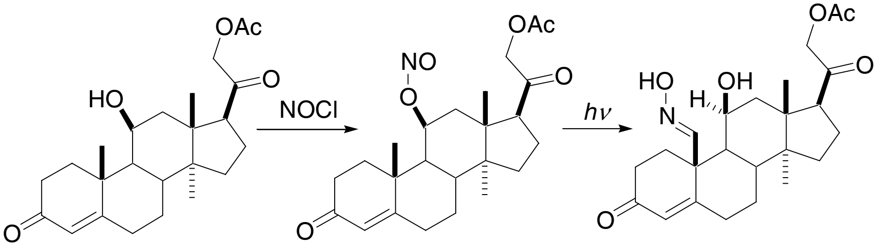


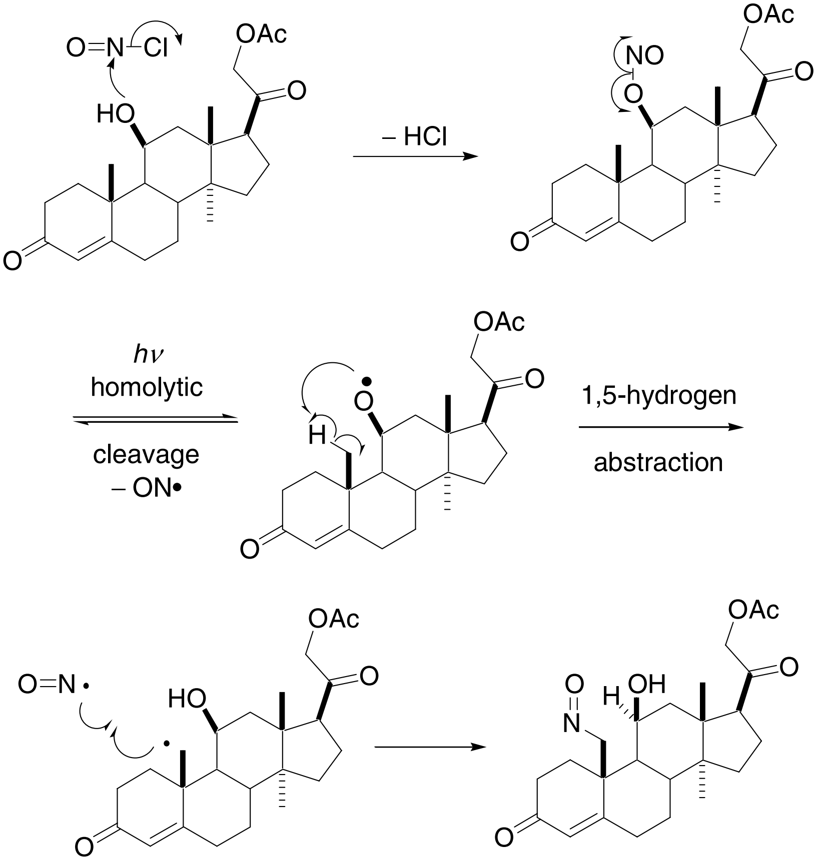
References

1. Barton, D. H. R.; McCombie, S. W. *J. Chem. Soc., Perkin Trans. 1* **1975**, 1574. Stuart McCombie, a Barton student, now works at Schering–Plough.
2. Zard, S. Z. *Angew. Chem., Int. Ed. Engl.* **1997**, *36*, 672.
3. Lopez, R. M.; Hays, D. S.; Fu, G. C. *J. Am. Chem. Soc.* **1997**, *119*, 6949.
4. Hansen, H. I.; Kehler, J. *Synthesis* **1999**, 1925.
5. Boussaguet, P.; Delmond, B.; Dumartin, G.; Pereyre, M. *Tetrahedron Lett.* **2000**, *41*, 3377.
6. Cai, Y.; Roberts, B. P. *Tetrahedron Lett.* **2001**, *42*, 763.
7. Clive, D. L. J.; Wang, J. *J. Org. Chem.* **2002**, *67*, 1192.
8. Rhee, J. U.; Bliss, B. I.; RajanBabu, T. V. *J. Am. Chem. Soc.* **2003**, *125*, 1492.
9. Gómez, A. M.; Moreno, E.; Valverde, S.; López, J. C. *Eur. J. Org. Chem.* **2004**, 1830.

Barton nitrite photolysis

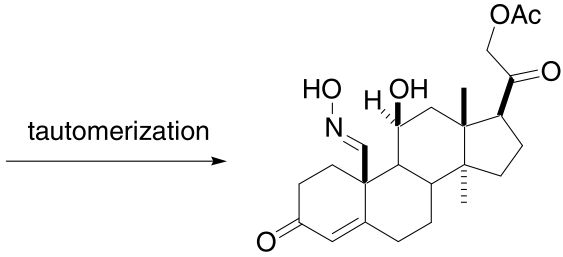
Photolysis of a nitrite ester to a γ-oximino alcohol.



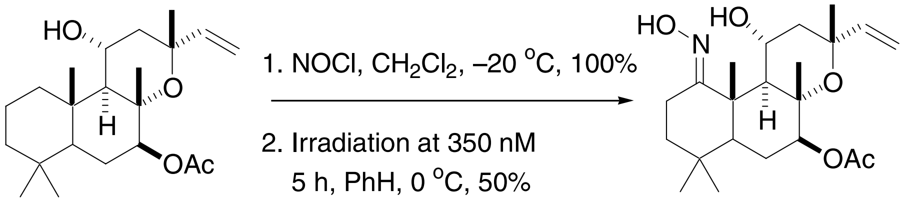


Nitric oxide radical is a stable, and therefore, long-lived radical

nitroso intermediate



Example[11]

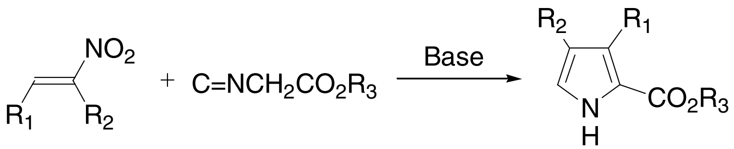


References

1. Barton, D. H. R.; Beaton, J. M.; Geller, L. E.; Pechet, M. M. *J. Am. Chem. Soc.* **1960**, *82*, 2640. In 1960, Derek Barton took a "vacation" in Cambridge, Massachusetts; he worked in a small research institute called the Research Institute for Medicine and Chemistry. In order to make the adrenocortical hormone aldosterol, Barton invented the Barton nitrite photolysis by simply writing down on a piece of paper what he thought would be an ideal process. His skilled collaborator, Dr. John Beaton, was able to reduce it to practice. They were able to make 40 to 50 g of aldosterol at a time when the total world supply was only about 10 mg. Barton considered it his most satisfying piece of work.
2. Barton, D. H. R.; Beaton, J. M. *J. Am. Chem. Soc.* **1960**, *82*, 2641.
3. Barton, D. H. R.; Beaton, J. M. *J. Am. Chem. Soc.* **1961**, *83*, 4083.
4. Kabasakalian, P.; Townley, E. *J. Am. Chem. Soc.* **1962**, *84*, 2723.
5. Barton, D. H. R.; Lier, E. F.; McGhie, J. M. *J. Chem. Soc., C* **1968**, 1031.
6. Suginome, H.; Sato, N.; Masamune, T. *Tetrahedron* **1971**, *27*, 4863.
7. Barton, D. H. R.; Hesse, R. H.; Pechet, M. M.; Smith, L. C. *J. Chem. Soc., Perkin Trans. 1* **1979**, 1159.
8. Barton, D. H. R. *Aldrichimica Acta* **1990**, *23*, 3. (Review).
9. Majetich, G.; Wheless, K. *Tetrahedron* **1995**, *51*, 7095. (Review).
10. Herzog, A.; Knobler, C. B.; Hawthorne, M. F. *Angew. Chem., Int. Ed.* **1998**, *37*, 1552.
11. Anikin, A.; Maslov, M.; Sieler, J.; Blaurock, S.; Baldamus, J.; Hennig, L.; Findeisen, M.; Reinhardt, G.; Oehme, R.; Welzel, P. *Tetrahedron* **2003**, *59*, 5295.
12. Suginome, H. *CRC Handbook of Organic Photochemistry and Photobiology* 2nd edn. **2004**, 102/1–102/16. (Review).

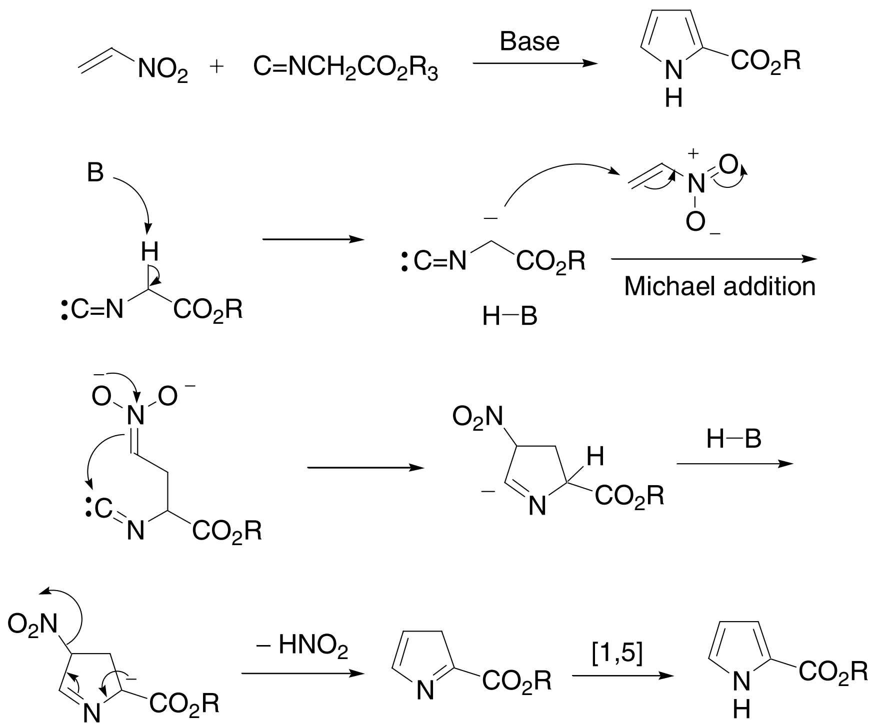
Barton–Zard reaction

Base-induced reaction of nitroalkenes with alkyl α-isocyanoacetates to afford pyrroles.

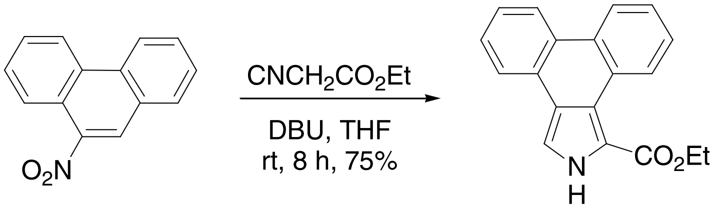


R_1 = H, alkyl, aryl
R_2 = H, alkyl
R_3 = Me, Et, *t*-Bu
Base = KO*t*-Bu, DBU, guanidine bases

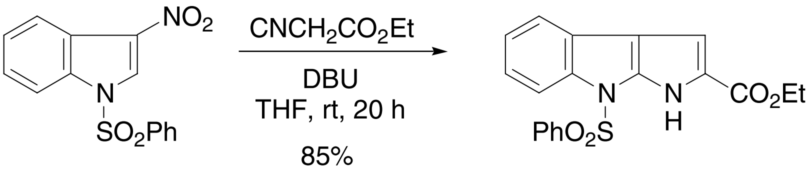
Example 1



Example 2[5]



Example 3[7]

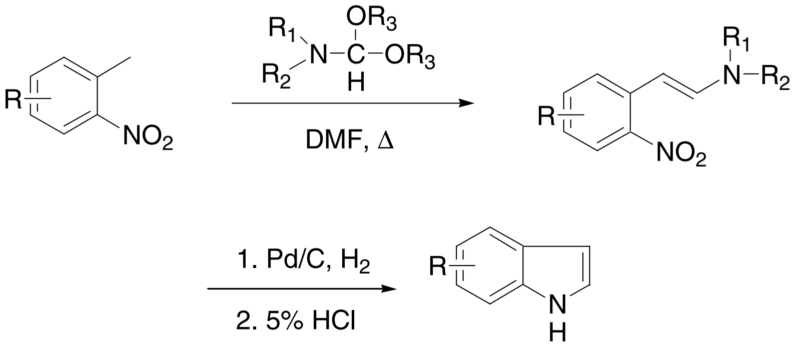


References

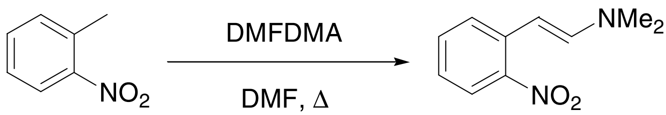
1. Barton, D. H. R.; Zard, S. Z. *J. Chem. Soc., Chem. Commun.* **1985**, 1098. Samir Z. Zard, a Barton student, emigrated from Lebanon to the UK in 1975. He is a professor at CNRS and École Polytechnique in France.
2. van Leusen, A. M.; Siderius, H.; Hoogenboom, B. E.; van Leusen, D. *Tetrahedron Lett.* **1972**, 5337.
3. Barton, D. H. R.; Kervagoret, J.; Zard, S. Z. *Tetrahedron* **1990**, *46*, 7587.
4. Sessler, J. L.; Mozaffari, A.; Johnson, M. R. *Org. Synth.* **1991**, *70*, 68.
5. Ono, N.; Hironaga, H.; Ono, K.; Kaneko, S.; Murashima, T.; Ueda, T.; Tsukamura, C.; Ogawa, T. *J. Chem. Soc., Perkin Trans. 1* **1996**, 417.
6. Murashima, T.; Fujita, K.; Ono, K.; Ogawa, T.; Uno, H.; Ono, N. *J. Chem. Soc., Perkin Trans. 1* **1996**, 1403.
7. Pelkey, E. T.; Chang, L.; Gribble, G. W. *Chem. Commun.* **1996**, 1909.
8. Uno, H.; Ito, S.; Wada, M.; Watanabe, H.; Nagai, M.; Hayashi, A.; Murashima, T.; Ono, N. *J. Chem. Soc., Perkin Trans. 1* **2000**, 4347.
9. Murashima, T.; Tamai, R.; Nishi, K.; Nomura, K.; Fujita, K.; Uno, H.; Ono, N. *J. Chem. Soc., Perkin Trans. 1* **2000**, 995.
10. Fumoto, Y.; Uno, H.; Tanaka, K.; Tanaka, M.; Murashima, T.; Ono, N. *Synthesis* **2001**, 399.
11. Lash, T. D.; Werner, T. M.; Thompson, M. L.; Manley, J. M. *J. Org. Chem.* **2001**, *66*, 3152.
12. Ferreira, V. F.; de Souza, M. C. B. V.; Cunha, A. C.; Pereira, L. O. R.; Ferreira, M. L. G. *Org. Prep. Proc. Int.* **2001**, *33*, 411. (Review).
13. Murashima, T.; Nishi, K.; Nakamoto, K.; Kato, A.; Tamai, R.; Uno, H.; Ono, N. *Heterocycles* **2002**, *58*, 301.
14. Gribble, G. W. *Barton–Zard Reaction* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 70–78. (Review).

Batcho–Leimgruber indole synthesis

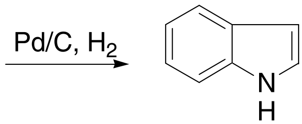
Condensation of *o*-nitrotoluene derivatives with formamide acetals, followed by reduction of the *trans*-β-dimethylamino-2-nitrostyrene to furnish indole derivatives.

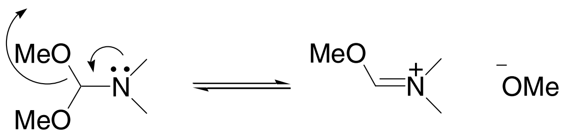


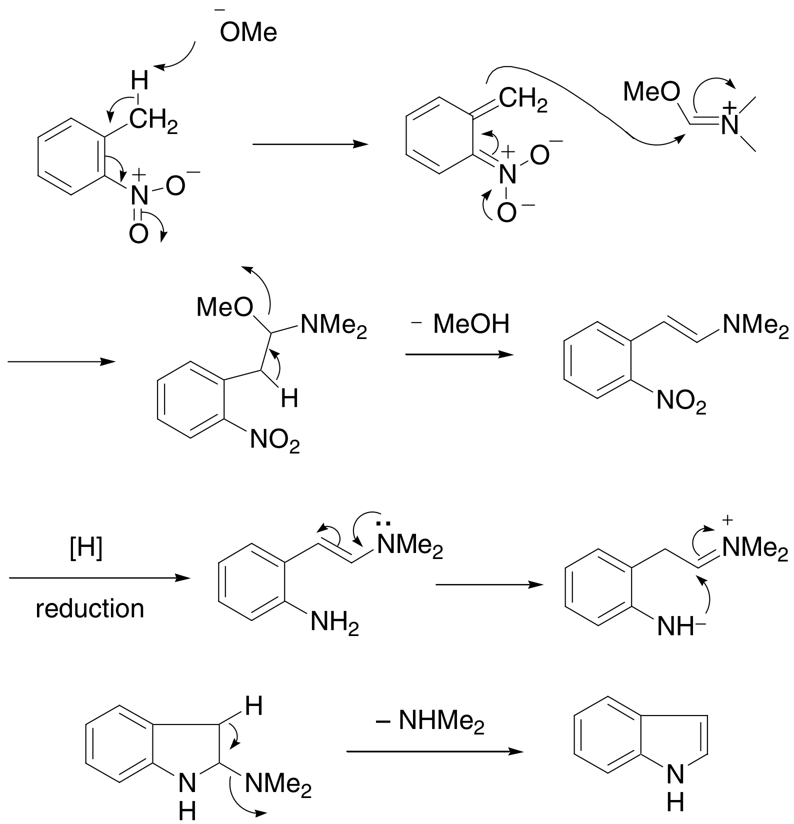
Example 1



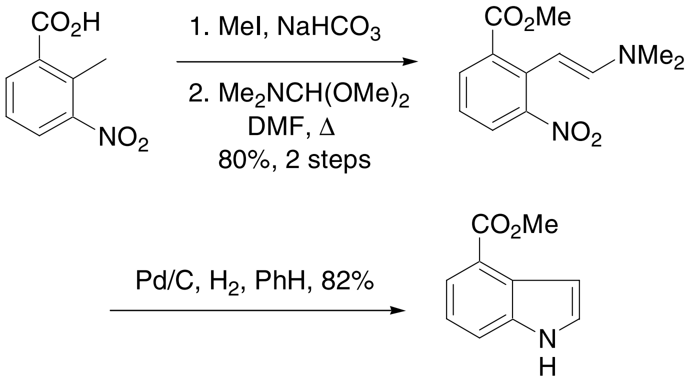
DMFDMA = *N,N*-dimethylformamide dimethyl acetal, $Me_2NCH(OMe)_2$



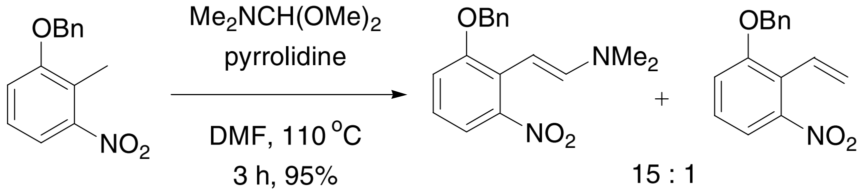


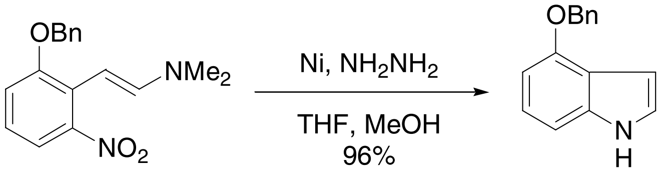

OMe
H
CH2
N
O
CH2
O
N
O
MeO
N
MeO
NMe2
H
NO2
– MeOH
NMe2
NO2
[H]
reduction
NMe2
NH2
NMe2
NH–
H
N
H
NMe2
– NHMe2
N
H

Example 2[5]


CO2H
NO2
1. MeI, NaHCO3
2. Me2NCH(OMe)2
DMF, Δ
80%, 2 steps
CO2Me
NMe2
NO2
Pd/C, H2, PhH, 82%
CO2Me
N
H

Example 3[14]





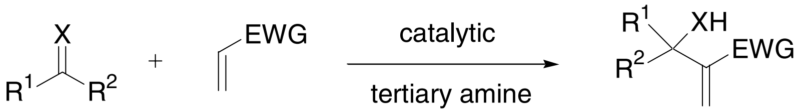
References

1. Leimgruber, W.; Batcho, A. D. *Third International Congress of Heterocyclic Chemistry*: Japan, **1971**. Andrew D. Batcho and Willy Leimgruber were both chemists at Hoffmann–La Roche in Nutley, NJ, USA.
2. Leimgruber, W.; Batcho, A. D. US 3732245 **1973**.
3. Abdulla, R. F.; Brinkmeyer, R. S. *Tetrahedron* **1979**, *35*, 1675.
4. Sundberg, R. J. *The Chemistry of Indoles*; Academic Press: New York & London, **1970**. (Review).
5. Kozikowski, A. P.; Ishida, H.; Chen, Y.-Y. *J. Org. Chem.* **1980**, *45*, 3550.
6. Maehr, H.; Smallheer, J. M. *J. Org. Chem.* **1981**, *46*, 1752.
7. Ferguson, W. J. *J. Heterocycl. Chem.* **1982**, *19*, 845.
8. Gupton, J. T.; Lizzi, M. J.; Polk, D. *Synth. Commun.* **1982**, *12*, 939.
9. Repke, D. B.; Ferguson, W. J. *J. Heterocycl. Chem.* **1982**, *19*, 845.
10. Clark, R. D.; Repke, D. B. *Heterocycles* **1984**, *22*, 195. (Review).
11. Clark, R. D.; Repke, D. B. *J. Heterocycl. Chem.* **1985**, *22*, 121.
12. Feldman, P. L.; Rapoport, H. *Synthesis* **1986**, 735.
13. Kozikowski, A. P.; Greco, M. N.; Springer, J. P. *J. Am. Chem. Soc.* **1982**, *104*, 7622.
14. Moyer, M. P.; Shiurba, J. F.; Rapoport, H. *J. Org. Chem.* **1986**, *51*, 5106.
15. Toste, F. D.; Still, I. W. J. *Org. Prep. Proced. Int.* **1995**, *27*, 576.
16. Coe, J. W.; Vetelino, M. G.; Bradlee, M. J. *Tetrahedron Lett.* **1996**, *37*, 6045.
17. Grivas, S. *Current Org. Chem.* **2000**, *4*, 707.
18. Siu, J.; Baxendale, I. R.; Ley, S. V. *Org. Biomolecular Chem.* **2004**, *2*, 160.
19. Li, J.; Cook, J. M. *Batcho–Leimgruber Indole Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 104–109. (Review).
20. Batcho, A. D.; Leimgruber, W. *Org. Synth.* **1984**, *63*, 214.

Baylis–Hillman reaction

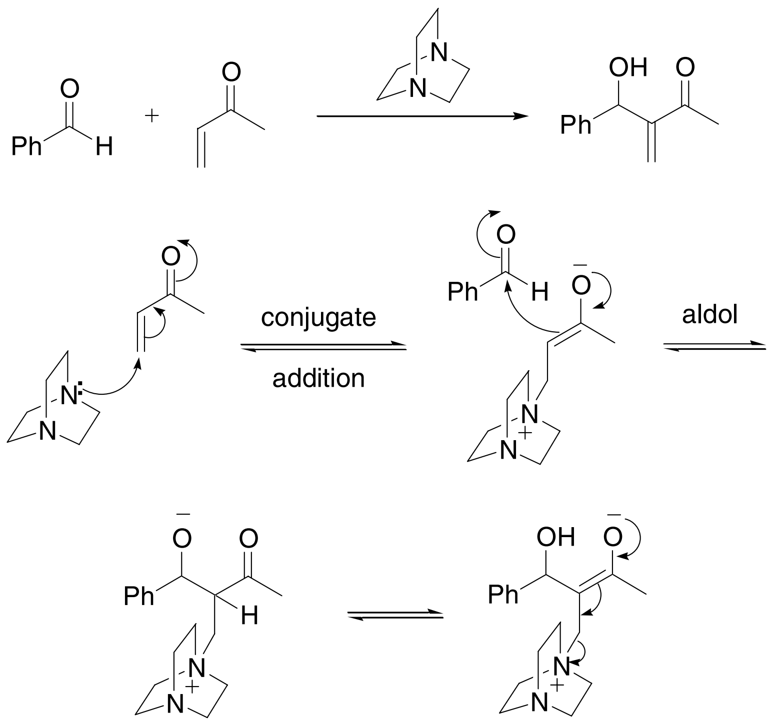
Also known as Morita–Baylis–Hillman reaction, and occasionally known as Rauhut–Currier reaction. It is a carbon–carbon bond-forming transformation of an electron-poor alkene with a carbon electrophile. Electron-poor alkenes include acrylic esters, acrylonitriles, vinyl ketones, vinyl sulfones, and acroleins. On the other hand, carbon electrophiles may be aldehydes, α-alkoxycarbonyl ketones, aldimines, and Michael acceptors.

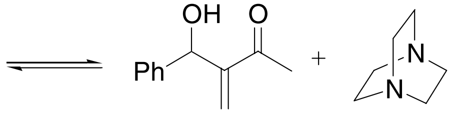
General scheme:



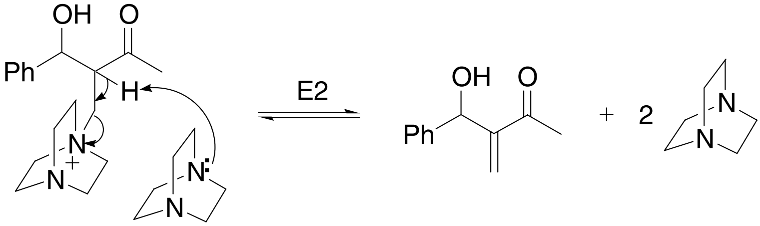
X = O, NR_2, EWG = CO_2R, COR, CHO, CN, SO_2R, SO_3R, $PO(OEt)_2$, $CONR_2$, $CH_2{=}CHCO_2Me$

Example 1:

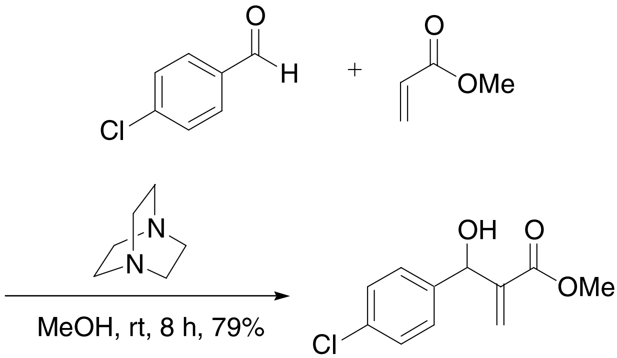




E2 (bimolecular elimination) mechanism is also operative here:



Example 2[10]



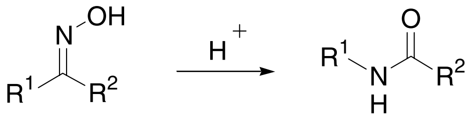
References

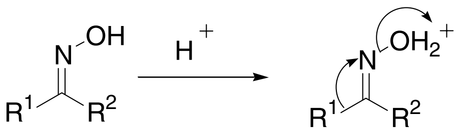
1. Baylis, A. B.; Hillman, M. E. D. Ger. Pat. 2,155,113, (**1972**). Both Anthony B. Baylis and Melville E. D. Hillman were at Celanese Corp. USA.
2. Drewes, S. E.; Roos, G. H. P. *Tetrahedron* **1988**, *44*, 4653.
3. Basavaiah, D.; Rao, P. D.; Hyma, R. S. *Tetrahedron* **1996**, *52*, 8001. (Review).
4. Ciganek, E. *Org. React.* **1997**, *51,* 201. (Review).
5. Shi, M.; Feng, Y.-S. *J. Org. Chem.* **2001**, *66*, 406.
6. Yu, C.; Hu, L. *J. Org. Chem.* **2002**, *67*, 219.
7. Wang L.-C.; Luis A. L.; Agapiou K.; Jang H.-Y.; Krische M. J. *J. Am. Chem. Soc.* **2002**, *124*, 2402.
8. Frank, S. A.; Mergott, D. J.; Roush, W. R. *J. Am. Chem. Soc.* **2002**, *124*, 2404.
9. Shi, M.; Li, C.-Q.; Jiang, J.-K. *Tetrahedron* **2003**, *59*, 1181.
10. Mi, X.; Luo, S.; Cheng, J.-P. *J. Org. Chem.* **2005**, *70*, 2338.
11. Price, K. E.; Broadwater, S. J.; Jung, H. M.; McQuade, D. T. *Org. Lett.* **2005**, *7*, 147. A novel mechanism involving a hemiacetal intermediate is proposed.

Beckmann rearrangement

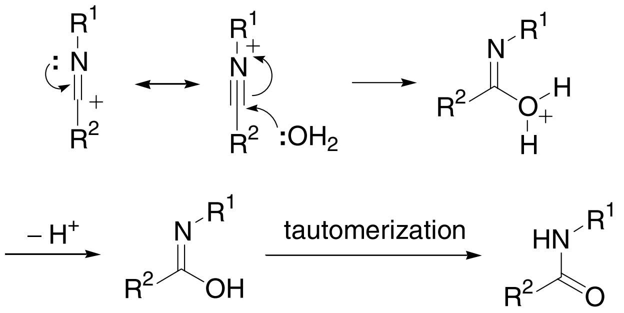
Acid-mediated isomerization of oximes to amides.

In protic acid:

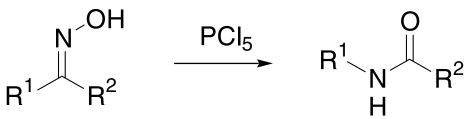


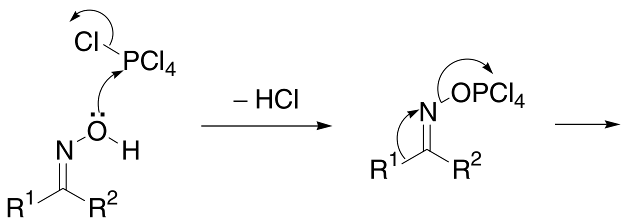


the substituent *trans* to the leaving group migrates

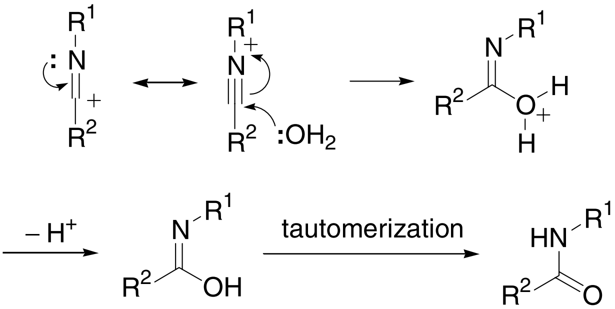


With PCl_5:

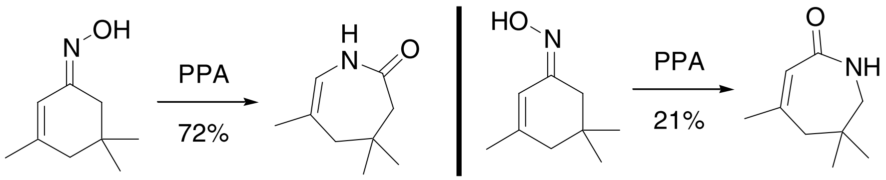




the substituent *trans* to the leaving group migrates



Example 1[12]



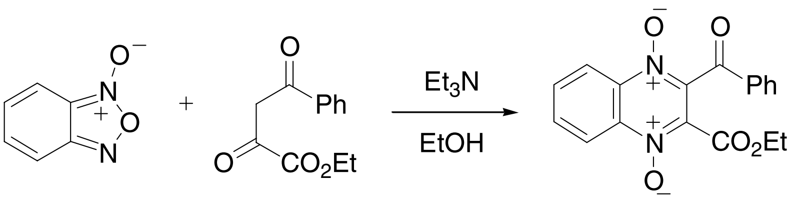
PPA = **p**oly**p**hosphoric **a**cid

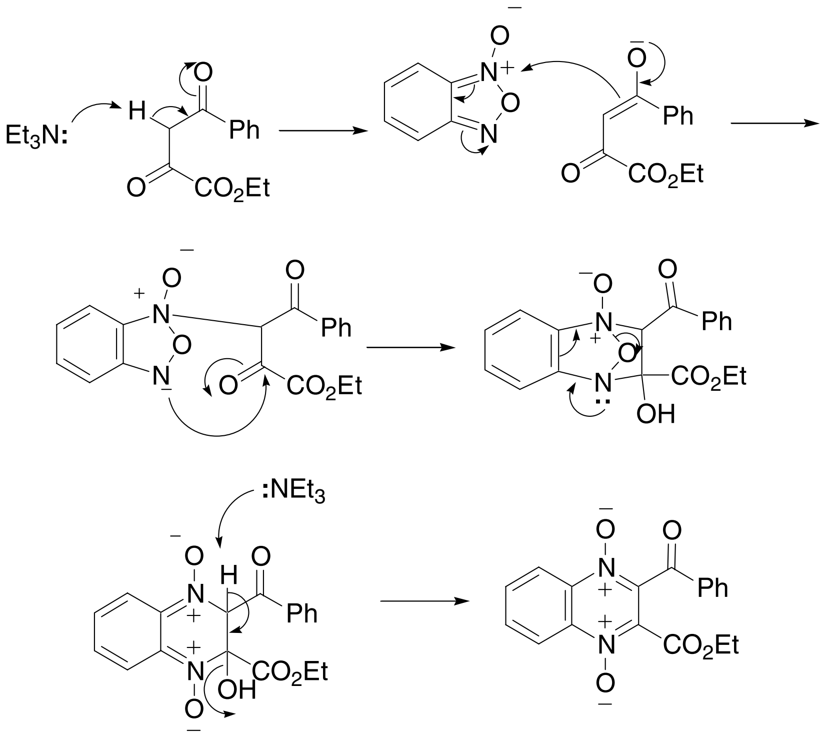
References

1. Beckmann, E. *Chem. Ber.* **1886**, *89*, 988. Ernst Otto Beckmann (1853–1923) was born in Solingen, Germany. He studied chemistry and pharmacy at Leipzig. In addition to the Beckmann rearrangement of oximes to amides, his name is associated with the Beckmann thermometer, used to measure freezing and boiling point depressions.
2. Mazur, R. H. *J. Org. Chem.* **1961**, *26*, 1289.
3. Chatterjea, J. N.; Singh, K. R. R. P. *J. Indian Chem. Soc.* **1982**, *59*, 527.
4. Gawley, R. E. *Org. React.* **1988**, *35*, 1–420. (Review).
5. Catsoulacos, P.; Catsoulacos, D. *J. Heterocycl. Chem.* **1993**, *30*, 1.
6. Anilkumar, R.; Chandrasekhar, S. *Tetrahedron Lett.* **2000**, *41*, 7235.
7. Khodaei, M. M.; Meybodi, F. A.; Rezai, N.; Salehi, P. *Synth. Commun.* **2001**, *31*, 2047.
8. Torisawa, Y.; Nishi, T.; Minamikawa, J.-i. *Bioorg. Med. Chem. Lett.* **2002**, *12*, 387.
9. Sharghi, H.; Hosseini, M. *Synthesis* **2002**, 1057.
10. Chandrasekhar, S.; Copalaiah, K. *Tetrahedron Lett.* **2003**, *44*, 755.
11. Wang, B.; Gu, Y.; Luo, C.; Yang, T.; Yang, L.; Suo, J. *Tetrahedron Lett.* **2004**, *45*, 3369.
12. Hilmey, D. G.; Paquette, L. A. *Org. Lett.* **2005**, *7*, 2067.
13. Li, D.; Shi, F.; Guo, S.; Deng, Y. *Tetrahedron Lett.* **2005**, *46*, 671.
14. Fernández, A. B.; Boronat, M.; Blasco, T.; Corma, A. *Angew. Chem., Int. Ed.* **2005**, *44*, 2370.

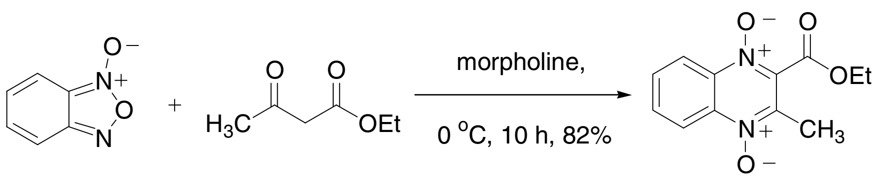
Beirut reaction

Synthesis of quinoxaline-1,4-dioxides from benzofurazan oxide.

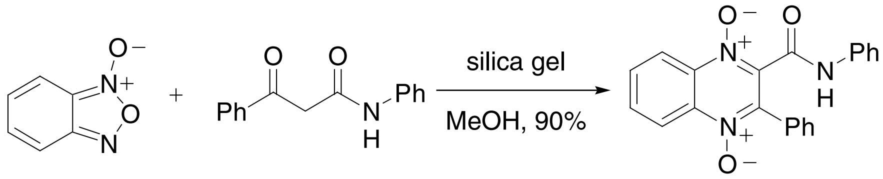




Example 1[3]



Example 2[7]

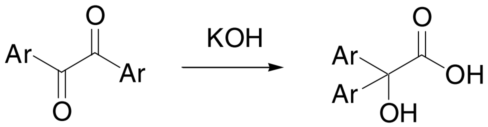


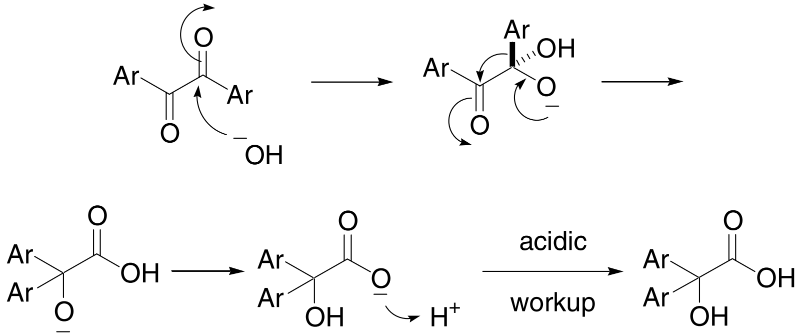
References

1. Haddadin, M. J.; Issidorides, C. H. *Heterocycles* **1976**, *4*, 767. The authors named the reaction after the city where it was discovered, Beirut, the capital of Lebanon.
2. Gaso, A.; Boulton, A. J. In *Advances in Heterocyclic Chem.;* Vol. 29, Katritzky, A. R.; Boulton, A. J., eds.; Academic Press: New York, **1981**, 251. (Review).
3. Vega, A. M.; Gil, M. J.; Fernández-Alvarez, E. *J. Heterocycl. Chem.* **1984**, *21*, 1271
4. Atfah, A.; Hill, J. *J. Chem. Soc., Perkin Trans. 1* **1989**, 221.
5. Haddadin, M. J.; Issidorides, C. H. *Heterocycles* **1993**, *35*, 1503.
6. El-Abadelah, M. M.; Nazer, M. Z.; El-Abadla, N. S.; Meier, H. *Heterocycles* **1995**, *41*, 2203.
7. Takabatake, T.; Miyazawa, T.; Kojo, M.; Hasegawa, M. *Heterocycles* **2000**, *53*, 2151.
8. Panasyuk, P. M.; Mel'nikova, S. F.; Tselinskii, I. V. *Russ. J. Org. Chem.* **2001**, *37*, 892.
9. Turker, L.; Dura, E. *Theochem* **2002**, *593*, 143.
10. Tinsley, J. M. *Beirut reaction* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 504–509. (Review).

Benzilic acid rearrangement

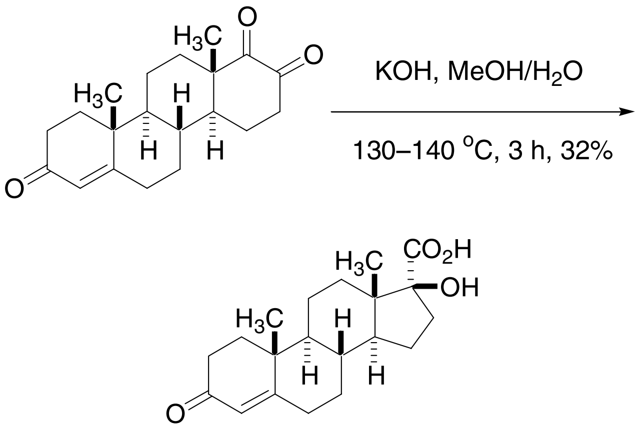
Rearrangement of benzil to benzylic acid *via* aryl migration.





Final deprotonation of the carboxylic acid drives the reaction forward.

Example 1[3]



References

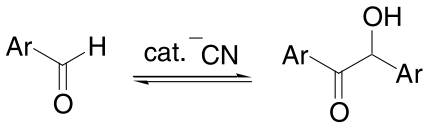
1. Liebig, J. *Ann.* **1838**, 27. Justus von Liebig (1803–1873) pursued his Ph.D. in organic chemistry in Paris under the tutelage of Joseph Louis Gay-Lussac (1778–1850). He was appointed the Chair of Chemistry at Giessen University, which incited a furious jealousy amongst several of the professors already working there because he was so young. Fortunately, time would prove the choice was a wise one for the department.

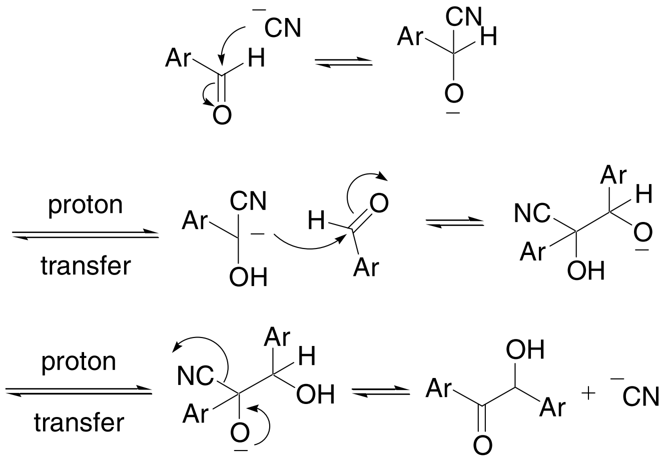
Liebig would soon transform Giessen from a sleepy university to the Mecca of organic chemistry in Europe. Liebig is now considered the father of organic chemistry. Many classic name reactions were published in the journal that still bears his name, *Justus Liebigs Annalen der Chemie.*[2]

2. Zinin, N. *Justus Liebigs Ann. Chem.* **1839**, *31*, 329.
3. Georgian, V.; Kundu, N. *Tetrahedron* **1963**, *19*, 1037.
4. Trost, B. M.; Hiemstra, H. *Tetrahedron* **1986**, *42*, 3323.
5. Rajyaguru, I.; Rzepa, H. S. *J. Chem. Soc., Perkin Trans. 2* **1987**, 1819.
6. Askin, D.; Reamer, R. A.; Jones, T. K.; Volante, R. P.; Shinkai, I. *Tetrahedron Lett.* **1989**, *30*, 671.
7. Toda, F.; Tanaka, K.; Kagawa, Y.; Sakaino, Y. *Chem. Lett.* **1990**, 373.
8. Robinson, J. M.; Flynn, E. T.; McMahan, T. L.; Simpson, S. L.; Trisler, J. C.; Conn, K. B. *J. Org. Chem.* **1991**, *56*, 6709.
9. Hatsui, T.; Wang, J.-J.; Ikeda, S.-y.; Takeshita, H. *Synlett* **1995**, 35.
10. Fohlisch, B.; Radl, A.; Schwetzler-Raschke, R.; Henkel, S. *Eur. J. Org. Chem.* **2001**, 4357.

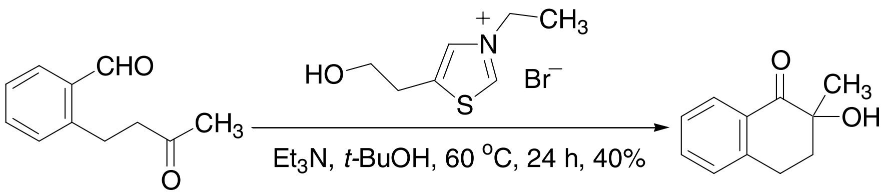
Benzoin condensation

Cyanide-catalyzed condensation of aryl aldehyde to benzoin. Now cyanide is mostly replaced by a thiazolium salt. *Cf.* Stetter reaction.

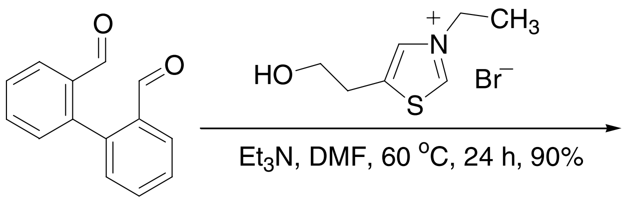


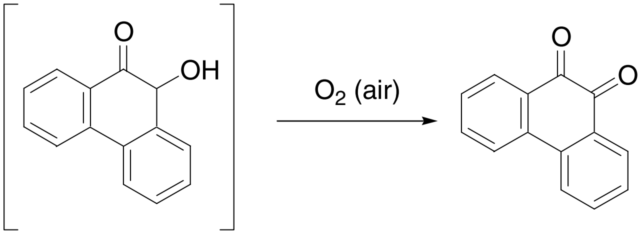


Example 1[11]



Example 2[11]



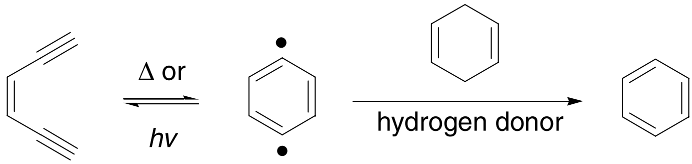


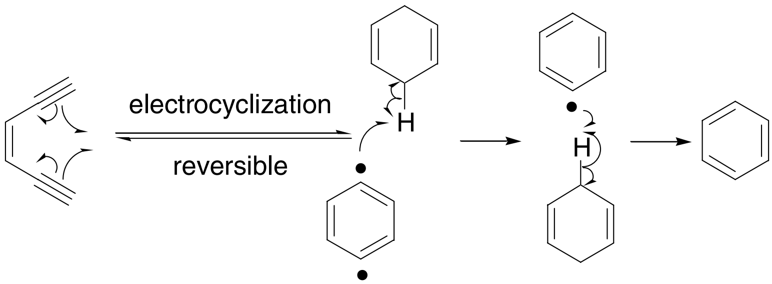
References

1. Lapworth, A. J. *J. Chem. Soc.* **1903**, *83*, 995. Arthur Lapworth (1872–1941) was born in Scotland. He was one of the great figures in the development of the modern view of the mechanism of organic reactions. Lapworth investigated the Benzoin condensation at the Chemical Department, The Goldsmiths' Institute, New Cross, UK.
2. Ide, W. S.; Buck, J. S. *Org. React.* **1948**, *4*, 269–304. (Review).
3. Stetter, H.; Kuhlmann, H. *Org. React.* **1991**, *40*, 407–496. (Review).
4. Kluger, R. *Pure Appl. Chem.* **1997**, *69*, 1957.
5. Demir, A. S.; Dunnwald, T.; Iding, H.; Pohl, M.; Muller, M. *Tetrahedron: Asymmetry* **1999**, *10*, 4769.
6. Davis, J. H., Jr.; Forrester, K. J. *Tetrahedron Lett.* **1999**, *40*, 1621.
7. White, M. J.; Leeper, F. J. *J. Org. Chem.* **2001**, *66*, 5124.
8. Enders, D.; Kallfass, U. *Angew. Chem., Int. Ed.* **2002**, *41*, 1743.
9. Duenkelmann, P.; Kolter-Jung, D.; Nitsche, A.; Demir, A. S.; Siegert, P.; Lingen, B.; Baumann, M.; Pohl, M.; Mueller, M. *J. Am. Chem. Soc.* **2002**, *124*, 12084.
10. Hachisu, Y.; Bode, J. W.; Suzuki, K. *J. Am. Chem. Soc.* **2003**, *125*, 8432.
11. Enders, D.; Niemeier, O. *Synlett* **2004**, 2111.
12. Johnson, J. S. *Angew. Chem., Int. Ed.* **2004**, *43*, 1326–1328. (Review).

Bergman cyclization

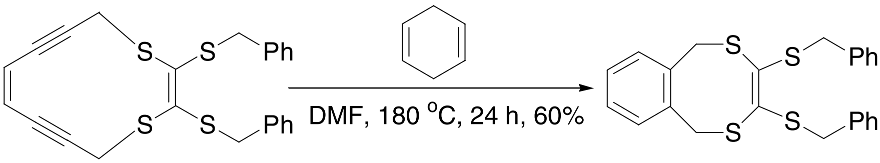
1,4-Benzenediyl diradical formation from enediyne *via* electrocyclization.



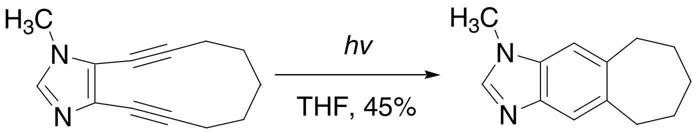


enediyne 1,4-benzenediyl diradical

Example 1[14]



Example 2[15]



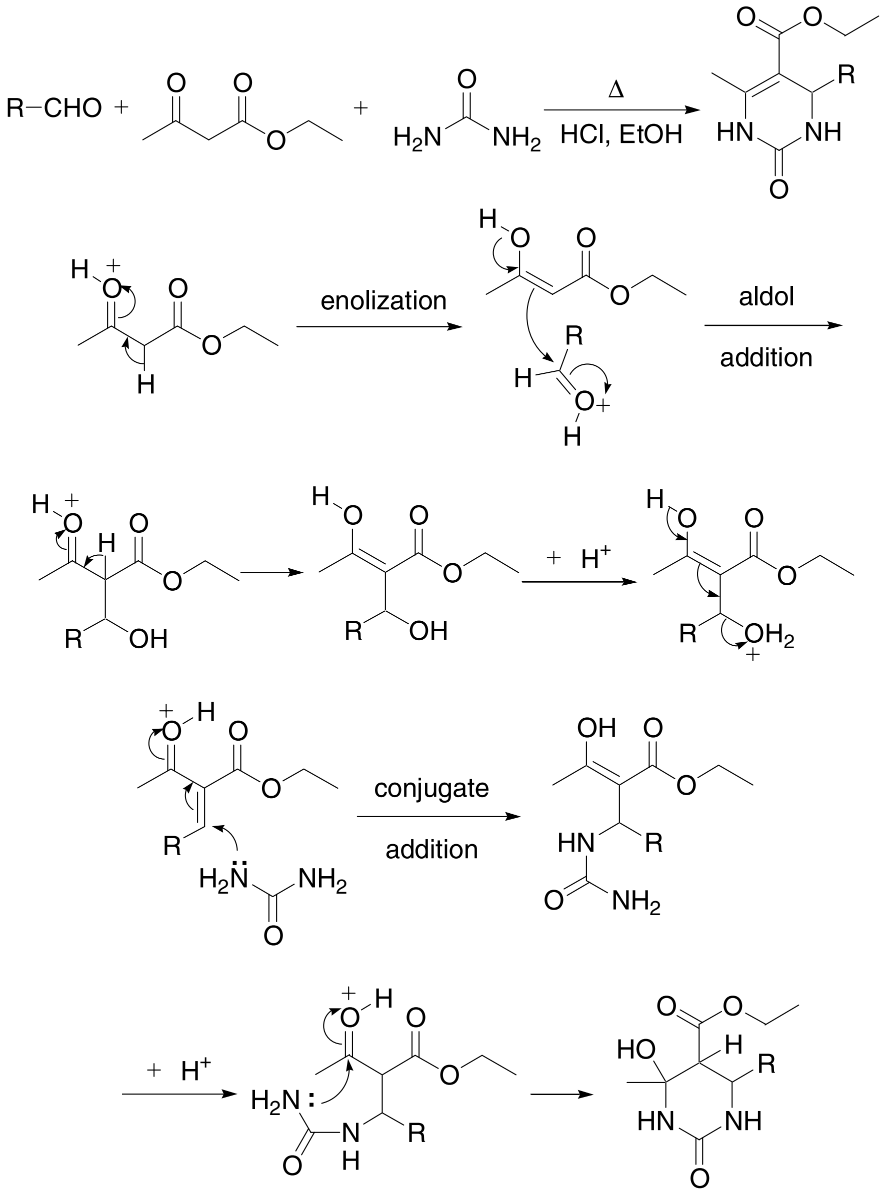
References

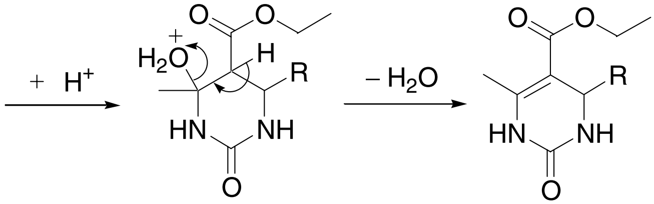
1. Jones, R. R.; Bergman, R. G. *J. Am. Chem. Soc.* **1972**, *94*, 660. Robert G. Bergman (1942–) is a professor at the University of California, Berkeley.
2. Bergman, R. G. *Acc. Chem. Res.* **1973**, *6*, 25. (Review).
3. Myers, A. G.; Proteau, P. J.; Handel, T. M. *J. Am. Chem. Soc.* **1988**, *110*, 7212.
4. Evenzahav, A.; Turro, N. J. *J. Am. Chem. Soc.* **1998**, *120*, 1835.

5. McMahon, R. J.; Halter, R. J.; Fimmen, R. L.; Wilson, R. J.; Peebles, S. A.; Kuczkowski, R. L.; Stanton, J. F. *J. Am. Chem. Soc*. **2000**, *122*, 939.
6. Rawat, D. S.; Zaleski, J. M. *Chem. Commun.* **2000**, 2493.
7. Clark, A. E.; Davidson, E. R.; Zaleski, J. M. *J. Am. Chem. Soc*. **2001**, *123*, 2650.
8. Alabugin, I. V.; Manoharan, M.; Kovalenko, S. V. *Org. Lett.* **2002**, *4*, 1119.
9. Stahl, F.; Moran, D.; Schleyer, P. von R.; Prall, M.; Schreiner, P. R. *J. Org. Chem.* **2002**, *67*, 1453.
10. Eshdat, L.; Berger, H.; Hopf, H.; Rabinovitz, M. *J. Am. Chem. Soc.* **2002**, *124*, 3822.
11. Yus, M.; Foubelo, F. *Rec. Res. Dev. Org. Chem*. **2002**, *6*, 205. (Review).
12. Feng, L.; Kumar, D.; Kerwin, S. M. *J. Org. Chem.* **2003**, *68*, 2234.
13. Basak A.; Mandal S.; Bag S. S. *Chem. Rev*. **2003**, *103*, 4077. (Review).
14. Bhattacharyya, S.; Pink, M.; Baik, M.-H.; Zaleski, J. M. *Angew. Chem., Int. Ed. Engl.* **2005**, *44*, 592.
15. Zhao, Z.; Peacock, J. G.; Gubler, D. A.; Peterson, M. A. *Tetrahedron Lett*. **2005**, *46*, 1373.

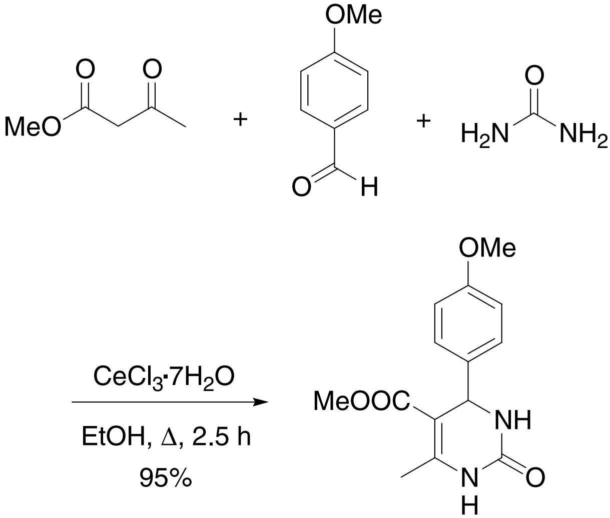
Biginelli pyrimidone synthesis

One-pot condensation of an aromatic aldehyde, urea, and ethyl acetoacetate in the acidic ethanolic solution and expansion of such a condensation thereof. It belongs to a class of transformations called multicomponent reactions (MCRs).





Example[9]



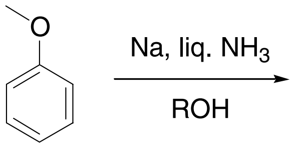
References

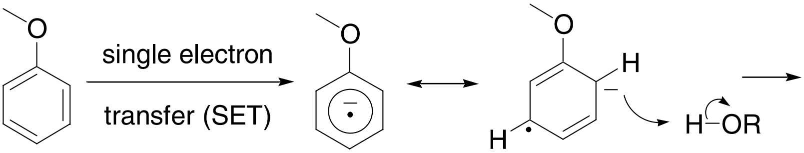
1. Biginelli, P. *Ber. Dtsch. Chem. Ges.* **1891**, *24*, 1317. Pietro Biginelli was at Lab. chim. della Sanita pubbl. Roma, Italy.
2. Sweet, F.; Fissekis, J. D. *J. Am. Chem. Soc.* **1973**, *95*, 8741.
3. Kappe, C. O. *Tetrahedron* **1993**, *49*, 6937. (Review).
4. Kappe, C. O. *Acc. Chem. Res.* **2000**, *33*, 879. (Review).
5. Kappe, C. O. *Eur. J. Med. Chem.* **2000**, *35*, 1043. (Review).
6. Lu, J.; Bai, Y.; Wang, Z.; Yang, B.; Ma, H. *Tetrahedron Lett.* **2000**, *41*, 9075.
7. Lu, J.; Bai, Y. *Synthesis* **2002**, 466.
8. Perez, R.; Beryozkina, T.; Zbruyev, O. I.; Haas, W.; Kappe, C. O. *J. Comb. Chem.* **2002**, *4*, 501.
9. Bose, D. S.; Fatima, L.; Mereyala, H. B. *J. Org. Chem.* **2003**, *68*, 587.
10. Kappe, C. O.; Stadler, A. *Org. React.* **2004**, *68*, 1–116. (Review).
11. Limberakis, C. *Biginelli Pyrimidone Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 509–520. (Review).

Birch reduction

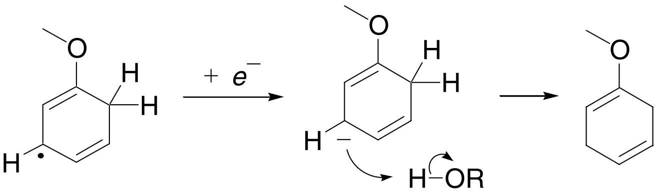
The Birch reduction is the 1,4-reduction of aromatics to their corresponding cyclohexadienes by alkali metals (Li, K, Na) dissolved in liquid ammonia in the presence of an alcohol.

Benzene ring bearing an electron-donating substituent:

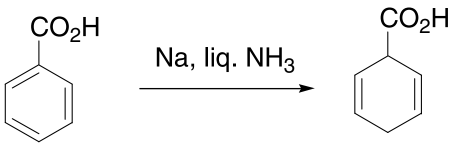


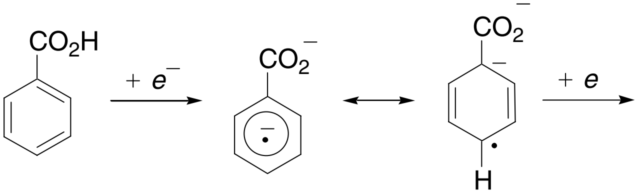


radical anion

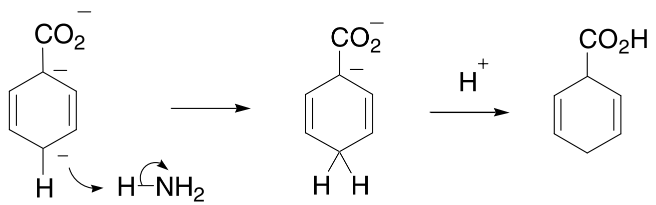


Benzene ring with an electron-withdrawing substituent:

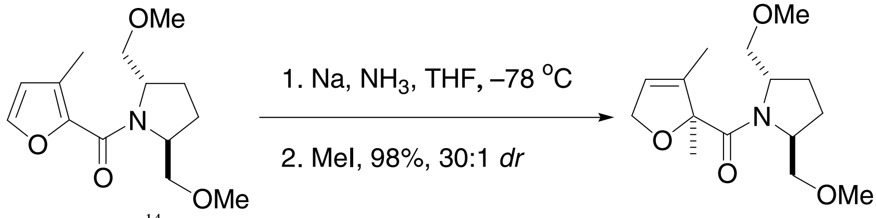




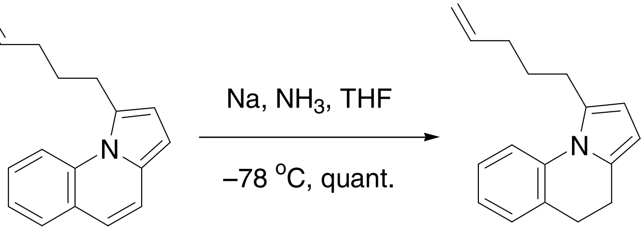
radical anion



Example 1[8]



Example 2[14]

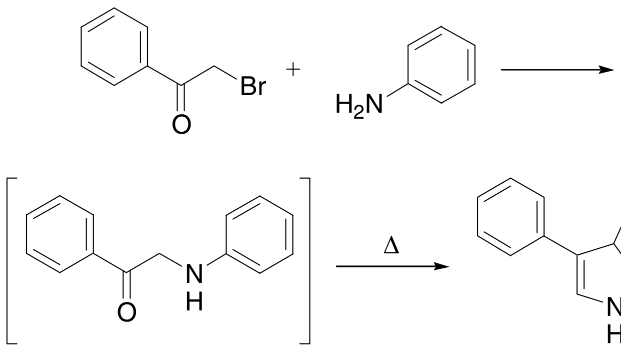


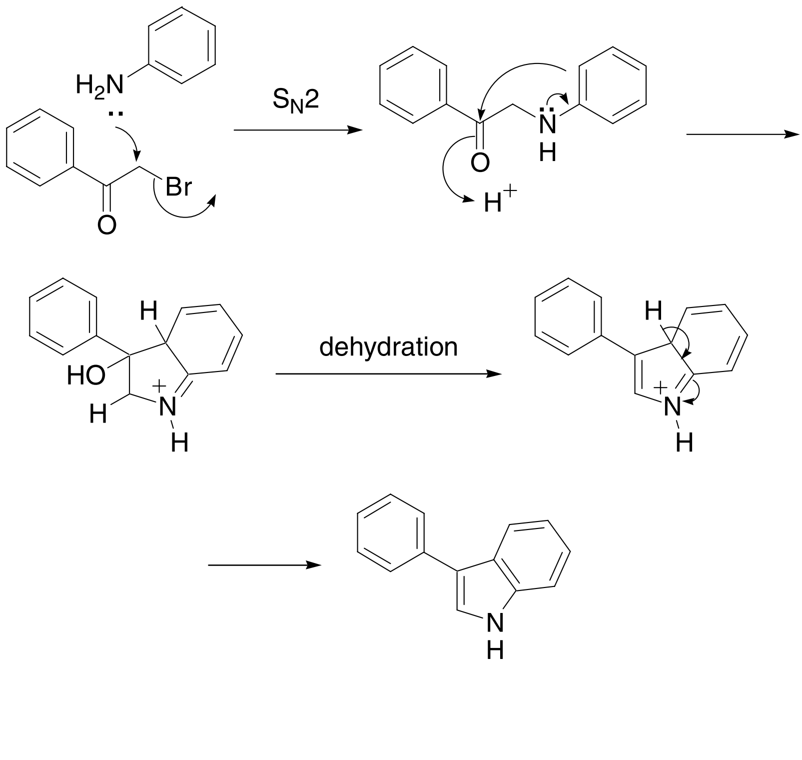
References

1. Birch, A. J. *J. Chem. Soc.* **1944**, 430. Arthur Birch (1915−1995), an Australian, developed the "Birch reduction" at Oxford University during WWII in Robert Robinson's laboratory. The Birch reduction was instrumental to the discovery of the birth control pill and many other drugs.
2. Rabideau, P. W.; Marcinow, Z. *Org. React.* **1992**, *42*, 1−334. (Review).
3. Birch, A. J. *Pure Appl. Chem.* **1996**, *68*, 553. (Review).
4. Schultz, A. G. *Chem. Commun.* **1999**, 1263.
5. Ohta, Y.; Doe, M.; Morimoto, Y.; Kinoshita, T. *J. Heterocycl. Chem.* **2000**, *37*, 751.
6. Labadie, G. R.; Cravero, R. M.; Gonzalez-Sierra, M. *Synth. Commun.* **2000**, *30*, 4065.
7. Guo, Z.; Schultz, A. G. *J. Org. Chem.* **2001**, *66*, 2154.
8. Donohoe, T. J.; Guillermin, J.-B.; Calabrese, A. A.; Walter, D. S. *Tetrahedron Lett.* **2001**, *42*, 5841.
9. Yamaguchi, S.; Hamade, E.; Yokoyama, H.; Hirai, Y.; Shiotani, S. *J. Heterocycl. Chem.* **2002**, *39*, 335.
10. Pellissier, H.; Santelli, M. *Org. Prep. Proced. Int.* **2002**, *34*, 611−642. (Review).
11. Jiang, J.; Lai, Y.-H. *Tetrahedron Lett.* **2003**, *44*, 1271.
12. Subba Rao, G. S. R. *Pure Appl. Chem.* **2003**, *75*, 1443−1451. (Review).
13. Zvilichovsky, G.; Gbara-Haj-Yahia, I. *J. Org. Chem.* **2004**, *69*, 5490.
14. Kim, J. T.; Gevorgyan, V. *J. Org. Chem.* **2005**, *70*, 2054.

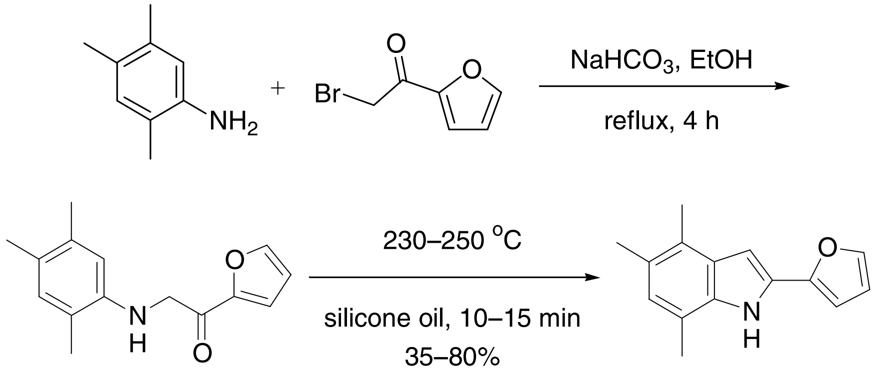
Bischler–Möhlau indole synthesis

3-Arylindoles from the cyclization of ω-arylamino-ketones and anilines.

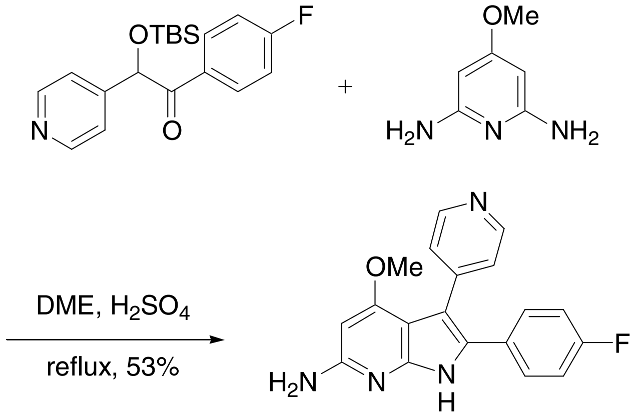




Example 1[5]



Example 2[9]

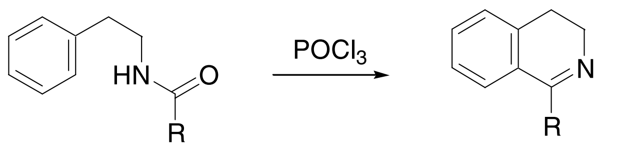


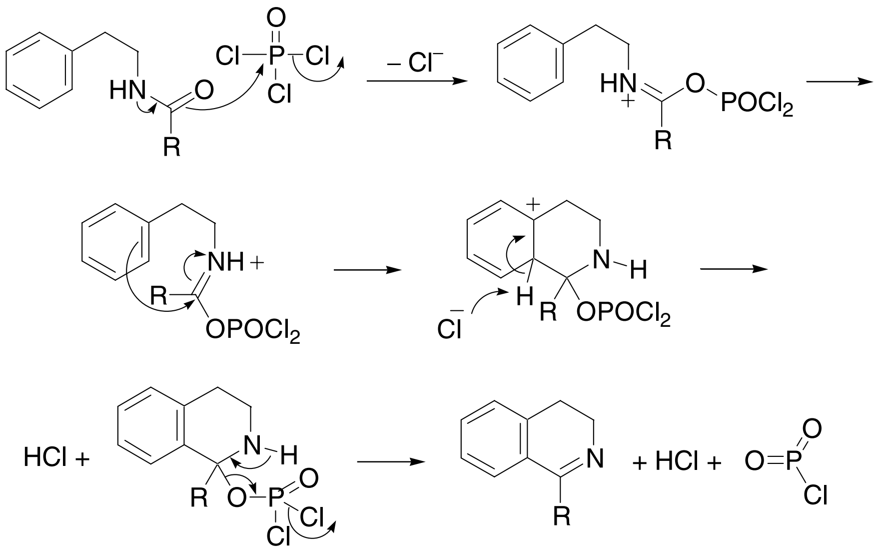
References

1. Möhlau, R. *Ber. Dtsch. Chem. Ges.* **1881**, *14*, 171.
2. Bischler, A.; Fireman, P. *Ber. Dtsch. Chem. Ges.* **1893**, *26*, 1346.
3. Sundberg, R. J. *The Chemistry of Indoles;* Academic Press: New York, **1970**, p 164. (Book).
4. Buu-Hoï, N. P.; Saint-Ruf, G.; Deschamps, D.; Bigot, P. *J. Chem. Soc. (C)* **1971**, 2606.
5. *The Chemistry of Heterocyclic Compounds, Indoles (Part 1),* Houlihan, W. J., ed.; Wiley & Sons: New York, **1972**. (Review).
6. Bigot, P.; Saint-Ruf, G.; Buu-Hoi, N. P. *J. Chem. Soc., J. Chem. Soc., Perkin 1* **1972**, 2573.
7. Bancroft, K. C. C.; Ward, T. J. *J. Chem. Soc., Perkin 1* **1974**, 1852.
8. Coic, J. P.; Saint-Ruf, G. *J. Heterocycl. Chem.* **1978**, *15*, 1367.
9. Henry, J. R.; Dodd, J. H. *Tetrahedron Lett.* **1998**, *39*, 8763.

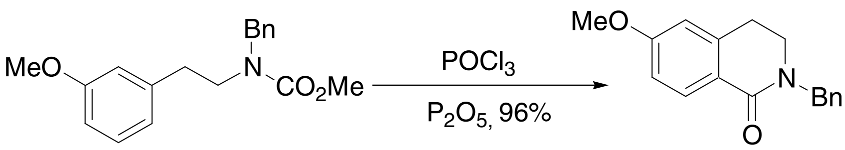
Bischler–Napieralski reaction

Dihydroisoquinolines from β-phenethylamides using phosphorus oxychloride.

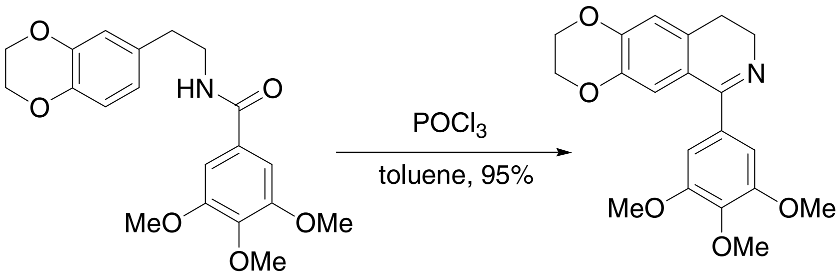




Example 1[6]



Example 2[10]

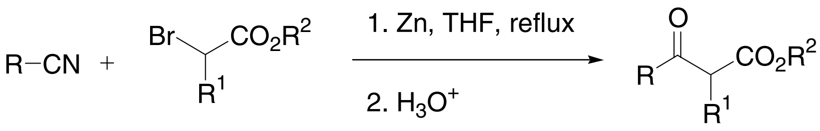


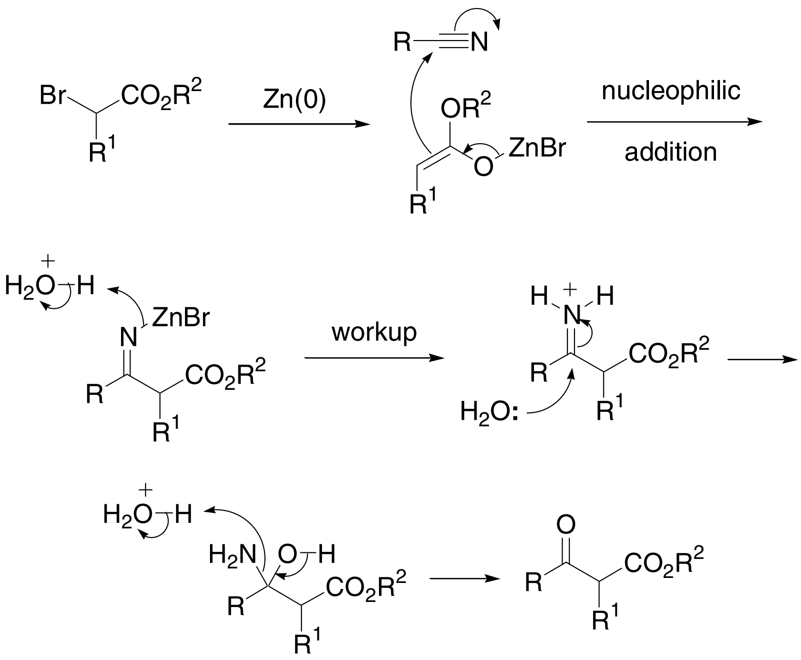
References

1. Bischler, A.; Napieralski, B. *Ber. Dtsch. Chem. Ges.* **1893**, *26*, 1903. Augustus Bischler (1865–1957) was born in South Russia. He studied in Zurich with Arthur Hantzsch. He discovered the Bischler–Napieralski reaction while studying alkaloids at Basel Chemical Works, Switzerland with his coworker, B. Napieralski.
2. Fodor, G.; Nagubandi, S. *Heterocycles* **1981**, *15*, 165.
3. Rozwadowska, M. D. *Heterocycles* **1994**, *39*, 903.
4. Sotomayor, N.; Dominguez, E.; Lete, E. *J. Org. Chem.* **1996**, *61*, 4062.
5. Doi, S.; Shirai, N.; Sato, Y. *J. Chem. Soc., Perkin Trans. 1* **1997**, 2217.
6. Wang, X.-j.; Tan, J.; Grozinger, K. *Tetrahedron Lett.* **1998**, *39*, 6609.
7. Sanchez-Sancho, F.; Mann, E.; Herradon, B. *Synlett* **2000**, 509.
8. Ishikawa, T.; Shimooka, K.; Narioka, T.; Noguchi, S.; Saito, T.; Ishikawa, A.; Yamazaki, E.; Harayama, T.; Seki, H.; Yamaguchi, K. *J. Org. Chem.* **2000**, *65*, 9143.
9. Miyatani, K.; Ohno, M.; Tatsumi, K.; Ohishi, Y.; Kunitomo, J.-I.; Kawasaki, I.; Yamashita, M.; Ohta, S. *Heterocycles* **2001**, *55*, 589.
10. Capilla, A. S.; Romero, M.; Pujol, M. D.; Caignard, D. H.; Renard, P. *Tetrahedron* **2001**, *57*, 8297.
11. Nicoletti, M.; O'Hagan, D.; Slawin, A. M. Z. *J. Chem. Soc., Perkin Trans. 1* **2002**, 116.
12. Wolfe, J. P. *Bischler–Napieralski Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 376–385. (Review).

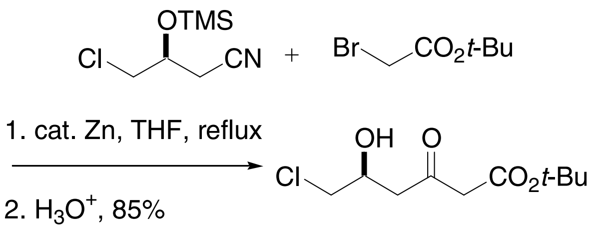
Blaise reaction

β-Ketoesters from nitriles and α-haloesters using Zn.

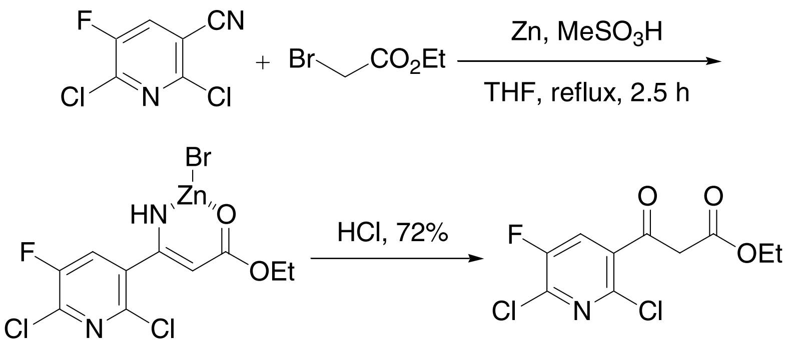




Example 1, preparation of the statin side chain[10]



Example 2[11]

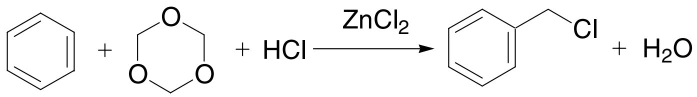


References

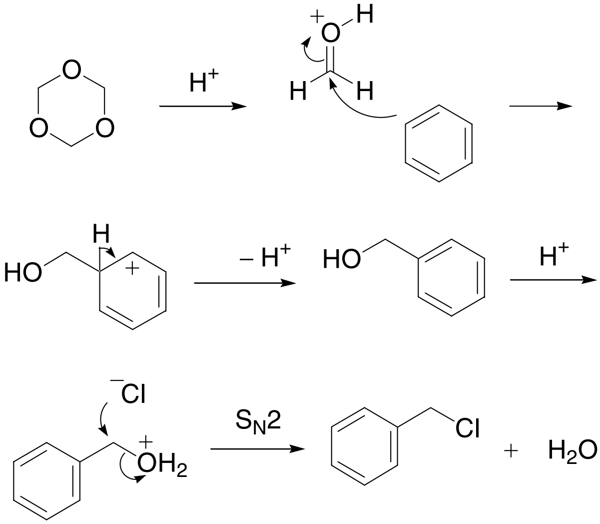
1. Blaise, E. E. *C. R. Hebd. Seances Acad. Sci.* **1901**, *132*, 478, 978. Blaise was at Institut Chimique de Nancy, France.
2. Hannick, S. M.; Kishi, Y. *J. Org. Chem.* **1983**, *48*, 3833.
3. Krepski, L. R.; Lynch, L. E.; Heilmann, S. M.; Rasmussen, J. K. *Tetrahedron Lett.* **1985**, *26*, 981.
4. Beard, R. L.; Meyers, A. I. *J. Org. Chem.* **1991**, *56*, 2091.
5. Syed, J.; Forster, S.; Effenberger, F. *Tetrahedron: Asymmetry* **1998**, *9*, 805.
6. Narkunan, K.; Uang, B.-J. *Synthesis* **1998**, 1713.
7. Erian, A. W. *J. Prakt. Chem.* **1999**, *341*, 147.
8. Deutsch, H. M.; Ye, X.; Shi, Q.; Liu, Z.; Schweri, M. M. *Eur. J. Med. Chem.* **2001**, *36,* 303.
9. Creemers, A. F. L.; Lugtenburg, J. *J. Am. Chem. Soc.* **2002**, *124*, 6324.
10. Shin, H.; Choi, B. S.; Lee, K. K.; Choi, H.-W.; Chang, J. H.; Lee, Kyu W.; Nam, D. H.; Kim, N.-S. *Synthesis* **2004**, 2629.
11. Choi, B. S.; Chang, J. H.; Choi, H.-W.; Kim, Y. K.; Lee, K. K.; Lee, K. W.; Lee, J. H.; Heo, T.; Nam, D. H.; Shin, H. *Org. Proc. Res. Dev.* **2005**, *9*, 311.

Blanc chloromethylation

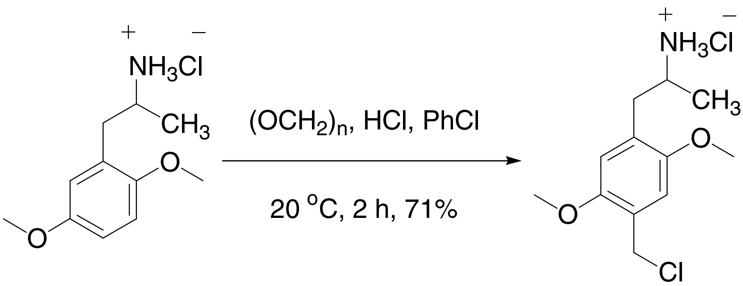
Lewis acid-promoted chloromethyl group installation onto the aromatics rings with 1,3,5-trioxane and HCl.



1,3,5-trioxane



Example 1[12]



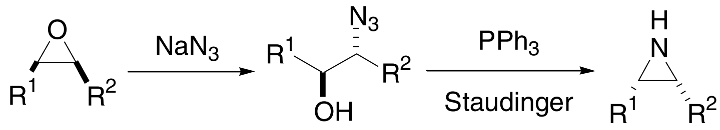
References

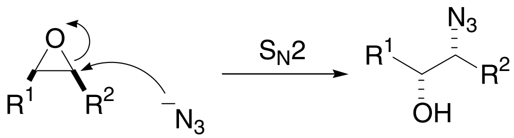
1. Blanc, G. *Bull. Soc. Chim. Fr.* **1923**, *33*, 313. Gustave Louis Blanc (1872–1927), born in Paris, France, studied under Charles Friedel in Paris. He developed the chloromethylation of aromatic hydrocarbons while he was a director at the Intendance militaire aux Invalides.

2. Fuson, R. C.; McKeever, C. H. *Org. React.* **1942**, *1,* 63. (Review).
3. Olah, G.; Tolgyesi, W. S. In *Friedel−Crafts and Related Reactions* vol. II, Part 2, Olah, G., Ed.; Interscience: New York, **1963**, pp 659−784. (Review).
4. Franke, A.; Mattern, G.; Traber, W. *Helv. Chim. Acta* **1975**, *58,* 283.
5. Sekine, Y.; Boekelheide, V. *J. Am. Chem. Soc*. **1981**, *103*, 1777.
6. Mallory, F. B.; Rudolph, M. J.; Oh, S. M. *J. Org. Chem.* **1989**, *54*, 4619.
7. Witiak, D. T.; Loper, J. T.; Ananthan, S.; Almerico, A. M.; Verhoef, V. L.; Filppi, J. A. *J. Med. Chem*. **1989**, *32*, 1636.
8. De Mendoza, J.; Nieto, P. M.; Prados, P.; Sanchez, C. *Tetrahedron* **1990**, *46*, 671.
9. Tashiro, M.; Tsuge, A.; Sawada, T.; Makishima, T.; Horie, S.; Arimura, T.; Mataka, S.; Yamato, T. *J. Org. Chem*. **1990**, *55*, 2404.
10. Miller, D. D.; Hamada, A.; Clark, M. T.; Adejare, A.; Patil, P. N.; Shams, G.; Romstedt, K. J.; Kim, S. U.; Intrasuksri, U.; *et al. J. Med. Chem*. **1990**, *33*, 1138.
11. Ito, K.; Ohba, Y.; Shinagawa, E.; Nakayama, S.; Takahashi, S.; Honda, K.; Nagafuji, H.; Suzuki, A.; Sone, T. *J. Heterocycl. Chem.* **2000**, *37*, 1479.
12. Harms, A.; Ulmer, E.; Kovar, K.-A. *Archiv. Pharmazie* **2003**, *336*, 155.

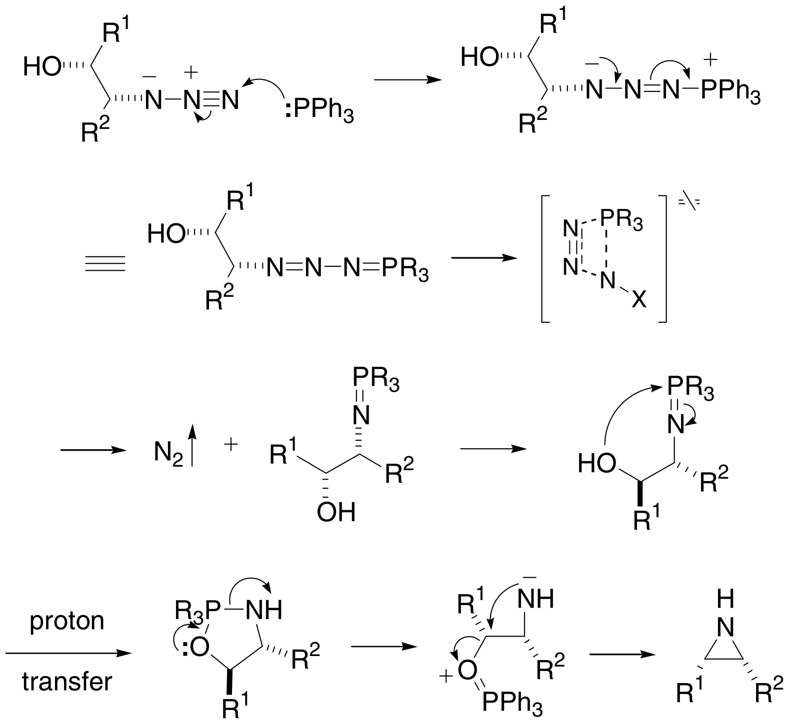
Blum aziridine synthesis

Ring opening of oxiranes using azide is followed by Staudinger reduction of the intermediate azido alcohol to give aziridines.

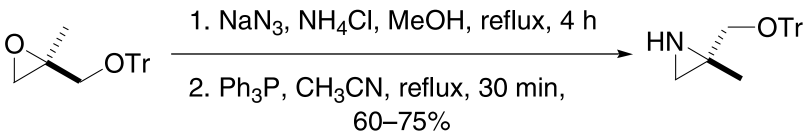




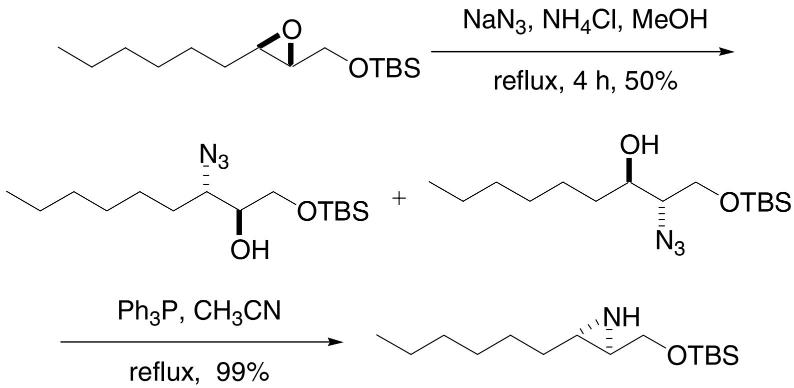
Regardless of the regioselectivity of the S_N2 reaction of the azide, the ultimate stereochemical outcome for the aziridine is the same.



Example 1[3]



Example 2[5]

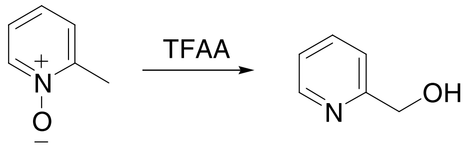


References

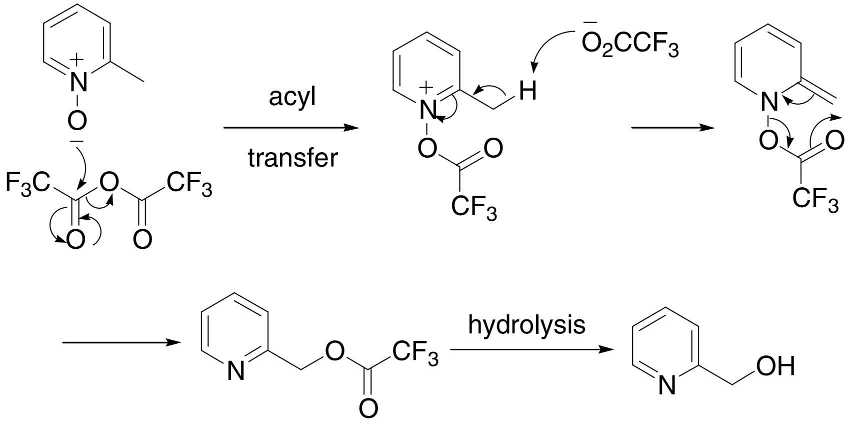
1. Ittah, Y.; Sasson, Y.; Shahak, I.; Tsaroom, S.; Blum, J. *J. Org. Chem.* **1978**, *43*, 4271. Jochanan Blum is a professor at The Hebrew University in Jerusalem, Israel.
2. Tanner, D.; Somfai, P. *Tetrahedron Lett.* **1987**, *28*, 1211.
3. Wipf, P.; Venkatraman, S.; Miller, C. P. *Tetrahedron Lett.* **1995**, *36*, 3639.
4. Fürmeier, S.; Metzger, J. O. *Eur. J. Org. Chem.* **2003**, 649.
5. Oh, K.; Parson, P. J.; Cheshire, D. *Synlett* **2004**, 2771.
6. Serafin, S. V.; Zhang, K.; Aurelio, L.; Hughes, A. B.; Morton, T. H. *Org. Lett.* **2004**, *6*, 1561.

Boekelheide reaction

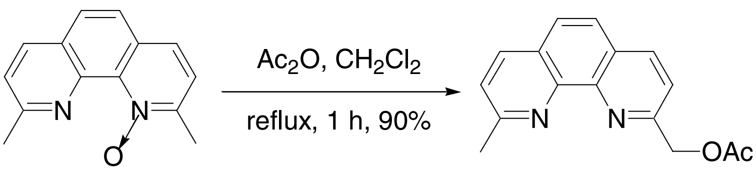
Treatment of 2-methylpyridine *N*-oxide with trifluoroacetic anhydride gives rise to 2-hydroxymethylpyridine.



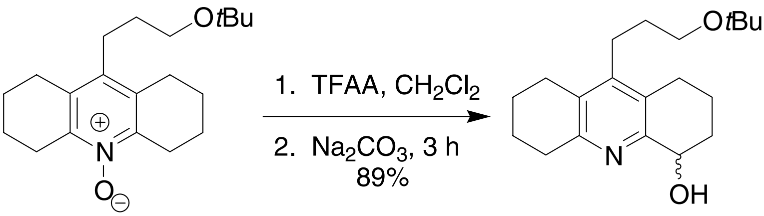
TFAA, trifluoroacetic anhydride



Example 1[6]



Example 2[9]

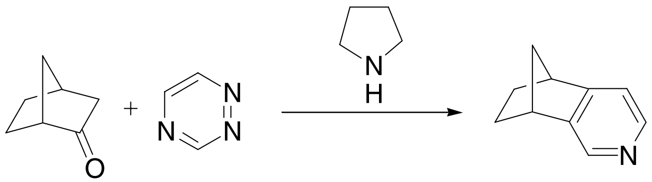


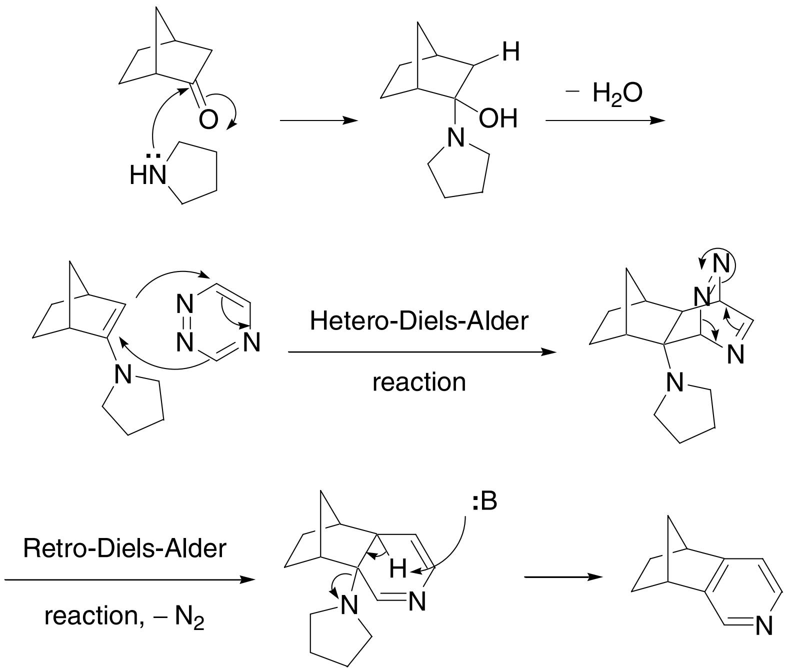
References

1. Boekelheide, V.; Linn, W. J. *J. Am. Chem. Soc.* **1954**, *76*, 1286. Virgil Boekelheide (1919–2003) was a professor at the University of Oregon.
2. Boekelheide, V.; Harrington, D. L. *Chem. Ind.* **1955**, 1423.
3. Boekelheide, V.; Lehn, W. L. *J. Org. Chem.* **1961**, *26*, 428.
4. Katritzky, A. R.; Lagowski, J. M. *Chemistry of the Heterocylic* N-*Oxides* Academic Press, NY, 1971. (Review).
5. Bell, T. W.; Firestone, A. *J. Org. Chem.* **1986**, *51*, 764.
6. Newkome, G. R.; Theriot, K. J.; Gupta, V. K.; Fronczek, F. R.; Baker, G. R. *J. Org. Chem.* **1989**, *54*, 1766.
7. Goerlitzer, K.; Schmidt, E. *Arch. Pharm.* **1991**, *324*, 359.
8. Katritzky, A. R.; Lam, J. N. *Heterocycles* **1992**, *33*, 1011−1049. (Review).
9. Fontenas, C.; Bejan, E.; Haddon, H. A.; Balavoine, G. G. A. *Synth. Commun.* **1995**, *25*, 629.
10. Goerlitzer, K.; Bartke, U. *Pharmazie* **2002**, *57*, 804.
11. Higashibayashi, S.; Mori, T.; Shinko, K.; Hashimoto, K.; Nakata, M. *Heterocycles* **2002**, *57*, 111.
12. Galatsis, P. *Boekelheide Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 340–349. (Review).

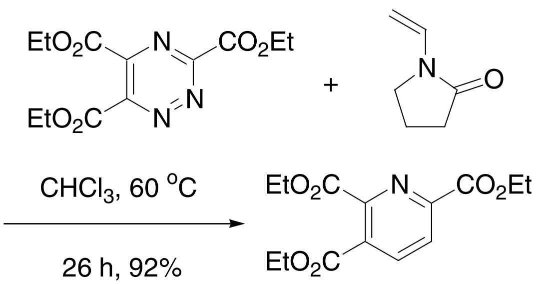
Boger pyridine synthesis

Pyridine synthesis *via* hetero-Diels–Alder reaction of 1,2,4-triazines and dienophiles (e.g. enamine) followed by extrusion of N_2.





Example 1[4]

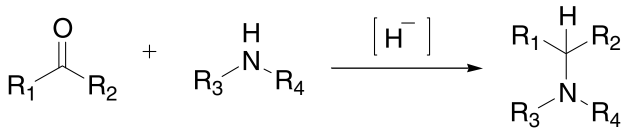


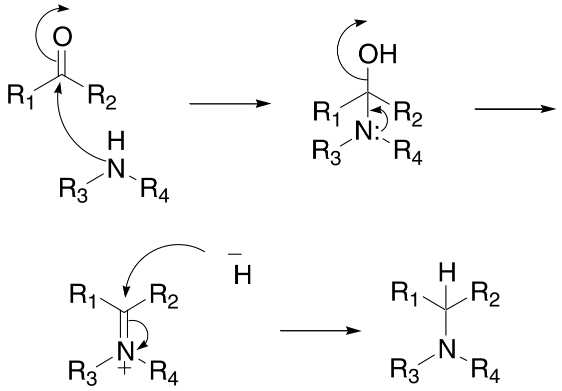
References

1. Boger, D. L.; Panek, J. S. *J. Org. Chem.* **1981**, *46*, 2179. Dale Boger is a professor at the Scripps Research Institute.
2. Boger, D. L.; Panek, J. S.; Meier, M. M. *J. Org. Chem.* **1982**, *47*, 895.
3. Boger, D. L. *Tetrahedron* **1983**, *39*, 2869−2939. (Review).
4. Boger, D. L. *Chem. Rev.* **1986**, *86*, 781−793. (Review).
5. Boger, D. L.; Panek, J. S.; Yasuda, M. *Org. Synth.* **1987**, *66*, 142.
6. Boger, D. L. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 451−512. (Review).
7. Golka, A.; Keyte, P. J.; Paddon-Row, M. N. *Tetrahedron* **1992**, *48*, 7663.
8. Behforouz, M.; Ahmadian, M.*Tetrahedron* **2000**, *56*, 5259−5288. (Review).
9. Buonora, P.; Olsen, J.-C.; Oh, T. *Tetrahedron* **2001**, *57*, 6099−6138. (Review).
10. Jayakumar, S.; Ishar, M. P. S.; Mahajan, M. P. *Tetrahedron* **2002**, *58*, 379−471. (Review).
11. Rykowski, A.; Olender, E.; Branowska, D.; Van der Plas, H. C. *Org. Prep. Proced. Int.* **2001**, *33*, 501.
12. Stanforth, S. P.; Tarbit, B.; Watson, M. D. *Tetrahedron Lett.* **2003**, *44*, 693.
13. Galatsis, P. *Boger Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 323−339. (Review).

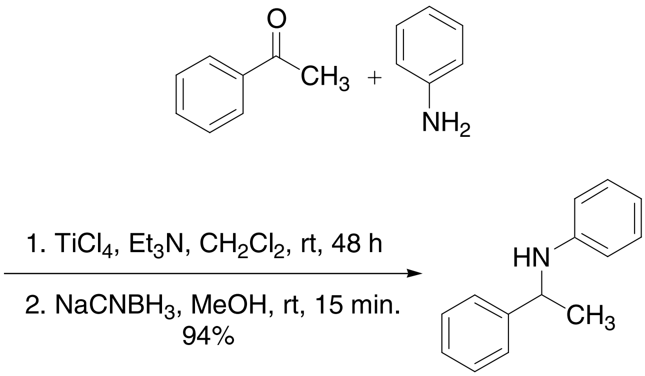
Borch reductive amination

Reduction (often using $NaCNBH_3$) of the imine formed by an amine and a carbonyl to afford the corresponding amine—basically, reductive amination.

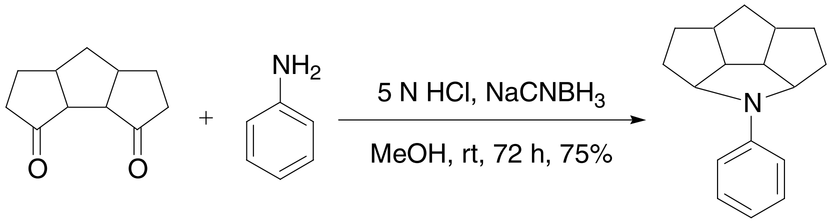




Example 1[4]



Example 2[5]

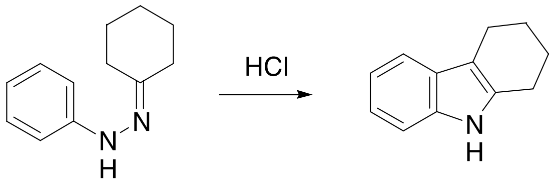


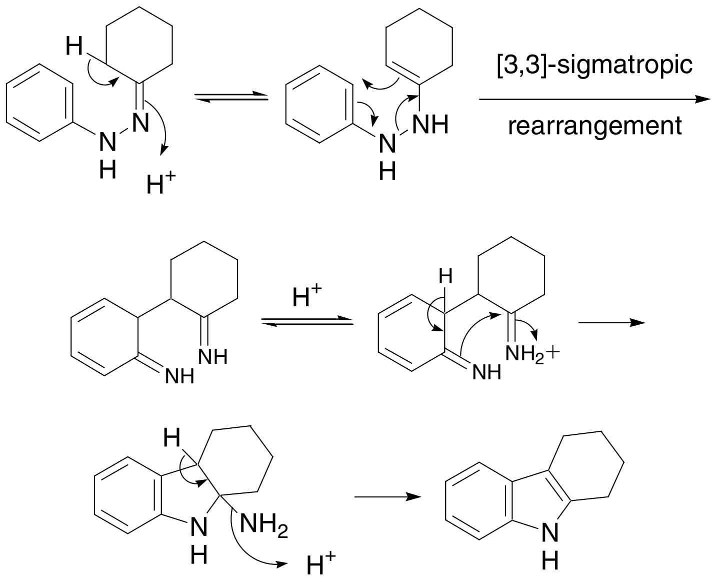
References

1. Borch, R. F. *J. Am. Chem. Soc.* **1969**, *91*, 3996. Richard F. Borch was born in Cleveland, Ohio. He was a professor at the University of Minnesota.
2. Borch, R. F.; Bernstein, M. D.; Durst, H. D. *J. Am. Chem. Soc.* **1971**, *93*, 2897.
3. Borch, R. F.; *J. Chem. Soc., Perkin I* **1984**, 717.
4. Barney, C. L.; Huber, E. W.; McCarthy, J. R. *Tetrahedron Lett.* **1990**, *31*, 5547.
5. Mehta, G.; Prabhakar, C. *J. Org. Chem.* **1995**, *60*, 4638.
6. Lewin, G.; Schaeffer, C. *Heterocycles* **1998**, *48*, 171.
7. Lewin, G.; Schaeffer, C.; Hocquemiller, R.; Jacoby, E.; Leonce, S.; Pierre, A.; Atassi, G. *Heterocycles* **2000**, *53*, 2353.

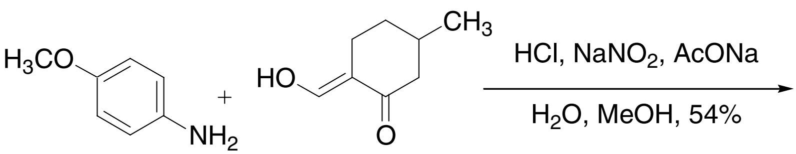
Borsche–Drechsel cyclization

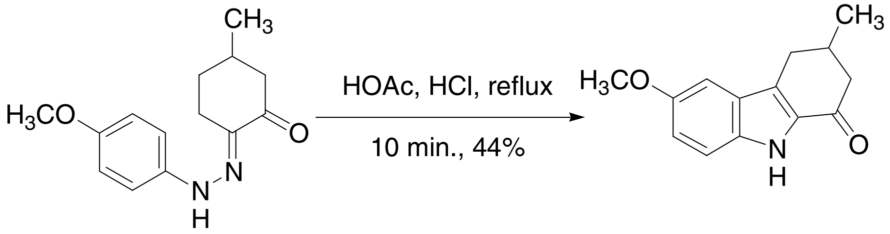
Tetrahydrocarbazole synthesis from cyclohexanone phenylhydrazone.
Cf. Fisher indole synthesis.





Example 1[8]



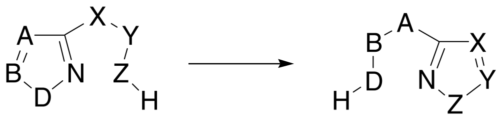


References

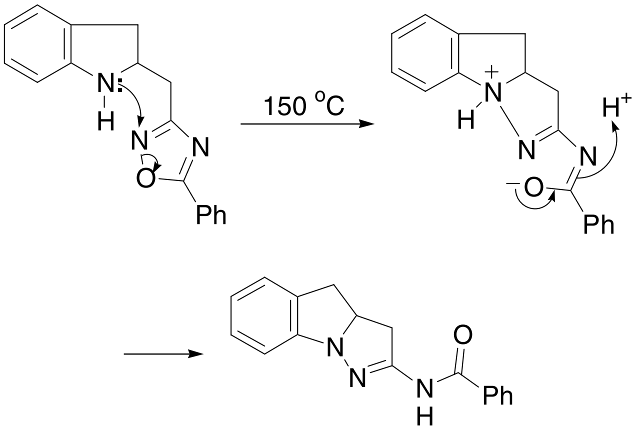
1. Drechsel, E. *J. Prakt. Chem.* **1858**, *38*, 69.
2. Borsche, W.; Feise, M. *Ber. Dtsch. Chem. Ges.* **1904**, *20*, 378. Walther Borsche was a professor at Chemischen Institut, Universität Göttingen, Germany when this paper was published. Borsche was completely devoid of the arrogance shown by many of his contemporaries. Borsche and his colleague at Frankfurt, Julius von Braun, both suffered under the Nazi regime for their independent minds.
3. Atkinson, C. M.; Biddle, B. N. *J. Chem. Soc. (C)* **1966**, 2053.
4. Bruck, P. *J. Org. Chem.* **1970**, *35,* 2222.
5. Gazengel, J. M.; Lancelot, J. C.; Rault, S.; Robba, M. *J. Heterocycl. Chem.* **1990**, *27,* 1947.
6. Abramovitch, R. A.; Bulman, A. *Synlett* **1992**, 795.
7. Murakami, Y.; Yokooa, H.; Watanabe, T. *Heterocycles* **1998**, *49,* 127.
8. Lin, G.; Zhang, A. *Tetrahedron* **2000**, *56,* 7163.
9. Ergun, Y.; Bayraktar, N.; Patir, S.; Okay, G. *J. Heterocycl. Chem.* **2000**, *37*, 11.
10. Rebeiro, G. L.; Khadilkar, B. M. *Synthesis* **2001**, 370.

Boulton–Katritzky rearrangement

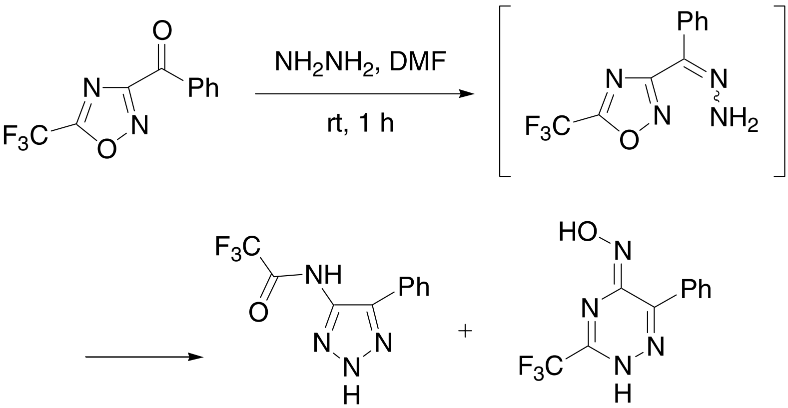
Rearrangement of one five-membered heterocycle into another under thermolysis.



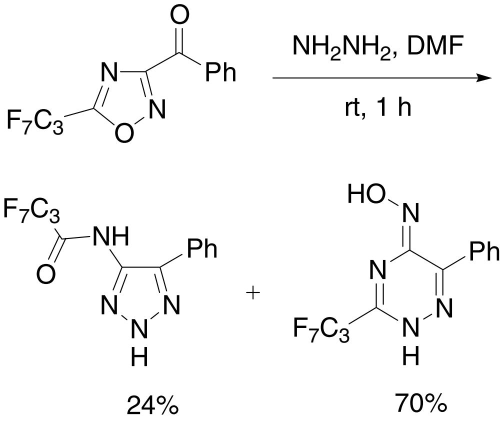
Example 1[7]



Example 2[11]



5%   92%

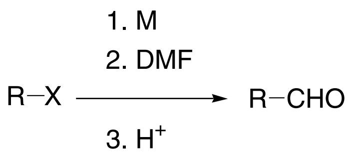


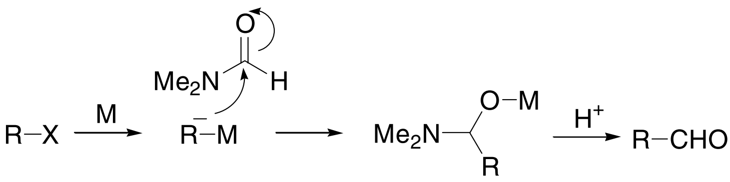
References

1. Boulton, A. J.; Katritzky, A. R.; Hamid, A. M. *J. Chem. Soc. (C)* **1967**, 2005. Alan Katritzky, a professor at the University of Florida, is best known for his series *Advances of Heterocyclic Chemistry*, now in its 87th volume.
2. Ruccia, M.; Vivona, N.; Spinelli, D. *Adv. Heterocyl. Chem.* **1981**, *29*, 141. (Review).
3. Butler, R. N.; Fitzgerald, K. J. *J. Chem. Soc., Perkin Trans. 1* **1988**, 1587.
4. Takakis, I. M.; Hadjimihalakis, P. M.; Tsantali, G. G. *Tetrahedron* **1991**, *47*, 7157.
5. Takakis, I. M.; Hadjimihalakis, P. M. *J. Heterocycl. Chem.* **1992**, *29*, 121.
6. Vivona, N.; Buscemi, S.; Frenna, V.; Cusmano, C. *Adv. Heterocyl. Chem.* **1993**, *56*, 49.
7. Katayama, H.; Takatsu, N.; Sakurada, M.; Kawada, Y. *Heterocycles* **1993**, *35*, 453.
8. Rauhut, G. *J. Org. Chem.* **2001**, *66*, 5444.
9. Crampton, M. R.; Pearce, L. M.; Rabbitt, L. C. *J. Chem. Soc., Perkin Trans. 2* **2002**, 257.
10. Pena-Gallego, A.; Rodriguez-Otero, J.; Cabaleiro-Lago, E. M. *J. Org. Chem.* **2004**, *69*, 7013.
11. Buscemi, S.; Pace, A.; Piccionello, A. P.; Macaluso, G.; Vivona, N.; Spinelli, D.; Giorgi, G. *J. Org. Chem.* **2005**, *70*, 3288.

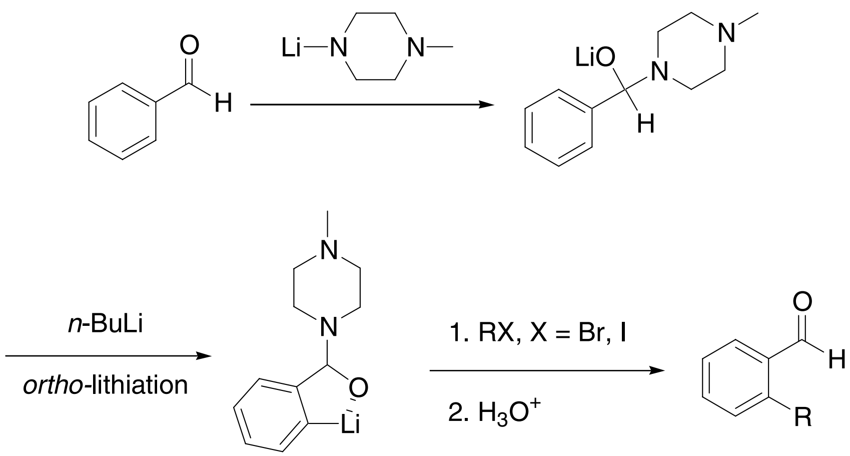
Bouveault aldehyde synthesis

Formylation of an alkyl or aryl halide to the homologous aldehyde by transformation to the corresponding organometallic reagent then addition of DMF (M = Li, Mg, Na, and K).

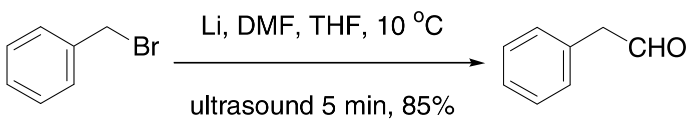




A modification by Comins:[7]



Example 1[6]

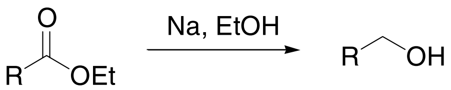


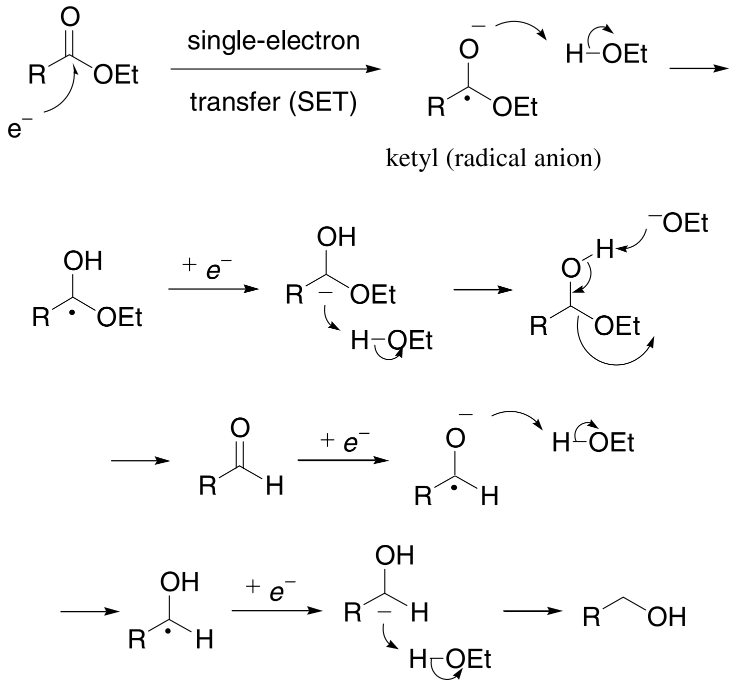
References

1. Bouveault, L. *Bull. Soc. Chim. Fr.* **1904**, *31*, 1306, 1322. Louis Bouveault (1864–1909) was born in Nevers, France. He devoted his short yet very productive life to teaching and to working in science.
2. Maxim, N.; Mavrodineanu, R. *Bull. Soc. Chim. Fr.* **1935**, *2*, 591.
3. Maxim, N.; Mavrodineanu, R. *Bull. Soc. Chim. Fr.* **1936**, *3*, 1084.
4. Smith, L. I.; Bayliss, M. *J. Org. Chem.* **1941**, *6*, 437.
5. Sicé, J. *J. Am. Chem. Soc.* **1953**, *75*, 3697.
6. Pétrier, C.; Gemal, A. L.; Luche, J. L. *Tetrahedron Lett.* **1982**, *23*, 3361.
7. Comins, D. L.; Brown, J. D. *J. Org. Chem.* **1984**, *49*, 1078.
8. Einhorn, J.; Luche, J. L. *Tetrahedron Lett.* **1986**, *27*, 1791.
9. Einhorn, J.; Luche, J. L. *Tetrahedron Lett.* **1986**, *27*, 1793.
10. Denton, S. M.; Wood, A. *Synlett* **1999**, 55.
11. Meier, H.; Aust, H. *J. Prakt. Chem.* **1999**, *341*, 466.

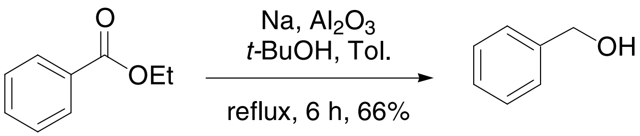
Bouveault–Blanc reduction

Reduction of esters to the corresponding alcohols using sodium in an alcoholic solvent.





Example 1[8]



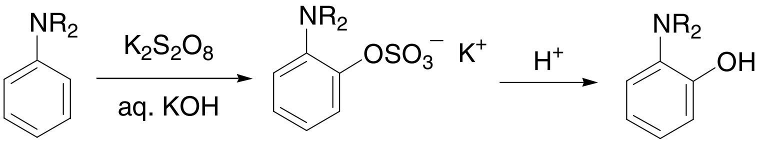
References

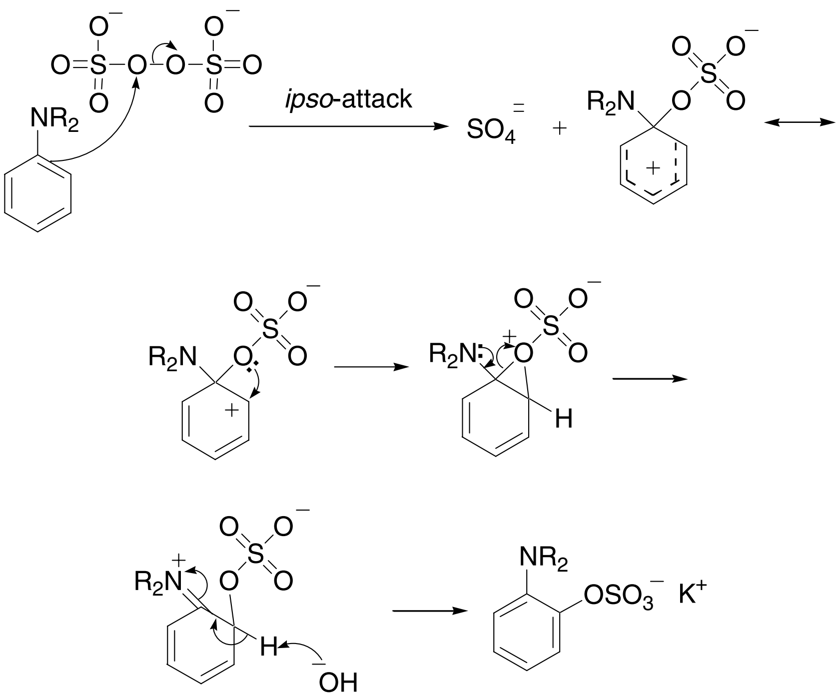
1. Bouveault, L.; Blanc, G. *Compt. Rend.* **1903**, *136*, 1676.
2. Bouveault, L.; Blanc, G. *Bull. Soc. Chim.* **1904**, *31*, 666.
3. Ruehlmann, K.; Seefluth, H.; Kiriakidis, T.; Michael, G.; Jancke, H.; Kriegsmann, H. *J. Organomet. Chem.* **1971**, *27*, 327.
4. Castells, J.; Grandes, D.; Moreno-Manas, M.; Virgili, A. *An. Quim.* **1976**, *72*, 74.

5. Sharda, R.; Krishnamurthy, H. G. *Indian J. Chem., Sect. B* **1980**, *19B*, 405.
6. Banerji, J.; Bose, P.; Chakrabarti, R.; Das, B. *Indian J. Chem., Sect. B* **1993**, *32B*, 709.
7. Seo, B. I.; Wall, L. K.; Lee, H.; Buttrum, J. W.; Lewis, D. E. *Synth. Commun.* **1993**, *23*, 15.
8. Singh, S.; Dev, S. *Tetrahedron* **1993**, *49*, 10959.
9. Schopohl, Matthias C.; Bergander, Klaus; Kataeva, Olga; Froehlich, Roland; Waldvogel, Siegfried R. *Synthesis* **2003**, 2689.

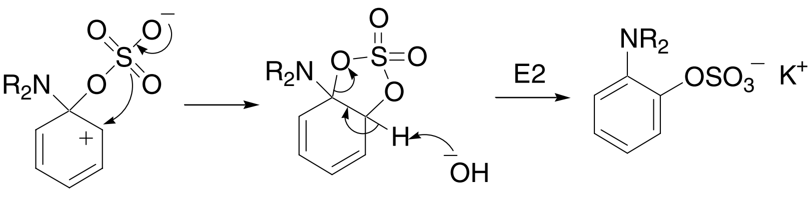
Boyland–Sims oxidation

Oxidation of anilines to phenols using alkaline persulfate.

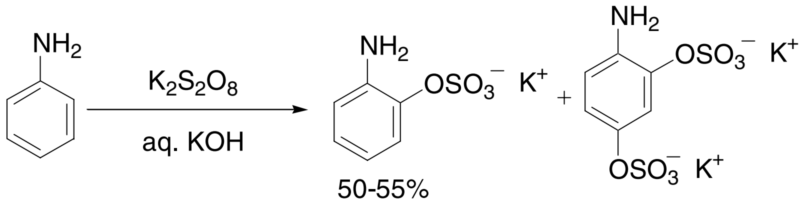




Another pathway is also operative:



Example 1[3]

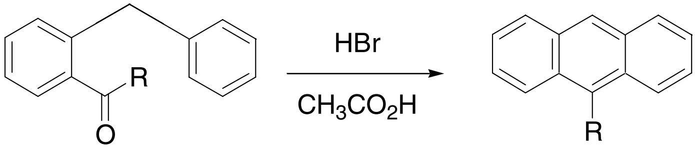


References

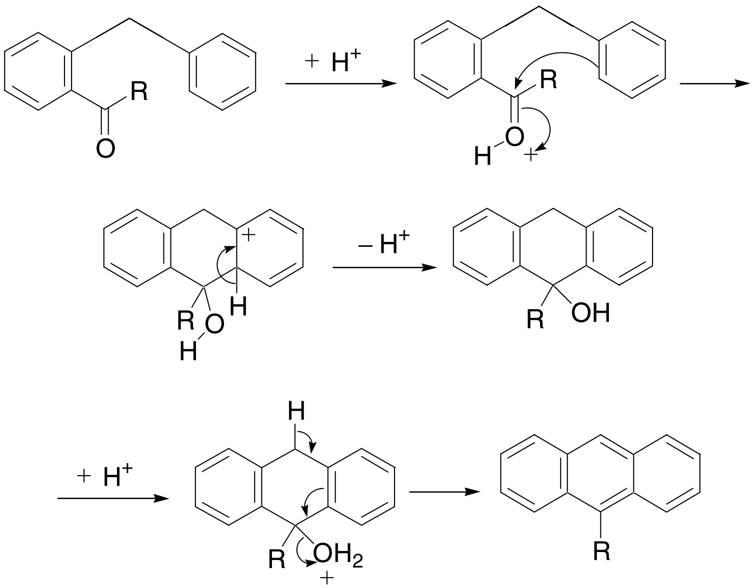
1. Boyland, E.; Manson, D.; Sims, P. *J. Chem. Soc*. **1953**, 3623. Eric Boyland and Peter Sims were at the Royal Cancer Hospital in London, UK.
2. Boyland, E.; Sims, P. *J. Chem. Soc*. **1954**, 980.
3. Behrman, E. J. *J. Am. Chem. Soc*. **1967**, *89*, 2424.
4. Krishnamurthi, T. K.; Venkatasubramanian, N. *Indian J. Chem., Sect. A* **1978**, *16A*, 28.
5. Behrman, E. J.; Behrman, D. M. *J. Org. Chem*. **1978**, *43*, 4551.
6. Srinivasan, C.; Perumal, S.; Arumugam, N. *J. Chem. Soc., Perkin Trans. 2* **1985**, 1855.
7. Behrman, E. J. *Org. React.* **1988**, *35,* 421–511. (Review).
8. Behrman, E. J. *J. Org. Chem*. **1992**, *57*, 2266.

Bradsher reaction

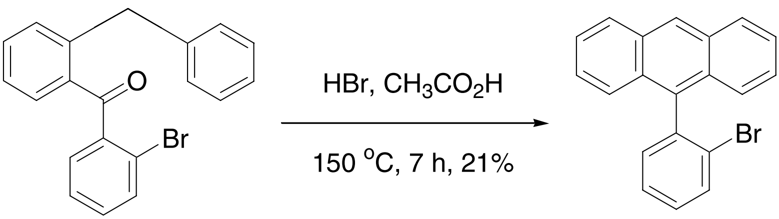
Anthracenes from *ortho*-acyl diarylmethanes *via* acid-catalyzed cyclodehydration.



anthracene



Example[5]



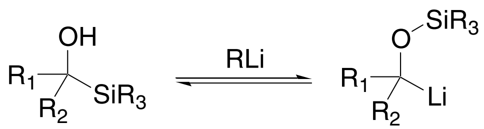
References

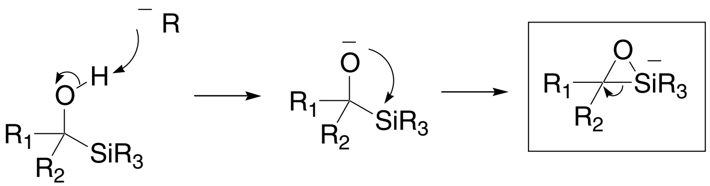
1. Bradsher, C. K. *J. Am. Chem. Soc.* **1940**, *62*, 486. Charles K. Bradsher was a professor at Duke University.
2. Bradsher, C. K.; Smith, E. S. *J. Am. Chem. Soc.* **1943**, *65*, 451.

3. Bradsher, C. K.; Vingiello, F. A. *J. Org. Chem.* **1948**, *13*, 786.
4. Bradsher, C. K.; Sinclair, E. F. *J. Org. Chem.* **1957**, *22*, 79.
5. Vingiello, F. A.; Spangler, M. O. L.; Bondurant, J. E. *J. Org. Chem.* **1960**, *25*, 2091.
6. Brice, L. K.; Katstra, R. D. *J. Am. Chem. Soc*. **1960**, *82*, 2669.
7. Saraf, S. D.; Vingiello, F. A. *Synthesis* **1970**, 655.
8. Ashby, J.; Ayad, M.; Meth-Cohn, O. *J. Chem. Soc., Perkin Trans. 1* **1974**, 1744.
9. Nicolas, T. E.; Franck, R. W. *J. Org. Chem.* **1995**, *60*, 6904.
10. Magnier, E.; Langlois, Y. *Tetrahedron Lett*. **1998**, *39*, 837.

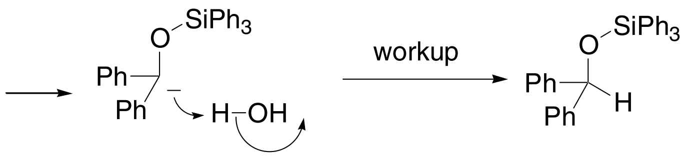
Brook rearrangement

Rearrangement of α-silyl oxyanions to α-silyloxy carbanions *via* a reversible process involving a pentacoordinate silicon intermediate is known as the [1,2]-Brook rearrangement, or [1,2]-silyl migration.

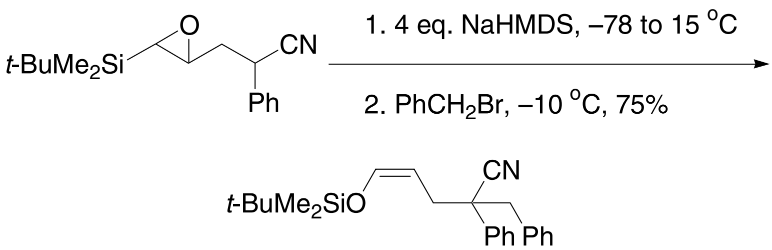




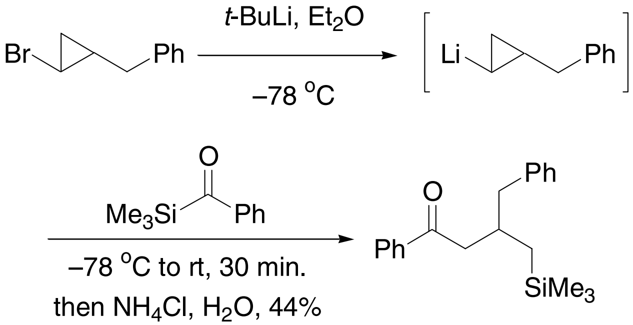
pentacoordinate silicon intermediate



Example 1[11]



Example 2[14]

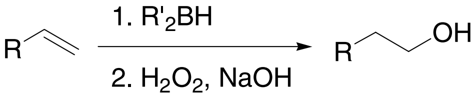


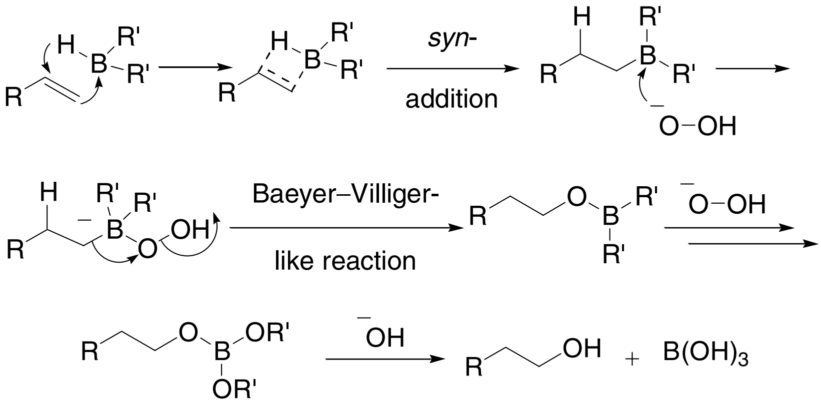
References

1. Brook, A. G. *J. Am. Chem. Soc.* **1958**, *80*, 1886. Adrian G. Brook (1924–) was born in Toronto, Canada. He is a professor in Lash Miller Chemical Laboratories, University of Toronto, Canada.
2. Brook, A. G. *Acc. Chem. Res.* **1974**, *7*, 77. (Review).
3. Page, P. C. B.; Klair, S. S.; Rosenthal, S. *Chem. Soc. Rev.* **1990**, *19*, 147. (Review).
4. Takeda, K.; Nakatani, J.; Nakamura, H.; Yosgii, E.; Yamaguchi, K. *Synlett* **1993**, 841.
5. Fleming, I.; Ghosh, U. *J. Chem. Soc., Perkin Trans. 1* **1994**, 257.
6. Takeda, K.; Takeda, K.; Ohnishi, Y. *Tetrahedron Lett.* **2000**, *41*, 4169.
7. Sumi, K.; Hagisawa, S. *J. Organomet. Chem.* **2000**, *611*, 449.
8. Moser, W. H. *Tetrahedron* **2001**, *57*, 2065. (Review).
9. Takeda, K.; Sawada, Y.; Sumi, K. *Org. Lett.* **2002**, *4*, 1031.
10. Takeda, K.; Haraguchi, H.; Okamoto, Y. *Org. Lett.* **2003**, *5*, 3705.
11. Okugawa, S.; Takeda, K. *Org. Lett.* **2004**, *6*, 2973.
12. Matsumoto, T.; Masu, H.; Yamaguchi, K.; Takeda, K. *Org. Lett.* **2004**, *6*, 4367.
13. Tanaka, K.; Takeda, K. *Tetrahedron Lett.* **2004**, *45*, 7859.
14. Clayden, J.; Watson, D. W.; Chambers, M. *Tetrahedron* **2005**, *61*, 3195.
15. Nahm, M. R.; Xin, L.; Potnick, J. R.; Yates, C. M.; White, P. S.; Johnson, J. S. *Angew. Chem., Int. Ed. Engl.* **2005**, *44*, 2377.

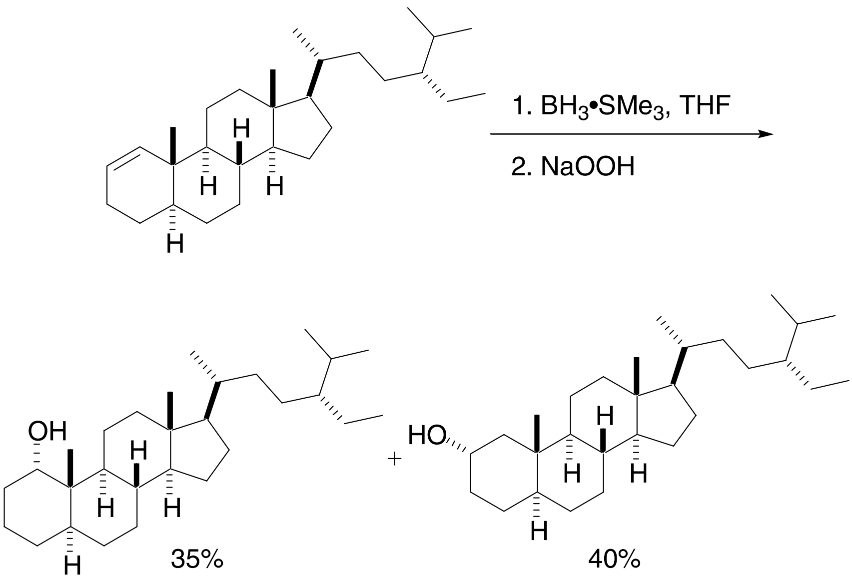
Brown hydroboration

Addition of boranes to olefins, followed by basic oxidation of the organoborane adducts, resulting in alcohols.

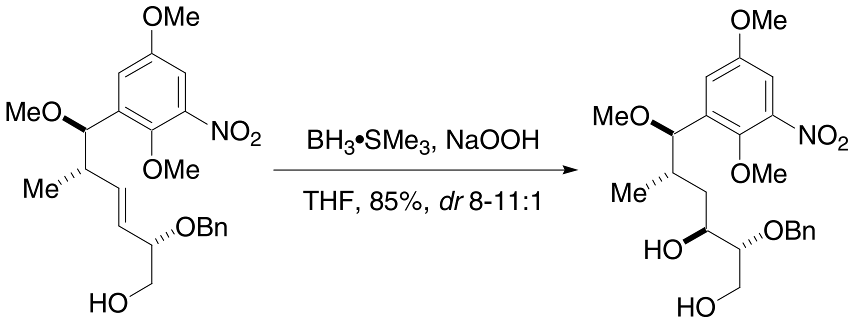




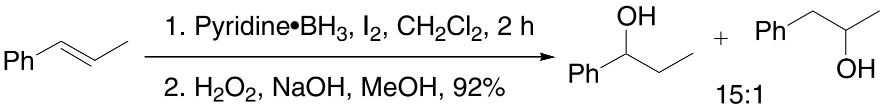
Example 1[2]



Example 2[13]



Example 3[14]

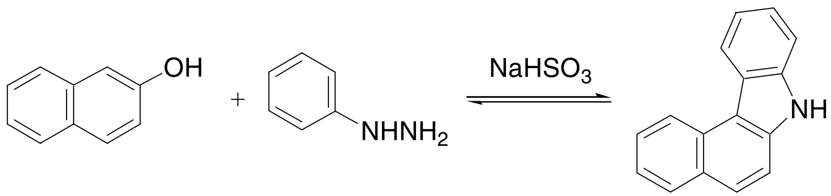


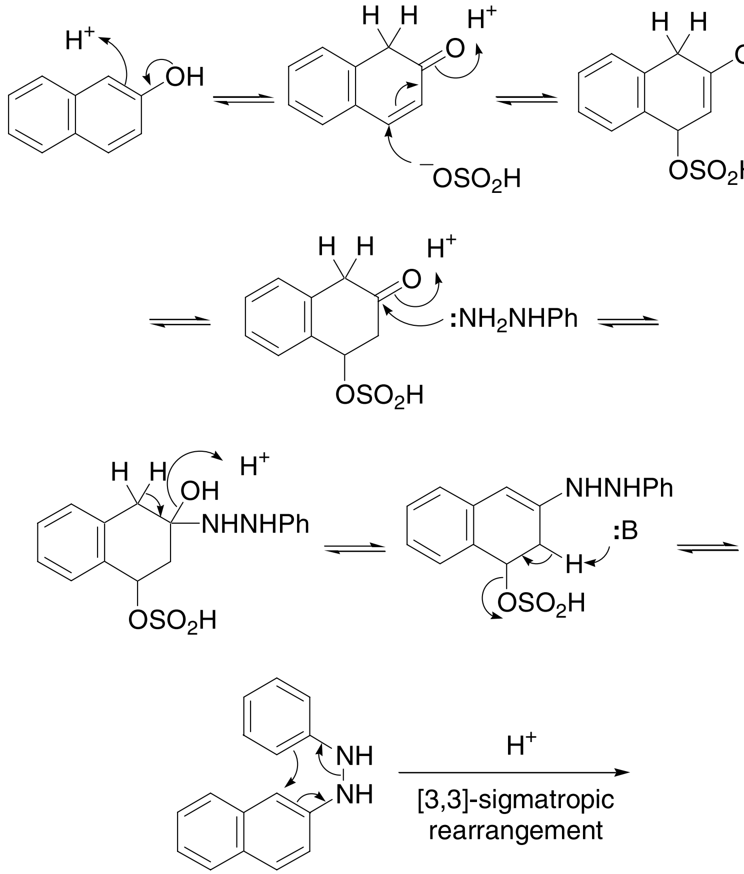
References

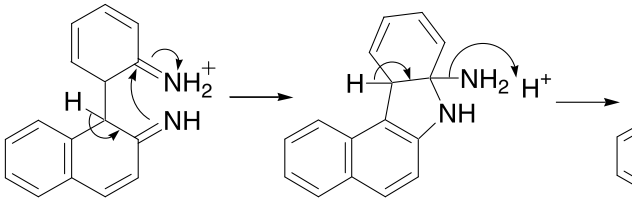
1. Brown, H. C.; Tierney, P. A. *J. Am. Chem. Soc.* **1958**, *80*, 1552. Herbert C. Brown (USA, 1912–2004) began his academic career at Wayne State University and moved on to Purdue University where he shared the Nobel Prize in Chemistry in 1981 with Georg Wittig (Germany, 1897–1987) for their development of organic boron and phosphorous compounds.
2. Nussium, M.; Mazur, Y.; Sondheimer, F. *J. Org. Chem.* **1964**, *29*, 1120.
3. Nussium, M.; Mazur, Y.; Sondheimer, F. *J. Org. Chem.* **1964**, *29*, 1131.
4. Streitwieser, A., Jr.; Verbit, L.; Bittman, R. *J. Org. Chem.* **1967**, *32*, 1530.
5. Herz, J. E.; Marquez, L. A. *J. Chem. Soc. (C)* **1971**, 3504.
6. Pelter, A.; Smith, K.; Brown, H. C. *Borane Reagents* Academic Press: New York, **1972**. (Review).
7. Brewster, J. H.; Negishi, E. *Science* **1980**, *207*, 44. (Review).
8. Brown, H. C.; vara Prasad, J. V. N. *Heterocycles* **1987**, *25*, 641.
9. Fu, G. C.; Evans, D. A.; Muci, A. R. *Advances in Catalytic Processes* **1995**, *1*, 95–121. (Review).
10. Hayashi, T. *Comprehensive Asymmetric Catalysis I–III* **1995**, *1*, 351–364. (Review).
11. Morrill, T. C.; D'Souza, C. A.; Yang, L.; Sampognaro, A. J. *J. Org. Chem.* **2002**, *67*, 2481.
12. Hupe, E.; Calaza, M. I.; Knochel, P. *Tetrahedron Lett.* **2001**, *42*, 8829.
13. Carter K. D; Panek J. S. *Org. Lett.* **2004**, *6*, 55.
14. Clay, J. M.; Vedejs, E. *J. Am. Chem. Soc.* **2005**, *127*, 5766.

Bucherer carbazole synthesis

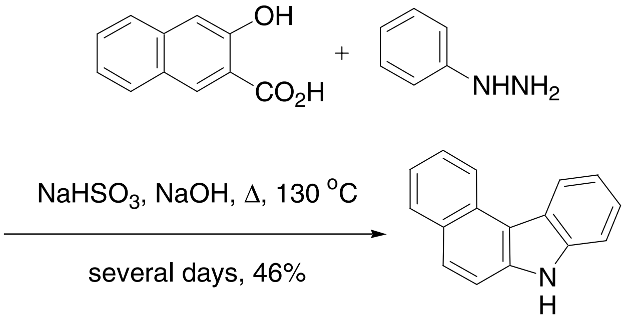
Carbazoles from naphthols and aryl hydrazines promoted by sodium bisulfite.



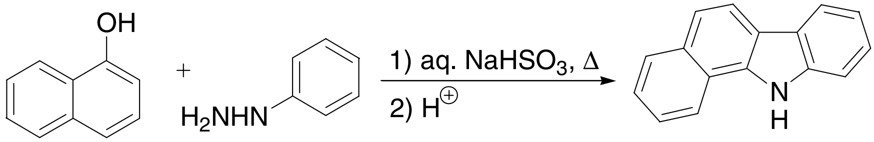




Example 1[3]



Example 2[4]



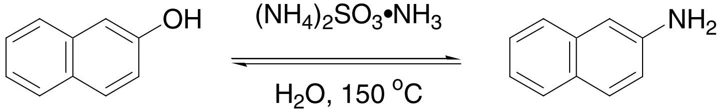
References

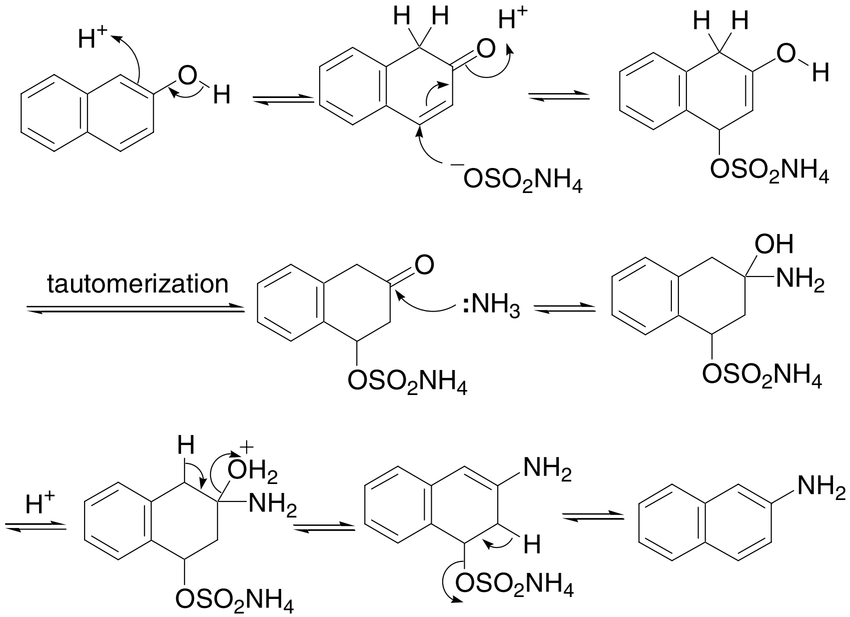
1. Bucherer, H. T. *J. Prakt. Chem.* **1904**, *69*, 49. Hans Th. Bucherer (1869–1949) was born in Ehrenfeld, Germany. He shuttled between industry and academia all through his career.
2. Bucherer, H. T.; Seyde, F. *J. Prakt. Chem.* **1908**, *77*, 403.
3. Bucherer, H. T.; Schmidt, M. *J. Prakt. Chem.* **1909**, *79*, 369.
4. Bucherer, H. T.; Sonnenburg, E. F. *J. Prakt. Chem.* **1909**, *81*, 1.
5. Friedländer, P. *Chem. Ztg.* **1916**, *40*, 918.
6. Fuchs, W.; Niszel, F. *Chem. Ber.* **1927**, *60*, 209.
7. Drake, N. L. *Org. React.* **1942**, *1*, 105. (Review).
8. Buu-Hoï, N. P.; Hoán, N.; Khôi, N. H. *J. Org. Chem.* **1949**, *14*, 492.
9. Buu-Hoï, N. P.; Royer, R.; Eckert, B.; Jacquignon, P. *J. Chem. Soc.* **1952**, 4867.
10. Zander, M.; Franke, W. *Chem. Ber.* **1963**, *96*, 699.
11. Seeboth, H.; Bärwolff, D.; Becker, B. *Justus Liebigs Ann. Chem.* **1965**, *683*, 85.
12. Seeboth, H. *Angew. Chem., Int. Ed. Engl.* **1967**, *6*, 307.
13. Thang, D. C.; Can, C. X.; Buu-Hoï, N. P.; Jacquignon, P. *J. Chem. Soc., Perkin Trans. 1* **1972**, 1932.

14. Robinson, B. *The Fischer Indole Synthesis*, Wiley-Interscience, New York, **1982**. (Book).
15. Hill, J. A.; Eaddy, J. F. *J. Labeled. Compd. Radiopharm.* **1994**, *34*, 697.
16. Pischel, I.; Grimme, S.; Kotila, S.; Nieger, M.; Vögtle, F. *Tetrahedron: Asymmetry* **1996**, *7*, 109.

Bucherer reaction

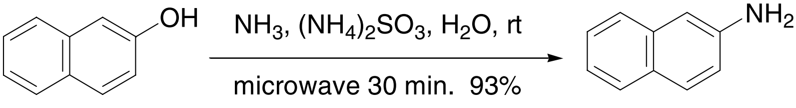
Transformation of β-naphthols to β-naphthylamines using ammonium sulfite.





Example[2]

Although the classic Bucherer reaction requires high temperature, it may be carried out at room temperature with the aid of microwave (150 watts):



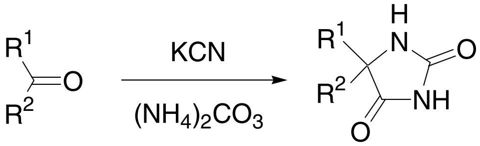
References

1. Bucherer, H. T. *J. Prakt. Chem.* **1904**, *69*, 49.
2. Drake, N. L. *Org. React.* **1942**, *1*, 105. (Review).
3. Reiche, A.; Seeboth, H. *Justus Liebigs Ann. Chem.* **1960**, *638*, 66.
4. Seeboth, H.; Reiche, A. *Justus Liebigs Ann. Chem.* **1964**, *671*, 77.

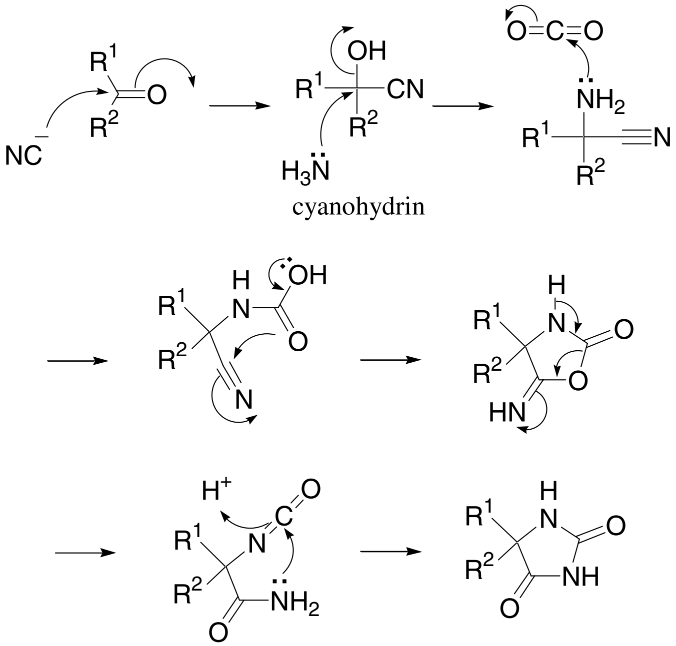
5. Gilbert, E. E. *Sulfonation and Related Reactions* Wiley: New York, **1965**, p166. (Review).
6. Seeboth, H. *Angew. Chem., Int. Ed. Engl.* **1967**, *6*, 307.
7. Gruszecka, E.; Shine, H. J. *J. Labelled. Compd. Radiopharm.* **1983**, *20*, 1257.
8. Belica, P. S.; Manchand, P. S. *Synthesis* **1990**, 539.
9. Cañete, A.; Meléndrez, M. X.; Saitz, C.; Zanocco, A. L. *Synth. Commun*. **2001**, *31*, 2143.

Bucherer–Bergs reaction

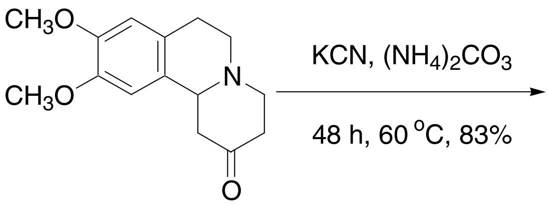
Formation of hydantoins from carbonyl compounds with potassium cyanide (KCN) and ammonium carbonate [$(NH_4)_2CO_3$] or from cyanohydrins and ammonium carbonate. It belongs to the category of multiple component reaction (MCR).

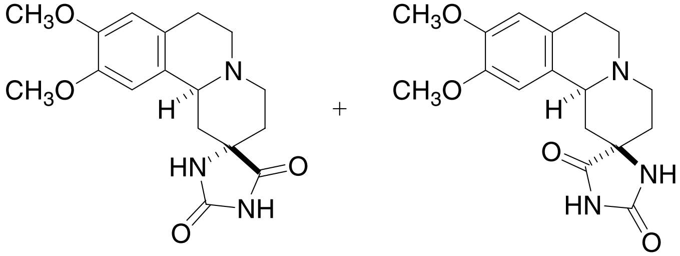


$(NH_4)CO_2 \leftrightarrow 2\ NH_3 + CO_2 + H_2O$

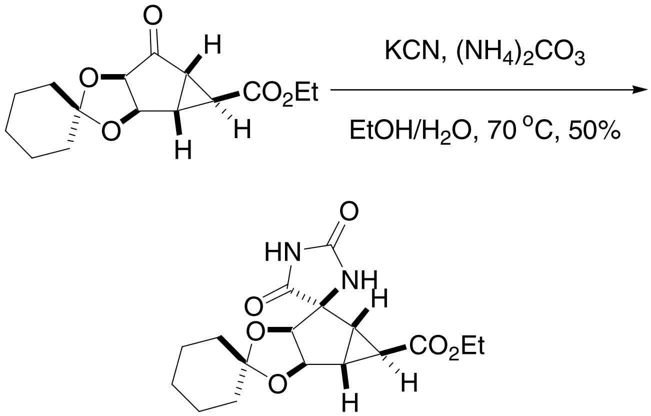


Example 1[10]





Example 2[11]

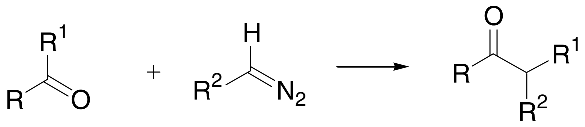


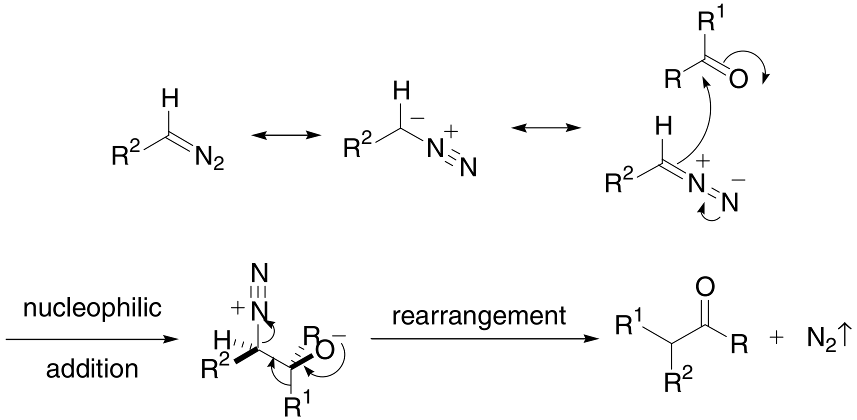
References

1. Bergs, H. Ger. Pat. 566, 094, **1929**. Hermann Bergs worked at I. G. Farben in Germany.
2. Bucherer, H. T., Fischbeck, H. T. *J. Prakt. Chem.* **1934**, *140*, 69.
3. Bucherer, H. T., Steiner, W. *J. Prakt. Chem.* **1934**, *140*, 291. (Mechanism).
4. E. Ware, *Chem. Rev.* **1950,** *46,* 403. (Review).
5. Wieland, H. *et al.,* in *Houben–Weyl's Methoden der organischen Chemie*, Vol. XI/2, **1958**, p 371.
6. Chubb, F. L.; Edward, J. T.; Wong, S. C. *J. Org. Chem.* **1980**, *45*, 2315.
7. Rousset, A.; Laspéras, M.; Taillades, J.; Commeyras, A. *Tetrahedron* **1980**, *36,* 2649.
8. Bowness, W. G.; Howe, R.; Rao, B. S. *J. Chem. Soc., Perkin Trans. 1* **1983**, 2649.
9. Haroutounian, S. A.; Georgiadis, M. P.; Polissiou, M. G. *J. Heterocycl. Chem.* **1989**, *26*, 1283.
10. Menéndez, J. C.; Díaz, M. P.; Bellver, C.; Söllhuber, M. M. *Eur. J. Med. Chem.* **1992**, *27*, 61.
11. Domínguez, C.; Ezquerra, A.; Prieto, L.; Espada, M.; Pedregal, C. *Tetrahedron: Asymmetry* **1997**, *8*, 511.
12. Micŏvá, J.; Steiner, B.; Kóoš, M.; Langer, V.; Gyepesova, D. *Synlett* **2002**, 1715.
13. Li, J. J. *Bucherer–Bergs Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 266–274. (Review).

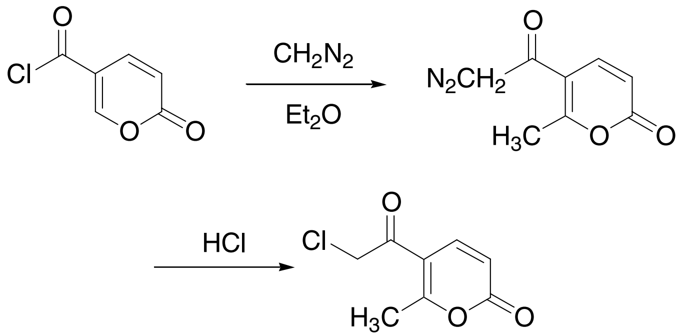
Büchner–Curtius–Schlotterbeck reaction

Reaction of carbonyl compounds with aliphatic diazo compounds to deliver homologated ketones.

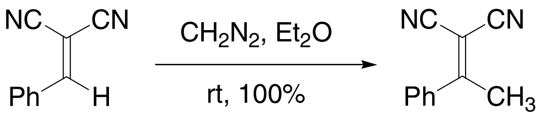


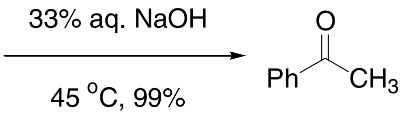


Example 1[3]



Example 2[6]



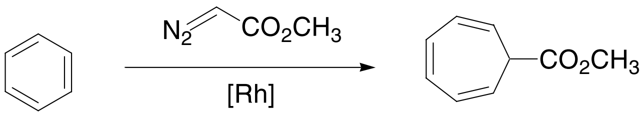


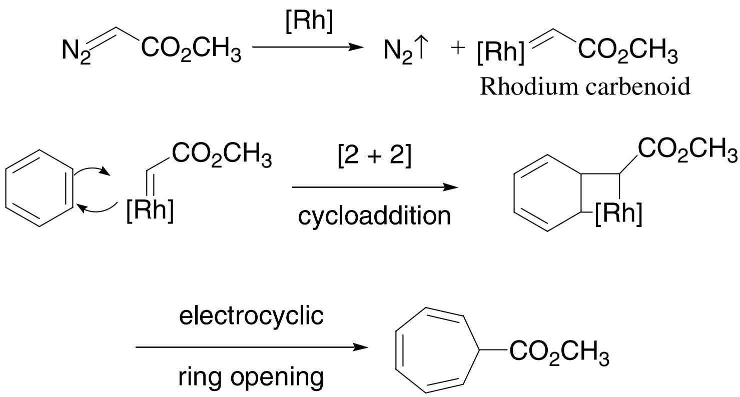
References

1. Büchner, E.; Curtius, T. *Ber. Dtsch. Chem. Ges.* **1885**, *18*, 2371. Eduard Büchner (Germany, 1860–1917) won the Nobel Prize in Chemistry in 1907 for biochemical studies and discovery of fermentation without cells.
2. Schlotterbeck, F. *Ber. Dtsch. Chem. Ges.* **1907**, *40*, 479.
3. Fried, J.; Elderfield, R. C. *J. Org. Chem.* **1941**, *6,* 577.
4. Gutsche, C. D. *Org. React.* **1954**, *8,* 364. (Review).
5. Bastús, J. B. *Tetrahedron Lett.* **1963**, 955.
6. Kirmse, W.; Horn, K. *Tetrahedron Lett.* **1967**, 1827.

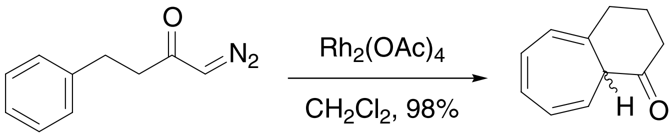
Büchner method of ring expansion

Reaction of benzene with diazoacetic esters to give cyclohepta-2,4,6-trienecarboxylic acid esters. *Cf.* Pfau–Platter azulene synthesis.

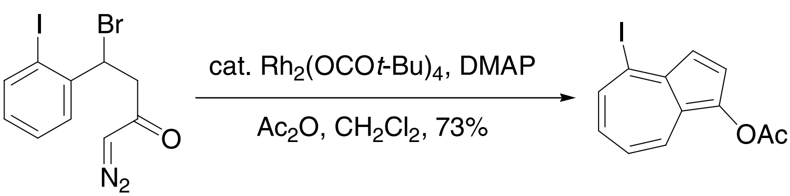




Example 1[7]



Example 2[8]



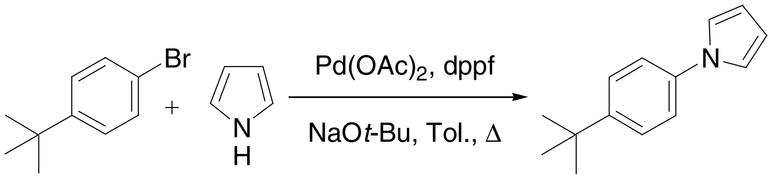
References

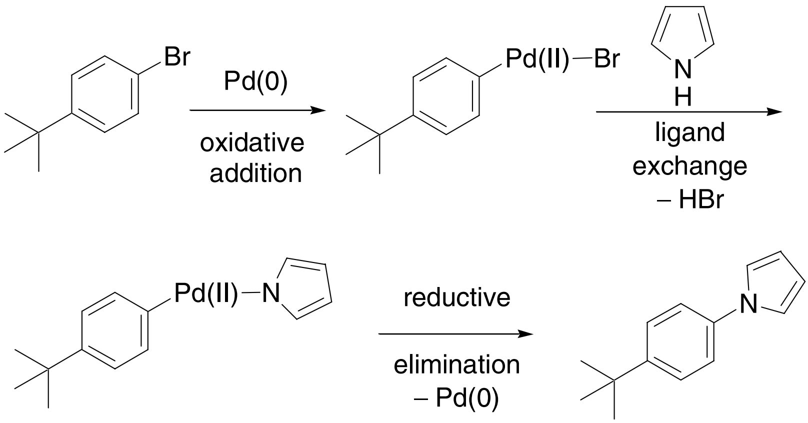
1. Büchner, E. *Ber. Dtsch. Chem. Ges.* **1896**, *29*, 106.
2. Dev, S. *J. Indian Chem. Soc*. **1955**, *32*, 513.
3. von Doering, W.; Knox, L. H. *J. Am. Chem. Soc.* **1957**, *79*, 352.

4. Marchard, A. P.; Brockway, N. M. *Chem. Rev.* **1974**, *74*, 431. (Review).
5. Anciaux, A. J.; Demonceon, A.; Noels, A. F.; Hubert, A. J.; Warin, R.; Teyssié, P. *J. Org. Chem.* **1981**, *46*, 873.
6. Doyle, M. P.; Hu, W.; Timmons, D. J. *Org. Lett.* **2001**, *3*, 933.
7. Manitto, P.; Monti, D.; Speranza, G. *J. Org. Chem.* **1995**, *60*, 484.
8. Crombie, A. L; Kane, J. L. Jr.; Shea, K. M.; Danheiser, R. L. *J. Org. Chem.* **2004**, *69*, 8652.

Buchwald–Hartwig C–N and C–O bond formation reactions

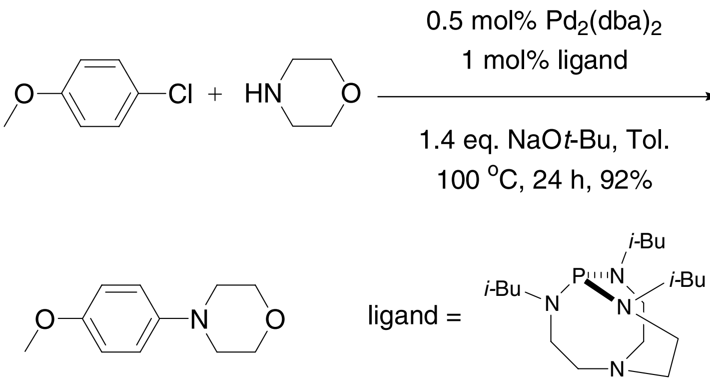
Direct Pd-catalyzed C–N and C–O bond formation from aryl halides and amines in the presence of stoichiometric amount of base.



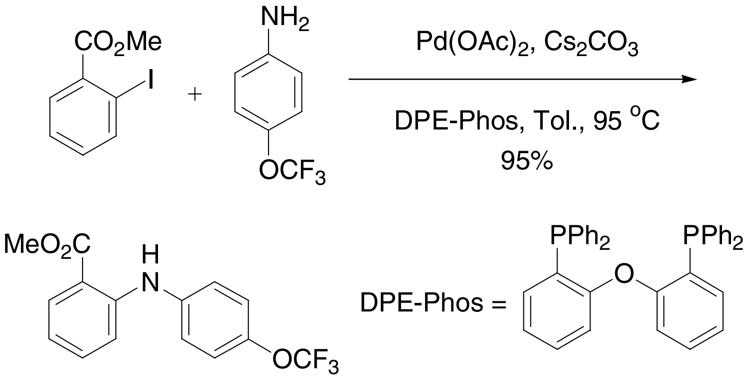


The C–O bond formation reaction follows a similar mechanistic pathway.[7–9]

Example 1[11]



Example 2[12]



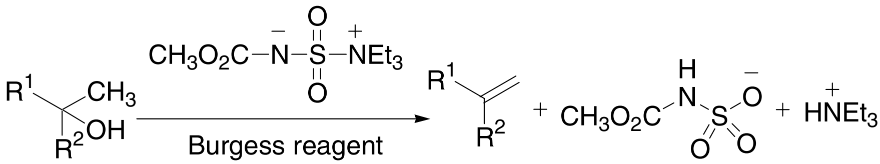
References

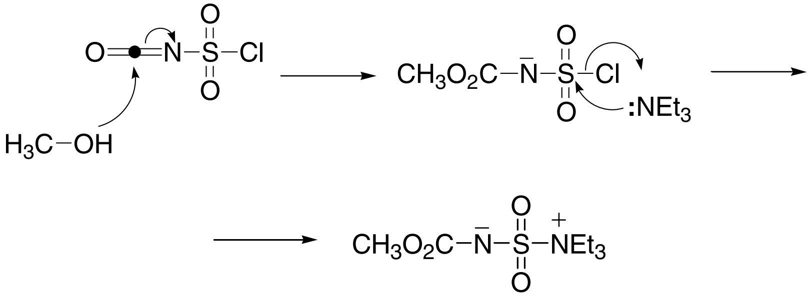
1. Paul, F.; Patt, J.; Hartwig, J. F. *J. Am. Chem. Soc.* **1994**, *116*, 5969. John Hartwig earned his Ph.D. under Bergman and Anderson. He has moved from Yale University to the University of Illinois at Urbana-Champaign in 2006. Hartwig and Buchwald independently discovered this chemistry.
2. Guram, A. S.; Buchwald, S. L. *J. Am. Chem. Soc.* **1994**, *116*, 7901. Steve Buchwald is a professor at MIT.
3. Palucki, M.; Wolfe, J. P.; Buchwald, S. L. *J. Am. Chem. Soc.* **1996**, *118*, 10333.
4. Mann, G.; Hartwig, J. F. *J. Org. Chem.* **1997**, *62*, 5413.
5. Mann, G.; Hartwig, J. F. *Tetrahedron Lett.* **1997**, *38*, 8005.
6. Wolfe, J. P.; Wagaw, S.; Marcoux, J.-F.; Buchwald, S. L. *Acc. Chem. Res.* **1998**, *31*, 805. (Review).
7. Hartwig, J. F. *Acc. Chem. Res.* **1998**, *31*, 852. (Review).
8. Frost, C. G.; Mendonça, P. *J. Chem. Soc., Perkin Trans. 1* **1998**, 2615. (Review).
9. Yang, B. H.; Buchwald, S. L. *J. Organomet. Chem.* **1999**, *576*, 125. (Review).
10. Ferreira, I. C. F. R.; Queiroz, M.-J. R. P.; Kirsch, G. *Tetrahedron* **2003**, *59*, 975.
11. Urgaonkar, S.; Verkade, J. G. *J. Org. Chem.* **2004**, *69*, 9135.
12. Csuk, R.; Barthel, A.; Raschke, C. *Tetrahedron* **2004**, *60*, 5737.
13. Li, C. S.; Dixon, D. D. *Tetrahedron Lett.* **2004**, *45*, 4257.
14. Gooßen, L. J.; Paetzold, J.; Briel, O.; Rivas-Nass, A.; Karch, R.; Kayser, B. *Synlett* **2005**, 275.

Burgess dehydrating reagent

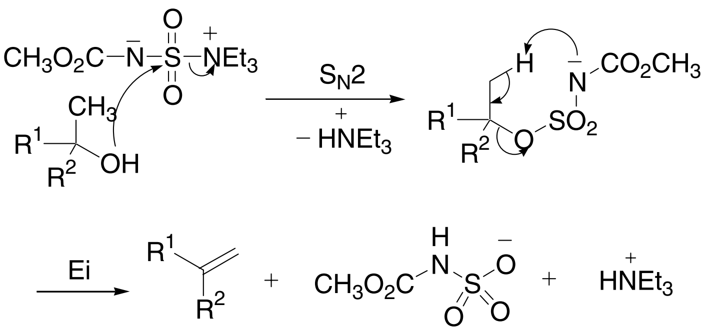
Burgess dehydrating reagent is efficient at generating olefins from secondary and tertiary alcohols where the first-order thermolytic Ei (during the elimination, the two groups leave at about the same time and bond to each other concurrently) mechanism prevails.

Reagen formation,

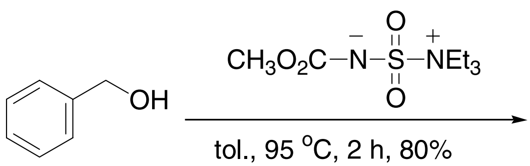


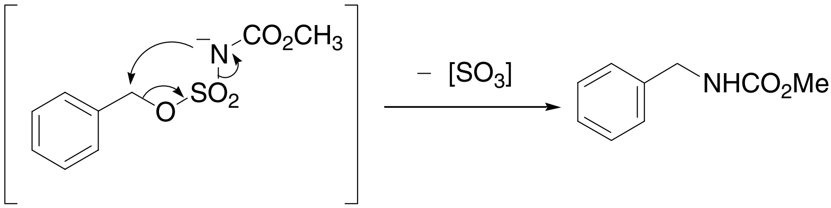


Reaction,

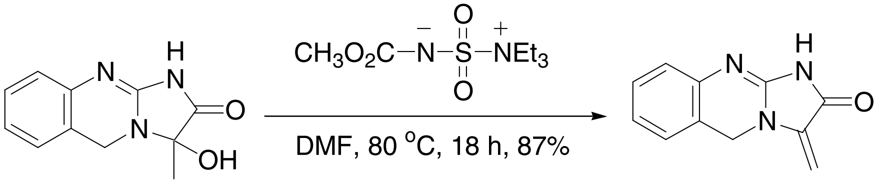


Example 1[4]

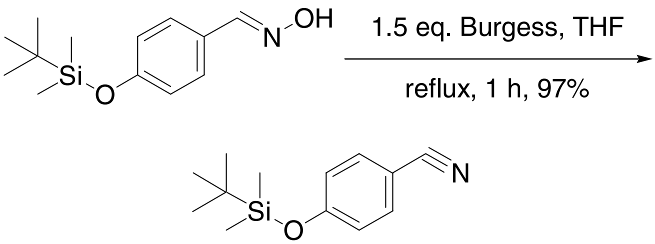




Example 2[5]



Example 3[10]

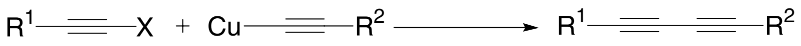


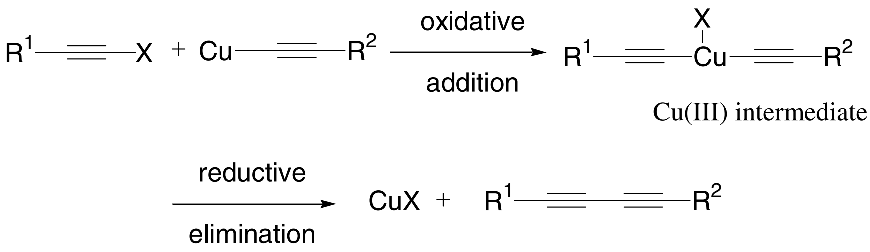
References

1. Atkins, G. M., Jr.; Burgess, E. M. *J. Am. Chem. Soc.* **1968**, *90*, 4744. Edward M. Burgess earned his Ph.D. at MIT under George Büchi. He discovered the Burgess reagent at Georgia Institute of Technology, Atlanta, Georgia.
2. Burgess, E. M.; Penton, H. R.; Taylor, E. A., Jr. *J. Am. Chem. Soc.* **1970**, *92*, 5224.
3. Atkins, G. M., Jr.; Burgess, E. M. *J. Am. Chem. Soc.* **1972**, *94*, 6135.
4. Burgess, E. M.; Penton, H. R.; Taylor, E. A. *J. Org. Chem.* **1973**, *38*, 26.
5. Stalder, H. *Helv. Chim. Acta* **1986**, *69*, 1887.
6. Claremon, D. A.; Phillips, B. T. *Tetrahedron Lett.* **1988**, *29*, 2155.
7. Creedon, S. M.; Crowley, H. K.; McCarthy, D. G. *J. Chem. Soc., Perkin Trans. 1* **1998**, 1015.
8. Lamberth, C. *J. Prakt. Chem.* **2000**, *342*, 518.
9. Burekhardt, S.; Svenja, B. *Synlett.* **2000**, 559.
10. Miller, C. P.; Kaufman, D. H. *Synlett* **2000**, 1169.
11. Nicolaou, K. C.; Huang, X.; Snyder, S. A.; Rao, P. B.; Reddy, M. V. *Angew. Chem., Int. Ed.* **2002**, *41*, 834.
12. Jose, B.; Unni, M. V. V.; Prathapan, S.; Vadakkan, J. J. *Synth. Commun.* **2002**, *32*, 2495.

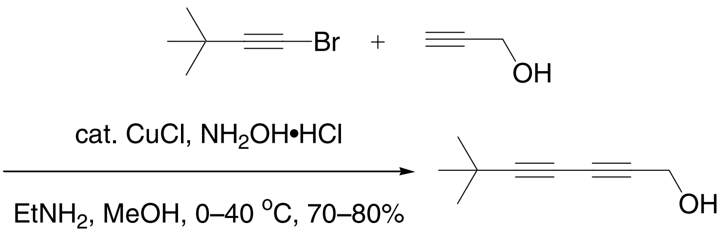
Cadiot–Chodkiewicz coupling

Bis-acetylene synthesis from alkynyl halides and alkynyl copper reagents.
Cf. Castro–Stephens reaction.

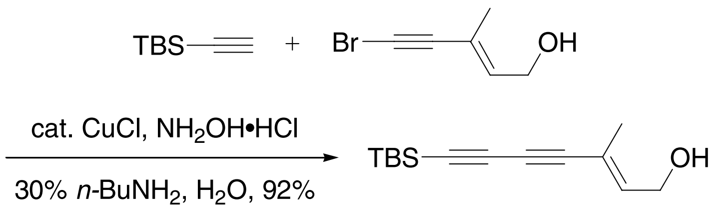




Example 1[6]



Example 2[11]



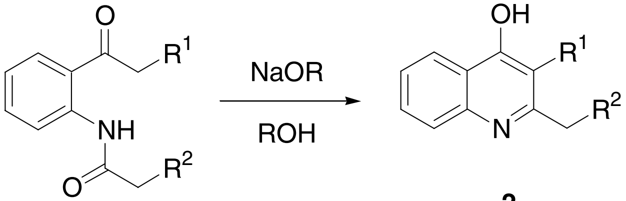
References

1. Chodkiewicz, W.; Cadiot, P. *C. R. Hebd. Seances Acad. Sci.* **1955**, *241*, 1055. Paul Cadiot (1923–) and Wladyslav Chodkiewicz (1921–) are both French chemists.
2. Cadiot, P.; Chodkiewicz, W. In *Chemistry of Acetylenes;* Viehe, H. G., ed.; Dekker: New York, **1969**, 597–647. (Review).
3. Eastmond, R.; Walton, D. R. M. *Tetrahedron* **1972**, *28*, 4591.
4. Ghose, B. N.; Walton, D. R. M. *Synthesis* **1974**, 890.
5. Hopf, H.; Krause, N. *Tetrahedron Lett.* **1985**, *26*, 3323.

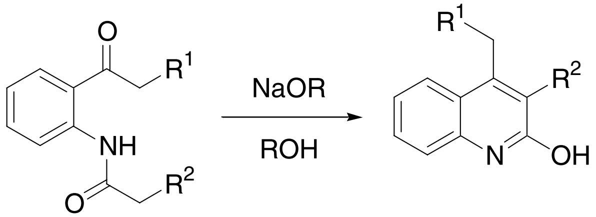
6. Gotteland, J.-P.; Brunel, I.; Gendre, F.; Désiré, J.; Delhon, A.; Junquéro, A.; Oms, P.; Halazy, S. *J. Med. Chem.* **1995**, *38*, 3207.
7. Bartik, B.; Dembinski, R.; Bartik, T.; Arif, A. M.; Gladysz, J. A. *New J. Chem.* **1997**, *21*, 739.
8. Montierth, J. M.; DeMario, D. R.; Kurth, M. J.; Schore, N. E. *Tetrahedron* **1998**, *54*, 11741.
9. Negishi, E.-i.; Hata, M.; Xu, C. *Org. Lett.* **2000**, *2*, 3687.
10. Steffen, W.; Laskoski, M.; Collins, G.; Bunz, U. H. F. *J. Organomet. Chem*. **2001**, *630*, 132.
11. Marino, J. P.; Nguyen, H. N. *J. Org. Chem*. **2002**, *67*, 6841.
12. Utesch, N. F.; Diederich, F. *Org. Biomol. Chem.* **2003**, *1*, 237.
13. Utesch, N. F.; Diederich, F.; Boudon, C.; Gisselbrecht, J.-P.; Gross, M. *Helv. Chim. Acta* **2004**, *87*, 698.

Camps quinolinol synthesis

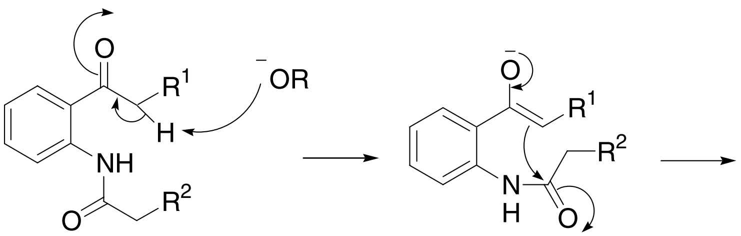
Base-catalyzed intramolecular condensation of a 2-acetamido acetophenone (**1**) to a 2-(and possibly 3)-substituted-quinolin-4-ol (**2**), a 4-(and possibly 3)-substituted-quinolin-2-ol (**3**), or a mixture.



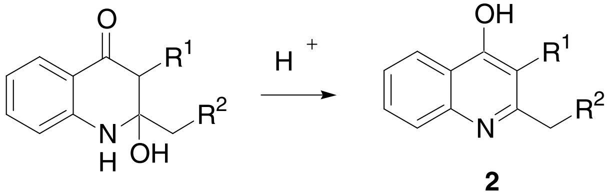
1 **2**



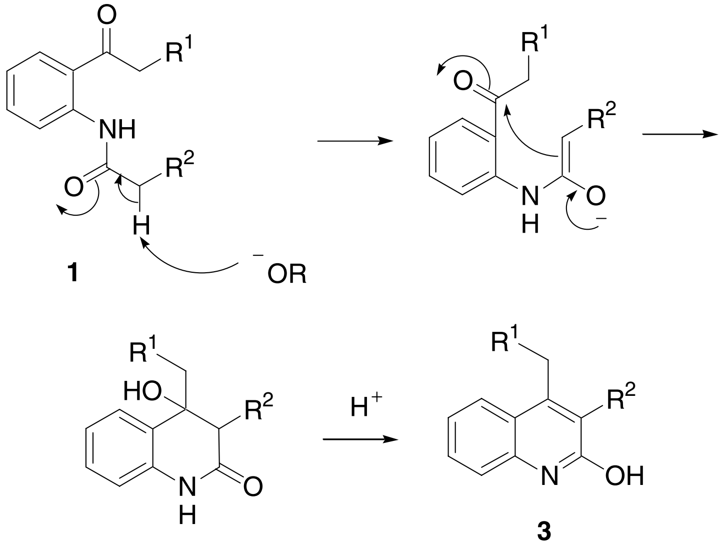
1 **3**



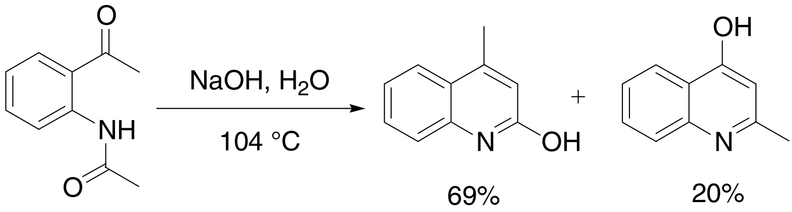
1



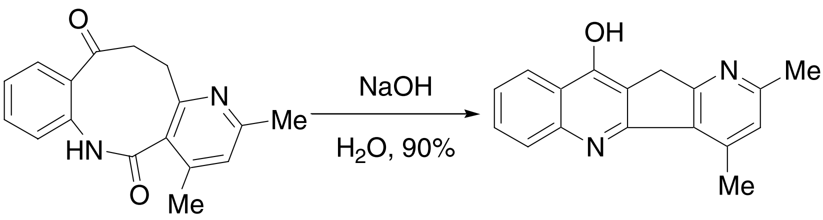
2



Example 1[1,2]



Example 2[8]



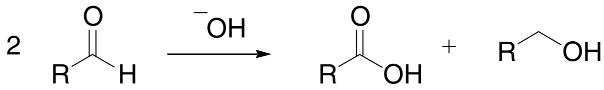
References

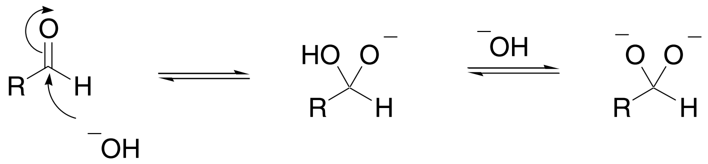
1. Camps, R. *Chem. Ber.* **1899**, *32*, 3228. Rudolf Camps worked under Professor Engler from 1899 to 1902 at the Technische Hochschule in Karlsruhe, Germany.
2. Camps, R. *Arch. Pharm.* **1899**, *237*, 659.
3. Clemence, F.; LeMartret, O.; Collard, J. *J. Heterocycl. Chem.* **1984**, *21*, 1345.
4. Elderfield, R. C.; Todd, W. H.; Gerber, S. *Heterocyclic Compounds* Vol. 6, R. C. Elderfield, ed. Wiley and Sons, New York, **1957**, 576. (Review).

5. Hino, K.; Kawashima, K.; Oka, M.; Nagai, Y.; Uno, H.; Matsumoto, J. *Chem. Pharm. Bull.* **1989**, *37*, 110.
6. Witkop, B.; Patrick, J. B.; Rosenblum, M. *J. Am. Chem. Soc.* **1951**, *73*, 2641.
7. Barret, R.; Ortillon, S.; Mulamba, M.; Laronze, J. Y.; Trentesaux, C.; Lévy, J. *J. Heterocycl. Chem.* **2000**, *37*, 241.
8. Pflum, D. A. *Camps Quinolinol Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 386–389. (Review).

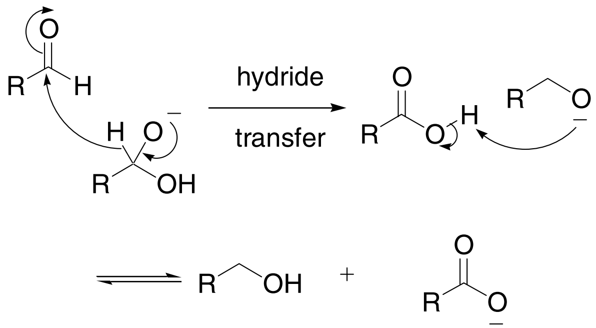
Cannizzaro disproportionation

Redox reaction between aromatic aldehydes, formaldehyde or other aliphatic aldehydes without α-hydrogen. Base is used to afford the corresponding alcohols and carboxylic acids.



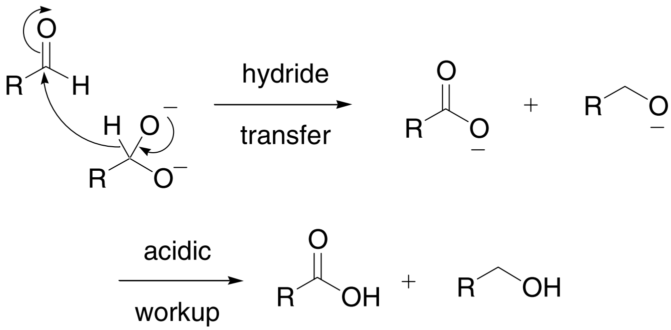


Pathway A:

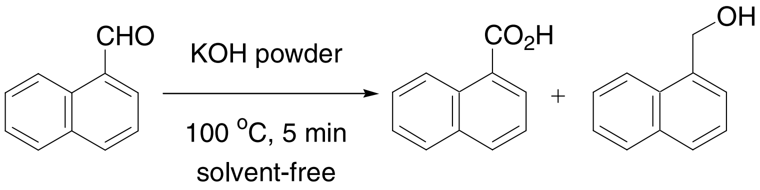


Final deprotonation of the carboxylic acid drives the reaction forward.

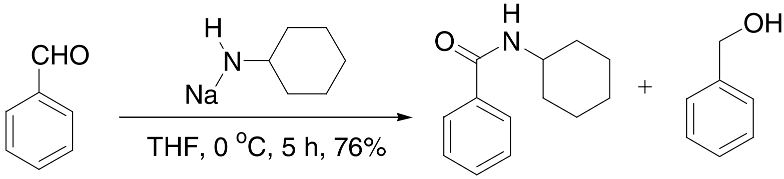
Pathway B:



Example 1[11]



Example 2[13]

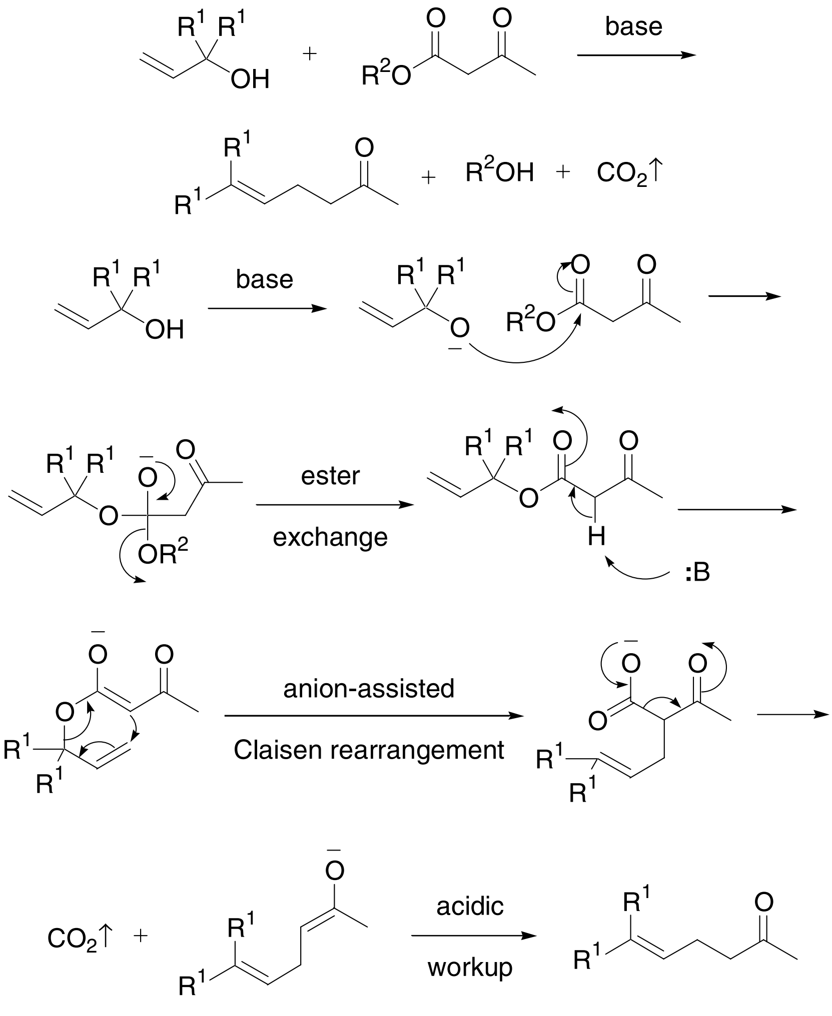


References

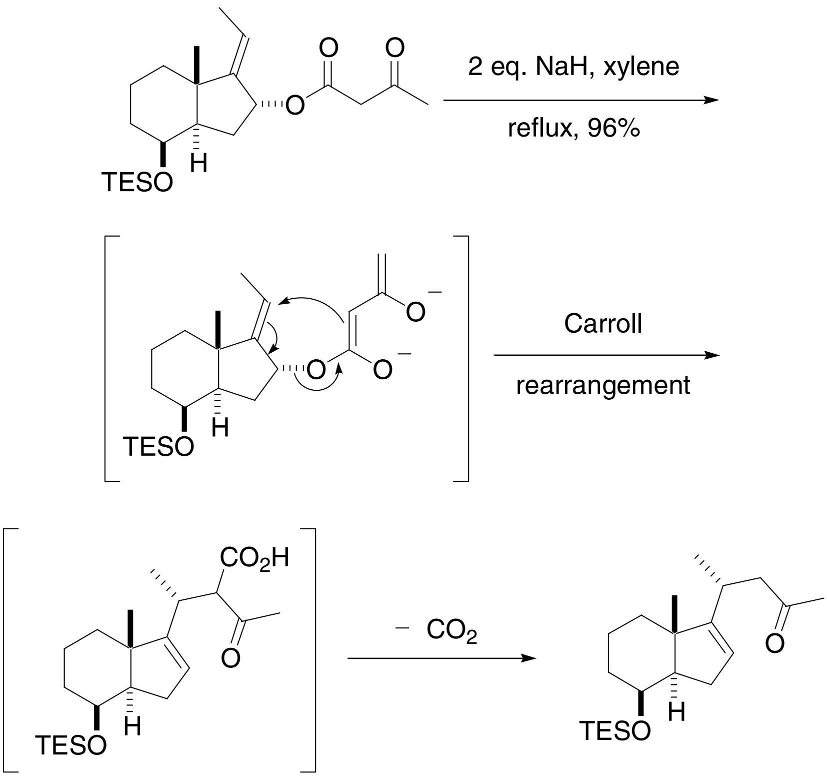
1. Cannizzaro, S. *Justus Liebigs Ann. Chem.* **1853**, *88*, 129. Stanislao Cannizzaro (1826−1910) was born in Palermo, Sicily, Italy. In 1847, he had to escape to Paris for participating in the Sicilian Rebellion. Upon his return to Italy, he discovered benzyl alcohol synthesis by the action of potassium hydroxide on benzaldehyde. Political interests brought Cannizzaro to the Italian Senate and he later became its vice president.
2. Geissman, T. A. *Org. React.* **1944**, *I*, 94. (Review).
3. Hazlet, S. E.; Stauffer, D. A. *J. Org. Chem.* **1962**, *27*, 2021.
4. Hazlet, S. E.; Bosmajian, G., Jr.; Estes, J. H.; Tallyn, E. F. *J. Org. Chem.* **1964**, *29*, 2034.
5. Sen Gupta, A. K. *Tetrahedron Lett.* **1968**, 5205.
6. Swain, C. G.; Powell, A. L.; Sheppard, W. A.; Morgan, C. R. *J. Am. Chem. Soc.* **1979**, *101*, 3576.
7. Mehta, G.; Padma, S. *J. Org. Chem.* **1991**, *56*, 1298.
8. Sheldon, J. C.; *et al. J. Org. Chem.* **1997**, *62*, 3931.
9. Thakuria, J. A.; Baruah, M.; Sandhu, J. S. *Chem. Lett.* **1999**, 995.
10. Russell, A. E.; Miller, S. P.; Morken, J. P. *J. Org. Chem.* **2000**, *65*, 8381.
11. Yoshizawa, K.; Toyota, S.; Toda, F. *Tetrahedron Lett.* **2001**, *42*, 7983.
12. Reddy, B. V. S; Srinvas, R.; Yadav, J. S.; Ramalingam, T. *Synth. Commun.* **2002**, *32*, 219.
13. Ishihara, K.; Yano, T. *Org. Lett.* **2004**, *6*, 1983.
14. Curini, M.; Epifano, F.; Genovese, S.; Marcotullio, M. C.; Rosati, O. *Org. Lett.* **2005**, *7*, 1331.

Carroll rearrangement

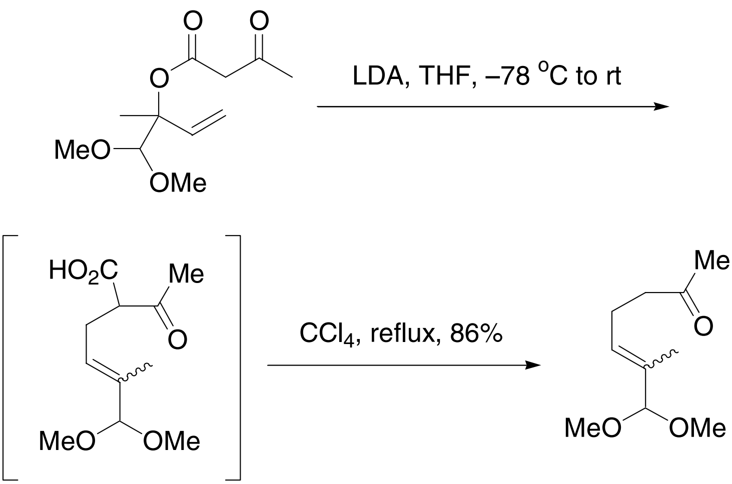
Thermal rearrangement of β-ketoesters followed by decarboxylation to yield γ-unsaturated ketones *via* anion-assisted Claisen rearrangement. It is a variant of the Claisen rearrangement (page 131).



Example 1[9]



Example 2[10]

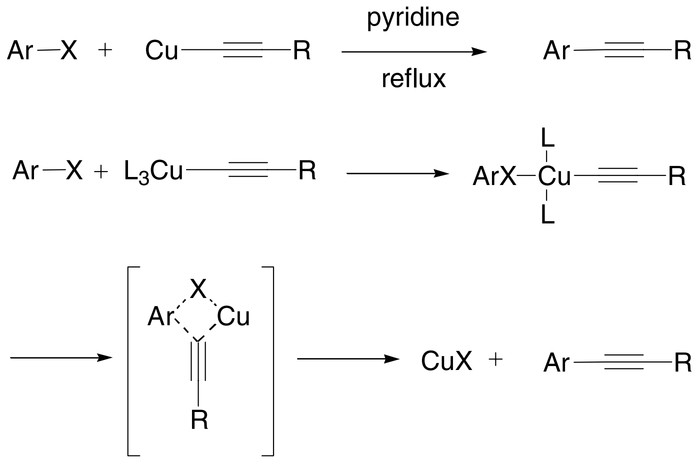


References

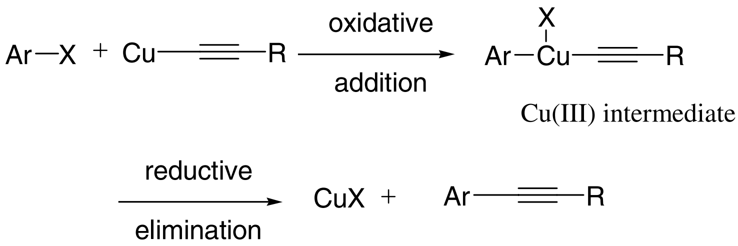
1. Carroll, M. F. *J. Chem. Soc.* **1940**, 704. Michael F. Carroll worked at A. Boake, Roberts and Co. Ltd., in London, UK.
2. Carroll, M. F. *J. Chem. Soc.* **1941**, 507.
3. Wilson, S. R.; Price, M. F. *J. Org. Chem.* **1984**, *49*, 722.
4. Gilbert, J. C.; Kelly, T. A. *Tetrahedron* **1988**, *44*, 7587.
5. Ziegler, F. E. *Chem. Rev.* **1988**, *88*, 1423. (Review).
6. Ouvrard, N.; Rodriguez, J.; Santelli, M. *Tetrahedron Lett*. **1993**, *34*, 1149.
7. Enders, D.; Knopp, M.; Runsink, J.; Raabe, G. *Angew. Chem., Int. Ed. Engl.* **1995**, *34*, 2278.
8. Enders, D.; Knopp, M.; Runsink, J.; Raabe, G. *Liebigs Ann.* **1996**, 1095.
9. Hatcher, M. A.; Posner, G. H. *Tetrahedron Lett*. **2002**, *43*, 5009.
10. Jung, M. E.; Duclos, B. A. *Tetrahedron Lett*. **2004**, *45*, 107.
11. Burger, E. C.; Tunge, J. A. *Org. Lett*. **2004**, *6*, 2603.

Castro–Stephens coupling

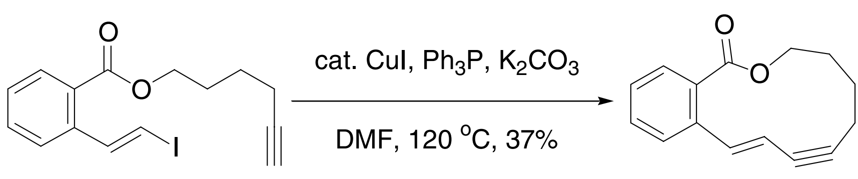
Aryl-acetylene synthesis, *Cf.* Cadiot–Chodkiewicz coupling and Sonogashira coupling. The Castro–Stephens coupling uses stoichiometric copper, whereas the Sonogashira variant uses catalytic palladium and copper.



An alternative mechanism similar to that of the Cadiot–Chodkiewicz coupling:



Example[7]

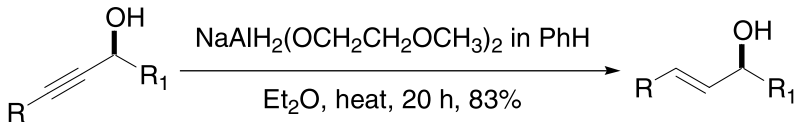


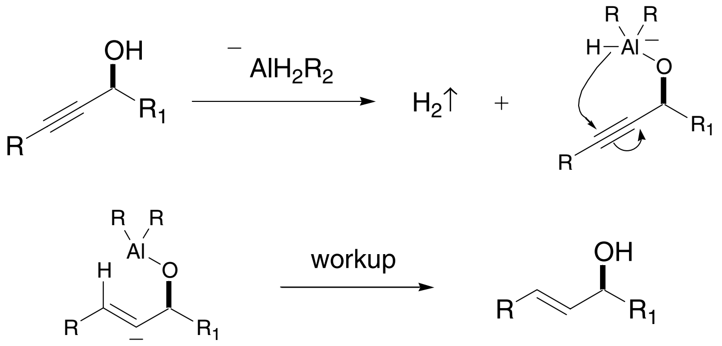
References

1. Castro, C. E.; Stephens, R. D. *J. Org. Chem.* **1963**, *28*, 2163. Castro and Stephens were in the Department of Nematology and Chemistry at University of California, Riverside.
2. Castro, C. E.; Stephens, R. D. *J. Org. Chem.* **1963**, *28*, 3313.
3. Staab, H. A.; Neunhoeffer, K. *Synthesis* **1974**, 424.
4. Kabbara, J.; Hoffmann, C.; Schinzer, D. *Synthesis* **1995**, 299.
5. von der Ohe, F.; Brückner, R. *New J. Chem.* **2000**, *24*, 659.
6. White, J. D.; Carter, R. G.; Sundermann, K. F.; Wartmann, M. *J. Am. Chem. Soc.* **2001**, *123*, 5407.
7. Coleman, R. S.; Garg, R. *Org. Lett.* **2001**, *3*, 3487.
8. Rawat, D. S.; Zaleski, J. M. *Synth. Commun.* **2002**, *32*, 1489.

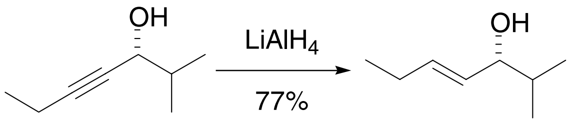
Chan alkyne reduction

Stereoselective reduction of acetylenic alcohols to *E*-allylic alcohols using **s**odium bis(2-**m**ethoxy**e**thoxy)**a**luminum **h**ydride (SMEAH, also known as Red-Al) or Li-AlH_4.

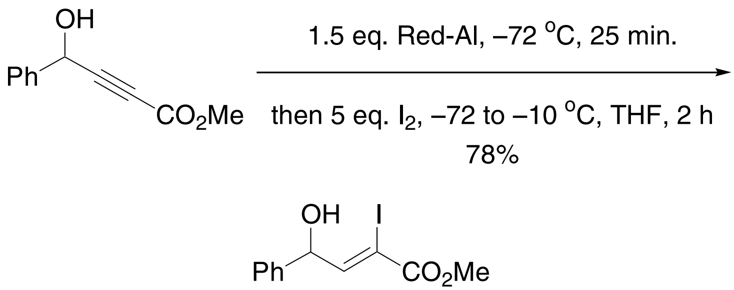




Example 1[3]



Example 2[4]

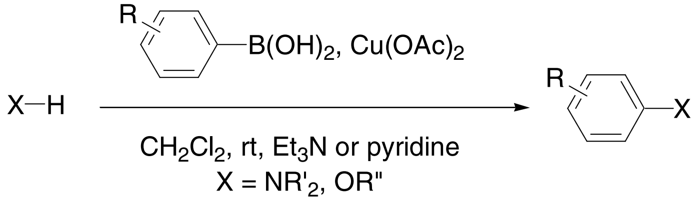


References

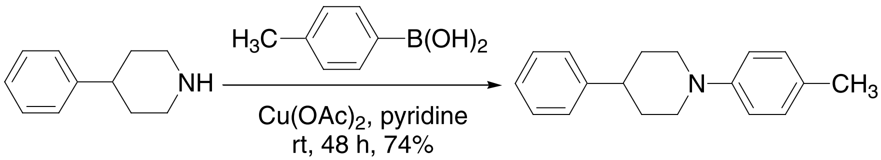
1. Chan, K.-K.; Cohen, N.; De Noble, J. P.; Specian, A. C., Jr.; Saucy, G. *J. Org. Chem.* **1976**, *41*, 3497. Ka-Kong Chan was a chemist at Hoffmann–La Roche, Inc., Nutley, NJ, USA.
2. Blunt, J. W.; Hartshorn, M. P.; Munro, M. H. G.; Soong, L. T.; Thompson, R. S.; Vaughan, J. *J. Chem. Soc., Chem. Commun.* **1980**, 820.
3. Midland, M. M.; Gabriel, J. *J. Org. Chem.* **1985**, *50*, 1143.
4. Meta, C. T.; Koide, K. *Org. Lett.* **2004**, *6*, 1785.
5. Yamazaki, T.; Ichige, T.; Kitazume, T. *Org. Lett.* **2004**, *6*, 4073.

Chan–Lam coupling reaction

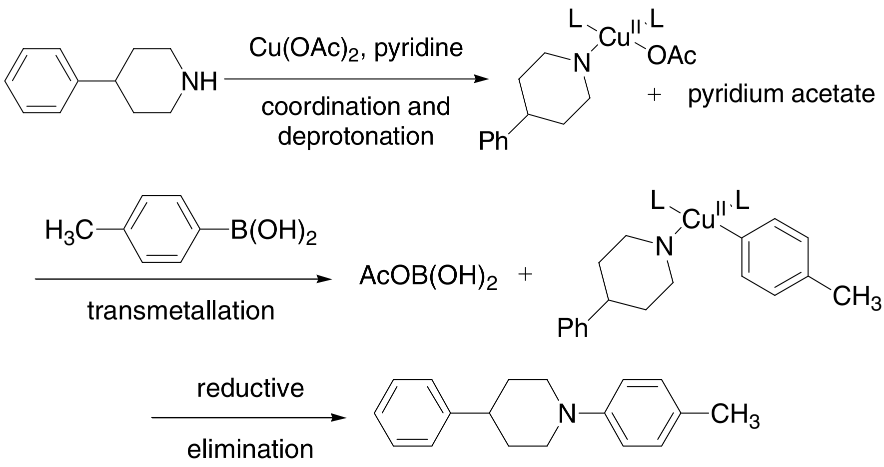
N-Arylation of a wide range of NH substrates by reaction with boronic acid in the presence of cupric acetate and either triethylamine or pyridine at room temperature. The reaction works even for poorly nucleophilic substrates such as arylamide.



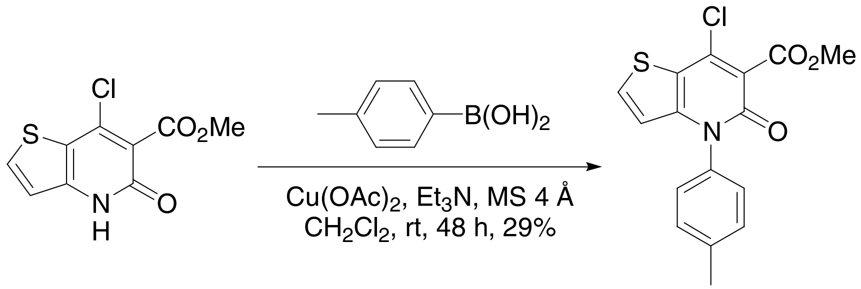
Example 1[1]



Mechanism:



Example 2[3]

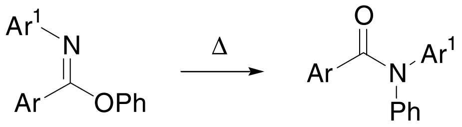


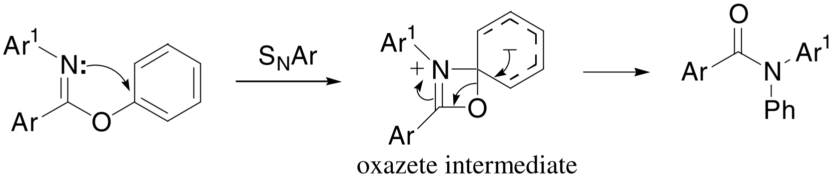
References

1. Chan, D. M. T.; Monaco, K. L.; Wang, R.-P.; Winters, M. P. *Tetrahedron Lett*. **1998**, *39*, 2933. Dominic M. T. Chan and Patrick Y. S. Lam were both chemists at DuPont Pharmaceuticals Company, Wilmington, DE, USA.
2. Lam, P. Y. S.; Clark, C. G.; Saubern, S.; Adams, J.; Winters, M. P.; Chan, D. M. T.; Combs, A. *Tetrahedron Lett*. **1998**, *39*, 2941.
3. Mederski, W. W. K. R.; Lefort, M.; Germann, M.; Kux, D. *Tetrahedron* **1999**, *55*, 12757.
4. Lam, P. Y. S.; Clark, C. G.; Saubern, S.; Adams, J.; Averill, K. M.; Chan, D. M. T.; Combs, A. *Synlett* **2000**, 674.
5. Lam, P. Y. S.; Vincent, G.; Clark, C. G.; Deudon, S.; Jadhav, P. K. *Tetrahedron Lett*. **2001**, *42*, 3415.
6. Antilla, J. C.; Buchwald, S. L. *Org. Lett.* **2001**, *3*, 2077.
7. Combs, A. P.; Tadesse, S.; Rafalski, M.; Haque, T. S.; Lam, P. Y. S. *J. Comb. Chem*. **2002**, *4*, 179.
8. Chan, D. M. T.; Monaco, K. L.; Li, R.; Bonne, D.; Clark, C. G.; Lam, P. Y. S. *Tetrahedron Lett*. **2003**, *44*, 3863.
9. Quach, T. D.; Batey, R. A. *Org. Lett.* **2003**, *5*, 4397.
10. Chiang, G. C. H.; Olsson, T. *Org. Lett.* **2004**, *6*, 3079.

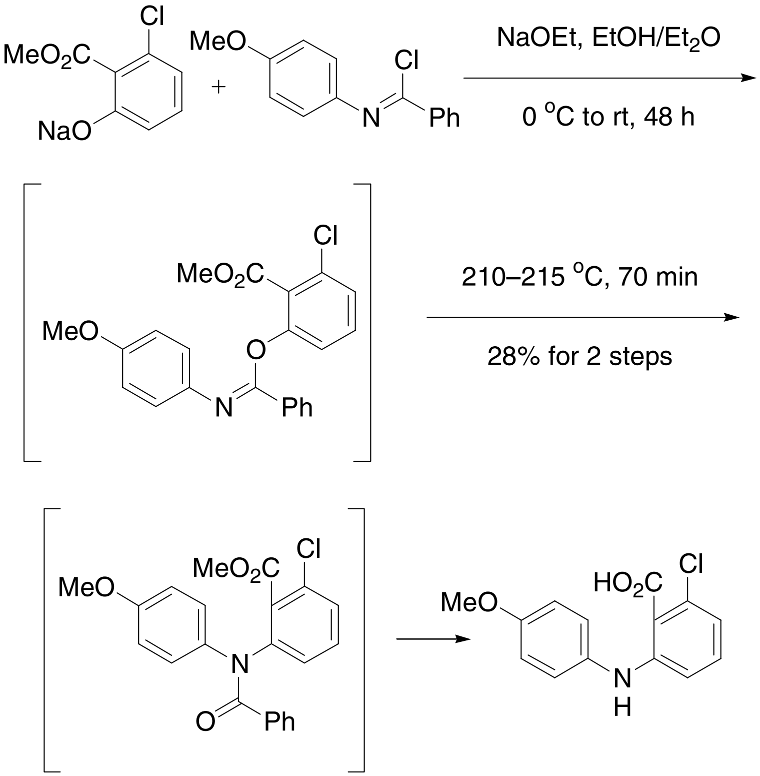
Chapman rearrangement

Thermal aryl rearrangement of *O*-aryliminoethers to amides.

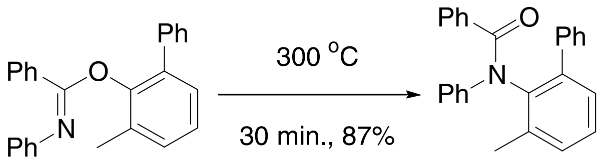




Example 1[2]



Example 2[4]

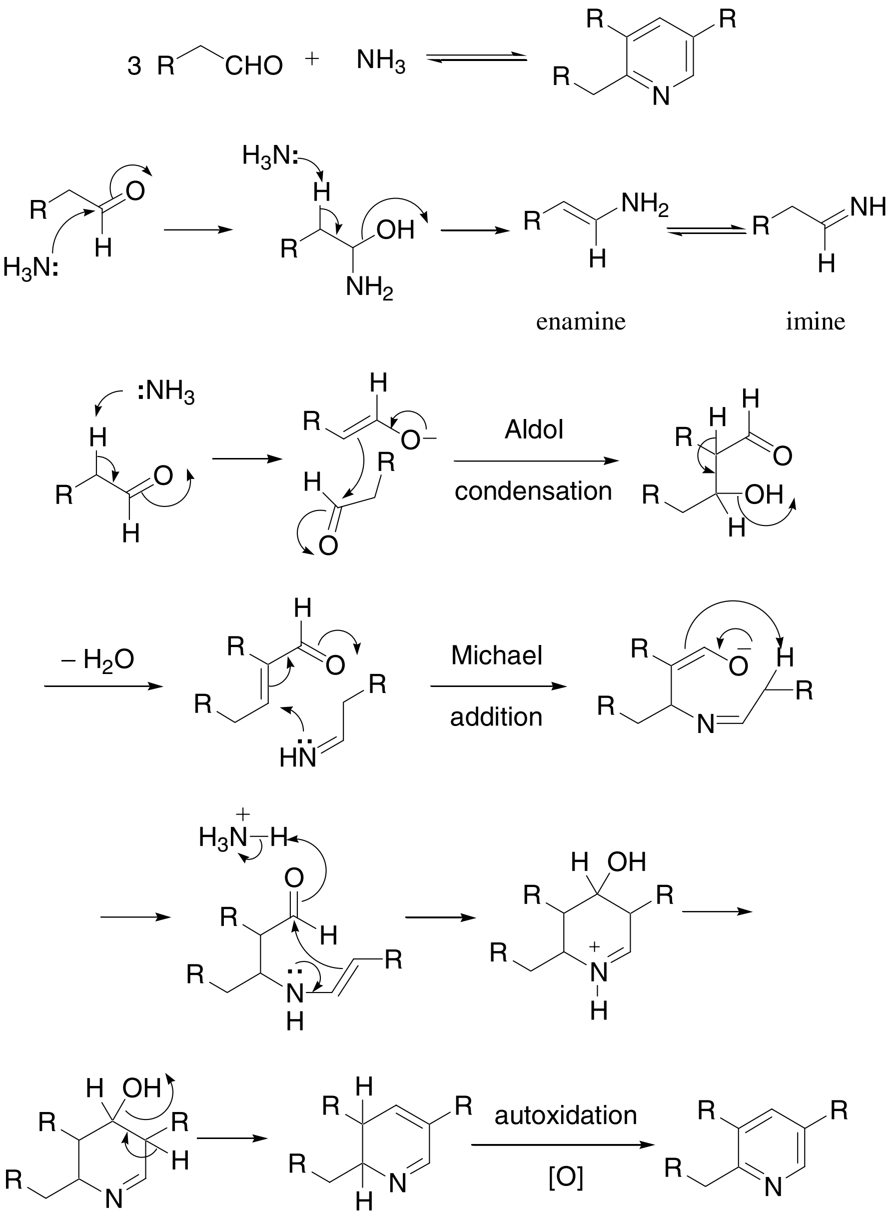


References

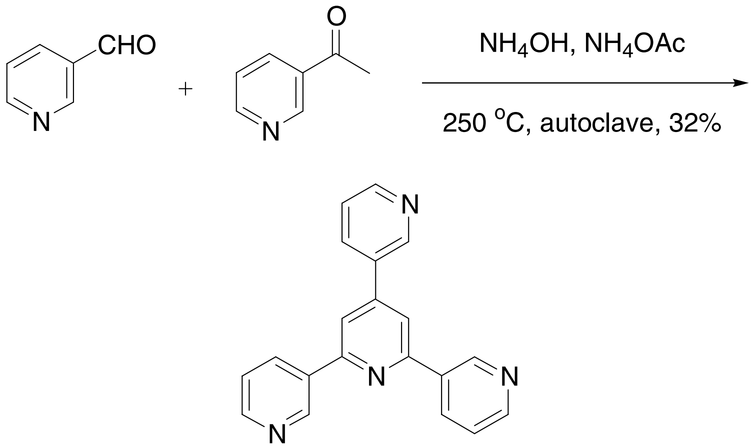
1. Chapman, A. W. *J. Chem. Soc.* **1925**, *127*, 1992. Arthur William Chapman was born in 1898 in London, England. He was Lecturer in Organic Chemistry and later became Registrar of the University of Sheffield from 1944 to 1963.
2. Dauben, W. G.; Hodgson, R. L. *J. Am. Chem. Soc.* **1950**, *72*, 3479.
3. Schulenberg, J. W.; Archer, S. *Org. React.* **1965**, *14*, 1–51. (Review).
4. Relles, H. M. *J. Org. Chem.* **1968**, *33*, 2245.
5. Wheeler, O. H.; Roman, F.; Rosado, O. *J. Org. Chem.* **1969**, *34*, 966.
6. Shawali, A. S.; Hassaneen, H. M. *Tetrahedron* **1972**, *28*, 5903.
7. Kimura, M. *J. Chem. Soc., Perkin Trans. 2* **1987**, 205.
8. Kimura, M.; Okabayashi, I.; Isogai, K. *J. Heterocycl. Chem.* **1988**, *25,* 315.
9. Farouz, F.; Miller, M. J. *Tetrahedron Lett.* **1991**, *32*, 3305.
10. Dessolin, M.; Eisenstein, O.; Golfier, M.; Prange, T.; Sautet, P. *J. Chem. Soc., Chem. Commun.* **1992**, 132.
11. Shohda, K.-I.; Wada, T.; Sekine, M. *Nucleosides Nucleotides* **1998**, *17*, 2199.

Chichibabin pyridine synthesis

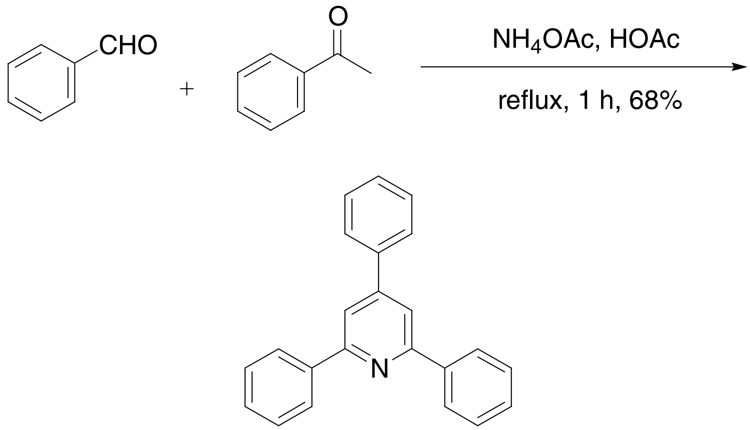
Condensation of aldehydes with ammonia to afford pyridines.



Example 1[4]



Example 2[5]



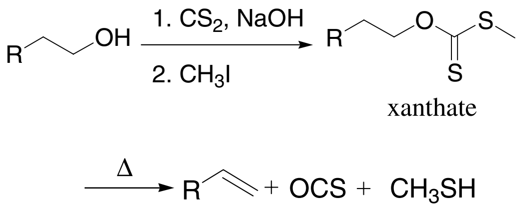
References

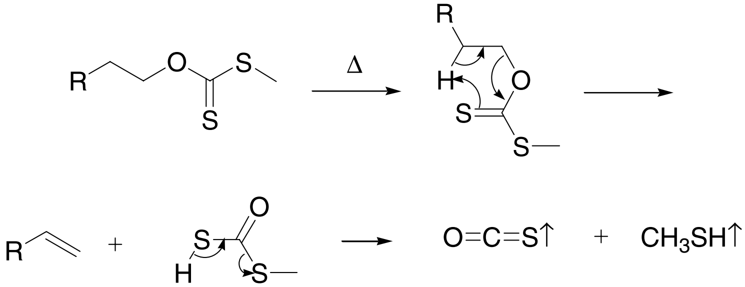
1. Chichibabin, A. E. *J. Russ. Phys. Chem. Soc.* **1906**, *37*, 1229. Alexei E. Chichibabin (1871−1945) was born in Kuzemino, Russia. He was Markovnikov's favorite student. Markovnikov's successor, Zelinsky (of Hell–Volhard–Zelinsky reaction fame) did not want to cooperate with the pupil and gave Chichibabin a negative judgment on his Ph.D. work, earning Chichibabin the nickname "the self-educated man."
2. Sprung, M. M. *Chem. Rev*. **1940**, *40*, 297−338. (Review).
3. Frank, R. L.; Seven, R. P. *J. Am. Chem. Soc.* **1949**, *71*, 2629.
4. Frank, R. L.; Riener, E. F. *J. Am. Chem. Soc.* **1950**, *72*, 4182.
5. Weiss, M. *J. Am. Chem. Soc.* **1952**, *74*, 200.
6. Herzenberg, J.; Boccato, G. *Chem. Ind.* **1950**, *80,* 248.

7. Levitt, L. S.; Levitt, B. W. *Chem. Ind.* **1963**, 1621.
8. Kessar, S. V.; Nadir, U. K.; Singh, M. *Indian J. Chem.* **1973**, *11*, 825.
9. Shimizu, S.; Abe, N.; Iguchi, A.; Dohba, M.; Sato, H.; Hirose, K.-I. *Microporous Mesoporous Materials* **1998**, *21*, 447.
10. Galatasis, P. *Chichibabin (Tschitschibabin) Pyridine Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 308–309. (Review).

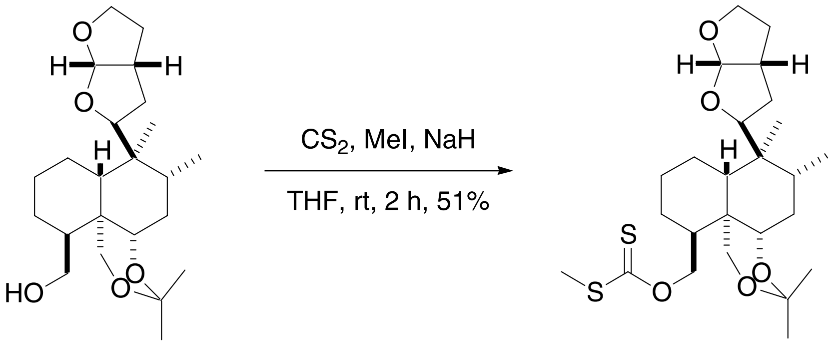
Chugaev elimination

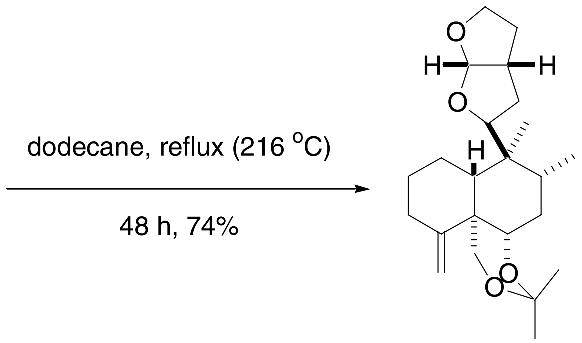
Thermal elimination of xanthates to olefins.



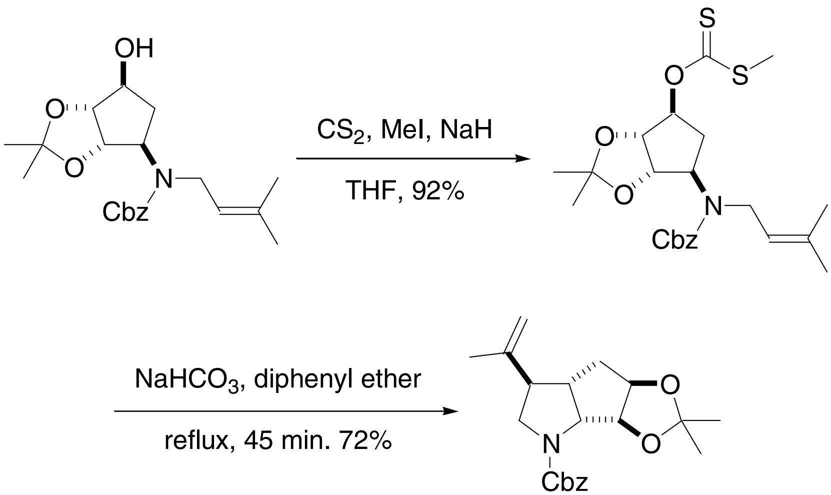


Example 1[6]





Example 2, Chugaev *syn*-elimination is followed by an intramolecular ene reaction[7]

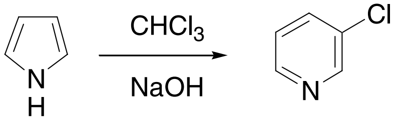


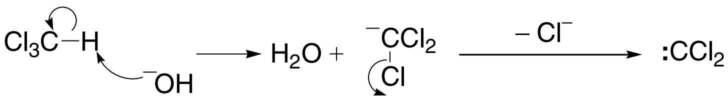
References

1. Chugaev, L. *Ber. Dtsch. Chem. Ges.* **1899**, *32*, 3332. Lev A. Chugaev (1873−1922) was born in Moscow, Russia. He was a Professor of Chemistry at Petrograd, a position once held by Dimitri Mendeleyev and Paul Walden. In addition to terpenoids, Chugaev also investigated nickel and platinum chemistry. He completely devoted his life to science. The light in Chugaev's study would invariably burn until 4 to 5 a.m.
2. Chande, M. S.; Pranjpe, S. D. *Indian J. Chem.* **1973**, *11*, 1206.
3. Kawata, T.; Harano, K.; Taguchi, T. *Chem. Pharm. Bull.* **1973**, *21*, 604.
4. Harano, K.; Taguchi, T. *Chem. Pharm. Bull.* **1975**, *23*, 467.
5. Ho, T.-L.; Liu, S.-H. *J. Chem. Soc., Perkin Trans. 1* **1984**, 615.
6. Meulemans, T. M.; Stork, G. A.; Macaev, F. Z.; Jansen, B. J. M.; de Groot, A. *J. Org. Chem.* **1999**, *64*, 9178.
7. Nakagawa, H.; Sugahara, T.; Ogasawara, K. *Org. Lett.* **2000**, *2*, 3181.
8. Nakagawa, H.; Sugahara, T.; Ogasawara, K. *Tetrahedron Lett.* **2001**, *42*, 4523.

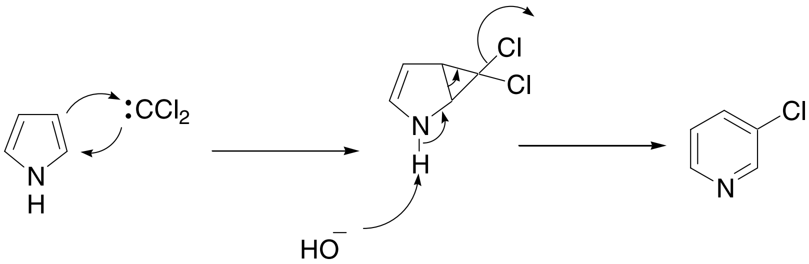
Ciamician–Dennsted rearrangement

Cyclopropanation of a pyrrole with dichlorocarbene generated from $CHCl_3$ and NaOH. Subsequent rearrangement takes place to give 3-chloropyridine.

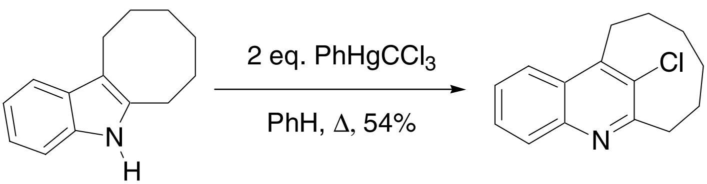




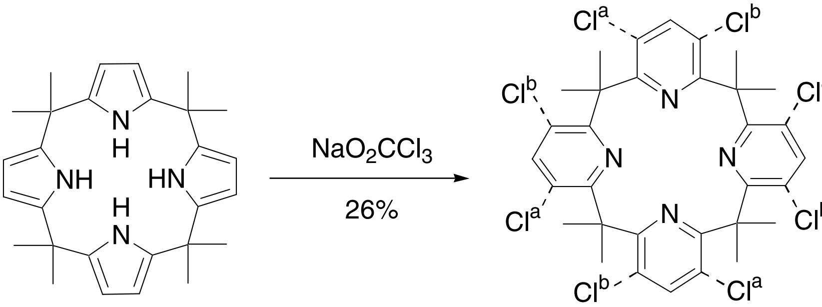
carbene



Example 1[8]



Example 2[10]

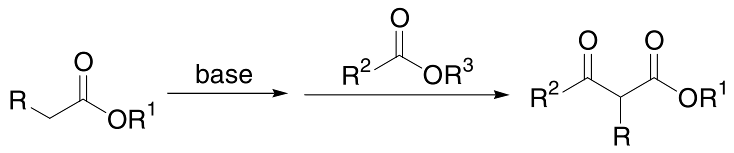


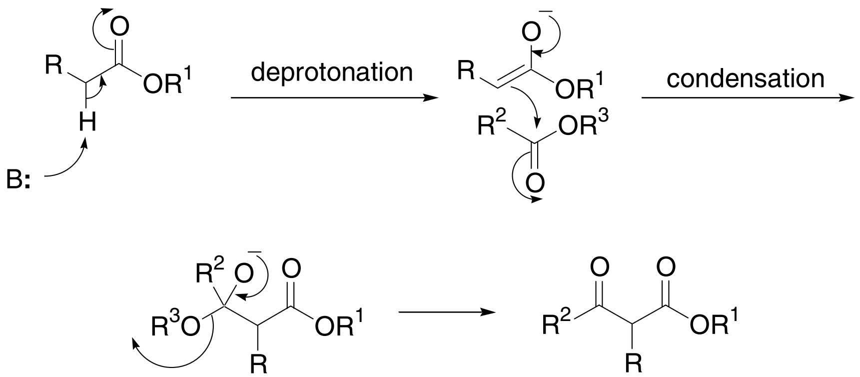
References

1. Ciamician, G. L.; Dennsted, M. *Ber. Dtsch. Chem. Ges.* **1881**, *14*, 1153. Giacomo Luigi Ciamician (1857−1922) was born in Trieste, Italy. After his Ph.D. training at Giessen, Germany, Ciamician carried out most of his work at the University of Bologna, Italy. Ciamician is considered the father of modern organic photochemistry.
2. Cantor, P. A.; VanderWerf, C. A. *J. Am. Chem. Soc.* **1958**, *80*, 970.
3. Krauch, H.; Kunz, W. *Chemiker-Ztg.* **1959**, *83*, 815.
4. Vogel, E. *Angew. Chem., Int. Ed.* **1960**, *72*, 4.
5. Wynberg, H. *Chem. Rev.* **1960**, *60*, 169. (Review).
6. Wynberg, H. and Meijer, E. W. *Org. React.* **1982**, *28*, 1. (Review).
7. Josey, A. D.; Tuite, R. J.; Snyder, H. R. *J. Am. Chem. Soc.* **1960**, *82*, 1597.
8. Parham, W. E.; Davenport, R. W.; Biasotti, J. B. *J. Org. Chem.* **1970**, *35*, 3775.
9. De Angelis, F.; Inesi, A.; Feroci, M.; Nicoletti R. *J. Org. Chem.* **1995**, *60*, 445.
10. Král, V.; Gale, P. A.; Anzenbacher, P. Jr.; K. Jursíková; Lynch, V.; Sessler, J. L. *J. Chem. Soc., Chem. Comm.* **1998**, 9.
11. Pflum, D. A. *Ciamician–Dennsted Rearrangement* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 350–354. (Review).

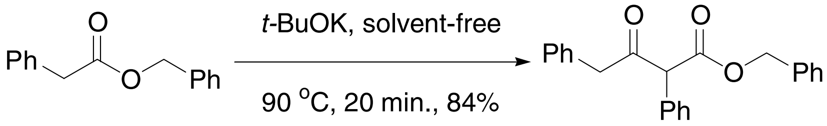
Claisen condensation

Base-catalyzed condensation of esters to afford β-keto esters.

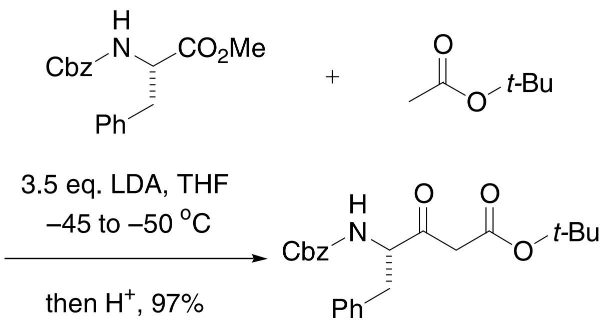




Example 1[9]



Example 2[12]



References

1 Claisen, R. L.; Lowman, O. *Ber. Dtsch. Chem. Ges.* **1887**, *20*, 651. Rainer Ludwig Claisen (1851–1930), born in Cologne, Germany, probably had the best pedigree in the history of organic chemistry. He apprenticed under Kekulé, Wöhler, von Baeyer, and Fischer before embarking on his own independent research.

2 Hauser, C. R.; Hudson, B. E. *Org. React.* **1942**, *1*, 266–302. (Review).

3 Thaker, K. A.; Pathak, U. S. *Indian J. Chem.* **1965**, *3*, 416.

4 Schäfer, J. P.; Bloomfield, J. J. *Org. React.* **1967**, *15*, 1–203. (Review).

5 Tanabe, Y. *Bull. Chem. Soc. Jpn.* **1989**, *62*, 1917.

6 Leijonmarck, H. K. E. *Chem. Commun. Stockhol.* **1992**, *33*, 1. (Review).

7 Kashima, C.; Takahashi, K.; Fukusaka, K. *J. Heterocycl. Chem.* **1995**, *32*, 1775.

8 Tanabe, Y.; Hamasaki, R.; Funakoshi, S. *Chem. Commun.* **2001**, 1674.

9 Yoshizawa, K.; Toyota, S.; Toda, F. *Tetrahedron Lett.* **2001**, *42*, 7983.

10 Mogilaiah, K.; Kankaiah, G. *Indian J. Chem., Sect. B* **2002**, *41B*, 2194.

11 Heath, R. J.; Rock, C. O. *Nat. Prod. Rep.* **2002**, *19*, 581. (Review).

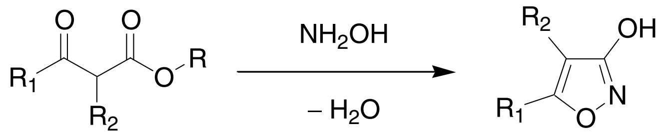
12 Honda, Y.; Katayama, S.; Kojima, M.; Suzuki, T.; Izawa, K. *Org. Lett.* **2002**, *4*, 447.

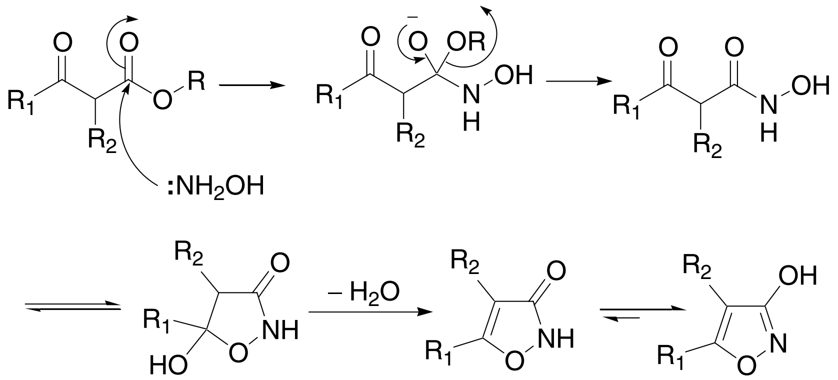
13 Mogilaiah, K.; Reddy, N. V. *Synth. Commun.* **2003**, *33,* 73.

14 Linderberg, M. T.; Moge, M.; Sivadasan, S. *Org. Pro. Res. Dev.* **2004**, *8,* 838.

Claisen isoxazole synthesis

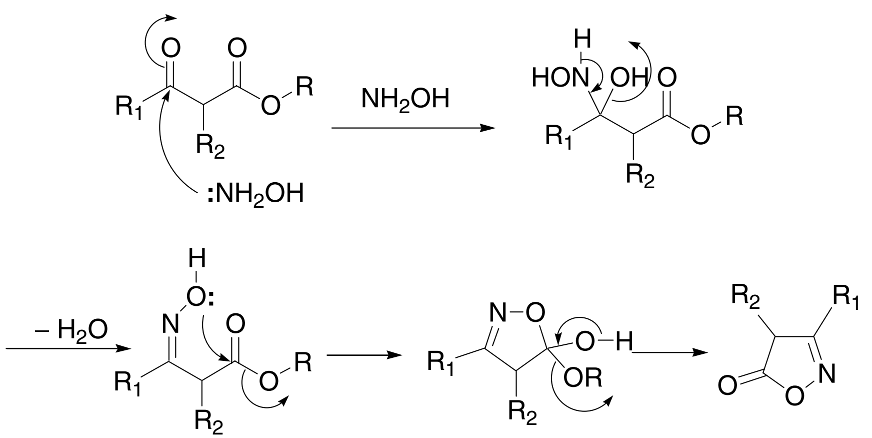
Cyclization of β-keto esters with hydroxylamine to provide 3-hydroxy-isoxazoles (3-isoxazolols).





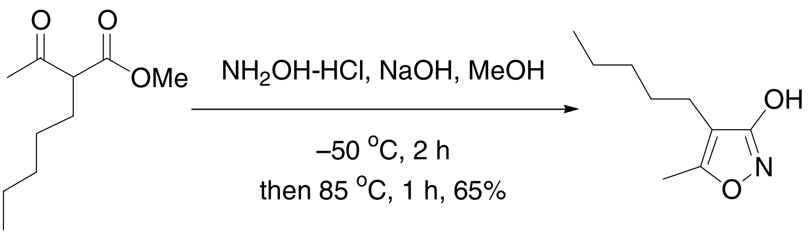
3-isoxazolol

A side reaction:



5-isoxazolone

Example[20]

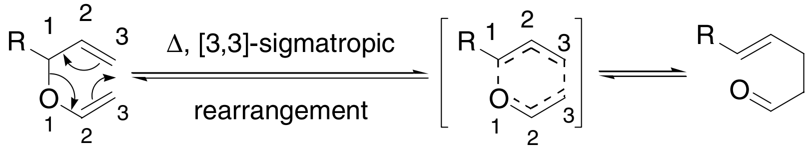


References

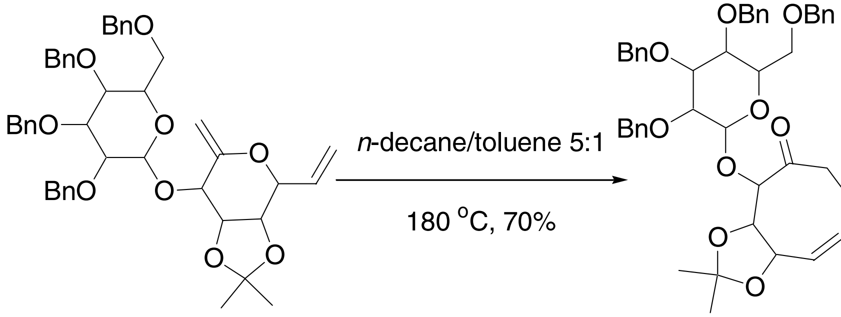
1. Claisen, L; Lowman, O. E. *Ber. Dtsch. Chem. Ges.* **1888**, *21*, 784.
2. Claisen, L.; Zedel, W. *Ber.* **1891**, *24*, 140.
3. Hantzsch *Ber.* **1891**, *24*, 495.
4. Barnes, R.A. In *Heterocyclic Compounds*; Elderfield, R. C., Ed.; Wiley: New York, **1957**; Vol. 5, p 474 ff. (Review).
5. Loudon, J. D. In *Chemistry of Carbon Compounds*; Rodd, E. H., Ed.; Elsevier: Amsterdam, **1957**; Vol. 4a, p. 345ff. (Review).
6. Boulton, A. J.; Katritzky, A. R. *Tetrahedron* **1961**, *12*, 41.
7. Boulton, A. J.; Katritzky, A. R. *Tetrahedron* **1961**, *12*, 51.
8. Katritzky, A.R.; Oksne, S.; Boulton, A. J. *Tetrahedron* **1962**, *18*, 777.
9. Katritzky, A. R.; Oksne, S. *Proc. Chem. Soc.* **1961**, 387.
10. Jacquier, R.; Petrus, C.; Petrus, F.; Verducci, J. *Bull. Soc. Chem. Fr.* **1970**, 2685.
11. Cocivera, M.; Effio, A.; Chen, H. E.; Vaish, S. *J. Am. Chem. Soc.* **1976**, *98*, 7362.
12. Jacobsen, N.; Kolind-Andersen, H.; Christensen, J. *Can. J. Chem.* **1984**, *62*, 1940.
13. Katritzky, A. R.; Barczynski, P.; Ostercamp, D. L.; Yousaf, T. I. *J. Org. Chem.* **1986**, *51*, 4037.
14. Krogsgaard-Larsen, K.; Sorensen, U. S. *Org. Prep. Proc. Int.* **2001**, *33*, 515.
15. Sorensen, U. S.; Falch, E.; Krogsgaard-Larsen, K. *J. Org. Chem.* **2000**, *65*, 1003.
16. Chen, B.-C. *Heterocycles*, **1991**, *32*, 529.
17. McNab, H. *Chem. Soc. Rev.* **1978**, *7*, 345. (Review).
18. Frølund, B.; Kristiansen, U.; Brehm, L.; Hansen, A.B.; Krogsgaard-Larsen, K.; Falch, E. *J. Med. Chem.* **1995**, *38*, 3287.
19. Frølund, B.; Tagmose, L.; Liljefors, T.; Stensbøl, T. B.; Engblom, C.; Kristiansen, U.; Krogsgaard-Larsen, K. *J. Med. Chem.* **2000**, *43*, 4930.
20. Madsen, U.; Bräuner-Osborne, H.; Frydenvang, K.; Hvene, L.; Johansen, T.N.; Nielsen, B.; Sánchez, C.; Stensbøl, T.B.; Bischoff, F.; Krogsgaard-Larsen, K. *J. Med. Chem.* **2001**, *44*, 1051.
21. Brooks, D. A. *Claisen Isoxazole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 220–224. (Review).

Claisen rearrangements

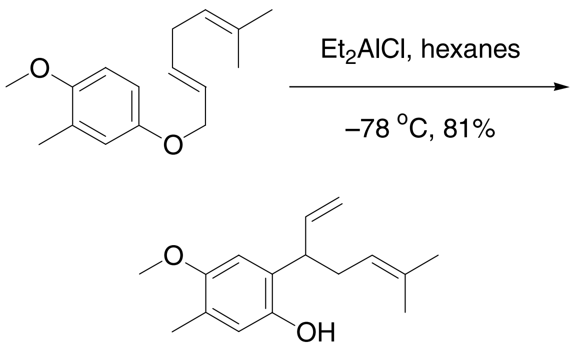
The Claisen, Johnson–Claisen, Ireland–Claisen, *para*-Claisen rearrangements, along with the Carroll rearrangement belong to the category of *[3,3]-sigmatropic rearrangements*. The Claisen rearrangement is a concerted process and the arrow pushing here is merely illustrative.



Example 1[7]



Example 2[8]



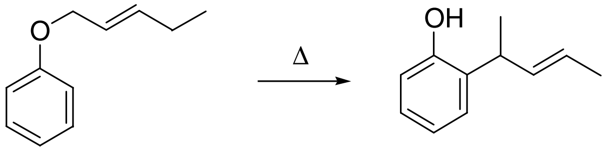
References

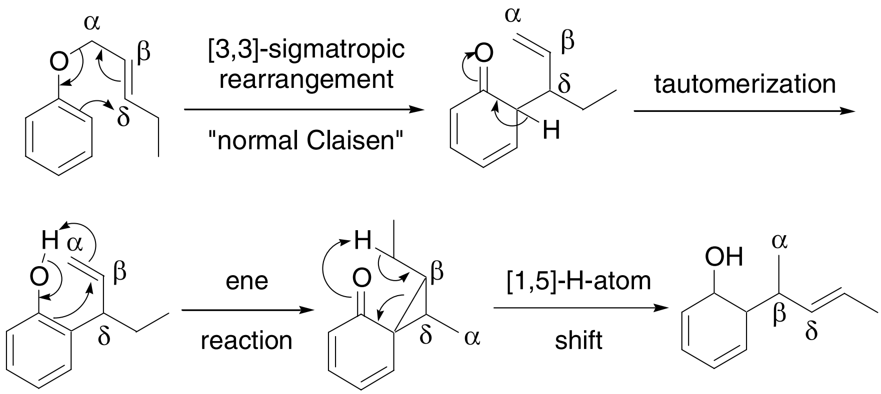
1. Claisen, L. *Ber. Dtsch. Chem. Ges.* **1912**, *45*, 3157.
2. Rhoads, S. J.; Raulins, N. R. *Org. React*. **1975**, *22*, 1–252. (Review).

3. Wipf, P. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 827–873. (Review).
4. Ganem, B. *Angew. Chem., Int. Ed. Engl*. **1996**, *35*, 936.
5. Ito, H.; Taguchi, T. *Chem. Soc. Rev*. **1999**, *28*, 43–50. (Review).
6. Castro, A. M. M. *Chem. Rev*. **2004**, *104*, 2939–3002. (Review).
7. Jürs, S.; Thiem, J. *Tetrahedron: Asymmetry* **2005**, *16*, 1631.
8. Vyvyan, J. R.; Oaksmith, J. M.; Parks, B. W.; Peterson, E. M. *Tetrahedron Lett*. **2005**, *46*, 2457.

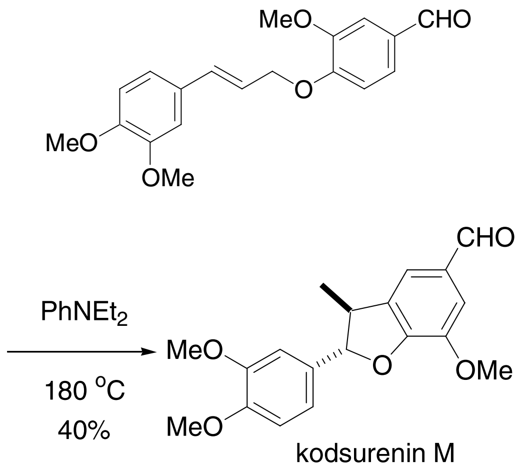
Abnormal Claisen rearrangement

Further rearrangement of the normal Claisen rearrangement product with the β-carbon becoming attached to the ring.

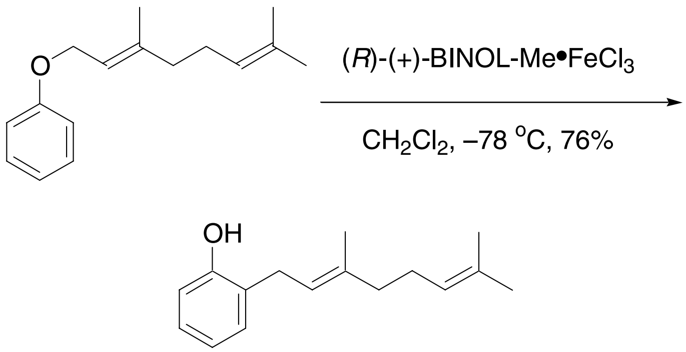




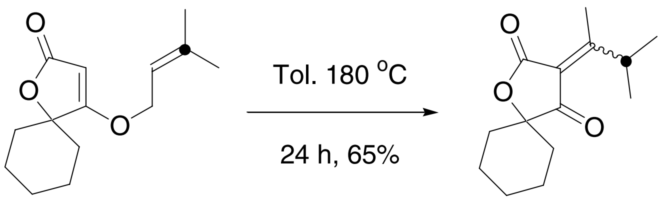
Example 1[4]



Example 2[5]



Example 3[6]

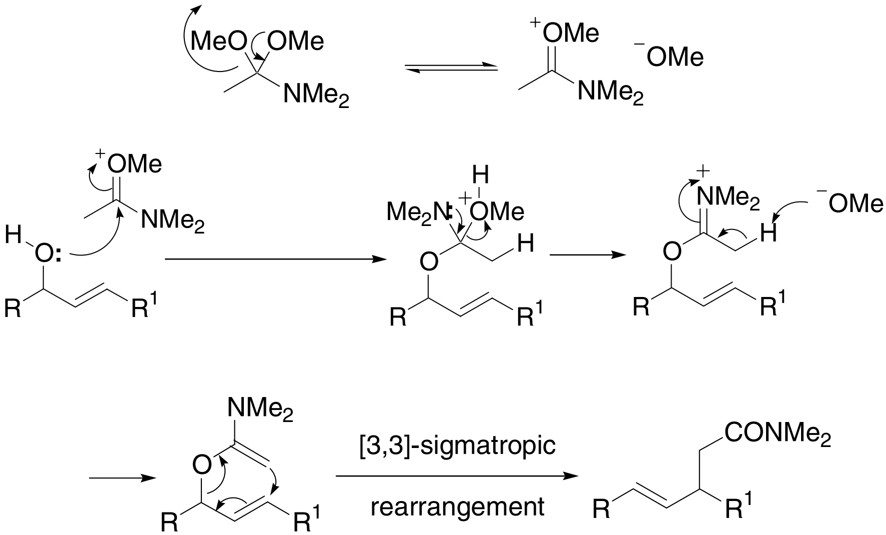


References

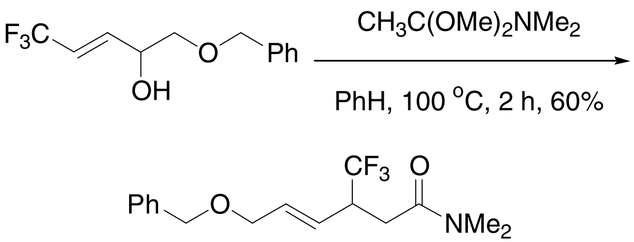
1. Hansen, H.-J. In *Mechanisms of Molecular Migrations;* vol. 3, Thyagarajan, B. S., ed.; Wiley-Interscience: New York, **1971**, pp 177–236. (Review).
2. Shah, R. R.; Trivedi, K. N. *Curr. Sci.* **1975**, *44*, 226.
3. Kilenyi, S. N.; Mahaux, J.-M.; van Durme, E. *J. Org. Chem.* **1991**, *56*, 2591.
4. Yi, W. M.; Xin, W. A.; Fu, P. X. *J. Chem. Soc., (S),* **1998**, 168.
5. Nakamura, S.; Ishihara, K.; Yamamoto, H. *J. Am. Chem. Soc.* **2000**, *122*, 8131.
6. Schobert, R.; Siegfried, S.; Gordon, G.; Mulholland, D.; Nieuwenhuyzen, M. *Tetrahedron Lett.* **2001**, *42*, 4561.
7. Puranik, R.; Rao, Y. J.; Krupadanam, G. L. D. *Indian J. Chem., Sect. B* **2002**, *41B*, 868.

Eschenmoser–Claisen amide acetal rearrangement

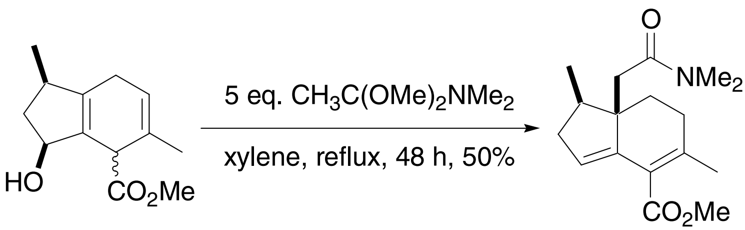
[3,3]-Sigmatropic rearrangement of *N,O*-ketene acetals to yield γ,δ-unsaturated amides. Since Eschenmoser was inspired by Meerwein's observations on the interchange of amide, the Eschenmoser–Claisen rearrangement is sometimes known as the Meerwein–Eschenmoser–Claisen rearrangement.



Example 1[7]



Example 2[9]

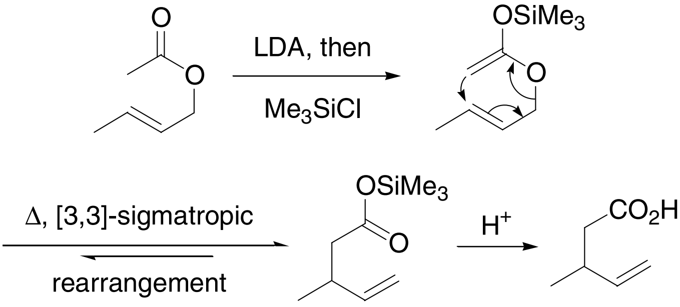


References

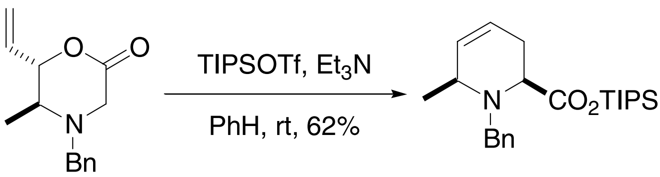
1. Meerwein, H.; Florian, W.; Schön, N.; Stopp, G. *Justus Liebigs Ann. Chem.* **1961**, *641*, 1.
2. Wick, A. E.; Felix, D.; Steen, K.; Eschenmoser, A. *Helv. Chim. Acta* **1964**, *47*, 2425. Albert Eschenmoser (Switzerland, 1925−) is best known for his work on, among many others, the monumental total synthesis of Vitamin B_{12} with R. B. Woodward in 1973. He now holds appointments at ETH Zürich and Scripps Research Institute, La Jolla.
3. Felix, D.; Gschwend-Steen, K.; Wick, A. E.; Eschenmoser, A. *Helv. Chim. Acta* **1969**, *52*, 1030.
4. Wipf, P. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 827−873. (Review).
5. Coates, B.; Montgomery, D.; Stevenson, P. J. *Tetrahedron Lett*. **1991**, *32*, 4199.
6. Ganem, B. *Angew. Chem., Int. Ed. Engl*. **1996**, *35*, 936.
7. Konno, T.; Nakano, H.; Kitazume, T. *J. Fluorine Chem*. **1997**, *86*, 81.
8. Ito, H.; Taguchi, T. *Chem. Soc. Rev*. **1999**, *28*, 43−50. (Review).
9. Loh, T.-P.; Hu, Q.-Y. *Org. Lett*. **2001**, *3*, 279.
10. Gradl, S. N.; Kennedy-Smith, J. J.; Kim, J.; Trauner, D. *Synlett* **2002**, 411.
11. Khaledy, M. M.; Kalani, M. Y. S.; Khuong, K. S.; Houk, K. N.; Aviyente, V.; Neier, R.; Soldermann, N.; Velker, J. *J. Org. Chem*. **2003**, *68*, 572.
12. Castro, A. M. M. *Chem. Rev*. **2004**, *104*, 2939−3002. (Review).
13. Gilbert, M. W.; Galkina, A.; Mulzer, J. *Synlett* **2004**, 2558.

Ireland–Claisen (silyl ketene acetal) rearrangement

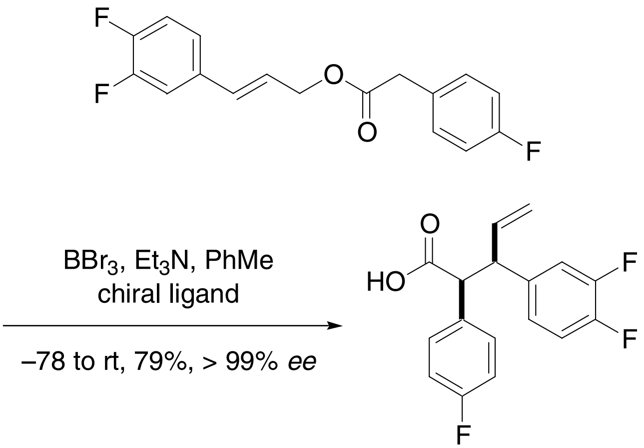
Rearrangement of allyl trimethylsilyl ketene acetal, prepared by reaction of allylic ester enolates with trimethylsilyl chloride, to yield γ,δ-unsaturated carboxylic acids. The Ireland–Claisen rearrangement seems to be advantageous to the other variants of the Claisen rearrangement in terms of *E/Z* geometry control and mild conditions.



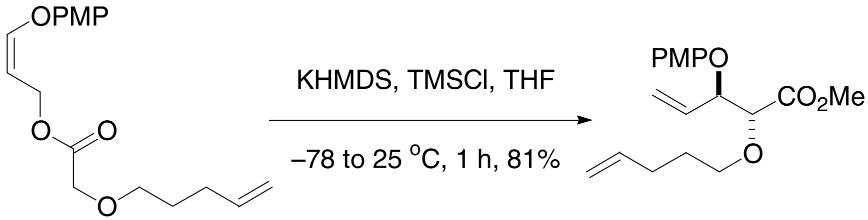
Example 1[3]



Example 2, a modified Ireland–Claisen rearrangement[10]



Example 3[14]

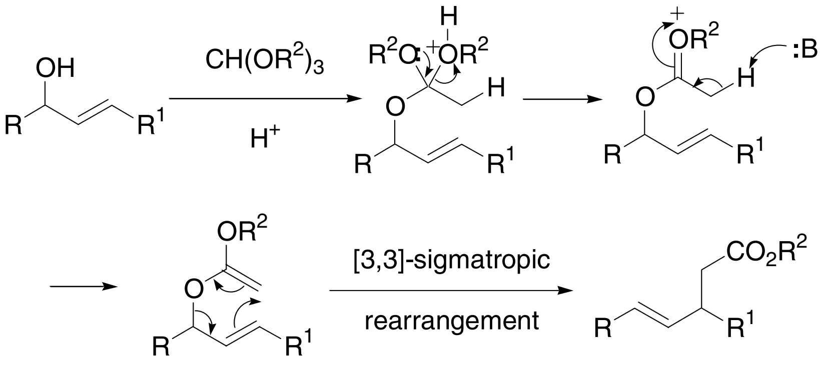


References

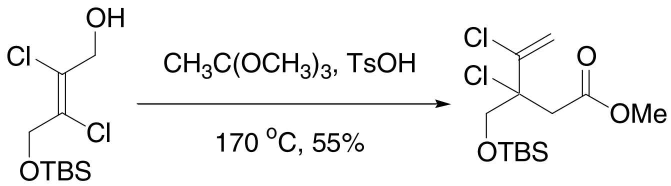
1. Ireland, R. E.; Mueller, R. H. *J. Am. Chem. Soc.* **1972**, *94*, 5897. Also *J. Am. Chem. Soc.* **1976**, *98*, 2868. Robert E. Ireland obtained his Ph.D. from William S. Johnson before becoming a professor at the University of Virginia and later at the California Institute of Technology. He is now retired.
2. Cha, J. K.; Lewis, S. C. *Tetrahedron Lett.* **1984**, *25*, 5263.
3. Corey, E. J.; Lee, D.-H. *J. Am. Chem. Soc.* **1991**, *113*, 4026. (Enantioselective variant of the Ireland–Claisen rearrangement).
4. Pereira, S.; Srebnik, M. *Aldrichimica Acta* **1993**, *26*, 17–29. (Review).
5. Ganem, B. *Angew. Chem., Int. Ed. Engl.* **1996**, *35*, 936.
6. Mohamed, M.; Brook, M. A. *Tetrahedron Lett.* **2001**, *42*, 191.
7. Hong, S.-p.; Lindsay, H. A.; Yaramasu, T.; Zhang, X.; McIntosh, M. C. *J. Org. Chem.* **2002**, *67*, 2042.
8. Chai, Y.; Hong, S.-p.; Lindsay, H. A.; McFarland, C.; McIntosh, M. C. *Tetrahedron* **2002**, *58*, 2905–2928. (Review).
9. Khaledy, M. M.; Kalani, M. Y. S.; Khuong, K. S.; Houk, K. N.; Aviyente, V.; Neier, R.; Soldermann, N.; Velker, J. *J. Org. Chem.* **2003**, *68*, 572.
10. Churcher, I.; Williams, S.; Kerrad, S.; Harrison, T.; Castro, J. L.; Shearman, M. S.; Lewis, H. D.; Clarke, E. E.; Wrigley, J. D. J.; Beher, D.; Tang, Y. S.; Liu, W. *J. Med. Chem.* **2003**, *46*, 2275.
11. Höck, S.; Koch, F.; Borschberg, H.-J. *Tetrahedron: Asymmetry* **2004**, *15*, 1801.
12. Hutchison, J. M.; Hong, S.-p.; McIntosh, M. C. *J. Org. Chem.* **2004**, *69*, 4185.
13. Gilbert, J. C.; Yin, J.; Fakhreddine, F. H.; Karpinski, M. L. *Tetrahedron* **2004**, *60*, 51.
14. Fujiwara, K.; Goto, A.; Sato, D.; Kawai, H.; Suzuki, T. *Tetrahedron Lett.* **2005**, *46*, 3465.

Johnson–Claisen orthoester rearrangement

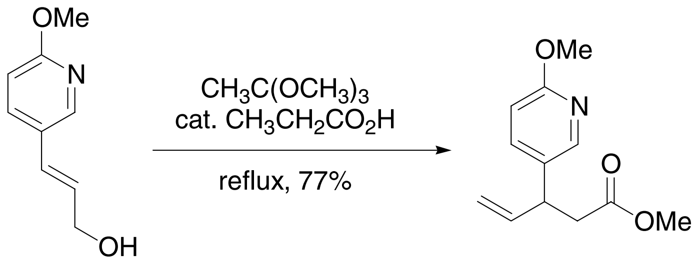
Heating of an allylic alcohol with an excess of trialkyl orthoacetate in the presence of trace amounts of a weak acid to give a mixed orthoester. The orthoester loses ethanol to generate the ketene acetal, which undergoes [3,3]-sigmatropic rearrangement to give a γ,δ-unsaturated ester.



Example 1[2]



Example 2[7]



References

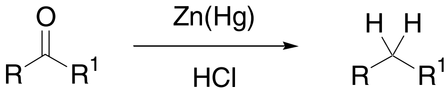
1. Johnson, W. S.; Werthemann, L.; Bartlett, W. R.; Brocksom, T. J.; Li, T.-t.; Faulkner, D. J.; Peterson, M. R. *J. Am. Chem. Soc.* **1970**, *92*, 741. William S. Johnson (1913–1995) was born in New Rochelle, New York. He earned his Ph.D. in only two years at Harvard under Louis Fieser. He was a professor at the University of Wiscon-

sin for 20 years before moving to Stanford University, where he was credited with building the modern-day Stanford Chemistry Department.

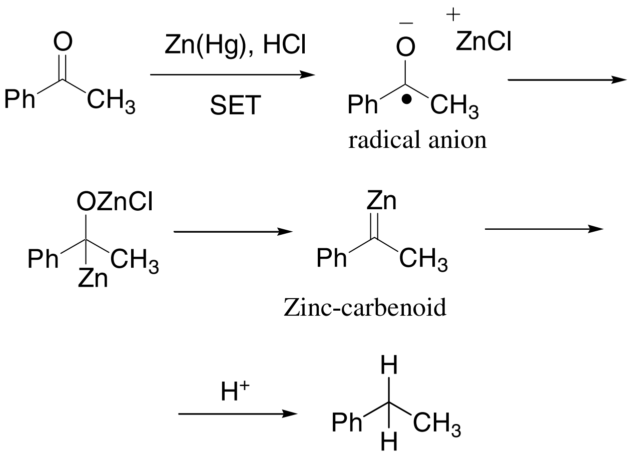
2. Schlama, T.; Baati, R.; Gouverneur, V.; Valleix, A.; Falck, J. R.; Mioskowski, C. *Angew. Chem., Int. Ed.* **1998**, *37*, 2085.
3. Giardiná, A.; Marcantoni, E.; Mecozzi, T.; Petrini, M. *Eur. J. Org. Chem.* **2001**, 713.
4. Funabiki, K.; Hara, N.; Nagamori, M.; Shibata, K.; Matsui, M. *J. Fluorine Chem.* **2003**, *122*, 237.
5. Montero, A.; Mann, E.; Herradón, B. *Eur. J. Org. Chem.* **2004**, 3063.
6. Scaglione, J. B.; Rath, N. P.; Covey, D. F. *J. Org. Chem.* **2005**, *70*, 1089.
7. Zartman, A. E.; Duong, L. T.; Fernandez-Metzler, C.; Hartman, G. D.; Leu, C.-T.; Prueksaritanont, T.; Rodan, G. A.; Rodan, S. B.; Duggan, M. E.; Meissner, R. S. *Bioorg. Med. Chem. Lett.* **2005**, *15*, 1647.

Clemmensen reduction

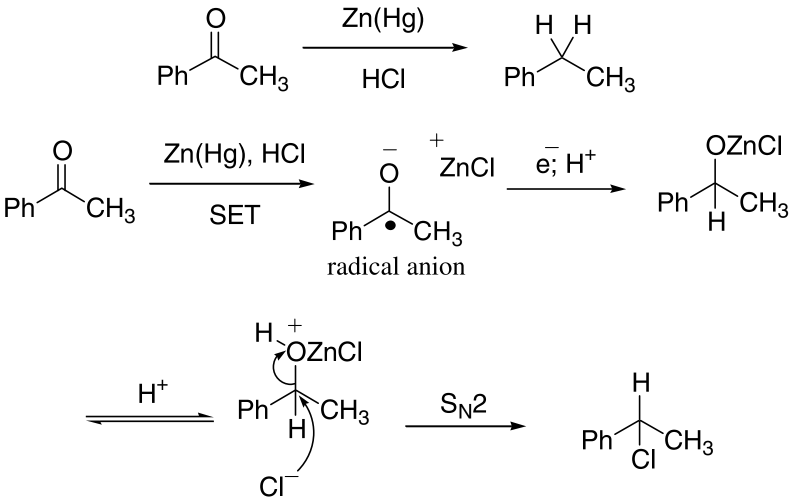
Reduction of aldehydes and ketones to the corresponding methylene compounds using amalgamated zinc and hydrogen chloride.

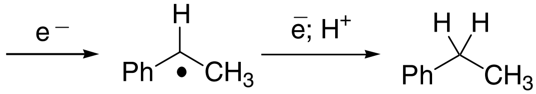


The zinc-carbenoid mechanism:[6]

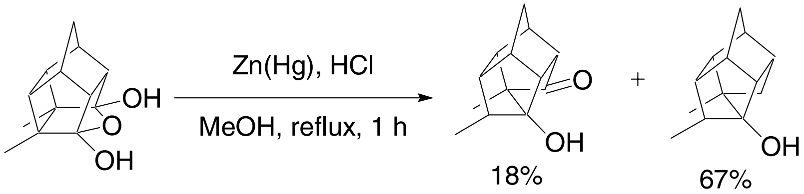


The radical anion mechanism:

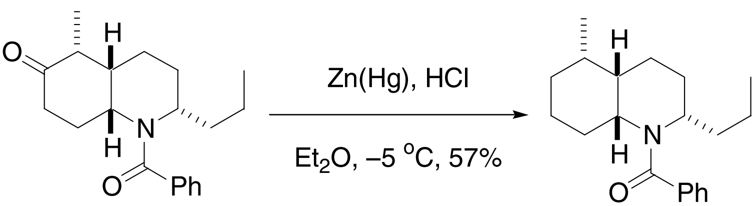




Example 1[8]



Example 2[10]



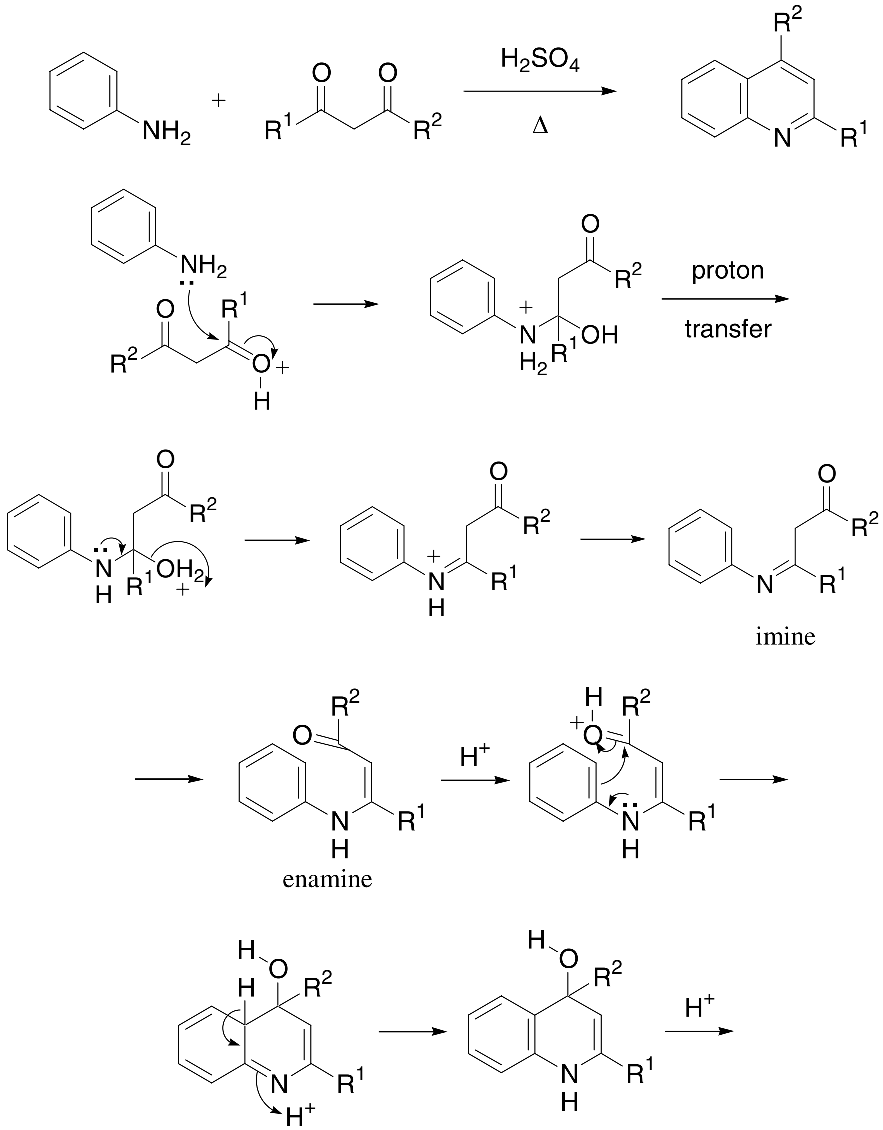
References

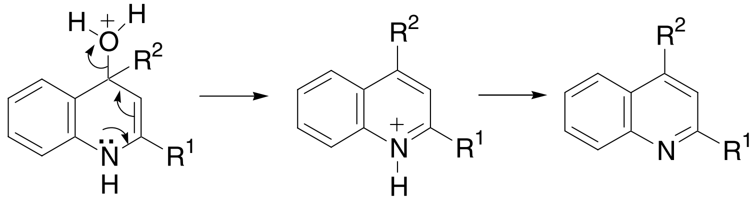
1. Clemmensen, E. *Ber. Dtsch. Chem. Ges.* **1913**, *46*, 1837. Erik C. Clemmensen (1876–1941) was born in Odense, Denmark. He received the M.S. degree from the Royal Polytechnic Institute in Copenhagen. In 1900, Clemmensen immigrated to the United States, and worked at Parke, Davis and Company in Detroit (now part of Pfizer) as a research chemist for 14 years, where he discovered the reduction of carbonyl compounds with amalgamated zinc. Clemmensen later founded a few chemical companies and was the president of one of them, the Clemmensen Chemical Corporation in Newark, New York.
2. Martin, E. L. *Org. React.* **1942**, *1*, 155–209. (Review).
3. Brewster, J. H. *J. Am. Chem. Soc.* **1954**, *76*, 6361.
4. Vedejs, E. *Org. React.* **1975**, *22*, 401–422. (Review).
5. Elphimoff-Felkin, I.; Sarda, P. *Tetrahedron Lett*. **1983**, *24*, 4425.
6. Burdon, J.; Price, R. C. *Chem. Commun.* **1986**, 893.
7. Talpatra, S. K.; Chakrabarti, S.; Mallik, A. K.; Talapatra, B. *Tetrahedron* **1990**, *46*, 6047.
8. Martins, F. J. C.; Viljoen, A. M.; Coetzee, M.; Fourie, L.; Wessels, P. L. *Tetrahedron* **1991**, *47*, 9215.
9. Ni, Y.; Kim, H. S.; Wilson, W. K.; Kisic, A.; Schroepfer, G. J., Jr. *Tetrahedron Lett.* **1993**, *34*, 3687.
10. Naruse, M.; Aoyagi, S.; Kibayashi, C. *J. Chem. Soc., Perkin Trans. 1* **1996**, 1113.
11. Cheng, L.; Ma, J. *Org. Prep. Proc. Int.* **1995**, *27*, 224.

12. Kappe, T.; Aigner, R.; Roschger, P.; Schnell, B.; Stadlbauer, W. *Tetrahedron* **1995**, *51*, 12923.
13. Kohara, T.; Tanaka, H.; Kimura, K.; Fujimoto, T.; Yamamoto, I.; Arita, M. *Synthesi*s **2002**, 355.
14. Alessandrini, L.; Ciuffreda, P.; Santaniello, E.; Terraneo, G. *Steroids* **2004**, *69*, 789.

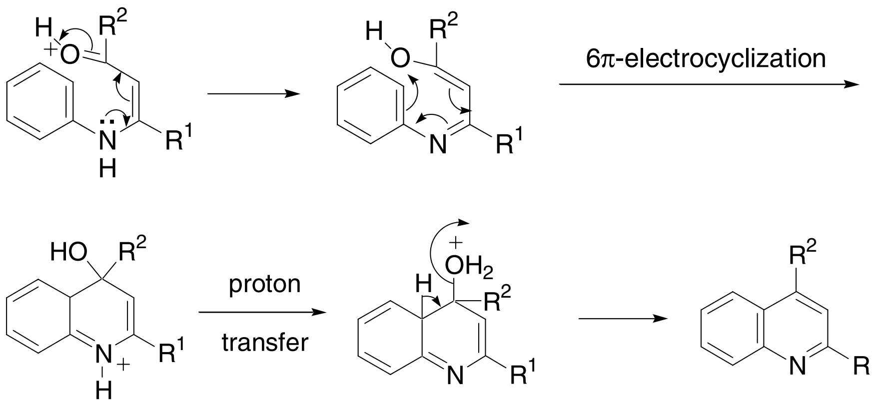
Combes quinoline synthesis

Acid-catalyzed condensation of anilines and β-diketones to assemble quinolines. *Cf.* Conrad-Limpach reaction.

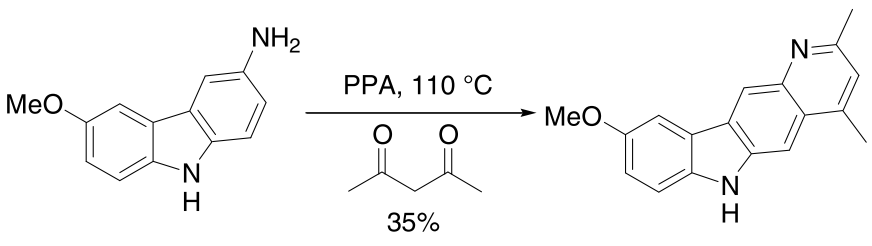




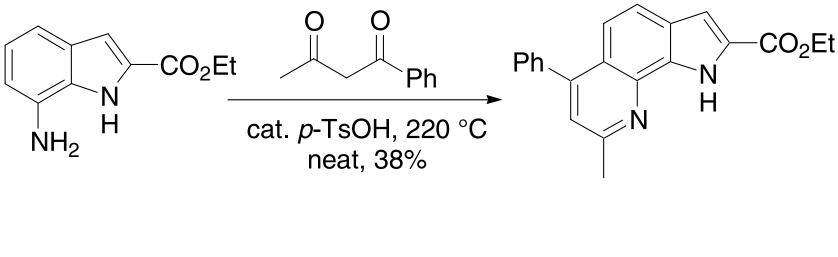
An electrocyclization mechanism is also possible:



Example 1[10]



Example 2[11]

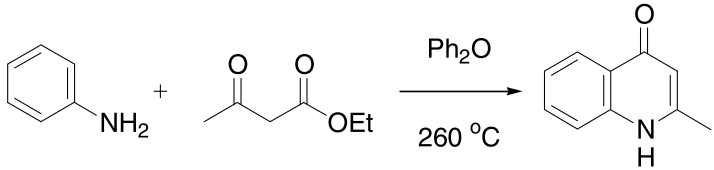


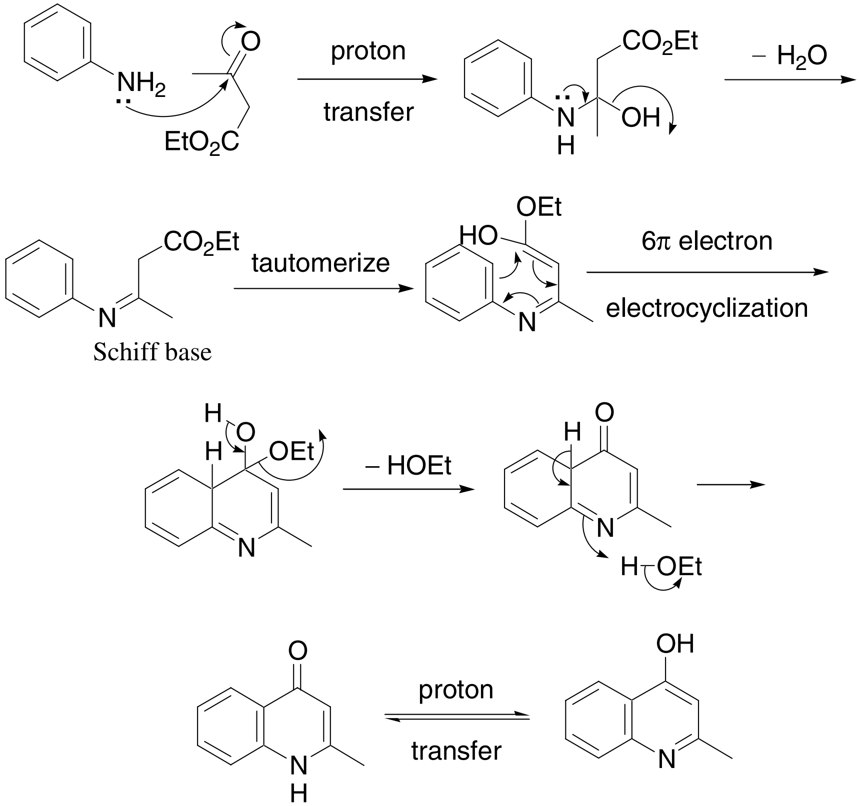
References

1. Combes, A. *Bull. Soc. Chim. Fr.* **1888**, *49*, 89. Alphonse-Edmond Combes (1858–1896) was born in St. Hippolyte-du-Fort, France. He apprenticed with Wurtz at Paris. He also collaborated with Charles Friedel of the Friedel–Crafts reaction fame. He became the president of the French Chemical Society in 1893 at the age of 35. His sudden death shortly after his 38th birthday was a great loss to organic chemistry.
2. Roberts, E. and Turner, E. *J. Chem Soc*. **1927**, 1832. (Review).
3. Elderfield, R. C. In *Heterocyclic Compounds*, Elderfield, R. C., ed., Wiley & Sons, New York, **1952**, vol. 4, 36–38. (Review).
4. Popp, F. D. and McEwen, W. E. *Chem. Rev*. **1958**, *58*, 321–401. (Review).
5. Coscia, A. T.; Dickerman, S. C. *J. Am. Chem. Soc.* **1959**, *81*, 3098.
6. Claret, P. A.; Osborne, A. G. *Org. Prep. Proced. Int.* **1970**, *2*, 305.
7. Born, J. L. *J. Org. Chem*. **1972**, *37*, 3952.
8. Jones, G. In *Chemistry of Heterocyclic Compounds*, Jones, G., ed.; Wiley & Sons, New York, **1977**, Quinolines Vol. 32, pps.119–125. (Review).
9. Ruhland, B.; Leclerc, G. *J. Heterocycl. Chem*. **1989**, *26*, 469.
10. Alunni-Bistocchi, G.; Orvietani, P., Bittoun, P., Ricci, A.; Lescot, E. *Pharmazie* **1993**, *48*, 817.
11. El Ouar, M.; Knouzi, N.; Hamelin, J. *J. Chem. Research (S)* **1998**, 92.
12. Curran, T. T. *Combes Quinoline Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 390–397. (Review).

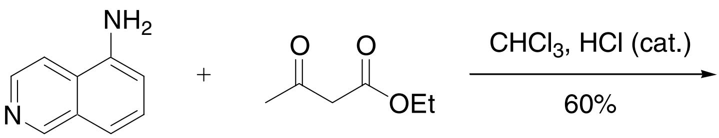
Conrad–Limpach reaction

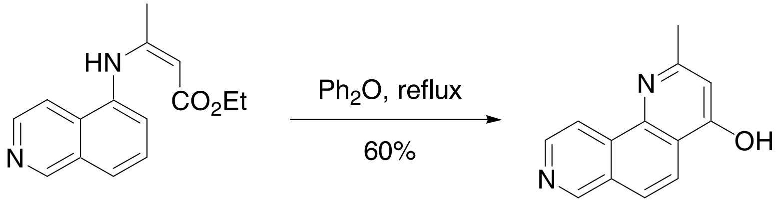
Thermal or acid-catalyzed condensation of anilines with β-ketoesters leads to quinolin-4-ones. *Cf.* Combes quinoline synthesis.



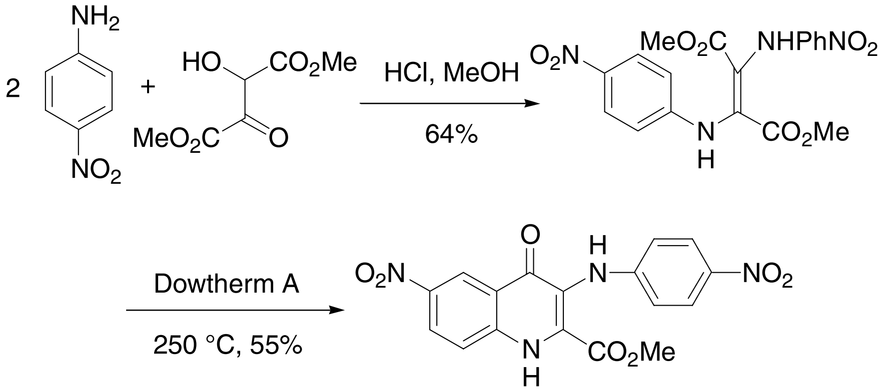


Example 1[3]





Example 2[12]

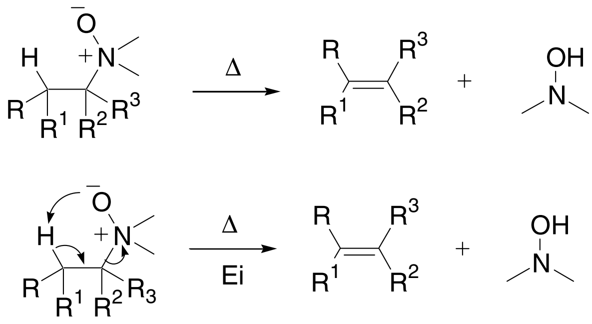


References

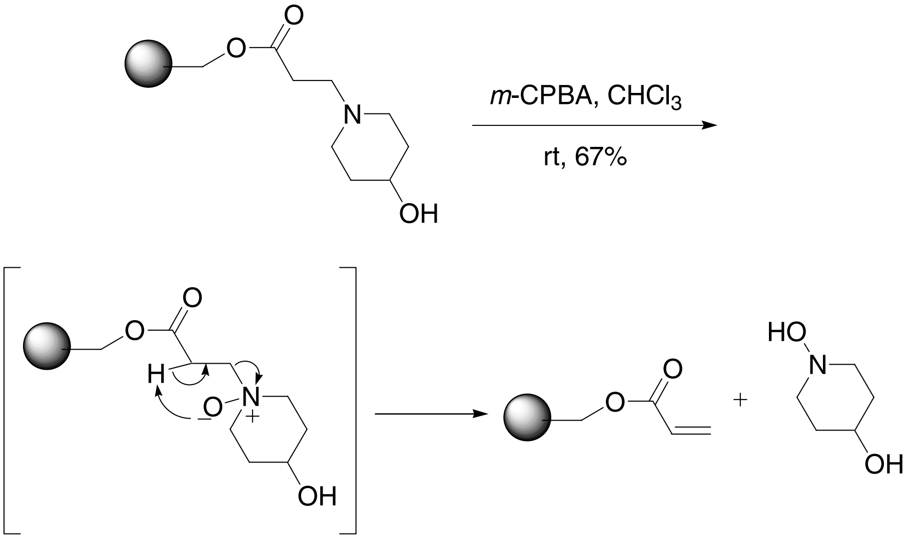
1. Conrad, M.; Limpach, L. *Ber. Dtsch. Chem. Ges.* **1887**, *20*, 944. Max Conrad (1848–1920), born in Munich, Germany, was a professor of the University of Würzburg, where he collaborated with Leonhard Limpach (1852–1933) on the synthesis of quinoline derivatives.
2. Manske, R. F., *Chem Rev*. **1942,** *30*, 113–114. (Review).
3. Misani, F.; Bogert, M. T. *J. Org. Chem.* **1945**, *10*, 347.
4. Reitsema, R. H. *Chem. Rev*. **1948**, *43*, 43–68. (Review).
5. Elderfield, R. C. In *Chemistry of Heterocyclic Compounds*, Elderfield, R. C., Wiley & Sons, New York, **1952**, vol. 4, 31–36. (Review).
6. Heindel, N. D.; Bechara, I. S.; Kennewell, P. D.; *et al. J. Med. Chem.* **1968**, *11*, 1218.
7. Perche, J. C.; Saint-Ruf, G. *J. Heterocycl. Chem.* **1974**, *11*, 93.
8. Jones, G. In *Heterocyclic Compounds*, Jones, G., ed.; John Wiley & Sons, New York, **1977**, Quinolines, Vol 32, 137–151. (Review).
9. Barker, J. M.; Huddleston, P. R.; Jones, A. W.; Edwards, M. *J. Chem. Res., (S)* **1980**, 4.
10. Guay, V.; Brassard, P. *J. Heterocycl. Chem.* **1987**, *24*, 1649.
11. Deady, L. W.; Werden, D. M. *J. Org. Chem*. **1987**, *52*, 3930.
12. Kemp, D. S.; Bowen, B. R. *Tetrahedron Lett*. **1988**, *29*, 5077.
13. Hormi, O. E. O.; Peltonen, C.; Heikkila, L. *J. Org. Chem*. **1990**, *55*, 2513.
14. Billah, M.; Buckley, G. M.; Cooper, N; *et al. Bioorg. Med. Chem*. **2002**, *12*, 1617.
15. Curran, T. T. *Conrad–Limpach Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 398–406. (Review).

Cope elimination reaction

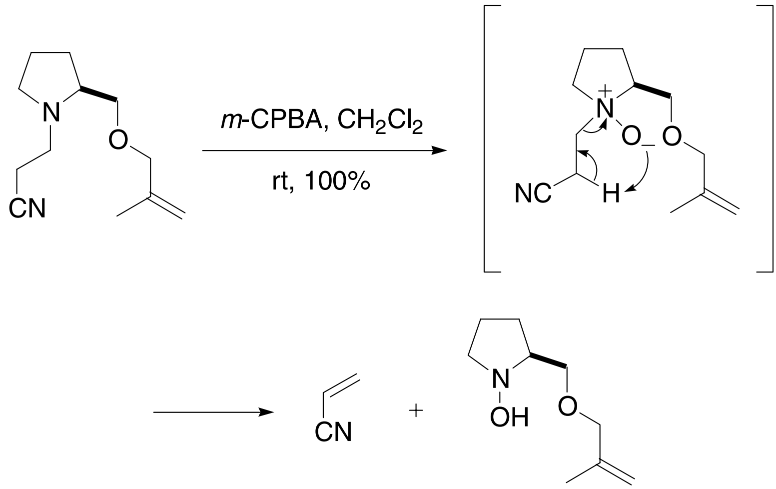
Thermal elimination of *N*-oxides to olefins and *N*-hydroxyl amines.



Example 1[7]



Example 2[11]

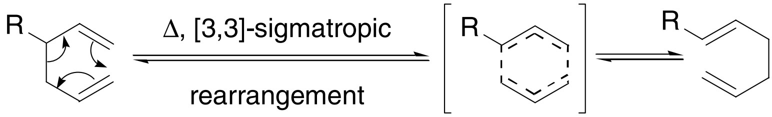


References

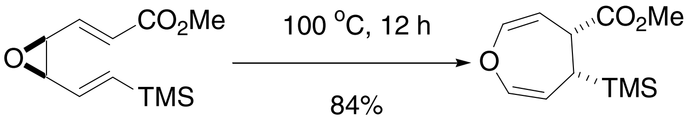
1. Cope, A. C.; Foster, T. T.; Towle, P. H. *J. Am. Chem. Soc.* **1949**, *71*, 3929. Arthur Clay Cope (1909–1966) was born in Dunreith, Indiana. He was a professor at MIT when he discovered the Cope elimination reaction and the Cope rearrangement. The Arthur Cope Award is a prestigious award in organic chemistry from the American Chemical Society.
2. Cope, A. C.; Trumbull, E. R. *Org. React.* **1960**, *11*, 317–493. (Review).
3. DePuy, C. H.; King, R. W. *Chem. Rev.* **1960**, *60*, 431–457. (Review).
4. Gallagher, B. M.; Pearson, W. H. *Chemtracts: Org. Chem.* **1996**, *9*, 126–130. (Review).
5. Vidal, T.; Magnier, E.; Langlois, Y. *Tetrahedron* **1998**, *54*, 5959.
6. Gravestock, M. B.; Knight, D. W.; Malik, K. M. A.; Thornton, S. R. *J. Chem. Soc., Perkin 1* **2000**, 3292.
7. Sammelson, R. E.; Kurth, M. J. *Tetrahedron Lett.* **2001**, *42*, 3419.
8. Bagley, M. C.; Tovey, J. *Tetrahedron Lett.* **2001**, *42*, 351.
9. Remen, L.; Vasella, A. *Helv. Chim. Acta* **2002**, *85*, 1118.
10. Garcia Martinez, A.; Teso Vilar, E.; Garcia Fraile, A.; de la Moya Cerero, S.; Lora Maroto, B. *Tetrahedron: Asymmetry* **2002**, *13*, 17.
11. O'Neil, I. A.; Ramos, V. E.; Ellis, G. L.; Cleator, E.; Chorlton, A. P.; Tapolczay, D. J.; Kalindjian, S. B. *Tetrahedron Lett.* **2004**, *45*, 3659.

Cope rearrangement

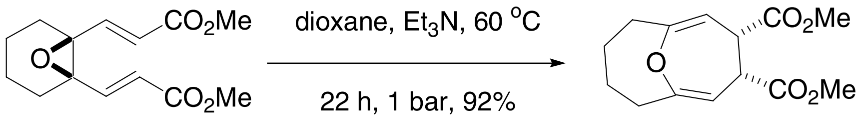
The Cope, oxy-Cope, and anionic oxy-Cope rearrangements belong to the category of *[3,3]-sigmatropic rearrangements*. Since it is a concerted process, the arrow pushing here is only illustrative. *Cf.* Claisen rearrangement.



Example 1[5]



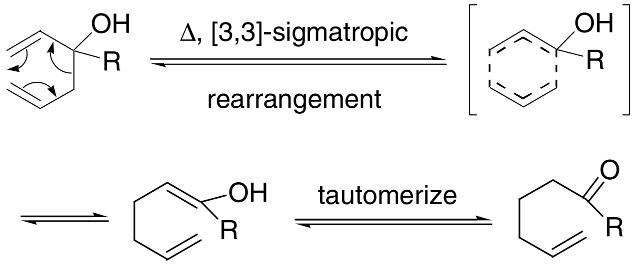
Example 2[8]



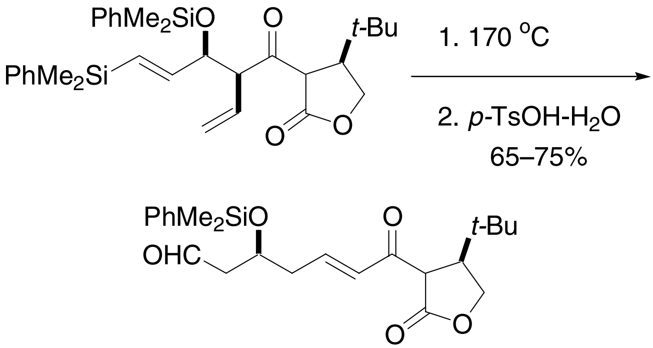
References

1. Cope, A. C.; Hardy, E. M. *J. Am. Chem. Soc.* **1940**, *62*, 441.
2. Frey, H. M.; Walsh, R. *Chem. Rev.* **1969**, *69*, 103–124. (Review).
3. Rhoads, S. J.; Raulins, N. R. *Org. React.* **1975**, *22*, 1–252. (Review).
4. Hill, R. K. In *Comprehensive Organic Synthesis* Trost, B. M.; Fleming, I., Eds., Pergamon, **1991**, *Vol. 5*, 785–826. (Review).
5. Chou, W.-N.; White, J. B.; Smith, W. B. *J. Am. Chem. Soc.* **1992**, *114*, 4658.
6. Davies, H. M. L. *Tetrahedron* **1993**, *49*, 5203–5223. (Review).
7. Miyashi, T.; Ikeda, H.; Takahashi, Y. *Acc. Chem. Res.* **1999**, *32*, 815–824. (Review).
8. Von Zezschwitz, P.; Voigt, K.; Lansky, A.; Noltemeyer, M.; De Meijere, A. *J. Org. Chem.* **1999**, *64*, 3806.
9. Nakamura, H.; Yamamoto, Y. In *Handbook of Organopalladium Chemistry for Organic Synthesis* **2002**, *2*, 2919–2934. (Review).
10. Clive, D. L. J.; Ou, L. *Tetrahedron Lett.* **2002**, *43*, 4559.
11. Hrovat, D. A.; Brown, E. C.; Williams, R. V.; Quast, H.; Borden, W. T. *J. Org. Chem.* **2005**, *70*, 2627.

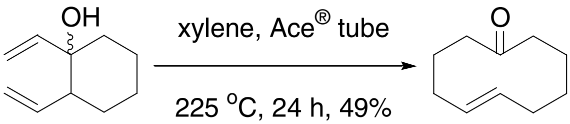
Oxy-Cope rearrangement



Example 1[2]



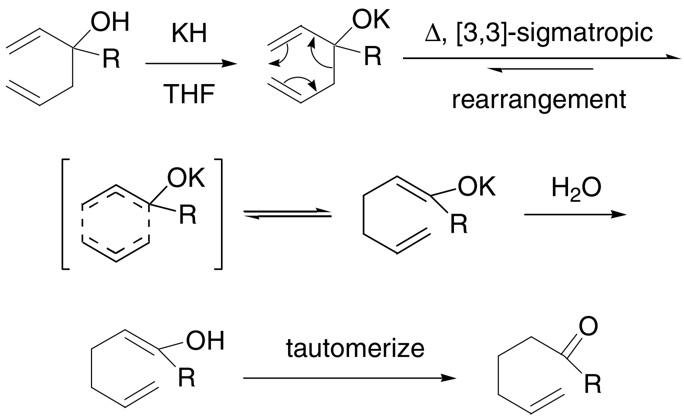
Example 2[4]



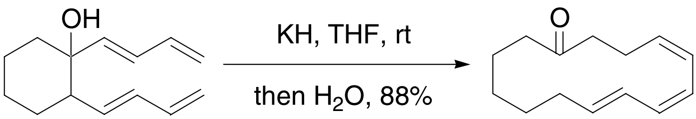
References

1. Paquette, L. A. *Angew. Chem., Int. Ed. Engl.* **1990**, *29*, 609–626. (Review).
2. Schneider, C.; Rehfeuter, M. *Chem. Eur. J.* **1999**, *5*, 2850.
3. Schneider, C. *Synlett* **2001**, 1079–1091. (Review on siloxy-Cope rearrangement).
4. DiMartino, G.; Hursthouse, M. B.; Light, M. E.; Percy, J. M.; Spencer, N. S.; Tolley, M. *Org. Biomol. Chem.* **2003**, *1*, 4423.

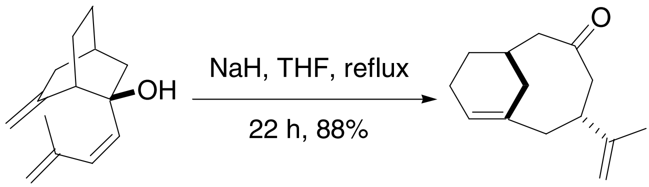
Anionic oxy-Cope rearrangement



Example 1[1]



Example 2[6]

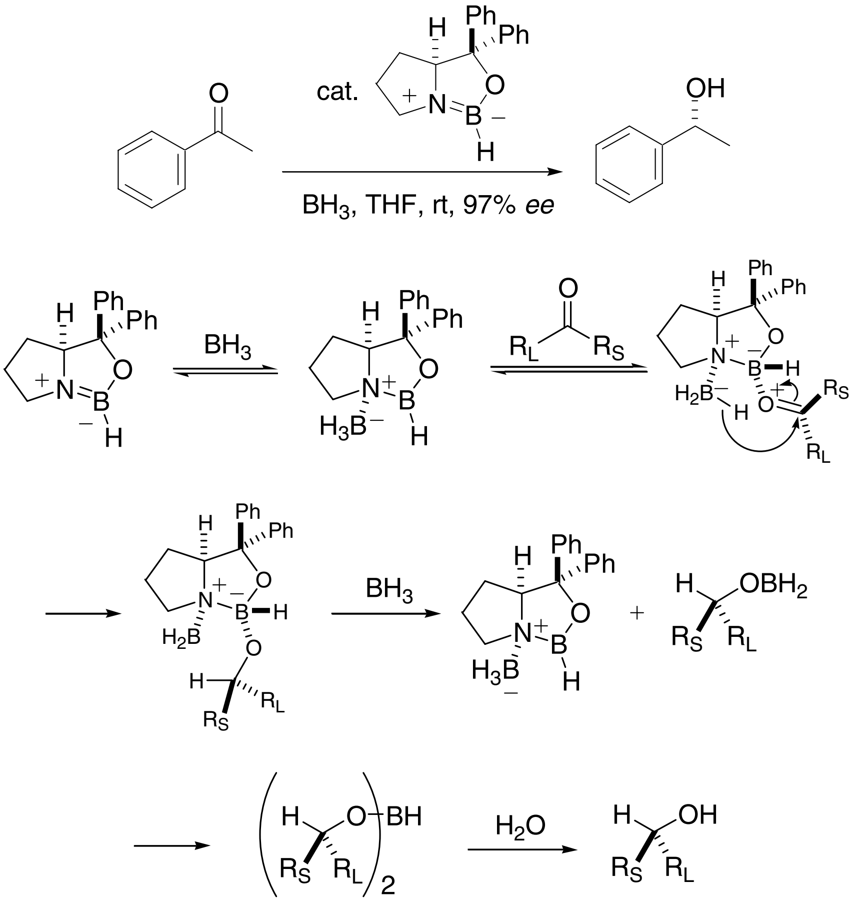


References

1. Wender, P. A.; Sieburth, S. M.; Petraitis, J. J.; Singh, S. K. *Tetrahedron* **1981**, *37*, 3967.
2. Wender, P. A.; Ternansky, R. J.; Sieburth, S. M. *Tetrahedron Lett.* **1985**, *26*, 4319.
3. Paquette, L. A. *Tetrahedron* **1997**, *53*, 13971–14020. (Review).
4. Voigt, B.; Wartchow, R.; Butenschon, H. *Eur. J. Org. Chem.* **2001**, 2519.
5. Hashimoto, H.; Jin, T.; Karikomi, M.; Seki, K.; Haga, K.; Uyehara, T. *Tetrahedron Lett.* **2002**, *43*, 3633.
6. Gentric, L.; Hanna, I.; Huboux, A.; Zaghdoudi, R. *Org. Lett.* **2003**, *5*, 3631.

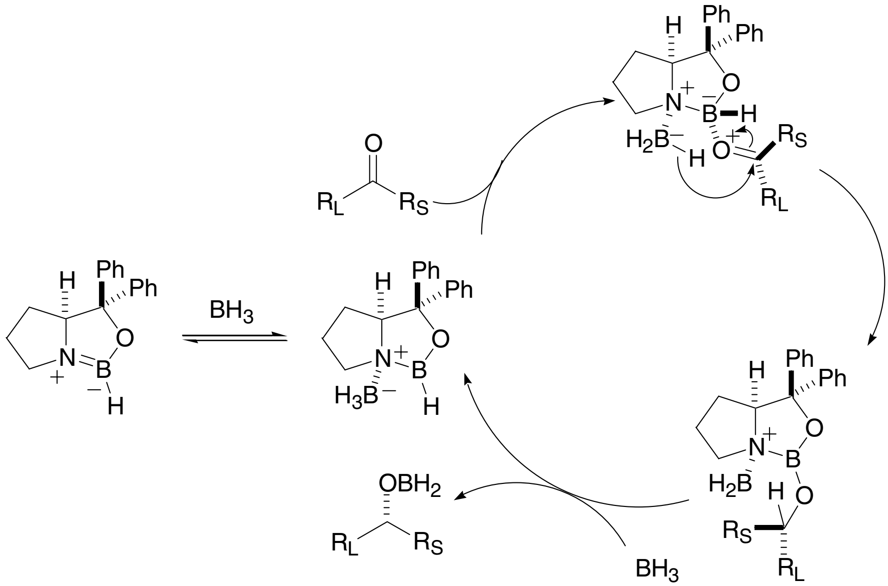
Corey–Bakshi–Shibata (CBS) reduction

Enantioselective borane reduction of ketones catalyzed by chiral oxazaborolidines.

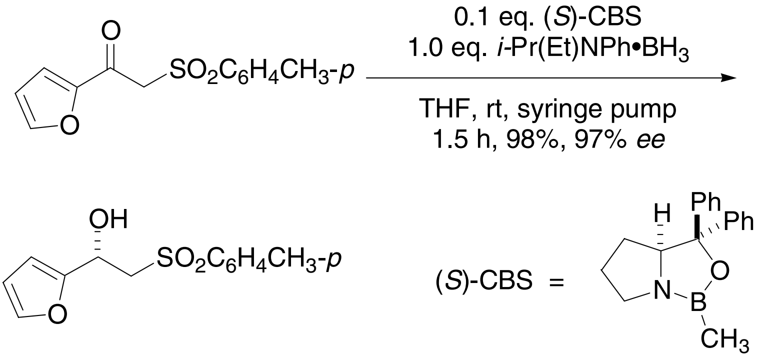


The catalytic cycle is shown on the next page.

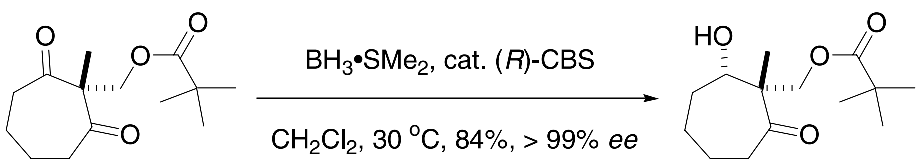
The catalytic cycle:



Example 1[9]



Example 2[14]

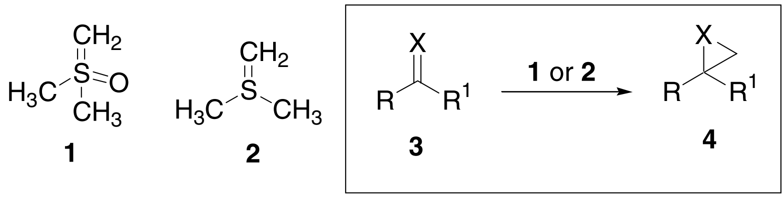


References

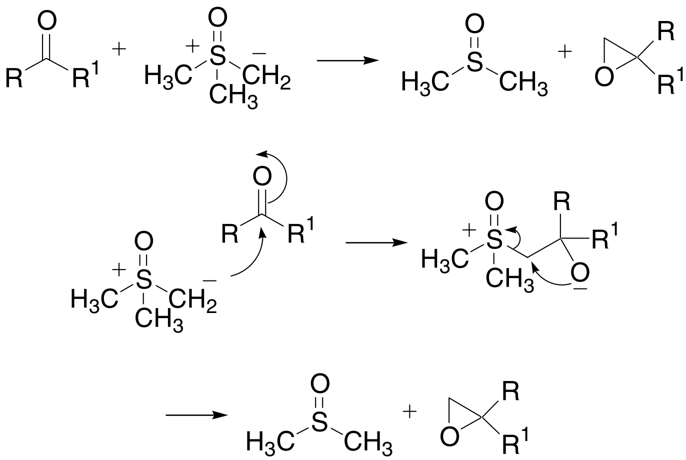
1. Corey, E. J.; Bakshi, R. K.; Shibata, S. *J. Am. Chem. Soc.* **1987**, *109*, 5551. Elias J. Corey (1928–) was born in Methuen, Massachusetts. After earning his Ph.D. at MIT from John Sheehan at age 22, he began his independent academic career at the University of Illinois in 1950 and moved to Harvard University in 1959. Corey won the Nobel Prize in Chemistry in 1990 for development of novel methods for the synthesis of complex natural compounds and retrosynthetic analysis. He is still carrying out active research at Harvard. Prof. Corey has been a consultant to Pfizer for more than 50 years.
2. Corey, E. J.; Bakshi, R. K.; Shibata, S.; Chen, C.-P.; Singh, V. K. *J. Am. Chem. Soc.* **1987**, *109*, 7925.
3. Corey, E. J.; Shibata, S.; Bakshi, R. K. *J. Org. Chem.* **1988**, *53*, 2861.
4. Cho, B. T.; Chun, Y. S. *Tetrahedron: Asymmetry* **1992**, *3*, 1583.
5. Corey, E. J.; Helal, C. J. *Tetrahedron Lett.* **1996**, *37*, 4837.
6. Clark, W. M.; Tickner-Eldridge, A. M.; Huang, G. K.; Pridgen, L. N.; Olsen, M. A.; Mills, R. J.; Lantos, I.; Baine, N. H. *J. Am. Chem. Soc.* **1998**, *120*, 4550.
7. Itsuno, S. *Org. React.* **1998**, *52*, 395–576. (Review).
8. Corey, E. J.; Helal, C. J. *Angew. Chem., Int. Ed.* **1998**, *37*, 1986–2012. (Review).
9. Cho, B. T.; Kim, D. J. *Tetrahedron: Asymmetry* **2001**, *12*, 2043.
10. de Koning, C. B.; Giles, R. G. F.; Green, I. R.; Jahed, N. M. *Tetrahedron Lett.* **2002**, *43*, 4199.
11. Price, M. D.; Sui, J. K.; Kurth, M. J.; Schore, N. E. *J. Org. Chem.* **2002**, *67*, 8086.
12. Fu, X.; McAllister, T. L.; Thiruvengadam, T. K.; Tann, C.-H.; Su, D. *Tetrahedron Lett.* **2003**, *44*, 801.
13. Degni, S.; Wilen, C.-E.; Rosling, A. *Tetrahedron: Asymmetry* **2004**, *15*, 1495.
14. Watanabe, H.; Iwamoto, M.; Nakada, M. *J. Org. Chem.* **2005**, *70*, 4652.

Corey–Chaykovsky reaction

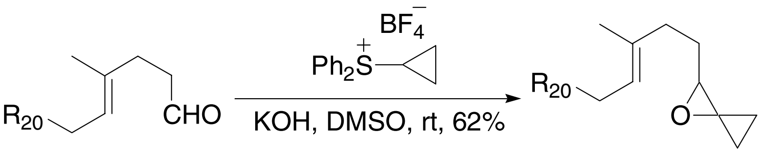
The Corey–Chaykovsky reaction entails the reaction of a sulfur ylide, either dimethylsulfoxonium methylide **1** (Corey's ylide) or dimethylsulfonium methylide **2**, with electrophile **3** such as carbonyl, olefin, imine, or thiocarbonyl, to offer **4** as the corresponding epoxide, cyclopropane, aziridine, or thiirane.



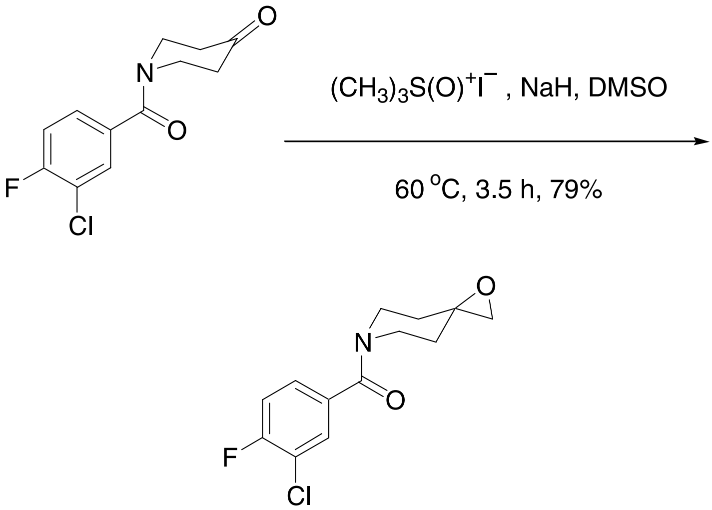
X = O, CH_2, NR^2, S, $CHCOR^3$, $CHCO_2R^3$, $CHCONR_2$, CHCN



Example 1[12]



Example 2[14]



References

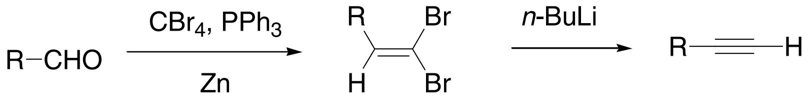
1 Corey, E. J.; Chaykovsky, M. *J. Am. Chem. Soc.* **1962**, *84*, 867. Michael Chaykovsky last published from Prospect Pharma, USA
2 Corey, E. J.; Chaykovsky, M. *Tetrahedron Lett.* **1963**, *4,* 169.
3 Corey, E. J.; Chaykovsky, M. *J. Am. Chem. Soc.* **1964**, *86*, 1640.
4 Corey, E. J.; Chaykovsky, M. *J. Am. Chem. Soc.* **1965**, *87*, 1353.
5 Trost, B. M.; Melvin, L. S., Jr. *Sulfur Ylides* Academic Press: New York, **1975**. (Review).
6 Block, E. *Reactions of Organosulfur Compounds* Academic Press: New York, **1978**. (Review).
7 Johnson, C. R. *Aldrichimica Acta* **1985**, *18*, 3−10. (Review).
8 Gololobov, Y. G.; Nesmeyanov, A. N., Iysenko, V. P.; Boldeskul, I. E. *Tetrahedron* **1987**, *43*, 2609−2651. (Review).
9 Aubé, J. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Ed.; Pergamon: Oxford, **1991**, *Vol. 1*, pp 820−825. (Review).
10 Okazaki, R.; Tokitoh, N. In *Encyclopedia of Reagents in Organic Synthesis;* Paquette, L. A., Ed.; Wiley: New York, **1995**, pp 2139−41. (Review).
11 Ng, J. S.; Liu, C. In *Encyclopedia of Reagents in Organic Synthesis;* Paquette, L. A., Ed.; Wiley: New York, **1995**, 2159−65. (Review).
12 Corey, E. J.; Cheng, H.; Baker, C. H.; Matsuda, S. P. T.; Li, D.; Song, X. *J. Am. Chem. Soc.* **1997**, *119*, 1277.
13 Li, A.-H.; Dai, L.-X.; Aggarwal, V. K. *Chem. Rev.* **1997**, *97*, 2341−2372. (Review).
14 Vacher, B.; Bonnaud, B.; Funes, P.; *et al. J. Med. Chem.* **1999**, *42*, 1648.
15 Shea, K. J. *Chem. Eur. J.* **2000**, *6*, 1113−1119. (Review).
16 Saito, T.; Sakairi, M.; Akiba, D. *Tetrahedron Lett.* **2001**, *42*, 5451.
17 Mae, M.; Matsuura, M.; Amii, H.; Uneyama, K. *Tetrahedron Lett.* **2002**, *43*, 2069.

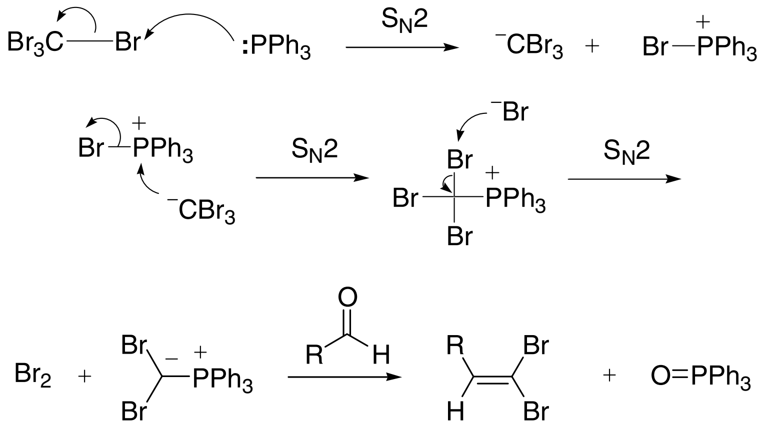
18 Chandrasekhar, S.; Narasihmulu, Ch.; Jagadeshwar, V.; Reddy, K. V. *Tetrahedron Lett.* **2003**, *44*, 3629.

19 Li, J. J. *Corey–Chaykovsky Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 1–14. (Review).

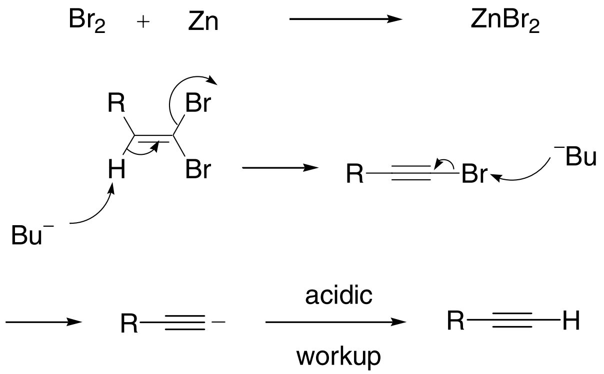
Corey−Fuchs reaction

One-carbon homologation of an aldehyde to dibromoolefin, which is then treated with *n*-BuLi to produce a terminal alkyne.

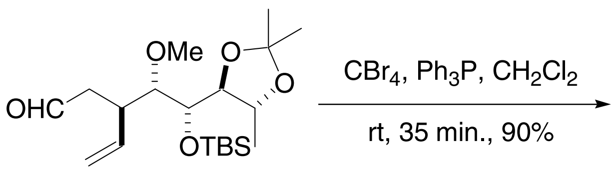


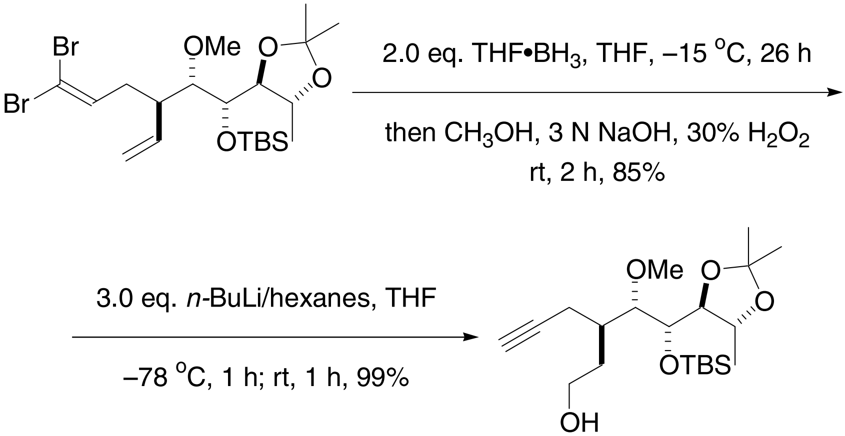


Wittig reaction (see page 621 for the mechanism)

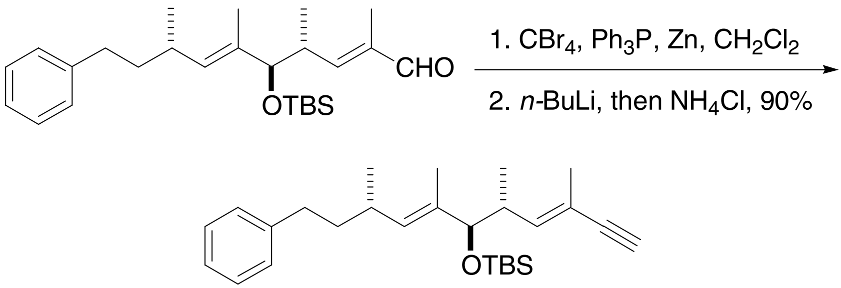


Example 1[3]





Example 2[8]



References

1 Corey, E. J.; Fuchs, P. L. *Tetrahedron Lett.* **1972**, *13,* 3769. Phil Fuchs is a professor at Purdue University.

2 For the synthesis of 1-bromalkynes see Grandjean, D.; Pale, P.; Chuche, J. *Tetrahedron Lett.* **1994**, *35*, 3529.

3 Gilbert, A. M.; Miller, R.; Wulff, W. D. *Tetrahedron* **1999**, *55*, 1607.

4 Muller, T. J. J. *Tetrahedron Lett*. **1999**, *40*, 6563.

5 Serrat, X.; Cabarrocas, G.; Rafel, S.; Ventura, M.; Linden, A.; Villalgordo, J. M. *Tetrahedron: Asymmetry* **1999**, *10*, 3417.

6 Okamura, W. H.; Zhu, G.-D.; Hill, D. K.; Thomas, R. J.; Ringe, K.; Borchardt, D. B.; Norman, A. W.; Mueller, L. J. *J. Org. Chem.* **2002**, *67*, 1637.

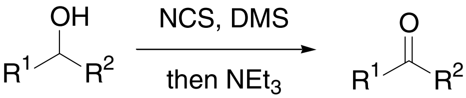
7 Falomir, E.; Murga, J.; Carda, M.; Marco, J. A. *Tetrahedron Lett*. **2003**, *44*, 539.

8 Zeng, X.; Zeng, F.; Negishi, E.-i. *Org. Lett*. **2004**, *6*, 3245.

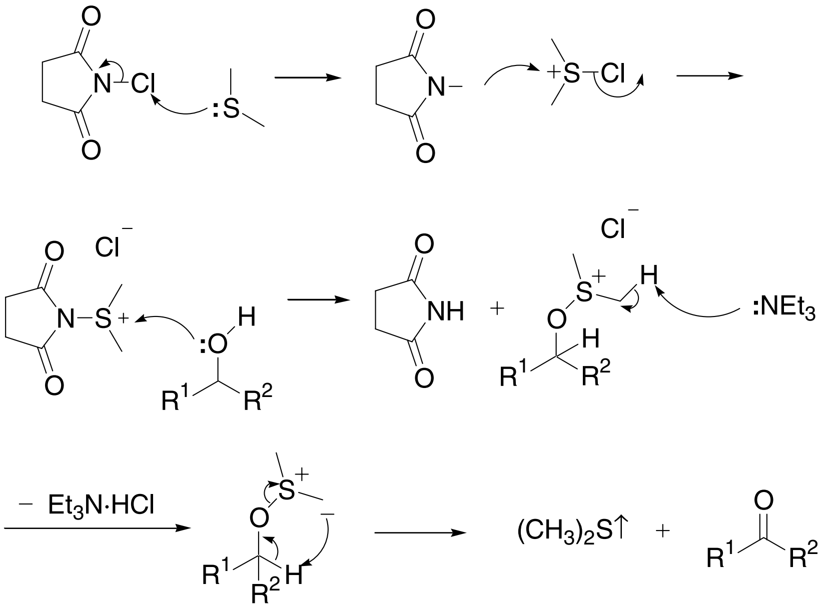
9 Quéron, E.; Lett, R. *Tetrahedron Lett*. **2004**, *45*, 4527.

Corey–Kim oxidation

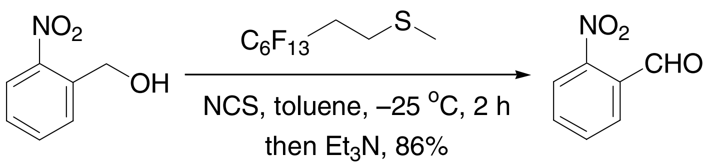
Oxidation of alcohol to the corresponding aldehyde or ketone using NCS/DMS, followed by treatment with a base. *Cf.* Swern oxidation.



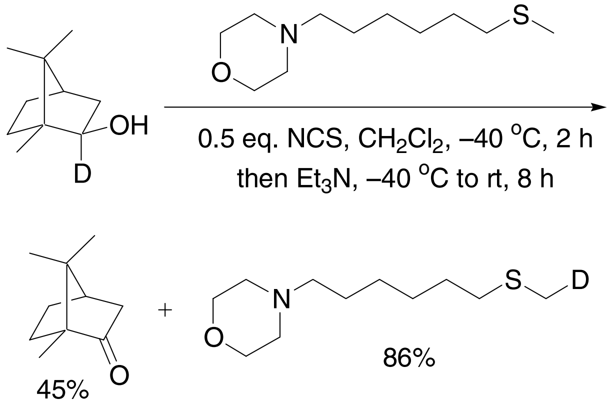
NCS = ***N*-C**hloro**s**uccinimide; DMS = **Dim**ethyl**s**ulfide.



Example 1, fluorous Corey–Kim reaction[5]



Example 2, odorless Corey–Kim reaction[8]

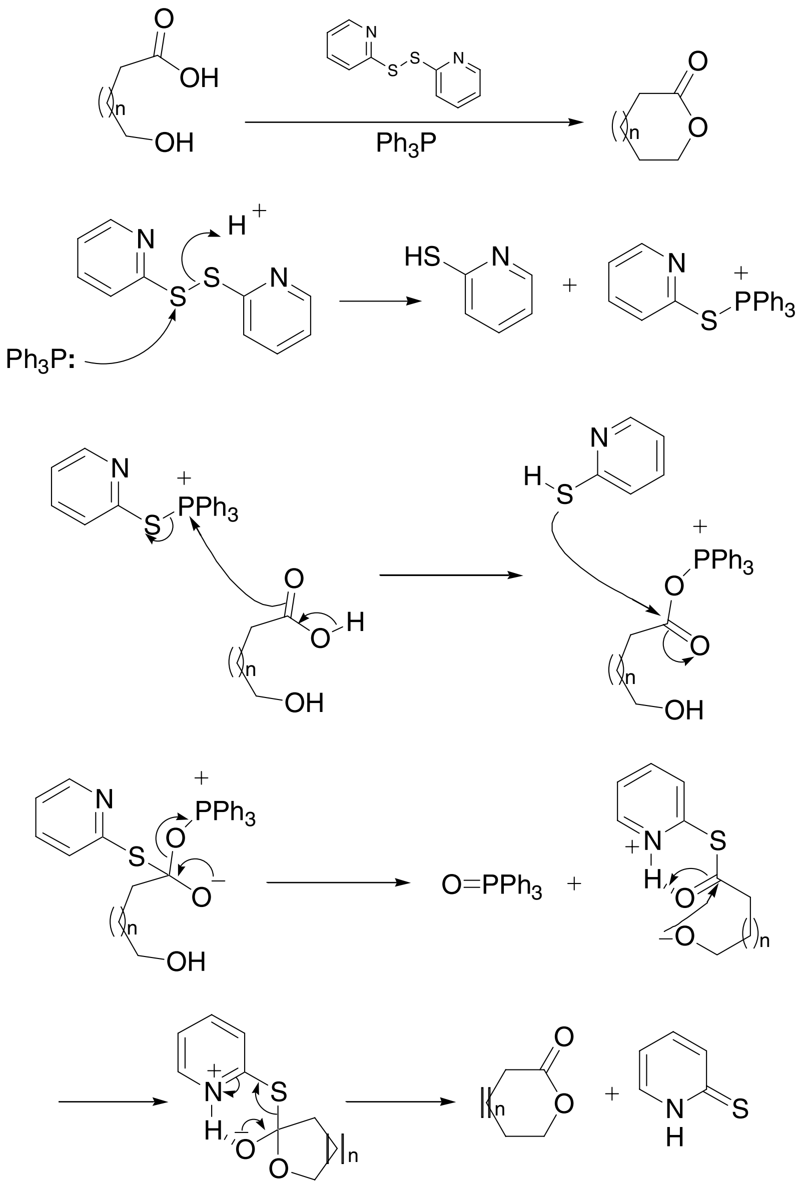


References

1 Corey, E. J.; Kim, C. U. *J. Am. Chem. Soc.* **1972**, *94*, 7586. Choung U. Kim now works at Gilead Sciences Inc., a company specialized in antiviral drugs in Foster City, California, where he co-discovered oseltamivir (Tamiflu).
2 Katayama, S.; Fukuda, K.; Watanabe, T.; Yamauchi, M. *Synthesis* **1988**, 178.
3 Shapiro, G.; Lavi, Y. *Heterocycles* **1990**, *31*, 2099.
4 Pulkkinen, J. T.; Vepsäläinen, J. J. *J. Org. Chem.* **1996**, *61*, 8604.
5 Crich, D.; Neelamkavil, S. *Tetrahedron* **2002**, *58*, 3865.
6 Nishide, K.; Ohsugi, S.-I.; Fudesaka, M.; Kodama, S.; Node, M. *Tetrahedron Lett.* **2002**, *43*, 5177.
7 Ohsugi, S.-I.; Nishide, K.; Oono, K.; Okuyama, K.; Fudesaka, M.; Kodama, S.; Node, M. *Tetrahedron* **2003**, *59*, 8393.
8 Nishide, K.; Patra, P. K.; Matoba, M.; Shanmugasundaram, K.; Node, M. *Green Chem.* **2004**, *6*, 142.

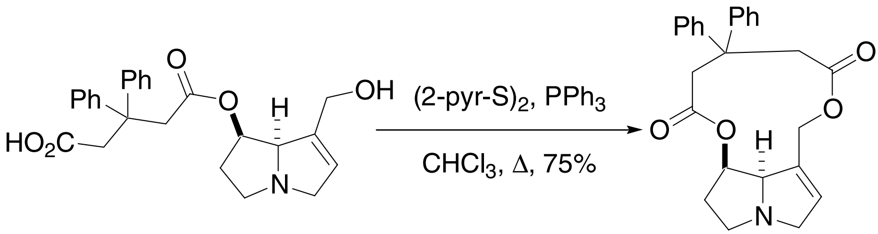
Corey–Nicolaou macrolactonization

Macrolactonization of ω-hydroxyl-acid using 2,2'-dipyridyl disulfide. Also known as Corey–Nicolaou double activation method.

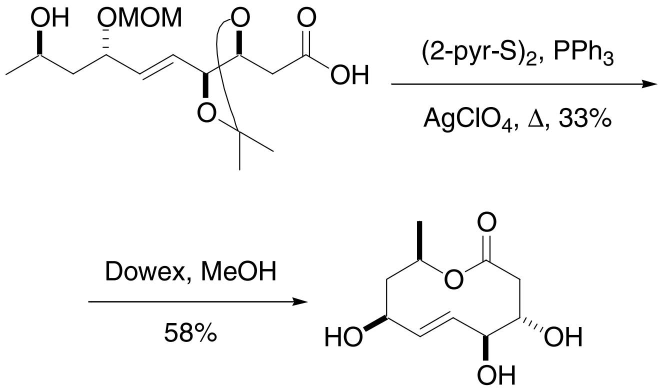


2-pyridinethione

Example 1[3]



Example 2[6]

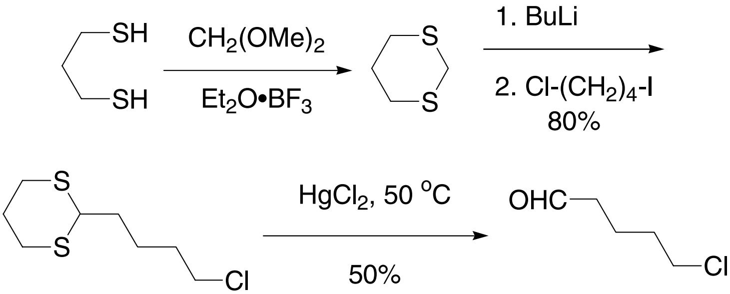


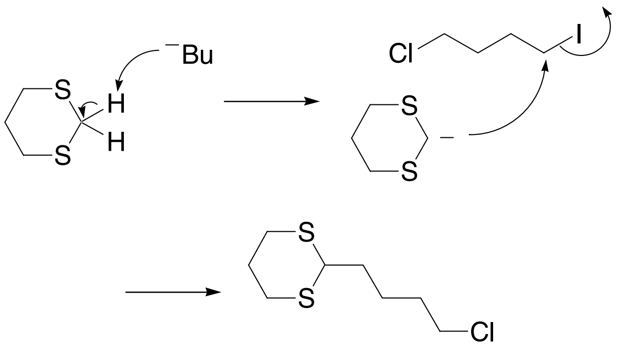
References

1. Corey, E. J.; Nicolaou, K. C. *J. Am. Chem. Soc.* **1974**, *96*, 5614.
2. Nicolaou, K. C. *Tetrahedron* **1977**, *33*, 683–710. (Review).
3. Devlin, J. A.; Robins, D. J.; Sakdarat, S. *J. Chem. Soc., Perkin Trans. 1* **1982**, 1117.
4. Barbour, R. H.; Robins, D. J. *J. Chem. Soc., Perkin Trans. 1* **1985**, 2475.
5. Barbour, R. H.; Robins, D. J. *J. Chem. Soc., Perkin Trans. 1* **1988**, 1169.
6. Andrus, M. B.; Shih, T.-L. *J. Org. Chem.* **1996**, *61*, 8780.
7. Lu, S.-F.; O'yang, Q. Q.; Guo, Z.-W.; Yu, B.; Hui, Y.-Z. *J. Org. Chem.* **1997**, *62*, 8400.
8. Sasaki, T.; Inoue, M.; Hirama, M. *Tetrahedron Lett.* **2001**, *42*, 5299.

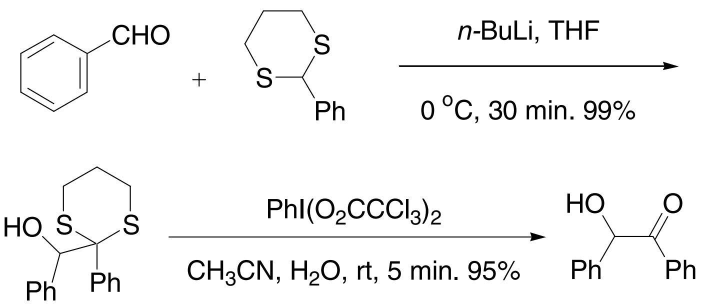
Corey–Seebach reaction

Dithiane as a nucleophile, serving as a masked carbonyl equivalent. This is an example of umpolung.

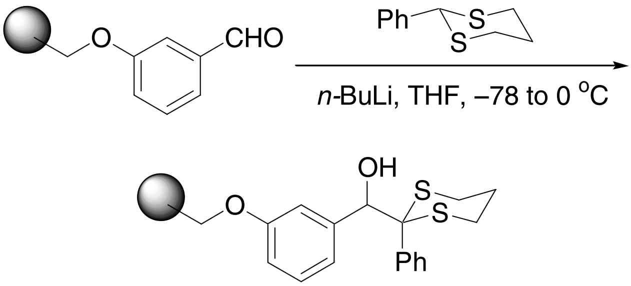




Example 1[6]



Example 2[8]

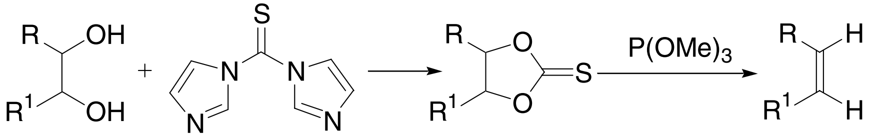


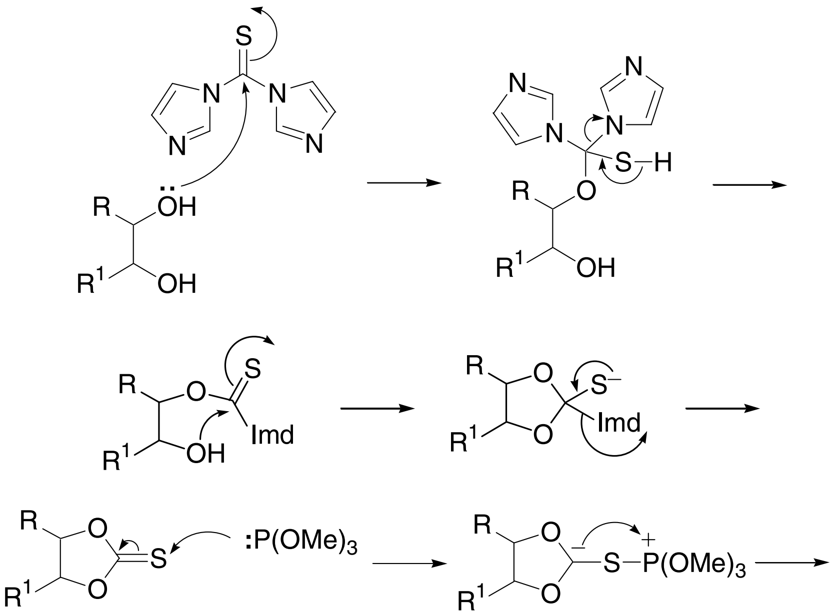
References

1. Corey, E. J.; Seebach, D. *Angew. Chem., Int. Ed.* **1965**, *4,* 1075, 1077. Dieter Seebach is a professor at ETH in Zürich, Switzerland.
2. Corey, E. J.; Seebach, D. *J. Org. Chem.* **1966**, *31*, 4097.
3. Seebach, D.; Jones, N. R.; Corey, E. J. *J. Org. Chem.* **1968**, *33*, 300.
4. Seebach, D.; Corey, E. J. *Org. Synth.* **1968**, *50*, 72.
5. Seebach, D.; Corey, E. J. *J. Org. Chem.* **1975**, *40*, 231.
6. Stowell, M. H. B.; Rock, R. S.; Rees, D. C.; Chan, S. I. *Tetrahedron Lett.* **1996**, *37*, 307.
7. Hassan, H. H. A. M.; Tamm, C. *Helv. Chim. Acta* **1996**, *79*, 518.
8. Lee, H. B.; Balasubramanian, S. *J. Org. Chem.* **1999**, *64*, 3454.
9. Bräuer, M.; Weston, J.; Anders, E. *J. Org. Chem.* **2000**, *65*, 1193.

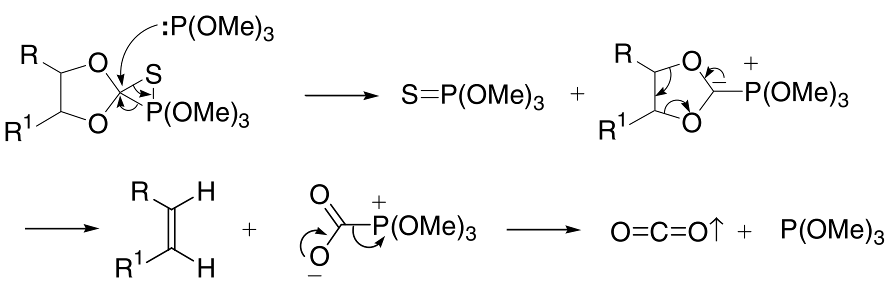
Corey–Winter olefin synthesis

Transformation of diols to the corresponding olefins by sequential treatment with 1,1'-thiocarbonyldiimidazole and trimethylphosphite. Also known as Corey–Winter reductive elimination, or Corey–Winter reductive olefination.

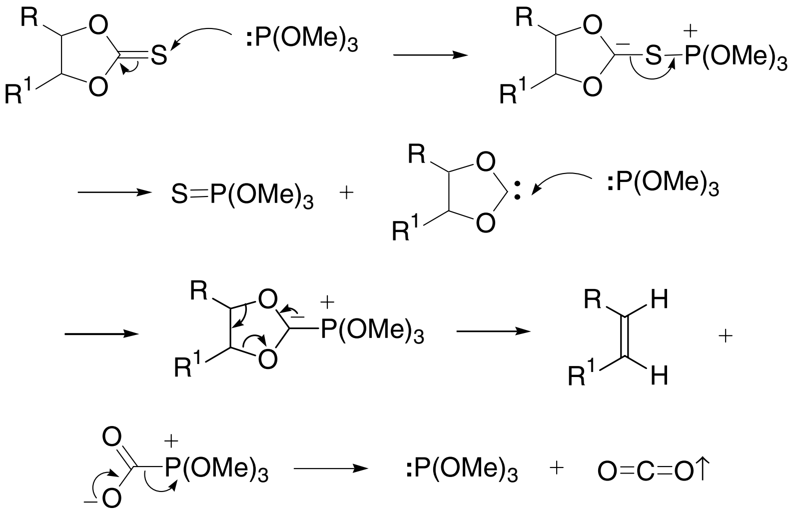




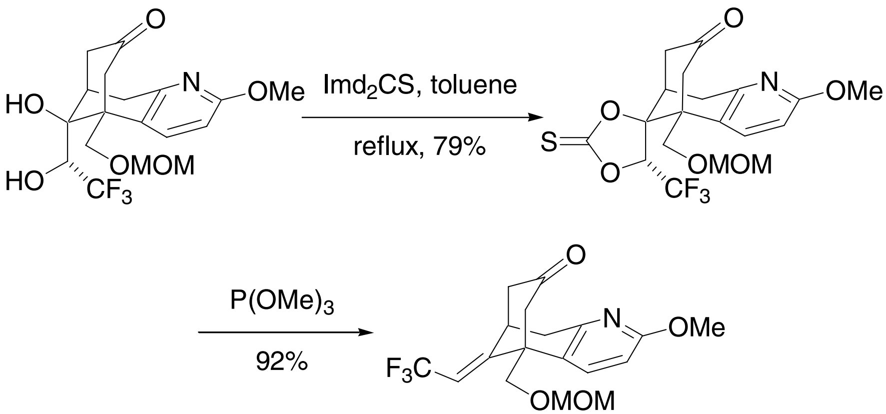
1,3-dioxolane-2-thione (cyclic thiocarbonate)



A mechanism involving a carbene intermediate can also be drawn and is supported by pyrolysis studies:

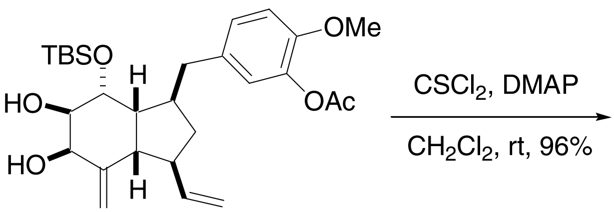


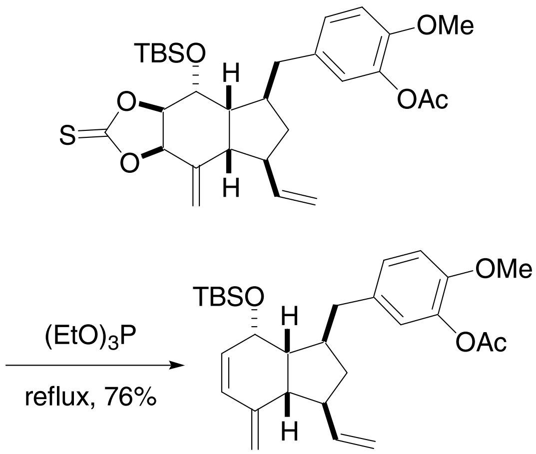
Example 1[7]



One olefin isomer

Example 2[11]



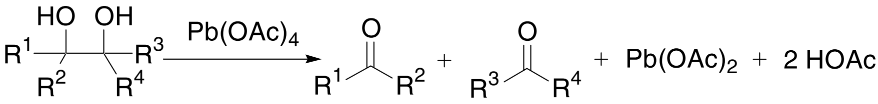


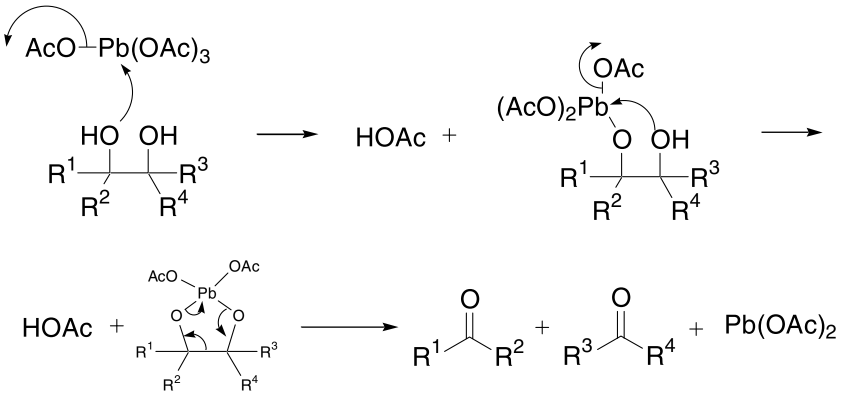
References

1. Corey, E. J.; Winter, R. A. E. *J. Am. Chem. Soc.* **1963**, *85*, 2677. Roland A. E. Winter is at Ciba Specialty Chemicals Corporation, USA.
2. Horton, D.; Tindall, C. G., Jr. *J. Org. Chem.* **1970**, *35*, 3558.
3. Hartmann, W.; Fischler, H.-M.; Heine, H.-G. *Tetrahedron Lett.* **1972**, *13,* 853.
4. Block, E. *Org. React.* **1984**, *30*, 457. (Review).
5. Dudycz, L. W. *Nucleosides Nucleotides* **1989**, *8*, 35.
6. Carr, R. L. K.; Donovan, T. A., Jr.; Sharma, M. N.; Vizine, C. D.; Wovkulich, M. J. *Org. Prep. Proced. Int.* **1990**, *22*, 245.
7. Kaneko, S.; Nakajima, N.; Shikano, M.; Katoh, T.; Terashima, S. *Tetrahedron* **1998**, *54*, 5485.
8. Crich, D.; Pavlovic, A. B.; Wink, D. J. *Synth. Commun.* **1999**, *29*, 359.
9. Palomo, C.; Oiarbide, M.; Landa, A.; Esnal, A.; Linden, A. *J. Org. Chem.* **2001**, *66*, 4180.
10. Saito, Y.; Zevaco, T. A.; Agrofoglio, L. A. *Tetrahedron* **2002**, *58*, 9593.
11. Araki, H.; Inoue, M.; Katoh, T. *Synlett* **2003**, 2401.

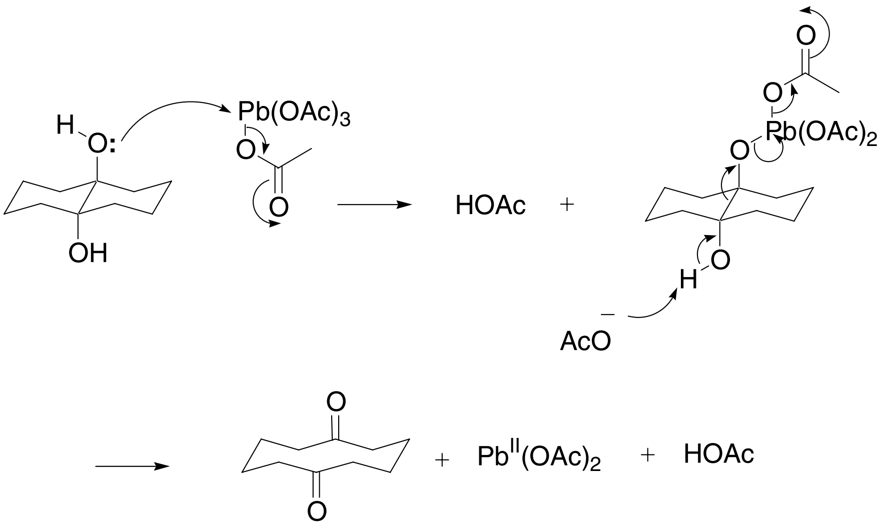
Criegee glycol cleavage

Vicinal diol is oxidized to the two corresponding carbonyl compounds using $Pb(OAc)_4$, **l**ead **t**etra**a**cetate (LTA).

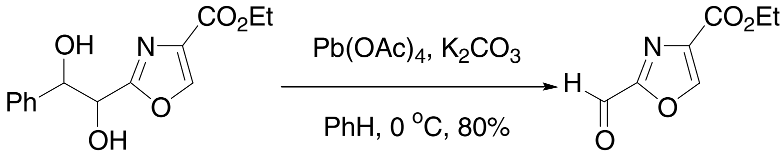




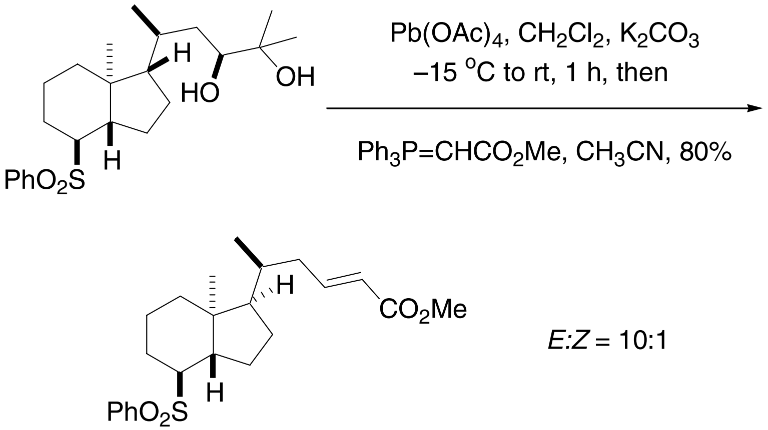
An acyclic mechanism is possible as well. It is much slower than the cyclic mechanism, but is operative when the cyclic intermediate can not form:[3]



Example 1[7]



Example 2[9]



References

1 Criegee, R. *Ber. Dtsch. Chem. Ges.* **1931**, *64*, 260. Rudolf Criegee (1902–1975) was born in Düsseldorf, Germany. He earned his Ph.D. at age 23 under K. Dimroth at Würzburg. Criegee became a professor at Technical Institute at Karlsruhe in 1937, a chair in 1947. He was known for his modesty, mater-of-factness, and his breadth of interests.

2 Mihailovici, M. L.; Cekovik, Z. *Synthesis* **1970**, 209–224. (Review).

3 March, J. *Advanced Organic Chemistry,* 5th ed., Wiley & Sons: Hoboken, NJ, **2003**.

4 Danielmeier, K.; Steckhan, E. *Tetrahedron: Asymmetry* **1995**, *6*, 1181.

5 Masuda, T.; Osako, K.; Shimizu, T.; Nakata, T. *Org. Lett.* **1999**, *1*, 941.

6 Lautens, M.; Stammers, T. A. *Synthesis* **2002**, 1993.

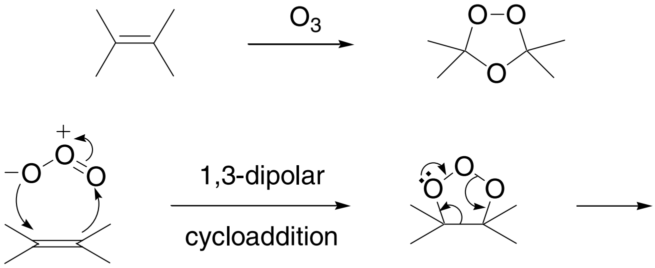
7 Hartung, I. V.; Eggert, U.; Haustedt, L. O.; Niess, B.; Schäfer, P. M.; Hoffmann, H. M. R. *Synthesis* **2003**, 1844.

8 Gaul, C.; Njardarson, J. T.; Danishefsky, S. J. *J. Am. Chem. Soc.* **2003**, *125*, 6042.

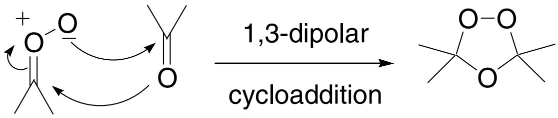
9 Gorobets, E.; Stepanenko, V.; Wicha, J. *Eur. J. Org. Chem.* **2004**, 783.

10 Mori, K.; Rikimaru, K.; Kan, T.; Fukuyama, T. *Org. Lett.* **2004**, *6*, 3095.

Criegee mechanism of ozonolysis



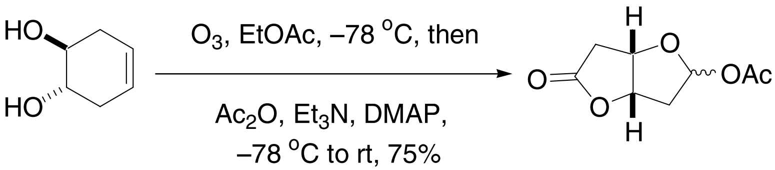
primary ozonide (1,2,3-trioxolane)



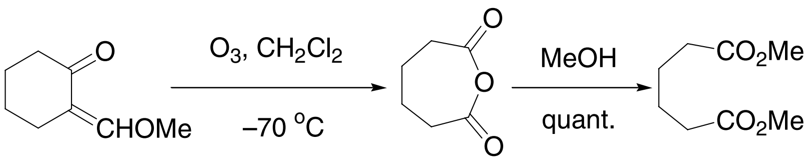
zwitterionic peroxide
(Criegee zwitterion)
also known as "carbonyl oxide"

secondary ozonide (1,2,4-trioxolane)

Example 1[14]



Example 2[15]



References

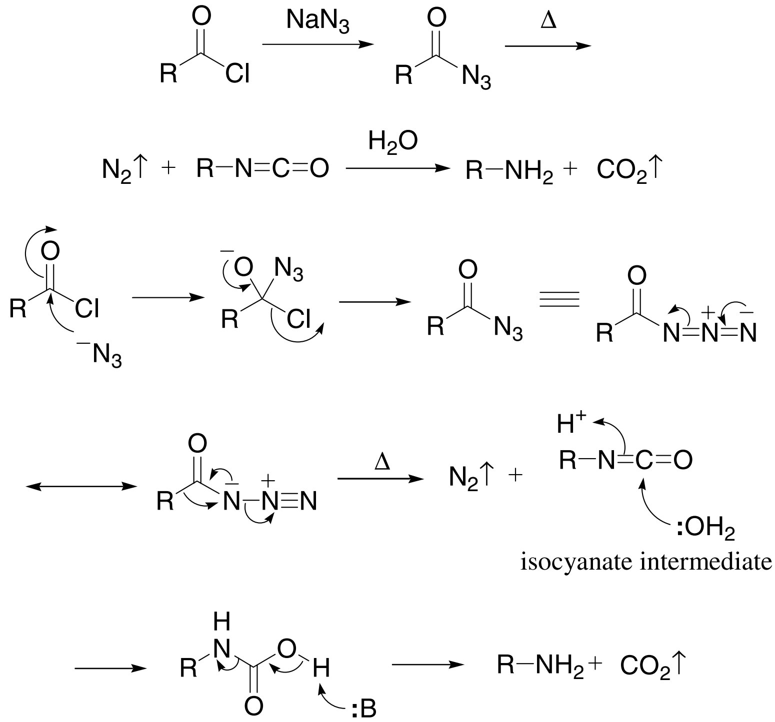
1. Criegee, R.; Wenner, G. *Justus Liebigs Ann. Chem.* **1949**, *564*, 9.
2. Criegee, R. *Rec. Chem. Prog.* **1957**, *18*, 111.
3. Criegee, R. *Angew. Chem.* **1975**, *87*, 765.
4. Klopman, G.; Joiner, C. M. *J. Am. Chem. Soc.* **1975**, *97*, 5287.
5. Bailey, P. S.; Ferrell, T. M. *J. Am. Chem. Soc.* **1978**, *100*, 899.

6. Schreiber, S. L.; Liew, W.-F. *Tetrahedron Lett*. **1983**, *24*, 2363.
7. Wojciechowski, B. J.; Pearson, W. H.; Kuczkowski, R. L. *J. Org. Chem*. **1989**, *54*, 115.
8. Bunnelle, W. H. *Chem. Rev.* **1991**, *91*, 335–362. (Review).
9. Kuczkowski, R. L. *Chem. Soc. Rev.* **1992**, *21*, 79–83. (Review).
10. Marshall, J. A.; Garofalo, A. W. *J. Org. Chem*. **1993**, *58*, 3675.
11. Ponec, R.; Yuzhakov, G.; Haas, Y.; Samuni, U. *J. Org. Chem*. **1997**, *62*, 2757.
12. Anglada, J. M.; Crehuet, R.; Maria Bofill, J. *Chem. Eur. J*. **1999**, *5*, 1809.
13. Dussault, P. H.; Raible, J. M. *Org. Lett*. **2000**, *2*, 3377.
14. Jiang, L.; Martinelli, J. R.; Burke, S. D. *J. Org. Chem*. **2003**, *68*, 1150.
15. Schank, K.; Beck, H.; Pistorius, S. *Helv. Chim. Acta* **2004**, *87*, 2025.

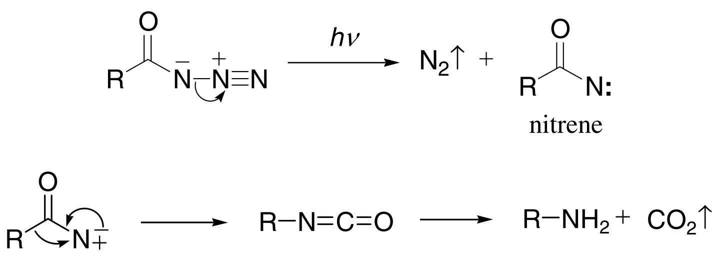
Curtius rearrangement

Thermal or photochemical rearrangement of acyl azides into amines *via* isocyanate intermediates. While the thermal rearrangement is a concerted process, the photochemical rearrangement goes through a nitrene intermediate.

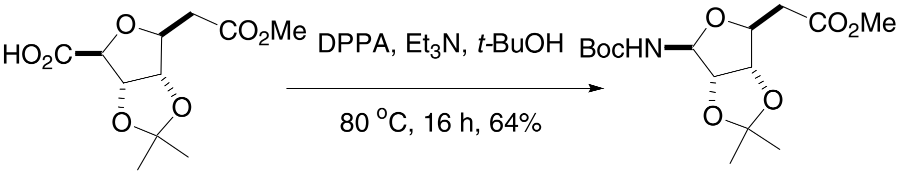
The thermal rearrangement:



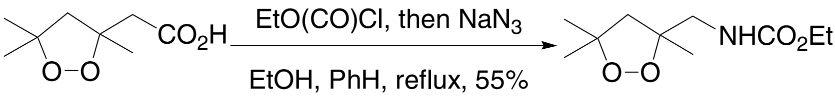
The photochemical rearrangement:



Example 1[9]



Example 2[11]

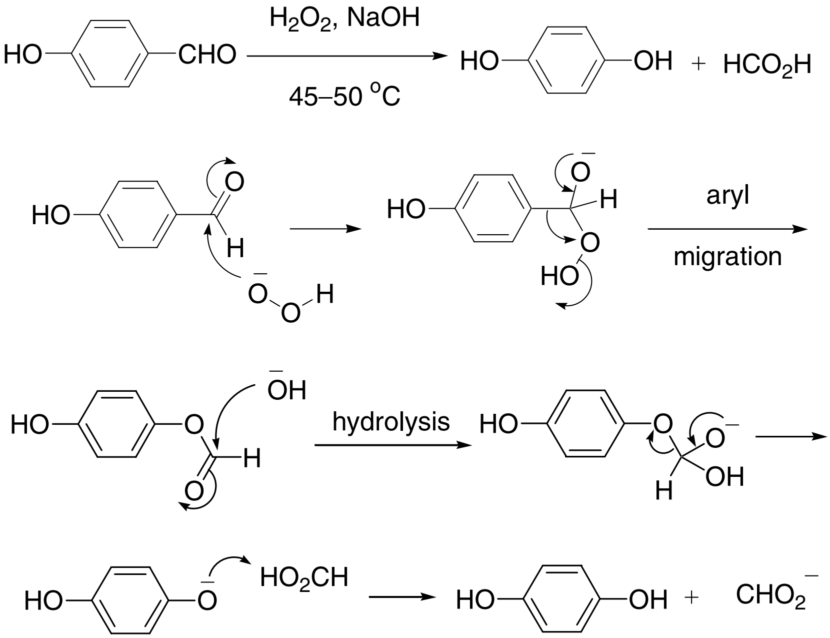


References

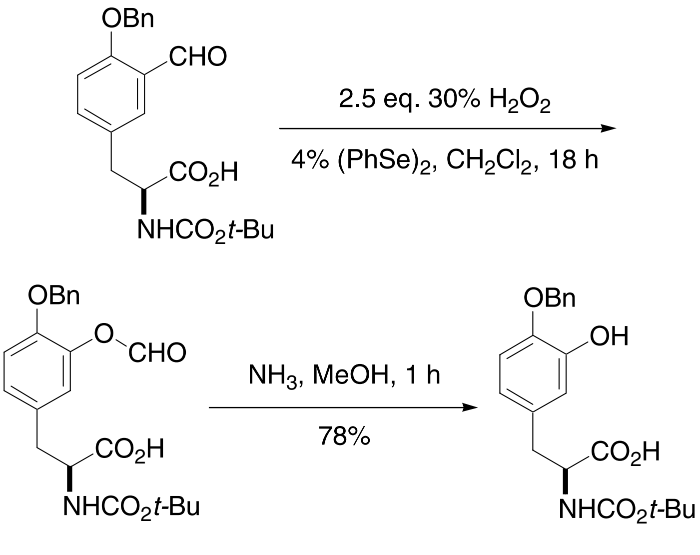
1. Curtius, T. *Ber. Dtsch. Chem. Ges.* **1890**, *23*, 3023. Theodor Curtius (1857–1928) was born in Duisburg, Germany. He studied music before switching to chemistry under Bunsen, Kolbe, and von Baeyer before succeeding Victor Meyer as a Professor of Chemistry at Heidelberg. He discovered diazoacetic ester, hydrazine, pyrazoline derivatives, and many nitrogen-heterocycles. Curtius also sang in concerts and composed music.
2. Chen, J. J.; Hinkley, J. M.; Wise, D. S.; Townsend, L. B. *Synth. Commun.* **1996**, *26*, 617.
3. am Ende, D. J.; DeVries, K. M.; Clifford, P. J.; Brenek, S. J. *Org. Process Res. Dev.* **1998**, *2*, 382.
4. Braibante, M. E. F.; Braibante, H. S.; Costenaro, E. R. *Synthesis* **1999**, 943.
5. Migawa, M. T.; Swayze, E. E. *Org. Lett.* **2000**, *2*, 3309.
6. El Haddad, M.; Soukri, M.; Lazar, S.; Bennamara, A.; Guillaumet, G.; Akssira, M. *J. Heterocycl. Chem.* **2000**, *37*, 1247.
7. Moore, J. D.; Sprott, K. T.; Hanson, P. R. *J. Org. Chem.* **2002**, *67*, 8123.
8. Mamouni, R.; Aadil, M.; Akssira, M.; Lasri, J.; Sepulveda-Arques, J. *Tetrahedron Lett.* **2003**, *44*, 2745.
9. van Well, R. M.; Overkleeft, H. S.; van Boom, J. H.; Coop, A.; Wang, J. B.; Wang, H.; van der Marel, G. A.; Overhand, M. *Eur. J. Org. Chem.* **2003**, 1704.
10. Kedrowski, B. L. *J. Org. Chem.* **2003**, *68*, 5403.
11. Dussault, P. H.; Xu, C. *Tetrahedron Lett.* **2004**, *45*, 7455.
12. Holt, J.; Andreassen, T.; Bakke, J. M.; Fiksdahl, A. *J. Heterocycl. Chem.* **2005**, *42*, 259.

Dakin oxidation

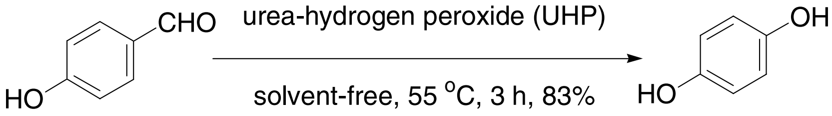
Oxidation of aryl aldehydes or aryl ketones to phenols using basic hydrogen peroxide conditions. *Cf.* Baeyer–Villiger oxidation.



Example 1[6]



Example 2[7]

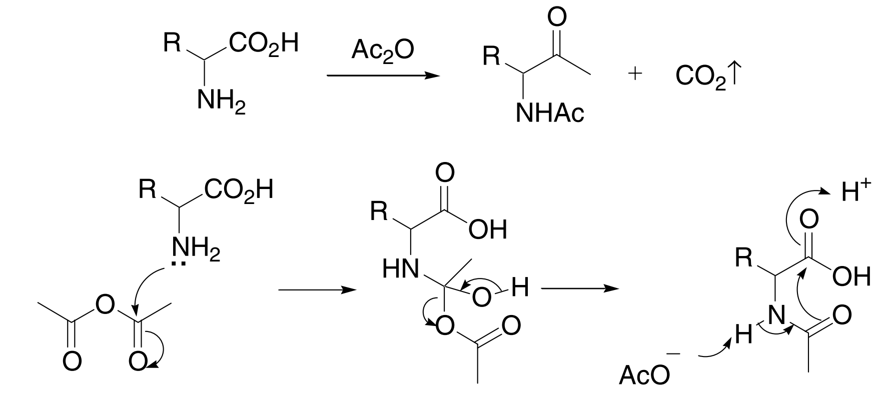


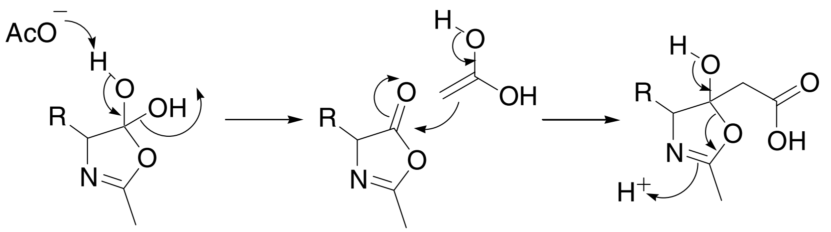
References:

1. Dakin, H. D. *J. Am. Chem. Soc.* **1909**, *42*, 477. Henry D. Dakin (1880–1952) was born in London, England. During WWI, he invented his hypochlorite solution (Dakin's solution), which became a popular antiseptic for the treatment of wounds. After the Great War, he emmigrated to New York, where he investigated the B vitamins.
2. Hocking, M. B.; Bhandari, K.; Shell, B.; Smyth, T. A. *J. Org. Chem.* **1982**, *47*, 4208.
3. Matsumoto, M.; Kobayashi, H.; Hotta, Y. *J. Org. Chem.* **1984**, *49*, 4740.
4. Zhu, J.; Beugelmans, R.; Bigot, A.; Singh, G. P.; Bois-Choussy, M. *Tetrahedron Lett.* **1993**, *34*, 7401.
5. Guzmán, J. A.; Mendoza, V.; García, E.; Garibay, C. F.; Olivares, L. Z.; Maldonado, L. A. *Synth. Commun.* **1995**, *25*, 2121.
6. Jung, M. E.; Lazarova, T. I. *J. Org. Chem.* **1997**, *62*, 1553.
7. Varma, R. S.; Naicker, K. P. *Org. Lett.* **1999**, *1*, 189.
8. Roy, A.; Reddy, K. R.; Mohanta, P. K.; Ila, H.; Junjappa, H. *Synth. Commun.* **1999**, *29*, 3781.
9. Lawrence, N. J.; Rennison, D.; Woo, M.; McGown, A. T.; Hadfield, J. A. *Bioorg. Med. Chem. Lett.* **2001**, *11*, 51.

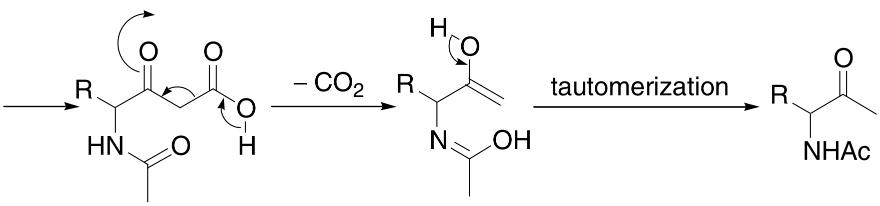
Dakin–West reaction

The direct conversion of an α-amino acid into the corresponding α-acetylamino-alkyl methyl ketone, *via* oxazoline (azalactone) intermediates. The reaction proceeds in the presence of acetic anhydride and a base such as pyridine with the evolution of CO_2.

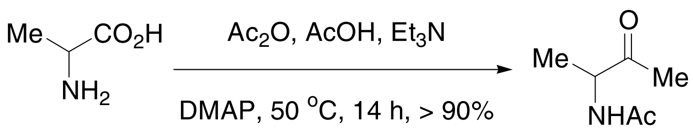




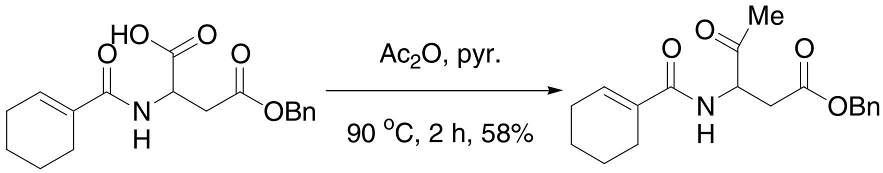
oxazolone (azalactone) intermediate



Example 1[12]



Example 2[14]

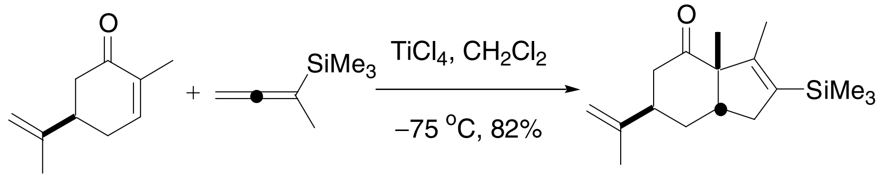


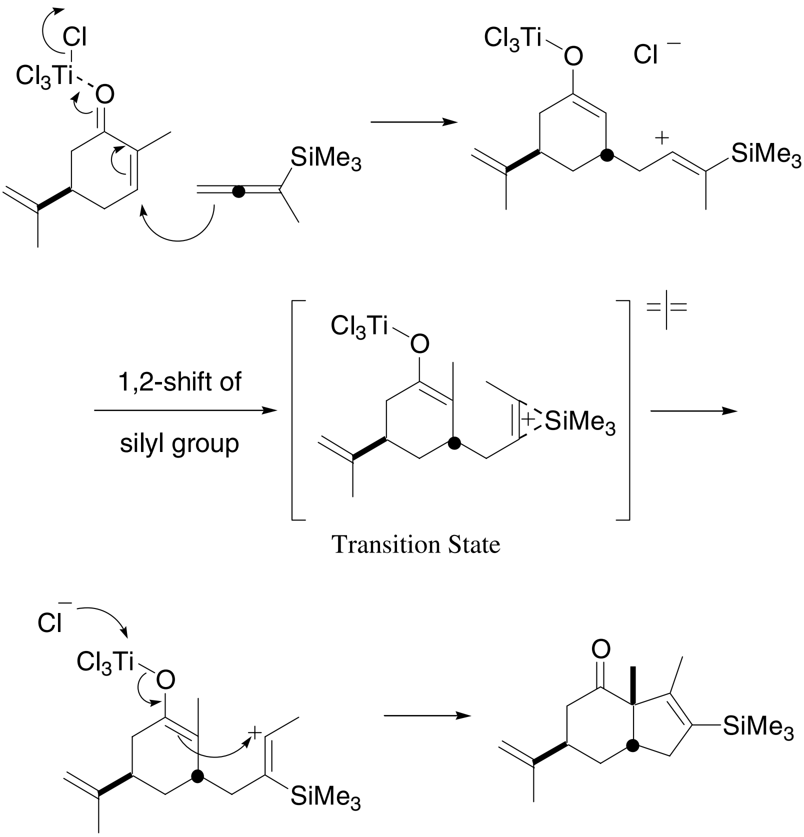
References:

1. Dakin, H. D.; West, R. *J. Biol. Chem.* **1928**, *78,* 91, 745, and 757. In 1928, Henry Dakin and Rudolf West, a clinician, reported on the reaction of α-amino acids with acetic anhydride to give α-acetamido ketones *via* azalactone intermediates. Interestingly, one year before this paper by Dakin and West, Levene and Steiger had observed both tyrosine and α-phenylananine gave "abnormal" products when acetylated under these conditions.[2,3] Unfortunately, they were slow to identify the products and lost an opportunity to be immortalized by a name reaction.
2. Levene, P. A.; Steiger, R. E. *J. Biol. Chem.* **1927**, *74,* 689.
3. Levene, P. A.; Steiger, R. E. *J. Biol. Chem.* **1928**, *79,* 95.
4. Cornforth, J. W.; Elliott, D. F. *Science* **1950**, *112*, 534.
5. Allinger, N. L.; Wang, G. L.; Dewhurst, B. B. *J. Org. Chem.* **1974**, *39*, 1730.
6. Buchanan, G. L. *Chem. Soc. Rev.* **1988**, *17*, 91. (Review).
7. Jung, M. E.; Lazarova, T. I. *J. Org. Chem.* **1997**, *62*, 1553.
8. Kawase, M.; Hirabayashi, M.; Koiwai, H.; Yamamoto, K.; Miyamae, H. *Chem. Commun.* **1998**, 641.
9. Kawase, M.; Okada, Y.; Miyamae, H. *Heterocycles* **1998**, *48*, 285.
10. Kawase, M.; Hirabayashi, M.; Kumakura, H.; Saito, S.; Yamamoto, K. *Chem. Pharm. Bull.* **2000**, *48*, 114.
11. Kawase, M.; Hirabayashi, M.; Saito, S. *Recent Res. Dev. Org. Chem.* **2001**, *4*, 283–293. (Review).
12. Fischer, R. W.; Misun, M. *Org. Proc. Res. Dev.* **2001**, *5*, 581.
13. Orain, D.; Canova, R.; Dattilo, M.; Klöppner, E.; Denay, R.; Koch, G.; Giger, R. *Synlett* **2002**, 1443.
14. Godfrey, A. G.; Brooks, D. A.; Hay, L. A.; Peters, M.; McCarthy, J. R.; Mitchell, D. *J. Org. Chem.* **2003**, *68*, 2623.
15. Khodaei, M. M.; Khosropour, A. R.; Fattahpour, P. *Tetrahedron Lett.* **2005**, *46*, 2105.

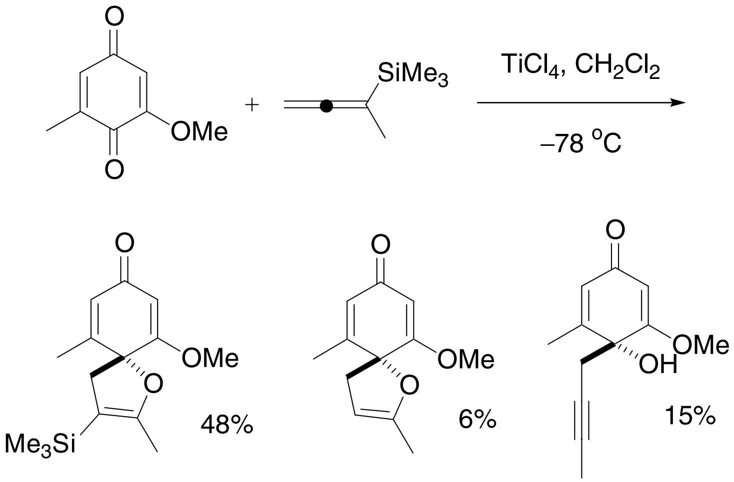
Danheiser annulation

Trimethylsilylcyclopentene annulation from an α,β-unsaturated ketone and trimethylsilylallene in the presence of a Lewis acid.

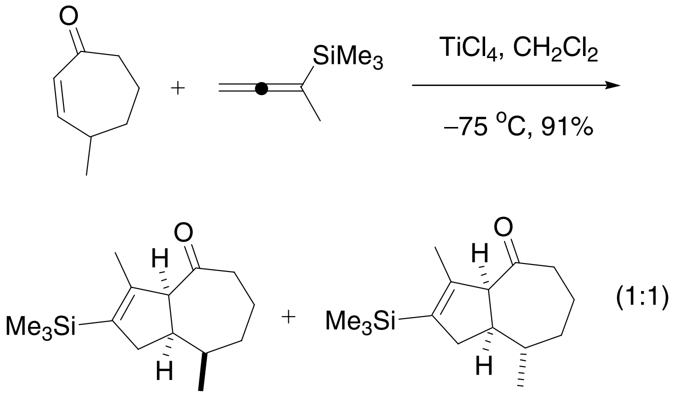




Example 1[7]



Example 2[8]

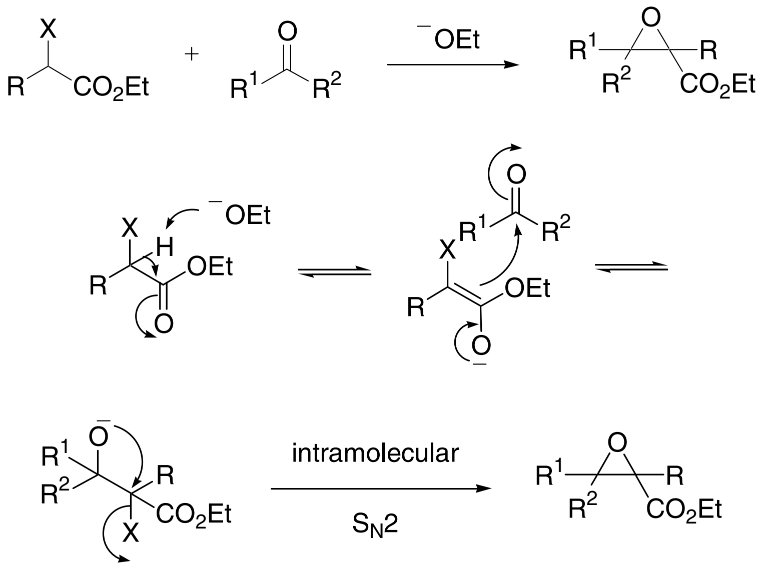


References

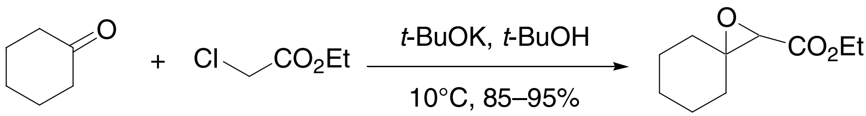
1. Danheiser, R. L.; Carini, D. J.; Basak, A. *J. Am. Chem. Soc.* **1981**, *103*, 1604. Rick L. Danheiser earned his Ph.D. at Harvard under E. J. Corey. He is a professor at MIT.
2. Danheiser, R. L.; Carini, D. J.; Fink, D. M.; Basak, A. *Tetrahedron* **1983**, *39*, 935.
3. Danheiser, R. L.; Kwasigroch, C. A.; Tsai, Y.-M. *J. Am. Chem. Soc.* **1985**, *107*, 7233.
4. Danheiser, R. L.; Carini, D. J.; Kwasigroch, C. A. *J. Org. Chem.* **1986**, *51*, 3870.
5. Danheiser, R. L.; Tsai, Y.-M.; Fink, D. M. *Org. Synth.* **1988**, *66,* 1.
6. Danheiser, R. L.; Dixon, B. R.; Gleason, R. W. *J. Org. Chem.* **1992**, *57*, 6094.
7. Engler, T. A.; Agrios, K.; Reddy, J. P.; Iyengar, R. *Tetrahedron Lett.* **1996**, *37*, 327.
8. Friese, J. C.; Krause, S.; Schäfer, H. J. *Tetrahedron Lett.* **2002**, *43*, 2683.

Darzens glycidic ester condensation

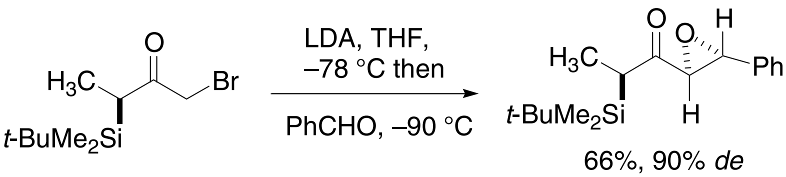
α,β-Epoxy esters (glycidic esters) from base-catalyzed condensation of α-haloesters with carbonyl compounds.



Example 1[4]



Example 2[9]



References

1 Darzens, G. A. *Compt. Rend. Acad. Sci.* **1904**, *139,* 1214. George Auguste Darzens (1867−1954) born in Moscow, Russia, studied at École Polytechnique in Paris and stayed there as a professor.

2 Newman, M. S.; Magerlein, B. J. *Org. React.* **1949**, *5*, 413–441. (Review).

3 Ballester, M. *Chem. Rev.* **1955**, *55*, 283–300. (Review).

4 Hunt, R. H.; Chinn, L. J.; Johnson, W. S. *Org. Syn. Coll.* **1963**, *4*, 459.

5 Bauman, J. G.; Hawley, R. C.; Rapoport, H. *J. Org. Chem.* **1984**, *49*, 3791.

6 Rosen, T. *Darzens Glycidic Ester Condensation* In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon: Oxford, **1991**, vol. 2, pp 409–439. (Review).

7 Takahashi, T.; Muraoka, M.; Capo, M.; Koga, K. *Chem. Pharm. Bull*. **1995**, *43*, 1821.

8 Ohkata, K.; Kimura, J.; Shinohara, Y.; Takagi, R.; Hiraga, Y. *Chem. Commun.* **1996**, 2411.

9 Enders, D.; Hett, R. *Synlett* **1998**, 961.

10 Takagi, R.; Kimura, J.; Shinohara, Y.; Ohba, Y.; Takezono, K.; Hiraga, Y.; Kojima, S.; Ohkata, K. *J. Chem. Soc., Perkin Trans. 1* **1998**, 689.

11 Hirashita, T.; Kinoshita, K.; Yamamura, H.; Kawai, M.; Araki, S. *J. Chem. Soc., Perkin Trans. 1* **2000**, 825.

12 Shinohara, Y.; Ohba, Y.; Takagi, R.; Kojima, S.; Ohkata, K. *Heterocycles* **2001**, *55*, 9.

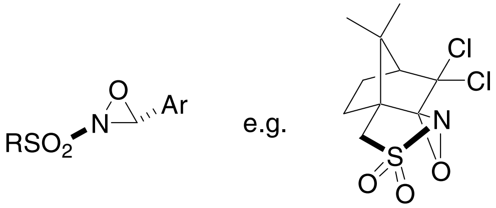
13 Arai, A.; Suzuki, Y.; Tokumaru, K.; Shioiri, T. *Tetrahedron Lett*. **2002**, *43*, 833.

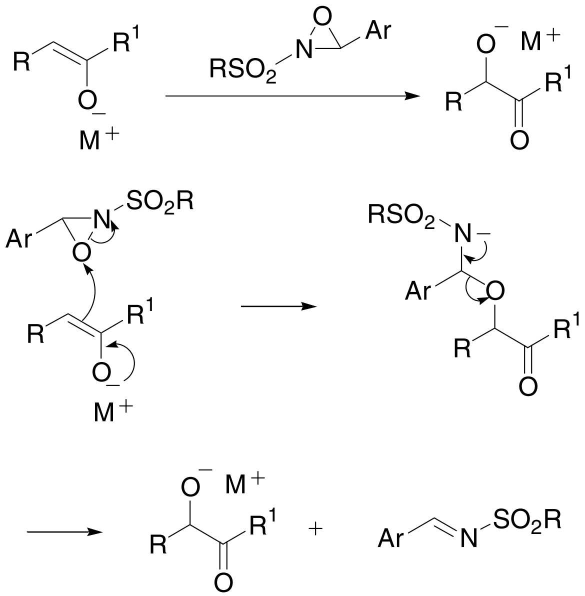
14 Davis, F. A.; Wu, Y.; Yan, H.; McCoull, W.; Prasad, K. R. *J. Org. Chem.* **2003**, *68*, 2410.

15 Myers, B. J. *Darzens Glycidic Ester Condensation* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 15–21. (Review).

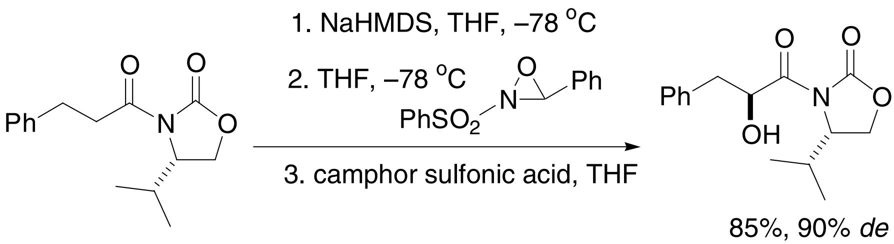
Davis chiral oxaziridine reagents

Chiral *N*-sulfonyloxaziridines employed for asymmetric hydroxylation, *etc.*

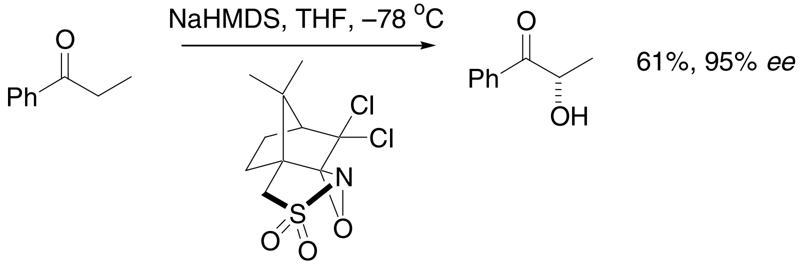




Example 1[2]



Example 2[5]



References

1 Davis, F. A.; Vishwakarma, L. C.; Billmers, J. M.; Finn, J. *J. Org. Chem.* **1984**, *49*, 3241. Franklin A. Davis developed this methodology while teaching at Drexel University, now he is at Temple University.

2 Evans, D. A.; Morrissey, M. M.; Dorow, R. L. *J. Am. Chem. Soc.* **1985**, *107*, 4346.

3 Davis, F. A.; Billmers, J. M.; Gosciniak, D. J.; Towson, J. C.; Bach, R. D. *J. Org. Chem.* **1986**, *51*, 4240.

4 Davis, F. A.; Sheppard, A. C. *Tetrahedron* **1989**, *45*, 5703. (Review).

5 Davis, F. A.; Weismiller, M. C. *J. Org. Chem.* **1990**, *55*, 3715.

6 Davis, F. A.; Chen, B.-C. *Chem. Rev.* **1992**, *92*, 919–934. (Review).

7 Davis, F. A.; Thimma Reddy, R.; Weismiller, M. C. *J. Am. Chem. Soc.* **1989**, *111*, 5964.

8 Davis, F. A.; Kumar, A.; Chen, B.-C. *J. Org. Chem.* **1991**, *56*, 1143.

9 Davis, F. A.; Reddy, R. T.; Han, W.; Carroll, P. J. *J. Am. Chem. Soc.* **1992**, *114*, 1428.

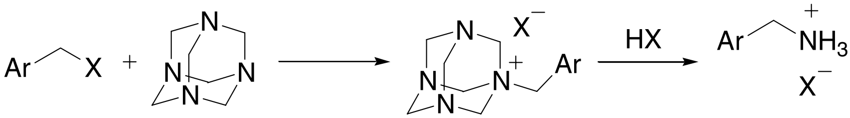
10 Tagami, K.; Nakazawa, N.; Sano, S.; Nagao, Y. *Heterocycles* **2000**, *53*, 771.

11 Takeda, K.; Sawada, Y.; Sumi, K. *Org. Lett.* **2002**, *4*, 1031.

12 Chen, B.-C.; Zhou, P.; Davis, F. A.; Ciganek, E. *Org. React.* **2003**, *62*, 1–356. (Review).

Delépine amine synthesis

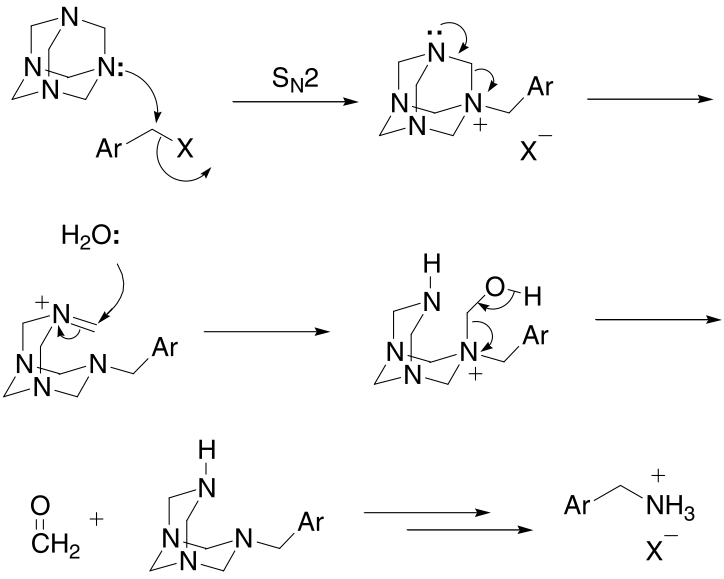
The reaction between alkyl halides and hexamethylenetetramine, followed by cleavage of the resulting salt with ethanolic HCl to yield primary amines.
Cf. Gabriel synthesis, where the product is also amine and Sommelet reaction, where the product is aldehyde. The Delépine works well for active halides such as benzyl, allyl halides, and α-halo-ketones.



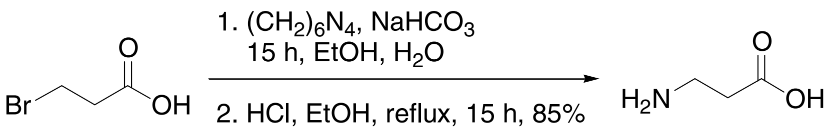
hexamethylenetetramine

$$[ArCH_2{}^{-}C_6H_{12}N_4]^{+}X^{-} \quad + \quad 3HCl \quad + 6H_2O$$

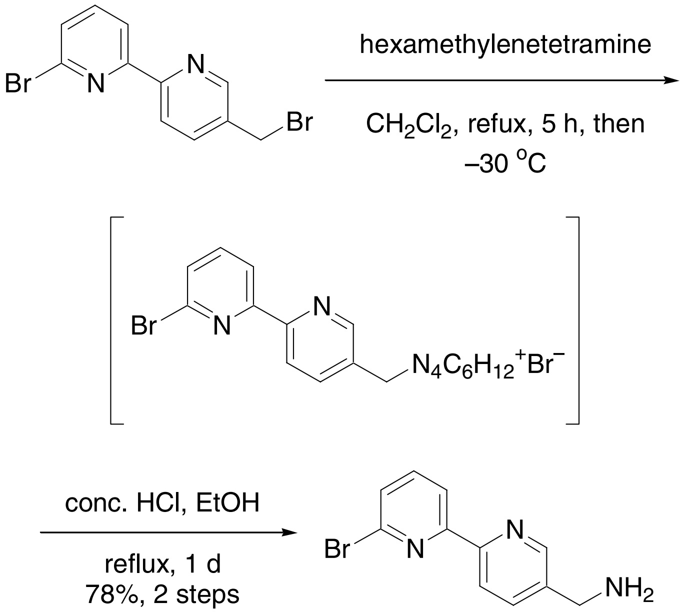
$$= \ ArCH_2NH_2{\bullet}HX \quad + \quad 6CH_2O \quad + \quad 3NH_4Cl$$



Example 1[4]



Example 2[8]

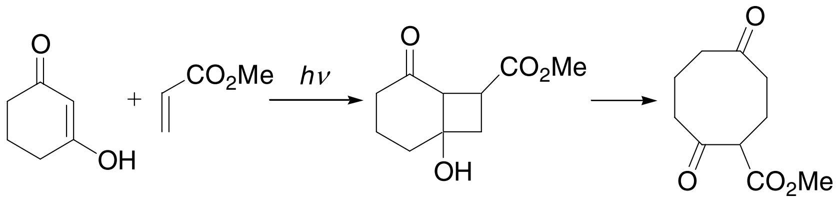


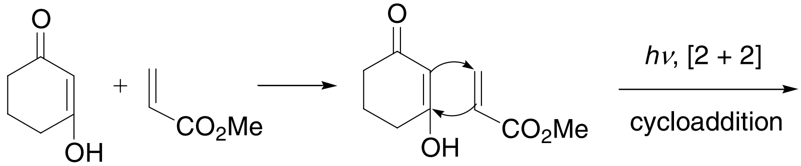
References

1. Delépine, M. *Bull. Soc. Chim. Paris* **1895**, *13*, 355; **1897**, *17*, 290. Stephe Marcel Delépine (1871–1965) was born in St. Martin le Gaillard, France. He was a professor at the Collège de France after working for M. Bertholet at that institute. Delépine's long and fruitful career in science encompassed organic chemistry, inorganic chemistry, and pharmacy.
2. Delépine, M. *Compt. Rend. Acad. Sci.* **1895**, *120*, 501. **1897**, *124*, 292.
3. Galat, A.; Elion, G. *J. Am. Chem. Soc.* **1939**, *61*, 3585.
4. Wendler, N. L. *J. Am. Chem. Soc.* **1949**, *71*, 375.
5. Quessy, S. N.; Williams, L. R.; Baddeley, V. G. *J. Chem. Soc., Perkin Trans. 1* **1979**, 512.
6. Blažzević, N.; Kolnah, D.; Belin, B.; Šunjić, V.; Kafjež, F. *Synthesis* **1979**, 161. (Review).
7. Henry, R. A.; Hollins, R. A.; Lowe-Ma, C.; Moore, D. W.; Nissan, R. A. *J. Org. Chem*. **1990**, *55*, 1796.
8. Charbonnière, L. J.; Weibel, N.; Ziessel, R. *Synthesis* **2002**, 1101.

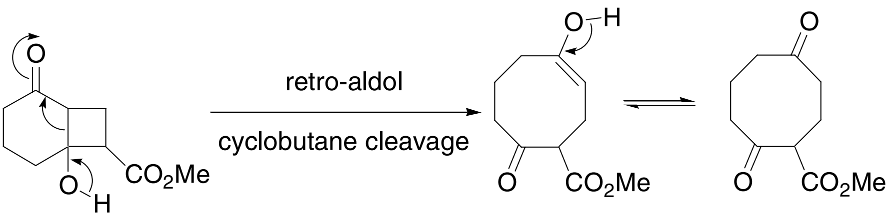
de Mayo reaction

[2 + 2] Photochemical cyclization of enones with olefins is followed by a retro-aldol reaction to give 1,5-diketones.

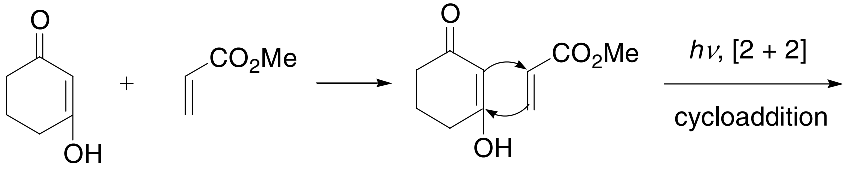




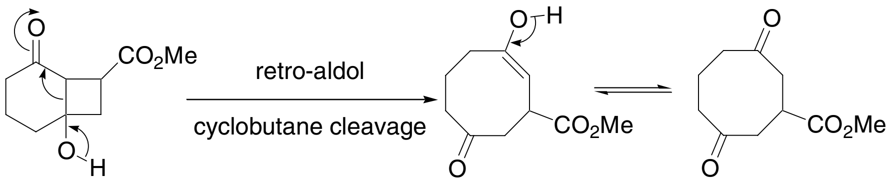
head-to-tail alignment



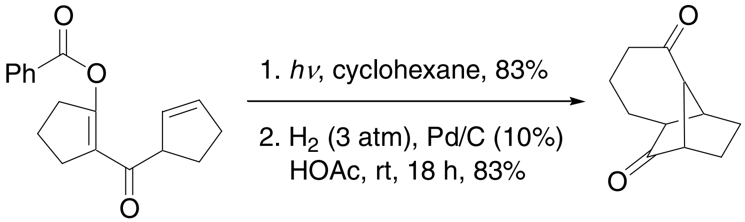
Minor regioisomer:



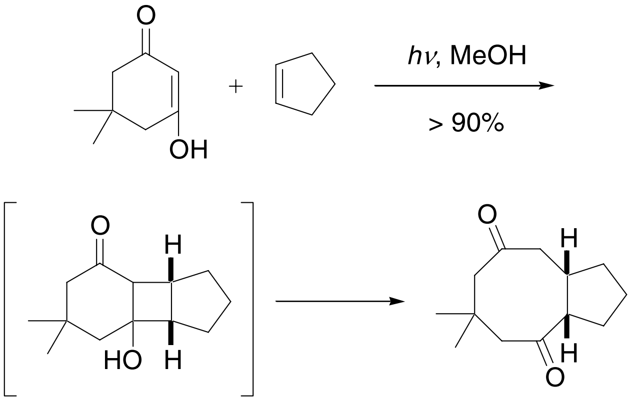
head-to-head alignment



Example 1[5]



Example 2[9]

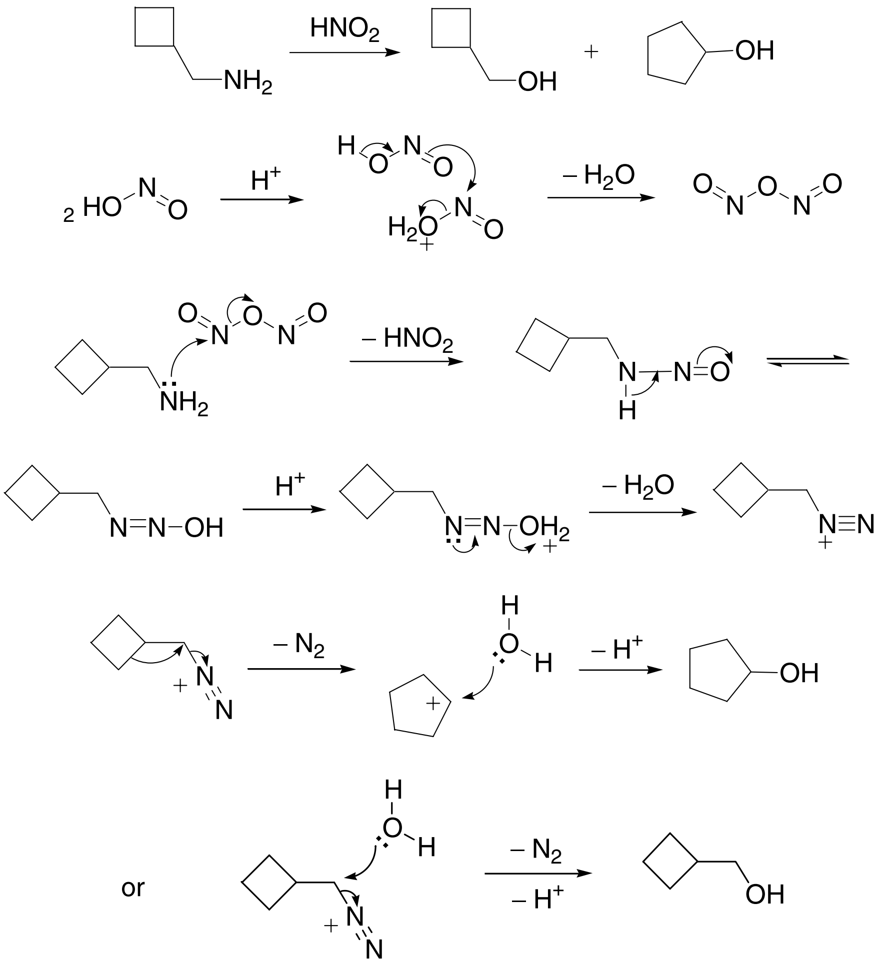


References

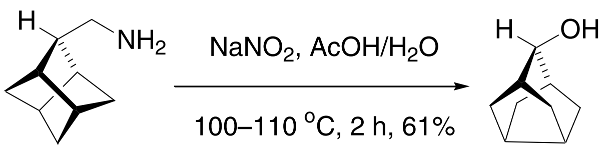
1. de Mayo, P.; Takeshita, H.; Sattar, A. B. M. A. *Proc. Chem. Soc., London* **1962**, 119. Paul de Mayo received his doctorate from Sir Derek Barton at Birkbeck College, University of London. He later became a professor at the University of Western Ontario in London, Ontario, Canada, where he discovered the de Mayo reaction.
2. Corey, E. J.; Bass, J. D.; LeMahieu, R.; Mitra, R. B. *J. Am. Chem. Soc.* **1964**, *86*, 5570.
3. Challand, B. D.; Hikino, H.; Kornis, G.; Lange, G.; de Mayo, P. *J. Org. Chem.* **1969**, *34*, 794.
4. de Mayo, P. *Acc. Chem. Res.* **1971**, *4*, 49. (Review).
5. Oppolzer, W.; Godel, T. *J. Am. Chem. Soc.* **1978**, *100*, 2583.
6. Oppolzer, W. *Pure Appl. Chem.* **1981**, *53*, 1181. (Review).
7. Pearlman, B. A. *J. Am. Chem. Soc.* **1979**, *101*, 6398.
8. Kaczmarek, R.; Blechert, S. *Tetrahedron Lett.* **1986**, *27*, 2845.
9. Disanayaka, B. W.; Weedon, A. C. *J. Org. Chem.* **1987**, *52*, 2905.
10. Crimmins, M. T.; Reinhold, T. L. *Org. React.* **1993**, *44*, 297−588. (Review).
11. Quevillon, T. M.; Weedon, A. C. *Tetrahedron Lett.* **1996**, *37*, 3939.
12. Blaauw, R. H.; Brière, J.-F.; de Jong, R.; Benningshof, J. C. J.; van Ginkel, A. E.; Fraanje, J.; Goubitz, K.; Schenk, H.; Rutjes, F. P. J. T.; Hiemstra, H. *J. Org. Chem.* **2001**, *66*, 233.
13. Minter, D. E.; Winslow, C. D. *J. Org. Chem.* **2004**, *69*, 1603.
14. Kemmler, M.; Herdtweck, E.; Bach, T. *Eur. J. Org. Chem.* **2004**, 4582.

Demjanov rearrangement

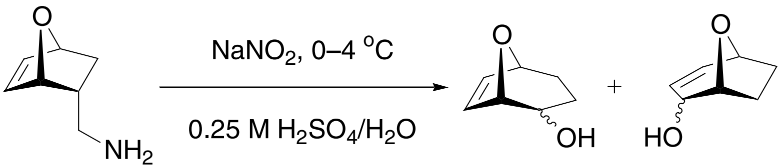
Carbocation rearrangement of primary amines *via* diazotization to give alcohols through C–C bond migration.



Example 1[7]



Example 2[9]

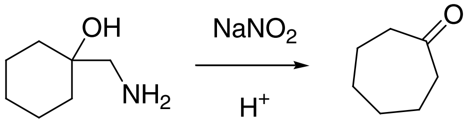


References

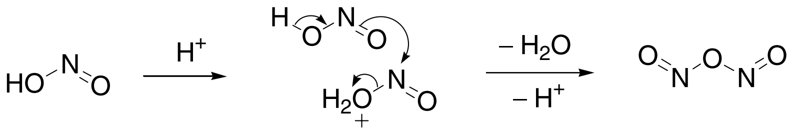
1. Demjanov, N. J.; Lushnikov, M. *J. Russ. Phys. Chem. Soc.* **1903**, *35*, 26. Nikolai J. Demjanov (1861−1938) was a Russian chemist.
2. Smith, P. A. S.; Baer, D. R. *Org. React.* **1960**, *11*, 157−188. (Review).
3. Kotani, R. *J. Org. Chem.* **1965**, *30*, 350.
4. Diamond, J.; Bruce, W. F.; Tyson, F. T. *J. Org. Chem.* **1965**, *30*, 1840.
5. Alam, S. N.; MacLean, D. B. *Can. J. Chem.* **1965**, *43*, 3433.
6. Cooper, C. N.; Jenner, P. J.; Perry, N. B.; Russell-King, J.; Storesund, H. J.; Whiting, M. C. *J. Chem. Soc., Perkin Trans. 2* **1982**, 605.
7. Nakazaki, M.; Naemura, K.; Hashimoto, M. *J. Org. Chem.* **1983**, *48*, 2289.
8. Uyehara, T.; Kabasawa, Y.; Furuta, T.; Kato, T. *Bull. Chem. Soc. Jpn.* **1986**, *59*, 539.
9. Fattori, D.; Henry, S.; Vogel, P. *Tetrahedron* **1993**, *49*, 1649.

Tiffeneau–Demjanov rearrangement

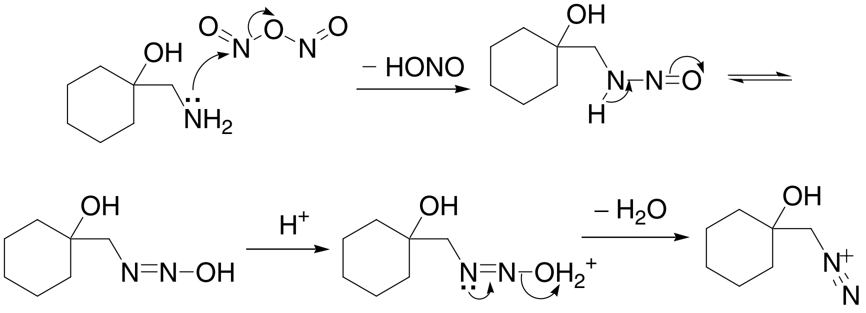
Carbocation rearrangement of β-aminoalcohols *via* diazotization to afford carbonyl compounds through C–C bond migration.



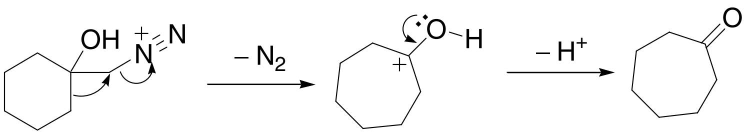
Step 1, Generation of N_2O_3



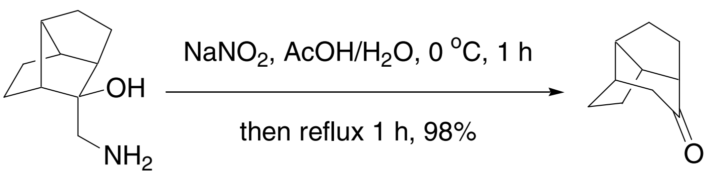
Step 2, Transformation of amine to diazonium salt



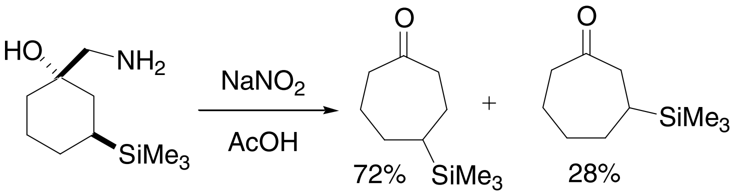
Step 3, Ring-expansion *via* rearrangement



Example 1[10]



Example 2[12]

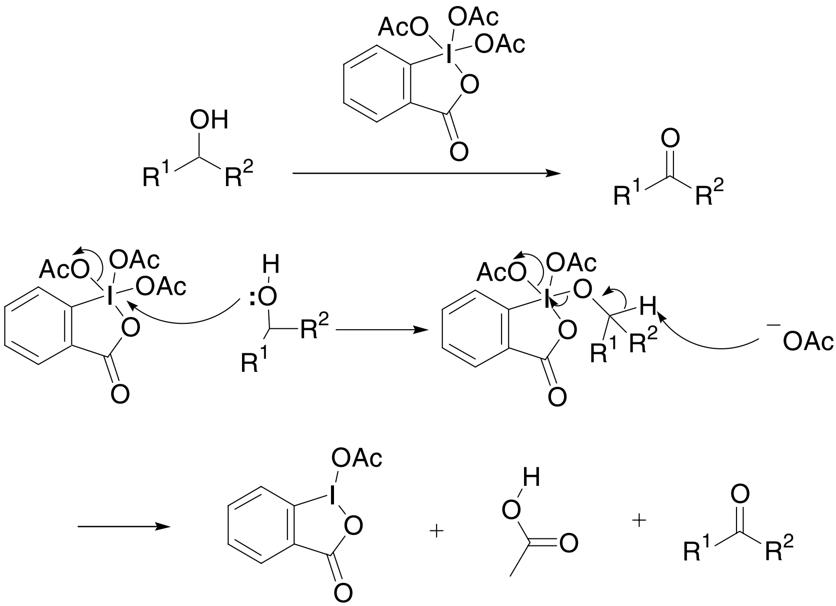


References

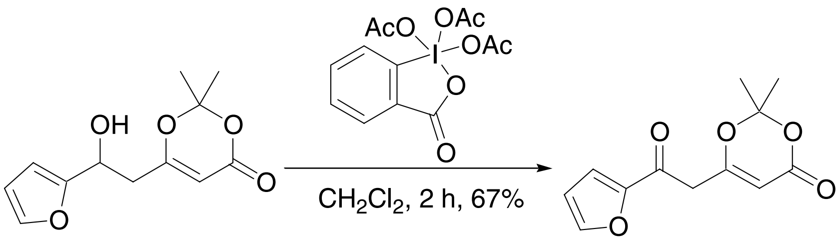
1. Tiffeneau, M.; Weill, P.; Tehoubar, B. *Compt. Rend.* **1937**, *205*, 54.
2. Smith, P. A. S.; Baer, D. R. *Org. React.* **1960**, *11*, 157. (Review).
3. Jones, J. B.; Price, P. *J. Chem. Soc.,D*. **1969**, 1478.
4. Parham, W. E.; Roosevelt, C. S. *J. Org. Chem.* **1972**, *37,* 1975.
5. McKinney, M. A.; Patel, P. P. *J. Org. Chem.* **1973**, *38,* 4059.
6. Jones, J. B.; Price, P. *Tetrahedron* **1973**, *29,* 1941.
7. Dave, V.; Stothers, J. B.; Warnhoff, E. W. *Can. J. Chem*. **1979**, *57,* 1557.
8. Haffer, G.; Eder, U.; Neef, G.; Sauer, G.; Wiechert, R. *Justus Liebigs Ann. Chem.* **1981**, 425.
9. Thomas, R. C.; Fritzen, E. L. *J. Antibiotics* **1988**, *41*, 1445.
10. Stern, A. G.; Nickon, A. *J. Org. Chem.* **1992**, *57,* 5342.
11. Fattori, D.; Henry, S.; Vogel, P. *Tetrahedron* **1993**, *49*, 1649.
12. Chow, L.; McClure, M.; White, J. *Org. Biomol. Chem*. **2004**, *2*, 648.

Dess−Martin periodinane oxidation

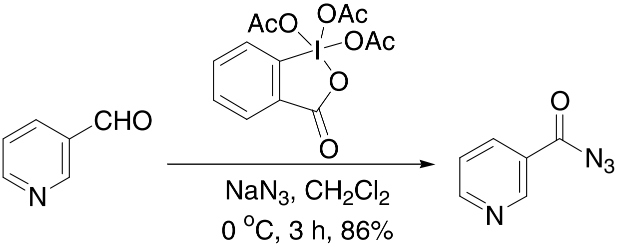
Oxidation of alcohols to the corresponding carbonyl compounds using triacetoxyperiodinane.



Example 1[9]



Example 2[15]

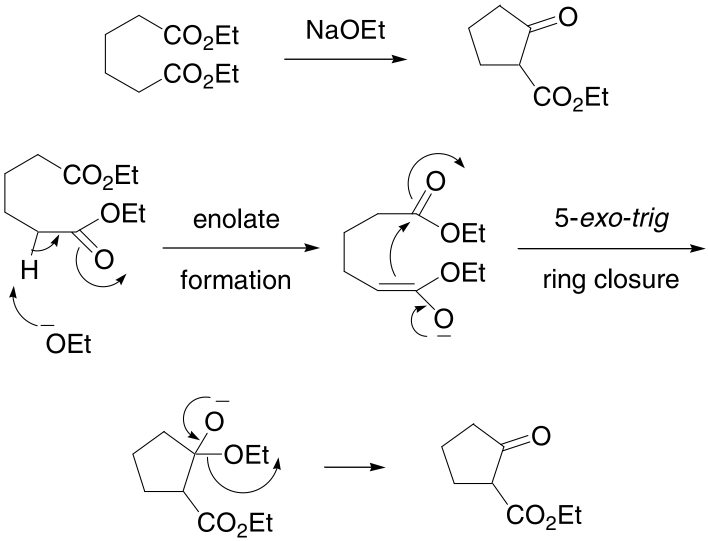


References

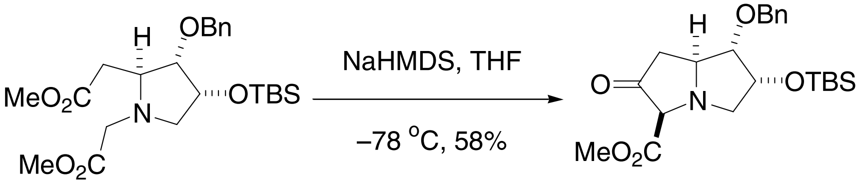
1. Dess, D. B.; Martin, J. C. *J. Org. Chem.* **1983**, *48*, 4155. James Cullen (J. C.) Martin (1928–1999) had a distinguished career spanning 36 years both at the University of Illinois at Urbana-Champaign and Vanderbilt University. J. C.'s formal training in physical organic chemistry with Don Pearson at Vanderbilt and P. D. Bartlett at Harvard prepared him well for his early studies on carbocations and radicals. However, it was his interest in understanding the limits of chemical bonding that led to his landmark investigations into hypervalent compounds of the main group elements. Over a 20-year period the Martin laboratories successfully prepared unprecedented chemical structures from sulfur, phosphorus, silicon and bromine while the ultimate "Holy Grail" of stable pentacoordinate carbon remained elusive. Although most of these studies were driven by J. C.'s fascination with unusual bonding schemes, they were not without practical value. Two hypervalent compounds, Martin's sulfurane (for dehydration, page 365) and the Dess-Martin periodinane have found widespread application in synthetic organic chemistry. J. C. Martin and his student Daniel Dess developed this methodology at the University of Illinois at Urbana. (Martin's biography is kindly supplied by Prof. Scott E. Denmark).
2. Dess, D. B.; Martin, J. C. *J. Am. Chem. Soc.* **1991**, *113*, 7277.
3. Ireland, R. E.; Liu, L. *J. Org. Chem.* **1993**, *58*, 2899.
4. Speicher, A.; Bomm, V.; Eicher, T. *J. Prakt. Chem.* **1996**, *338*, 588–590. (Review).
5. Chaudhari, S. S.; Akamanchi, K. G. *Synthesis* **1999**, 760.
6. Nicolaou, K. C.; Zhong, Y.-L.; Baran, P. S. *Angew. Chem., Int. Ed.* **2000**, *39,* 622.
7. Jenkins, N. E.; Ware, R. W., Jr.; Atkinson, R. N.; King, S. B. *Synth. Commun.* **2000**, *30,* 947.
8. Promarak, V.; Burn, P. L. *J. Chem. Soc., Perkin 1* **2001**, 14.
9. Bach, T.; Kirsch, S. *Synlett* **2001**, 1974.
10. Wavrin, L.; Viala, J. *Synthesis* **2002**, 326.
11. Wellner, E.; Sandin, H.; Pääkkönen, L. *Synthesis* **2003**, 223.
12. Langille, N. F.; Dakin, L. A.; Panek, J. S. *Org. Lett.* **2003**, *5*, 575.
13. Bose, D. S.; Reddy, A. V. N. *Tetrahedron Lett.* **2003**, *44*, 3543.
14. Tohma, H.; Kita, Y. *Adv. Synth. Catal.* **2004**, *346*, 111–124. (Review).
15. Deng, G.; Xu, B.; Liu, C. *Tetrahedron* **2005**, *61*, 5818.

Dieckmann condensation

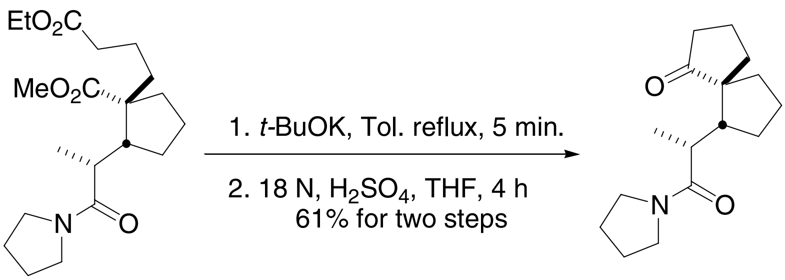
The Dieckmann condensation is the intramolecular version of the Claisen condensation.



Example 1[7]



Example 2[9]



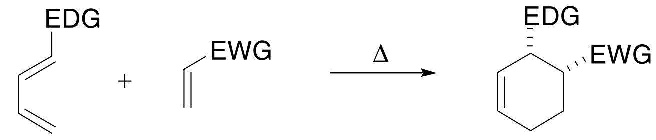
References

1. Dieckmann, W. *Ber. Dtsch. Chem. Ges.* **1894**, *27*, 102. Walter Dieckmann (1869–1925), born in Hamburg, Germany, studied with E. Bamberger at Munich. After serving as an assistant to von Baeyer in his private laboratory, he became a professor at Munich. At age 56, he died while working in his chemical laboratory at the Barvarian Academy of Science.
2. Davis, B. R.; Garratt, P. J. *Comp. Org. Synth.* **1991**, *2*, 795–863. (Review).
3. Toda, F.; Suzuki, T.; Higa, S. *J. Chem. Soc., Perkin Trans. 1* **1998**, 3521.
4. Shindo, M.; Sato, Y.; Shishido, K. *J. Am. Chem. Soc*. **1999**, *121*, 6507.
5. Balo, C.; Fernández, F.; García-Mera, X.; López, C. *Org. Prep. Proced. Int*. **2000**, *32*, 563.
6. Deville, J. P.; Behar, V. *Org. Lett.* **2002**, *4*, 1403.
7. Rabiczko, J.; Urbańczyk-Lipkowska, Z.; Chmielewski, M. *Tetrahedron* **2002**, *58*, 1433.
8. Ho, J. Z.; Mohareb, R. M.; Ahn, J. H.; Sim, T. B.; Rapoport, H. *J. Org. Chem.* **2003**, *68*, 109.
9. de Sousa, A. L.; Pilli, R. A. *Org. Lett.* **2005**, *7*, 1617.

Diels–Alder reaction

The Diels–Alder reaction, inverse electronic demand Diels–Alder reaction, as well as the hetero-Diels–Alder reaction, belong to the category of *[4+2]-cycloaddition reactions*, which are concerted processes. The arrow pushing here is merely illustrative.

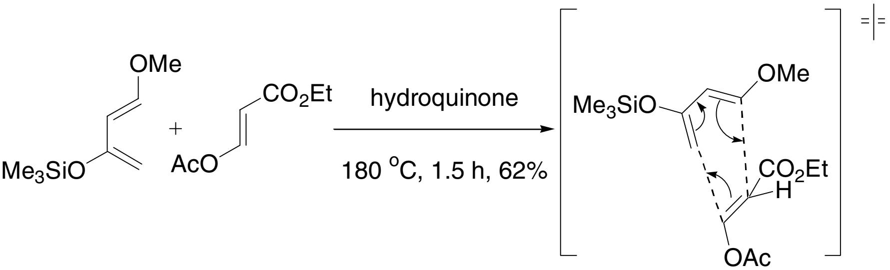
Normal Diels–Alder reaction



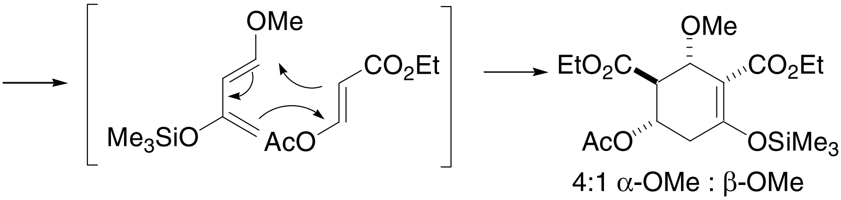
diene dienophile adduct

EDG = electron-donating group; EWG = electron-withdrawing group

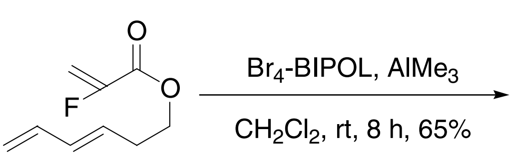
Example 1[13]



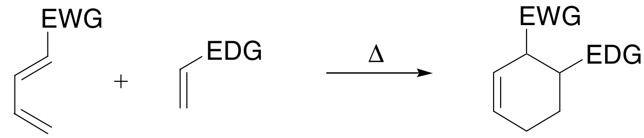
Danishefsky diene Alder's *endo* rule



Example 2[17]

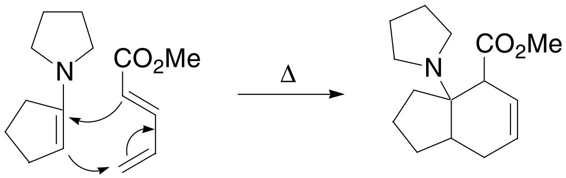


Inverse electronic demand Diels–Alder reaction



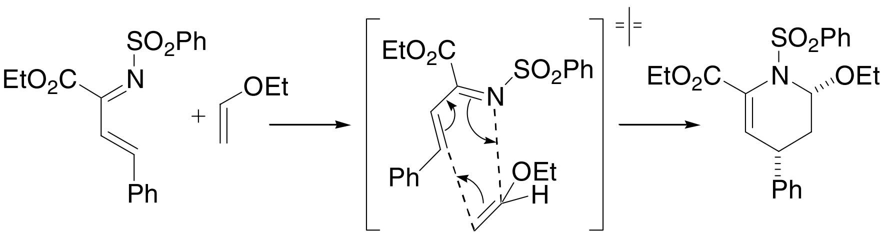
diene dienophile adduct

Example 1[2]

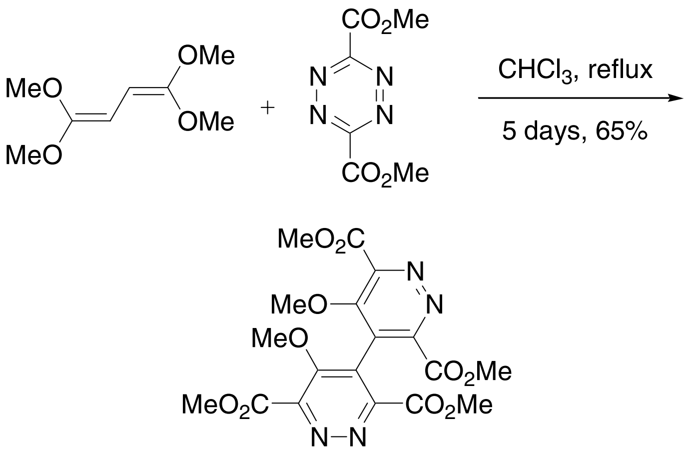


Hetero-Diels–Alder reaction

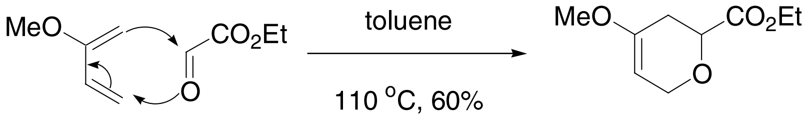
Heterodiene addition to dienophile



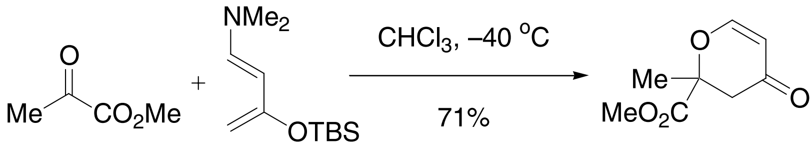
Example 1, the **Boger pyridine synthesis** (see page 67)[8]



Heterodienophile addition to diene[2]



Example 2, using the Rawal diene[9]

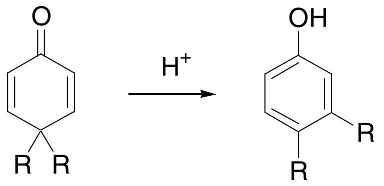


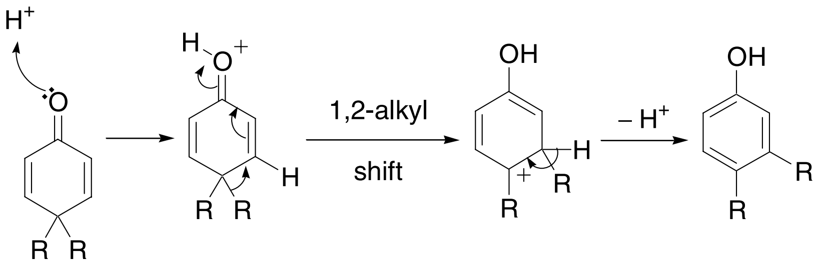
References

1. Diels, O.; Alder, K. *Justus Liebigs Ann. Chem.* **1928**, *460*, 98. Otto Diels (Germany, 1876–1954) and his student, Kurt Alder (Germany, 1902–1958), shared the Nobel Prize in Chemistry in 1950 for development of the diene synthesis. In this article they claimed their territory in applying the Diels–Alder reaction in total synthesis: "We explicitly reserve for ourselves the application of the reaction developed by us to the solution of such problems."
2. Wender, P. A.; Keenan, R. M.; Lee, H. Y. *J. Am. Chem. Soc*. **1987**, *109*, 4390.
3. Boger, D. L.; Panek, J. S.; Yasuda, M. *Org. Synth*. **1988**, *66*, 142.
4. Oppolzer, W. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 315–399. (Review).
5. Boger, D. L. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 451–512. (Review).
6. Weinreb, S. M. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 5*, 401–449. (Review).
7. Wasserman, H. H.; DeSimone, R. W.; Boger, D. L.; Baldino, C. M. *J. Am. Chem. Soc*. **1993**, *115*, 8457.
8. Boger, D. L.; Baldino, C. M. *J. Am. Chem. Soc*. **1993**, *115*, 11418.
9. Huang, Y.; Rawal, V. H. *Org. Lett.* **2000**, *2*, 3321.
10. Mehta, G.; Uma, R. *Acc. Chem. Res*. **2000**, *33*, 278. (Review).
11. Yli-Kauhaluoma, J. *Tetrahedron* **2001**, *57*, 7053. (Review).
12. Ghosh, A. K.; Shirai, M. *Tetrahedron Lett*. **2001**, *42*, 6231.
13. Wang, J.; Morral, J.; Hendrix, C.; Herdewijn, P. *J. Org. Chem*. **2001**, *66*, 8478.
14. Jørgensen, K. A. *Eur. J. Org. Chem*. **2004**, 2093. (Review).
15. Corey, E. J. *Angew. Chem., Int. Ed.* **2002**, *41*, 1650. (Review).
16. Nicolaou, K. C.; Snyder, S. A.; Montagnon, T.; Vassilikogiannakis, G. *Angew. Chem., Int. Ed*. **2002**, *41*, 1668. (Review).
17. Saito, A.; Yanai, H.; Sakamoto, W.; Takahashi, K.; Taguchi, T. *J. Fluorine Chem.* **2005**, *126*, 709.

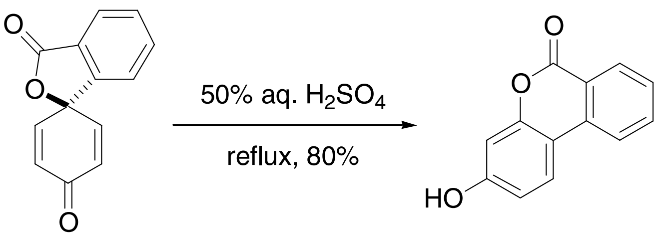
Dienone–phenol rearrangement

Acid-promoted rearrangement of 4,4-disubstituted cyclohexadienones to 3,4-disubstituted phenols.

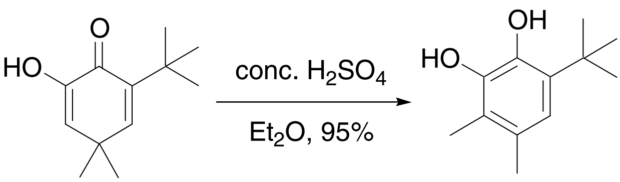




Example 1[4]



Example 2[5]



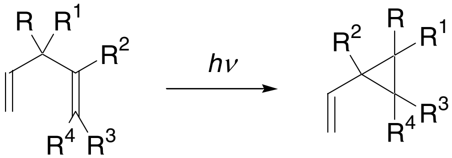
References

1. Shine, H. J. In Aromatic Rearrangements; Elsevier: New York, 1967, pp 55̃68. (Review).
2. Schultz, A. G.; Hardinger, S. A. J. Org. Chem. 1991, 56, 1105.

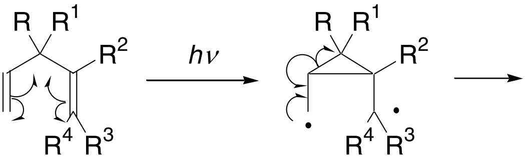
3. Schultz, A. G.; Green, N. J. J. Am. Chem. Soc. 1992, 114, 1824.
4. Hart, D. J.; Kim, A.; Krishnamurthy, R.; Merriman, G. H.; Waltos, A.-M. Tetrahedron 1992, 48, 8179.
5. Frimer, A. A.; Marks, V.; Sprecher, M.; Gilinsky-Sharon, P. J. Org. Chem. 1994, 59, 1831.
6. Oshima, T.; Nakajima, Y.-i.; Nagai, T. Heterocycles 1996, 43, 619.
7. Draper, R. W.; Puar, M. S.; Vater, E. J.; Mcphail, A. T. Steroids 1998, 63, 135.
8. Banerjee, A. K.; Castillo-Melendez, J. A.; Vera, W.; Azocar, J. A.; Laya, M. S. J. Chem. Res., (S) 2000, 324.
9. Kumar, V. S.; Nagaraja, B. M.; Shashikala, V.; Seetharamulu, P.; Padmasri, A. H.; Raju, B. D.; Rao, K. S. R. J. Mol. Catal. A: Chemical 2004, 223, 283.
10. Kodama, S.; Takita, H.; Kajimoto, T.; Nishide, K.; Node, M. Tetrahedron 2004, 60, 4901.

Di-π-methane rearrangement

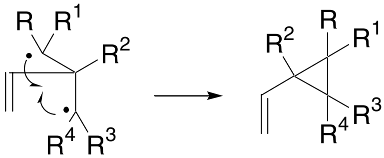
Conversion of 1,4-dienes to vinylcyclopropanes under photolysis. Also known as the Zimmerman rearrangement.



1,4-diene vinylcyclopropane

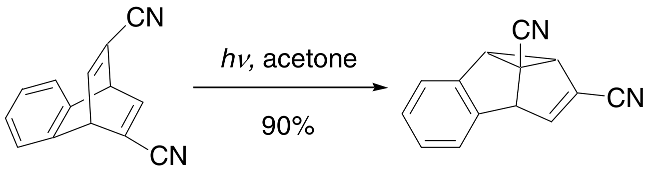


diradical

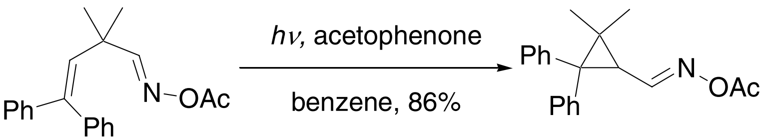


diradical

Example 1[9]



Example 2, aza-π-methane rearrangement[2]

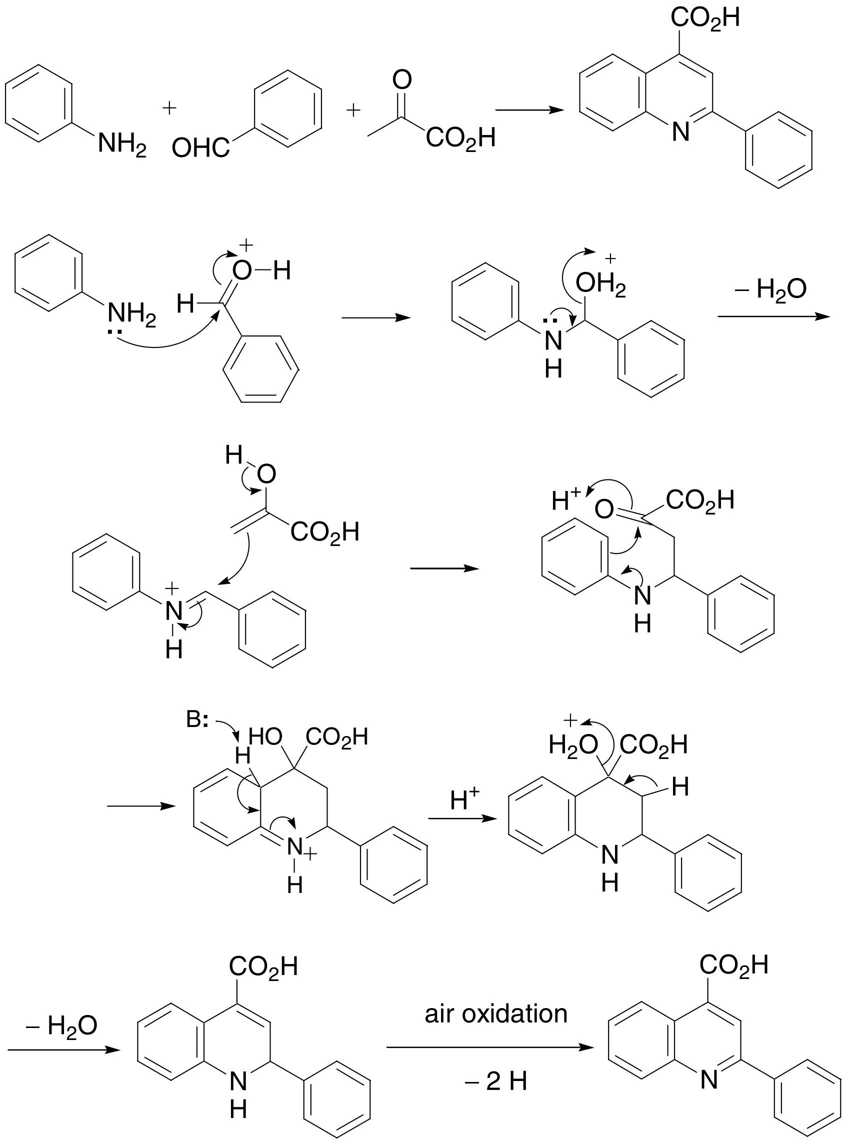


References

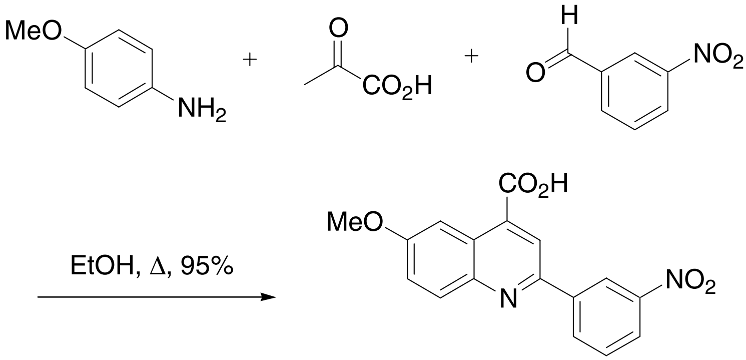
1. Zimmerman, H. E.; Grunewald, G. L. J. Am. Chem. Soc. 1966, 88, 183. Howard E. Zimmerman is a professor at the University of Wisconsin at Madison.
2. Armesto, D.; Horspool, W. M.; Langa, F.; Ramos, A. J. Chem. Soc. Perkin Trans. I 1991, 223.
3. Zimmerman, H. E.; Armesto, D. Chem. Rev. 1996, 96, 3065. (Review).
4. Janz, K. M.; Scheffer, J. R. Tetrahedron Lett. 1999, 40, 8725.
5. Zimmerman, H. E.; Církva, V. Org. Lett. 2000, 2, 2365.
6. Tu, Y. Q.; Fan, C. A.; Ren, S. K.; Chan, A. S. C. J. Chem. Soc., Perkin 1 2000, 3791.
7. Jiménez, M. C.; Miranda, M. A.; Tormos, R. Chem. Commun. 2000, 2341.
8. Ihmels, H.; Mohrschladt, C. J.; Grimme, J. W.; Quast, H. Synthesis 2001, 1175.
9. Ünaldi, N. S.; Balci, M. Tetrahedron Lett. 2001, 42, 8365.
10. Altundas, R.; Dastan, A.; Ünaldi, N. S.; Güven, K.; Uzun, O.; Balci, M. Eur. J. Org. Chem. 2002, 526.
11. Zimmerman, H. E.; Chen, W. Org. Lett. 2002, 4, 1155.
12. Tanifuji, N.; Huang, H.; Shinagawa, Y.; Kobayashi, K. Tetrahedron Lett. 2003, 44, 751.
13. Singh, V.; Vedantham, P.; Sahu, P. K. Tetrahedron 2003, 60, 8161.
14. Frutos, L. M.; Sancho, U.; Castano, O. J. Phys. Chem. A 2005, 109, 2993.

Doebner quinoline synthesis

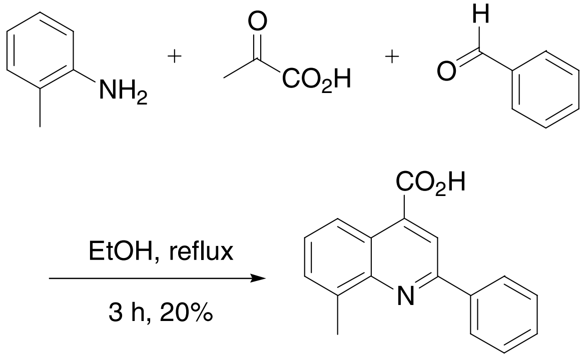
Three-component coupling of an aniline, pyruvic acid, and an aldehyde to provide a quinoline-4-carboxylic acid.



Example 1[2]



Example 2[6]

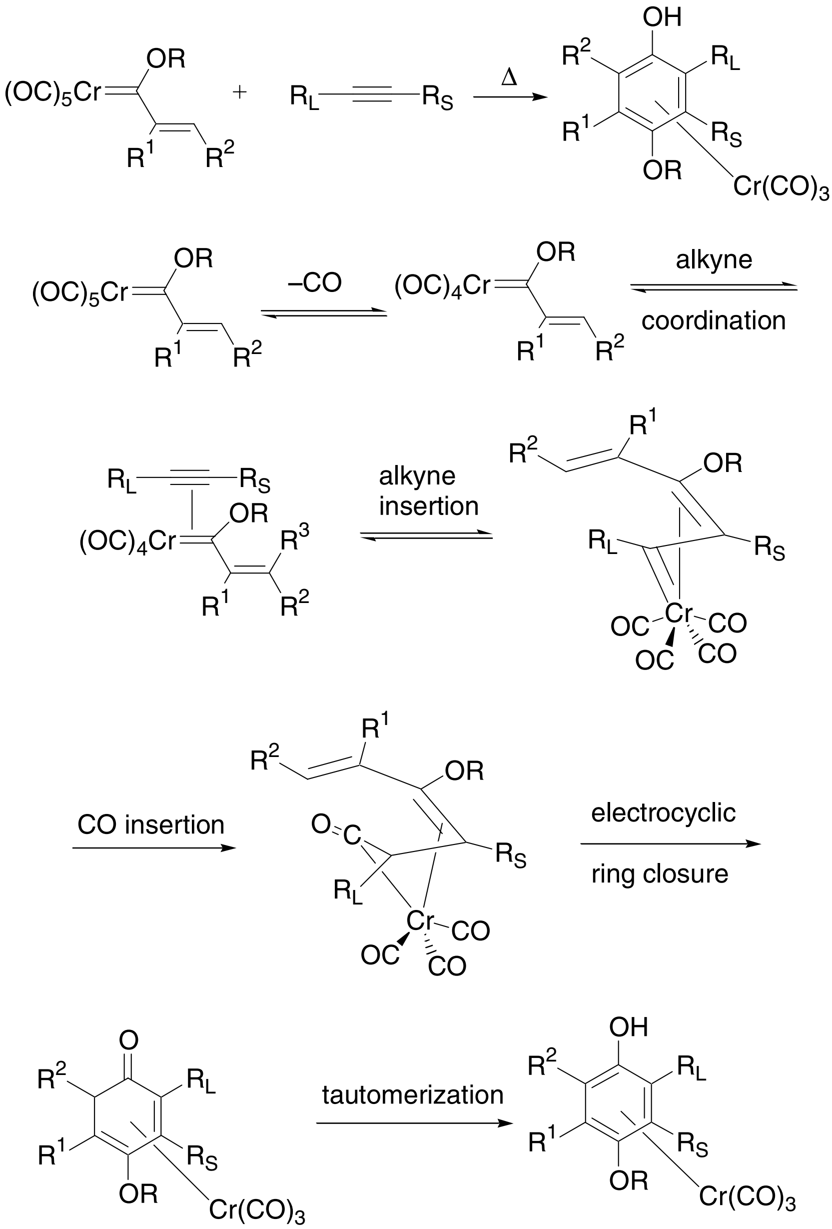


References

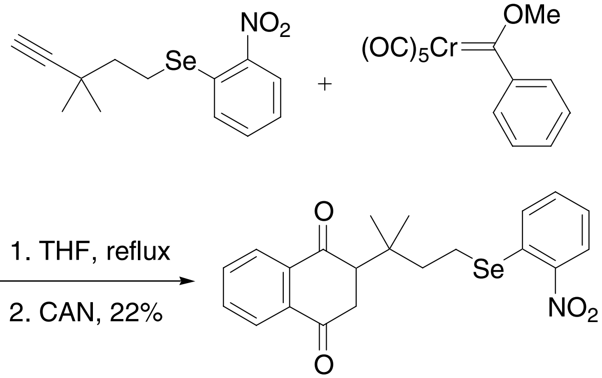
1. Doebner, O. G. *Justus Liebigs Ann. Chem.* **1887**, *242*, 265. Oscar Gustav Doebner (1850–1907) was born in Meiningen, Germany. After studying under Liebig, he actively took part in the Franco-Prussian War. He apprenticed with Otto and Hofmann for a few years after the war, then began his independent researches at the University at Halle.
2. Mathur, F. C.; Robinson, R. *J. Chem. Soc.* **1934**, 1520.
3. Allen, C. F. H.; Spangler, F. W.; Webster, E. R. *J. Org. Chem.* **1951**, *16*, 17.
4. Elderfield, R. C. *Heterocyclic Compounds*; Elderfield, R. C., Ed.; John Wiley & Sons, Inc.: New York, **1952**, *Vol. 4*, *Quinoline, Isoquinoline and Their Benzo Derivatives*, pp. 25–29. (Review).
5. Jones, G. in *Chemistry of Heterocyclic Compounds*, Jones, G., ed.; John Wiley & Sons, Inc.: New York, **1977**, *Vol. 32*; Quinolines, pp. 125–131. (Review).
6. Atwell, G. J.; Baguley, B. C.; Denny, W. A. *J. Med. Chem.* **1989**, *32*, 396.
7. Herbert, R. B.; Kattah, A. E.; Knagg, E. *Tetrahedron* **1990**, *46*, 7119.
8. Pflum, D. A. *Doebner Quinoline Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 407–410. (Review).

Dötz reaction

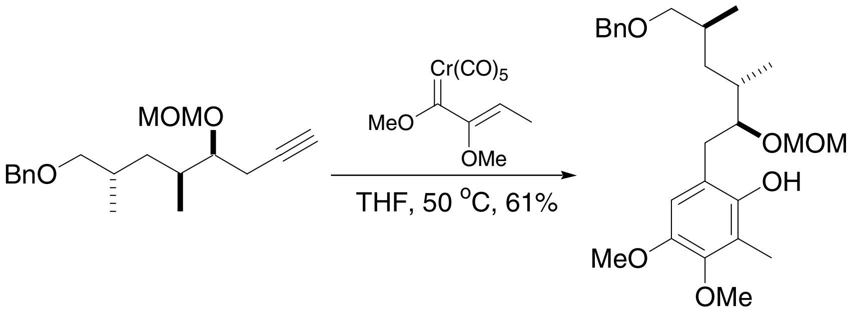
$Cr(CO)_3$-coordinated hydroquinone from vinylic alkoxy pentacarbonyl chromium carbene (Fischer carbene) complex and alkynes.



Example 1[7]



Example 2[11]

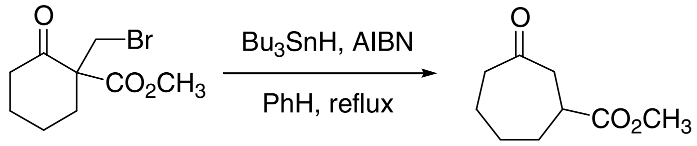


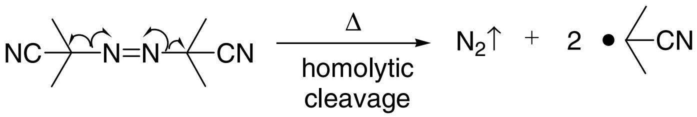
References

1. Dötz, K. H. *Angew. Chem., Int. Ed.* **1975**, *14*, 644. Karl H. Dötz (1943–) was a professor at the University of Munich in Germany.
2. Wulff, W. D.; Tang, P.-C.; McCallum, J. S. *J. Am. Chem. Soc.* **1981**, *103,* 7677.
3. Wulff, W. D. In *Advances in Metal-Organic Chemistry*; Liebeskind, L. S., ed.; JAI Press, Greenwich, CT; 1989; *Vol. 1.* (Review).
4. Wulff, W. D. In *Comprehensive Organometallic Chemistry II*; Abel, E. W., Stone, F. G. A., Wilkinson, G., eds.; Pergamon Press: Oxford, **1995**; *Vol. 12*. (Review).
5. Torrent, M. *Chem. Commun*. **1998**, 999.
6. Torrent, M.; Solá, M.; Frenking, G. *Chem. Rev*. **2000**, *100*, 439. (Review).
7. Caldwell, J. J.; Colman, R.; Kerr, W. J.; Magennis, E. J. *Synlett* **2001**, 1428.
8. Jackson, T. J.; Herndon, J. W. *Tetrahedron* **2001**, *57*, 3859.
9. Solá, M.; Duran, M.; Torrent, M. The Dötz reaction: A chromium Fischer carbene-mediated benzannulation reaction. In *Computational Modeling of Homogeneous Catalysis* Maseras, F.; Lledós, A. eds.; Kluwer Academic: Boston; **2002**, 269–287. (Review).
10. Pulley, S. R.; Czakó, B. *Tetrahedron Lett*. **2004**, *45*, 5511.
11. White, J. D; Smits, H. *Org. Lett*. **2005**, *7*, 235.

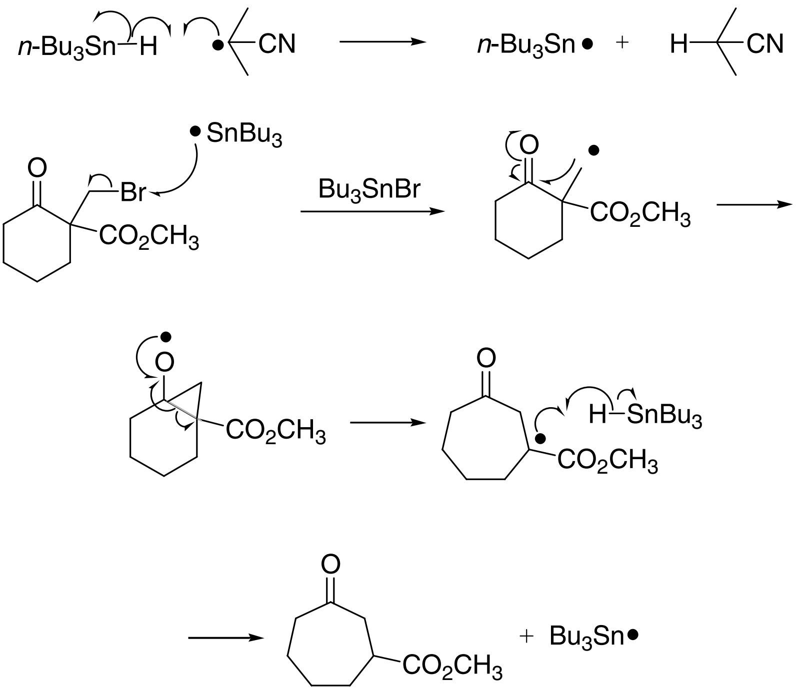
Dowd–Beckwith ring expansion

Radical-mediated ring expansion of 2-halomethyl cycloalkanones.

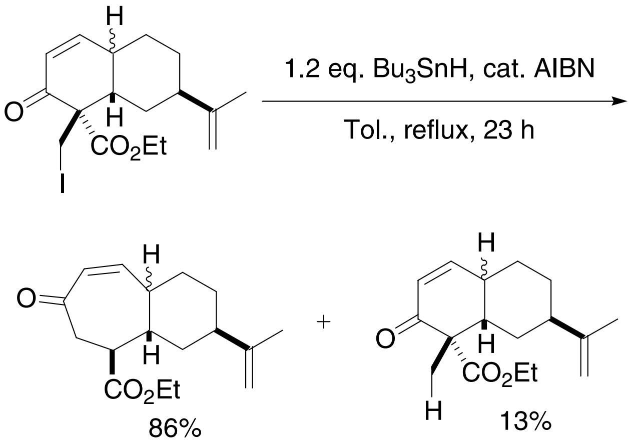




2,2'-azobisisobutyronitrile (AIBN)



Example 1[9]

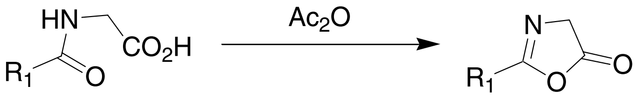


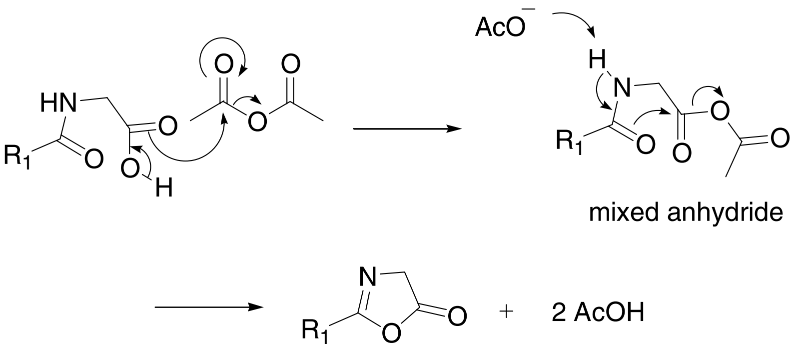
References

1. Dowd, P.; Choi, S.-C. *J. Am. Chem. Soc.* **1987**, *109*, 3493. Paul Dowd (1936–1996) was a professor at the University of Pittsburgh.
2. Beckwith, A. L. J.; O'Shea, D. M.; Gerba, S.; Westwood, S. W. *J. Chem. Soc., Chem. Commun.* **1987**, 666. Athelstan L. J. Beckwith is a professor at University of Adelaide, Adelaide, Australia.
3. Beckwith, A. L. J.; O'Shea, D. M.; Westwood, S. W. *J. Am. Chem. Soc.* **1988**, *110*, 2565.
4. Dowd, P.; Choi, S.-C. *Tetrahedron* **1989**, *45*, 77.
5. Dowd, P.; Choi, S.-C. *Tetrahedron Lett.* **1989**, *30*, 6129.
6. Dowd, P.; Choi, S.-C. *Tetrahedron* **1991**, *47*, 4847.
7. Bowman, W. R.; Westlake, P. J. *Tetrahedron* **1992**, *48*, 4027.
8. Dowd, P.; Zhang, W. *Chem. Rev.* **1993**, *93*, 2091. (Review).
9. Banwell, M. G.; Cameron, J. M. *Tetrahedron Lett.* **1996**, *37*, 525.
10. Wang, C.; Gu, X.; Yu, M. S.; Curran, D. P. *Tetrahedron* **1998**, *54*, 8355.
11. Hasegawa, E.; Kitazume, T.; Suzuki, K.; Tosaka, E. *Tetrahedron Lett.* **1998**, *39*, 4059.
12. Hasegawa, E.; Yoneoka, A.; Suzuki, K.; Kato, T.; Kitazume, T.; Yanagi, K. *Tetrahedron* **1999**, *55*, 12957.
13. Studer, A.; Amrein, S. *Angew. Chem., Int. Ed.* **2000**, *39*, 3080.
14. Kantorowski, E. J.; Kurth, M. J. *Tetrahedron* **2000**, *56*, 4317. (Review).
15. Sugi, M.; Togo, H. *Tetrahedron* **2002**, *58*, 3171.
16. Ardura, D.; Sordo, T. L. *Tetrahedron Lett.* **2004**, *45*, 8691.

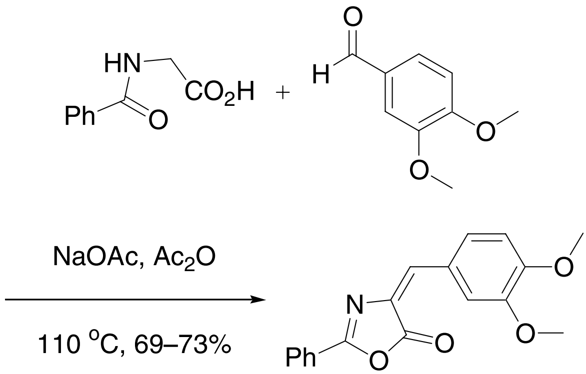
Erlenmeyer–Plöchl azlactone synthesis

Formation of 5-oxazolones (or 'azlactones') by intramolecular condensation of acylglycines in the presence of acetic anhydride.





Example[14]



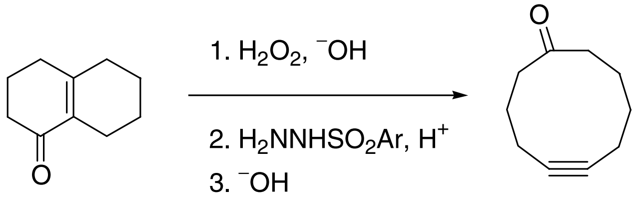
References

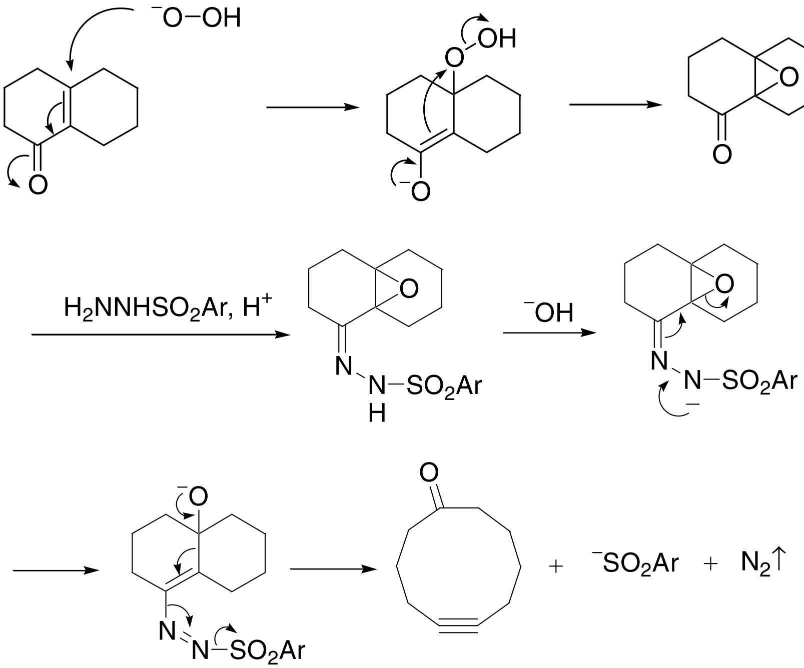
1. Plöchl, J. *Ber. Dtsch. Chem. Ges.* **1884**, *17*, 1616.
2. Erlenmeyer, E., Jr. *Ann.* **1893**, *275*, 1. Emil Erlenmeyer, Jr. (1864–1921) was born in Heidelberg, Germany to Emil Erlenmeyer (1825–1909), a famous chemistry professor at the University of Heidelberg. He investigated the Erlenmeyer–Plöchl azlactone synthesis while he was a Professor of Chemistry at Strasburg.
3. Carter, H. E. *Org. React.* **1946**, *3*, 198–239. (Review).
4. Baltazzi, E. *Quart. Rev. Chem. Soc.* **1955**, *9*, 150. (Review).

5. Filler, R.; Rao, Y. S. *New Development in the Chemistry of Oxazolines*, In *Adv. Heterocyclic Chem*; Katritzky, A. R. and Boulton, A. J., Eds; Academic Press, Inc: New York, **1977**, *Vol. 21*, pp. 175–206. (Review).
6. Kumar, P.; Mishra, H. D.; Mukerjee, A. K. *Synthesis* **1980**, *10*, 836.
7. Mukerjee, A. K.; Kumar, P. *Heterocycles* **1981**, *16*, 1995. (Review).
8. Mukerjee, A. K. *Heterocycles* **1987**, *26*, 1077. (Review).
9. Cornforth, J.; Ming-hui, D. *J. Chem. Soc. Perkin Trans. I* **1991,** 2183.
10. Ivanova, G. G. *Tetrahedron* **1992**, *48*, 177.
11. Combs, A. P.; Armstrong, R. W. *Tetrahedron Lett.* **1992**, *33*, 6419.
12. Monk, K. A.; Sarapa, D.; Mohan, R. S. *Synth. Commun.* **2000**, *30*, 3167.
13. Konkel, J. T.; Fan, J.; Jayachandran, B.; Kirk, K. L. *J. Fluorine Chem.* **2002**, *115*, 27.
14. Buck, J. S.; Ide, W.S. *Org. Synth. Coll.* **1943***,* 2, 55.
15. Brooks, D. A. *Erlenmeyer–Plöchl Azlactone Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 229–233. (Review).

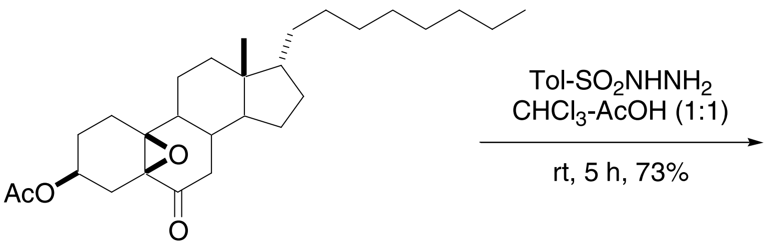
Eschenmoser–Tanabe fragmentation

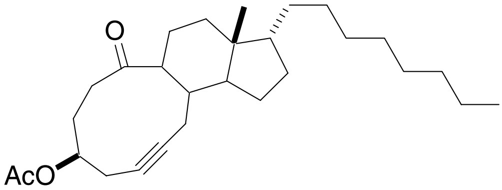
Fragmentation of α,β-epoxyketones *via* the intermediacy of α,β-epoxy sulfonyl-hydrazones.



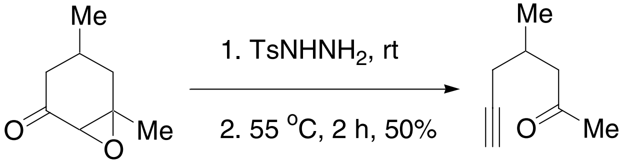


Example 1[4]





Example 2[7]

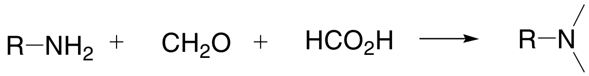


References

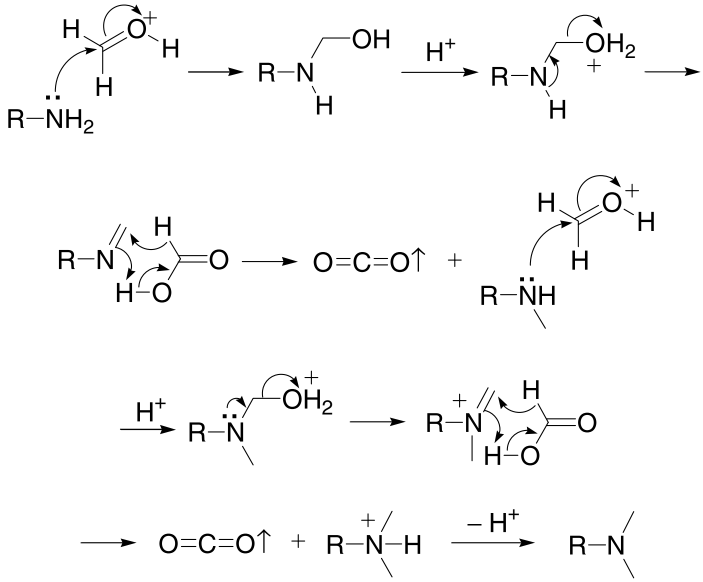
1. Eschenmoser, A.; Felix, D.; Ohloff, G. *Helv. Chim. Acta* **1967**, *50*, 708. Albert
2. Eschenmoser (Switzerland, 1925−) is best known for his work on, among many others, the monumental total synthesis of Vitamin B_{12} with R. B. Woodward in 1973. He now holds appointments at ETH Zürich and Scripps Research Institute, La Jolla.
3. Tanabe, M.; Crowe, D. F.; Dehn, R. L. *Tetrahedron Lett.* **1967**, 3943.
4. Felix, D.; Müller, R. K.; Horn, U.; Joos, R.; Schreiber, J.; Eschenmoser, A. *Helv. Chim. Acta* **1972**, *55*, 1276.
5. Batzold, F. H.; Robinson, C. H. *J. Org. Chem.* **1976**, *41*, 313.
6. Covey, D. F.; Parikh, V. D. *J. Org. Chem.* **1982**, *47*, 5315.
7. Chinn, L. J.; Lenz, G. R.; Choudary, J. B.; Nutting, E. F.; Papaioannou, S. E.; Metcalf, L. E.; Yang, P. C.; Federici, C.; Gauthier, M. *Eur. J. Med. Chem.* **1985**, *20*, 235.
8. Dai, W.; Katzenellenbogen, J. A. *J. Org. Chem.* **1993**, *58*, 1900.
9. Abad, A.; Arno, M.; Agullo, C.; Cuñat, A. C.; Meseguer, B.; Zaragoza, R. J. *J. Nat. Prod.* **1993**, *56*, 2133.
10. Mück-Lichtenfeld, C. *J. Org. Chem.* **2000**, *65*, 1366.

Eschweiler–Clarke reductive alkylation of amines

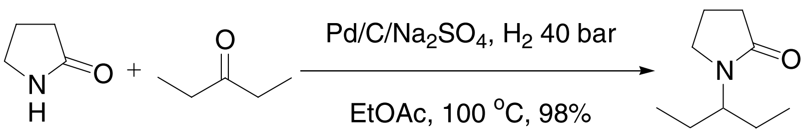
Reductive methylation of primary or secondary amines using formaldehyde and formic acid. *Cf.* Leuckart–Wallach reaction.



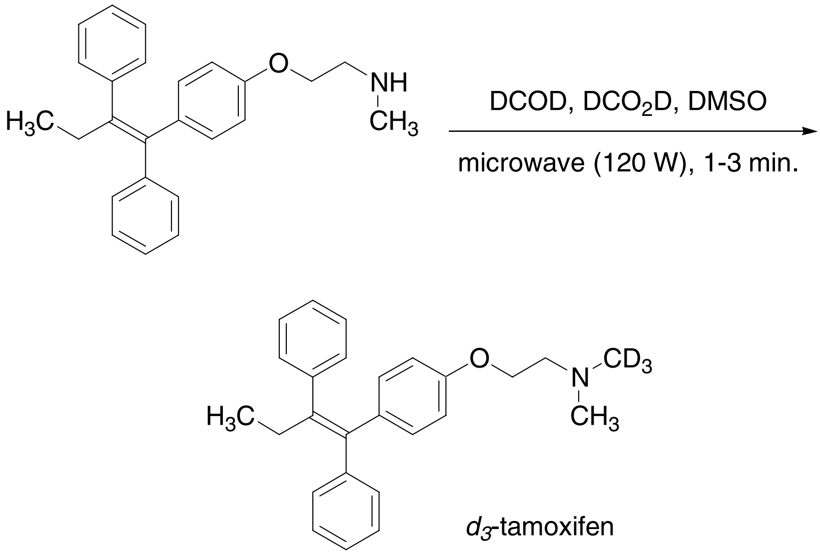
formic acid is the hydrogen source as a reducing agent



Example 1[7]



Example 2[11]

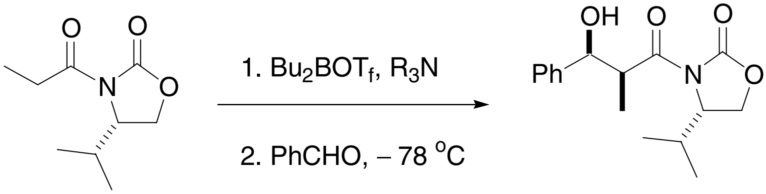


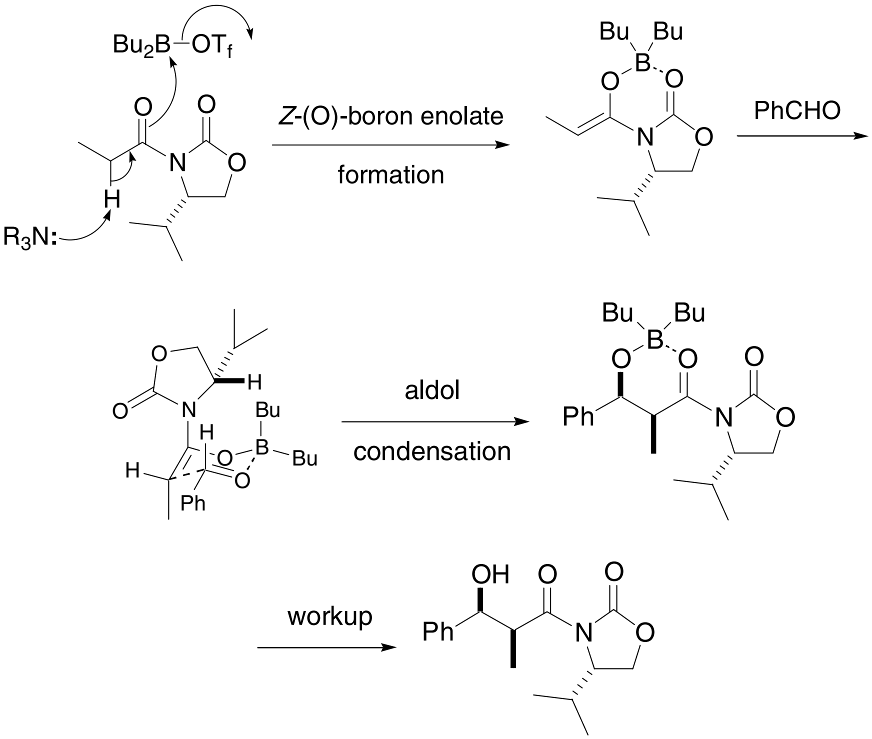
References

1 Eschweiler, W. *Chem. Ber.* **1905**, *38*, 880. Wilhelm Eschweiler (1860–1936) was born in Euskirchen, Germany.
2 Clarke, H. T.; Gillespie, H. B.; Weisshaus, S. Z. *J. Am. Chem. Soc.* **1933**, *55*, 4571. Hans T. Clarke (1887–1927) was born in Harrow, England.
3 Moore, M. L. *Org. React.* **1949**, *5*, 301. (Review).
4 Pine, S. H.; Sanchez, B. L. *J. Org. Chem.* **1971**, *36*, 829.
5 Bobowski, G. *J. Org. Chem.* **1985**, *50*, 929.
6 Alder, R. W.; Colclough, D.; Mowlam, R. W. *Tetrahedron Lett.* **1991**, *32*, 7755.
7 Fache, F.; Jacquot, L.; Lemaire, M. *Tetrahedron Lett.* **1994**, *35*, 3313.
8 Bulman Page, P. C.; Heaney, H.; Rassias, G. A.; Reignier, S.; Sampler, E. P.; Talib, S. *Synlett* **2000**, 104.
9 Torchy, S.; Barbry, D. *J. Chem. Res. Synop.* **2001**, 292.
10 Rosenau, T.; Potthast, A.; Röhrling, J.; Hofinger, A.; Sixta, H.; Kosma, P. *Synth. Commun.* **2002**, *32*, 457.
11 Harding, J. R.; Jones, J. R.; Lu, S.-Y.; Wood, R. *Tetrahedron Lett.* **2002**, *43*, 9487.
12 Chen, F.-L.; Sung, K. *J. Heterocycl. Chem.* **2004**, *41*, 697.

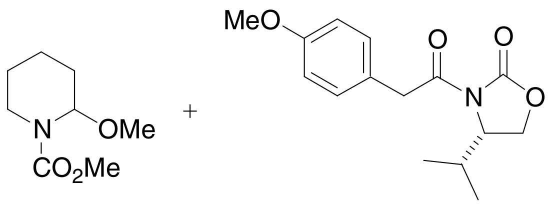
Evans aldol reaction

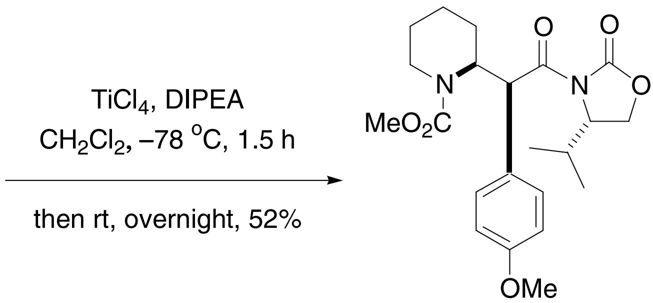
Asymmetric aldol condensation of aldehyde and chiral acyl oxazolidinone, the Evans chiral auxiliary.



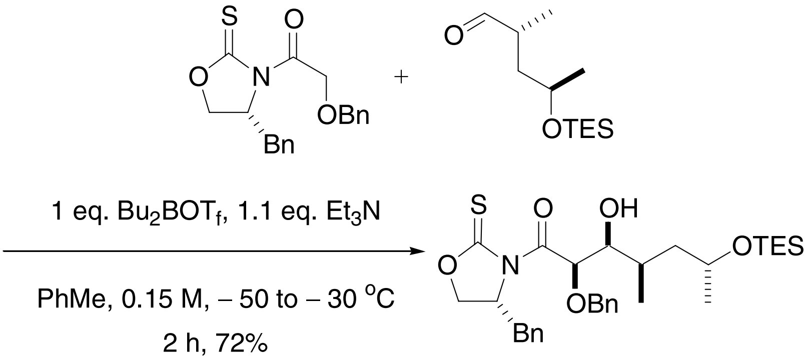


Example 1[7]





Example 2[13]



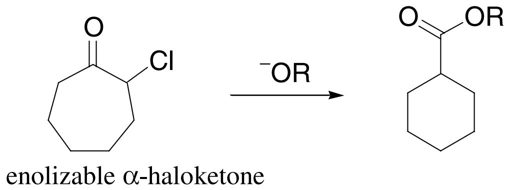
References

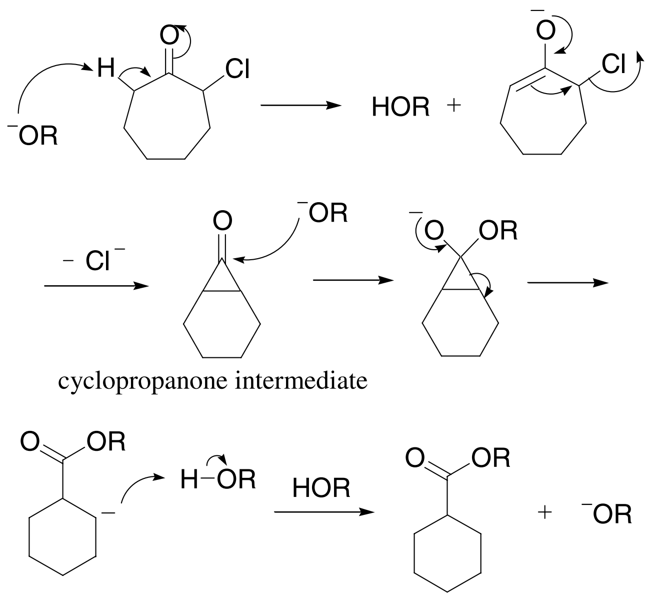
1. Evans, D. A.; Bartroli, J.; Shih, T. L. *J. Am. Chem. Soc.* **1981**, *103*, 2127. David Evans is a professor at Harvard University.
2. Evans, D. A.; McGee, L. R. *J. Am. Chem. Soc.* **1981**, *103*, 2876.
3. Allin, S. M.; Shuttleworth, S. J. *Tetrahedron Lett*. **1996**, *37*, 8023.
4. Ager, D. J.; Prakash, I.; Schaad, D. R. *Aldrichimica Acta* **1997**, *30*, 3. (Review).
5. Braddock, D. C.; Brown, J. M. *Tetrahedron: Asymmetry* **2000**, *11*, 3591.
6. Lu, Y.; Schiller, P. W. *Synthesis* **2001**, 1639.
7. Matsumura, Y.; Kanda, Y.; Shirai, K.; Onomura, O.; Maki, T. *Tetrahedron* **2000**, *56*, 7411.
8. Williams, D. R.; Patnaik, S.; Clark, M. P. *J. Org. Chem* **2001**, *66*, 8463.
9. Matsushima, Y.; Itoh, H.; Nakayama, T.; Horiuchi, S.; Eguchi, T.; Kakinuma, K. *J. Chem. Soc., Perkin 1* **2002**, 949.
10. Guerlavais, V.; Carroll, P. J.; Joullié, M. M. *Tetrahedron: Asymmetry* **2002**, *13*, 675.
11. Hein, J. E.; Hultin, P. G. *Synlett* **2003**, 635.
12. Li, G.; Xu, X.; Chen, D.; Timmons, C.; Carducci, M. D.; Headley, A. D. *Org. Lett.* **2003**, *5*, 329.
13. Zhang, W.; Carter, R. G.; Yokochi, A. F. T. *J. Org. Chem* **2004**, *69*, 2569.

Favorskii rearrangement and quasi-Favorskii rearrangement

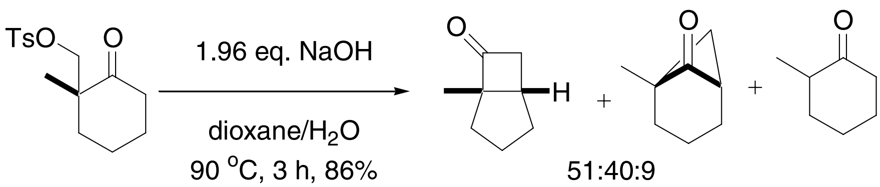
Favorskii rearrangement

Transformation of enolizable α-haloketones to esters, carboxylic acids, or amides *via* alkoxide-, hydroxide-, or amine-catalyzed rearrangements, respectively.

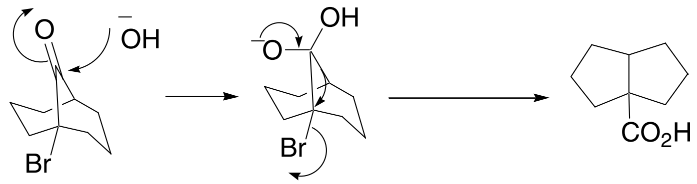




Example 1, homo-Favorskii rearrangement[3]

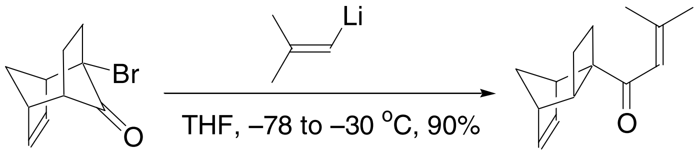


Quasi-Favorskii rearrangement



non-enolizable ketone

Example 1[11]

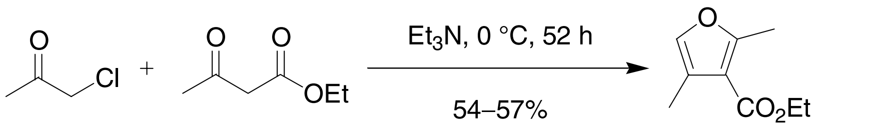


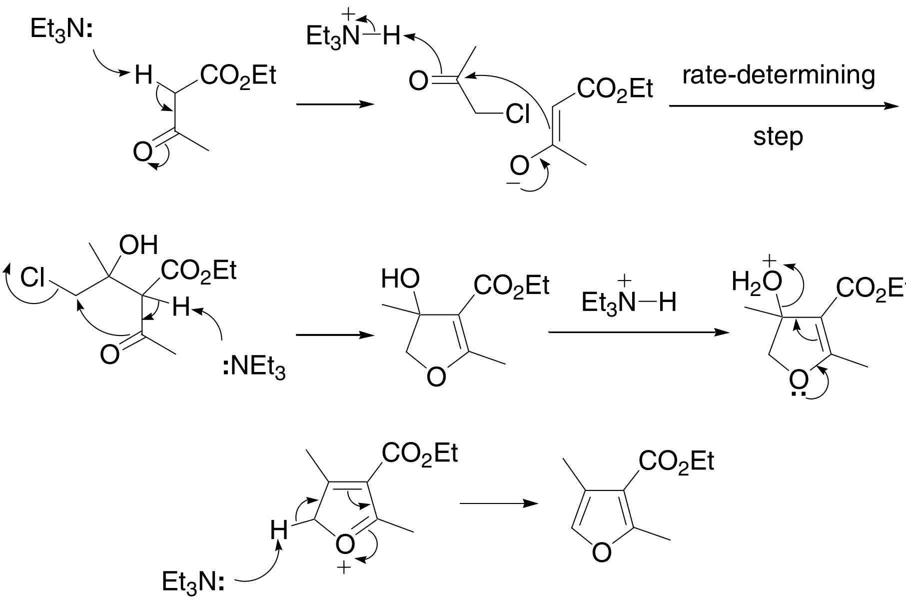
References

1. Favorskii, A. E. *J. Prakt. Chem.* **1895**, *51*, 533. Aleksei E. Favorskii (1860–1945), born in Selo Pavlova, Russia, studied at St. Petersburg State University, where he became a professor in 1900.
2. Favorskii, A. E. *J. Prakt. Chem.* **1913**, *88*, 658.
3. Wenkert, E.; Bakuzis, P.; Baumgarten, R. J.; Leicht, C. L.; Schenk, H. P. *J. Am. Chem. Soc.* **1971**, *93*, 3208.
4. Chenier, P. J. *J. Chem. Educ.* **1978**, *55*, 286–291. (Review).
5. Barreta, A.; Waegell, B. In *Reactive Intermediates*; Abramovitch, R. A., ed.; Plenum Press: New York, **1982**, *2,* pp 527–585. (Review).
6. Gambacorta, A.; Turchetta, S.; Bovicelli, P.; Botta, M. *Tetrahedron* **1991**, *47*, 9097.
7. Dhavale, D. D.; Mali, V. P.; Sudrik, S. G.; Sonawane, H. R. *Tetrahedron* **1997**, *53*, 16789.
8. Braverman, S.; Cherkinsky, M.; Kumar, E. V. K. S.; Gottlieb, H. E. *Tetrahedron* **2000**, *56*, 4521.
9. Mamedov, V. A.; Tsuboi, S.; Mustakimova, L. V.; Hamamoto, H.; Gubaidullin, A. T.; Litvinov, I. A.; Levin, Y. A. *Chem. Heterocyclic Compd.* **2001**, *36*, 911. (Review).
10. Zhang, L.; Koreeda, M. *Org. Lett.* **2002**, *4*, 3755.
11. Harmata, M.; Wacharasindhu, S. *Org. Lett.* **2005**, *7*, 2563. (quasi-Favorskii rearrangement).

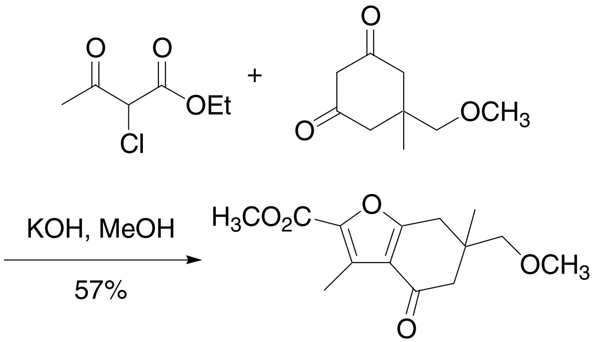
Feist–Bénary furan synthesis

α-Haloketones react with β-ketoesters in the presence of base to fashion furans.

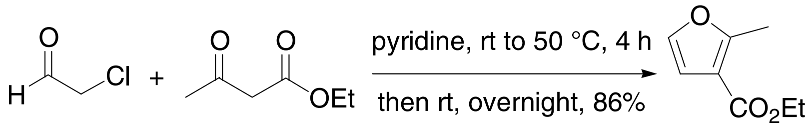




Example 1[4,5]



Example 2[6]



References

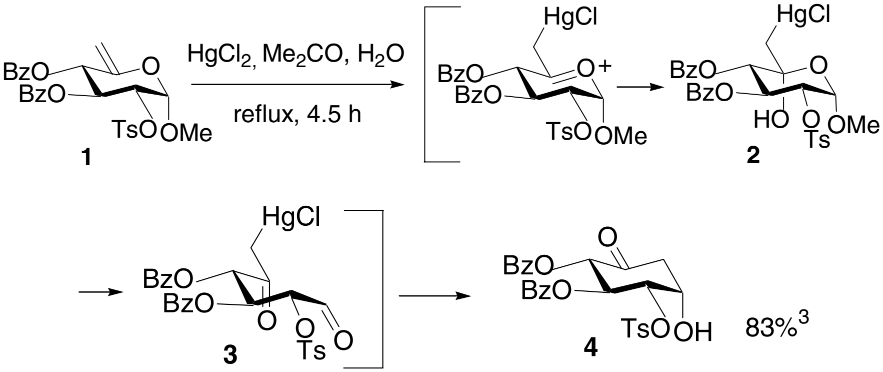
1. Feist, F. *Ber. Dtsch. Chem. Ges.* **1902**, *35*, 1537.
2. Bénary, E. *Ber. Dtsch. Chem. Ges.* **1911**, *44*, 489.
3. Bisagni, É.; Marquet, J.-P.; André-Louisfert, J.; Cheutin, A.; Feinte, F. *Bull. Soc. Chim. Fr.* **1967**, 2796.
4. Gopalan, A.; Magnus, P. *J. Am. Chem. Soc.* **1980**, *102*, 1756.
5. Gopalan, A.; Magnus, P. *J. Org. Chem.* **1984**, *49*, 2317.
6. Padwa, A.; Gasdaska, J. R. *Tetrahedron* **1988**, *44*, 4147.
7. Dean, F. M. *Recent Advances in Furan Chemistry. Part I* In *Advances in Heterocyclic Chemistry*, Katritzky, A. R., Ed.; Academic Press: New York, **1982**; Vol. 30, 167−238. (Review).
8. Cambie, R. C.; Moratti, S. C.; Rutledge, P. S.; Woodgate, P. D. *Synth. Commun.* **1990**, *20*, 1923.
9. Friedrichsen, W. *Furans and Their Benzo Derivatives: Synthesis*. In *Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R., Rees, C. W., Scriven, E. F. V.; Bird, C. V. Eds.; Pergamon: New York, **1996**; Vol. 2, 351−393. (Review).
10. König, B. *Product Class 9: Furans*. In *Science of Synthesis: Houben−Weyl Methods of Molecular Transformations*; Maas, G., Ed.; Georg Thieme Verlag: New York, **2001**; Cat. 2, Vol. 9, 183−278. (Review).
11. Calter, M.; Zhu, C. *Org. Lett.* **2002**, *4*, 205.
12. Calter, M.; Zhu, C.; Lachicotte, R. J. *Org. Lett.* **2002**, *4*, 209.
13. Shea, K. M. *Feist–Bénary Furan Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 160−167. (Review).

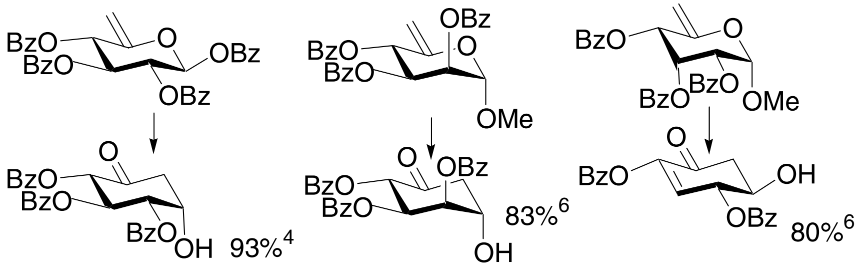
Ferrier carbocyclization

This process (also known as the "Ferrier II Reaction") has proved to be of considerable value for the efficient, one-step conversion of 5,6-unsaturated hexopyranose derivatives into functionalized cyclohexanones useful for the preparation of such enantiomerically pure compounds as inositols and their amino, deoxy, unsaturated and selectively *O*-substituted derivatives, notably phosphate esters. In addition, the products of the carbocyclization have been incorporated into many complex compounds of interest in biological and medicinal chemistry.[1,2]

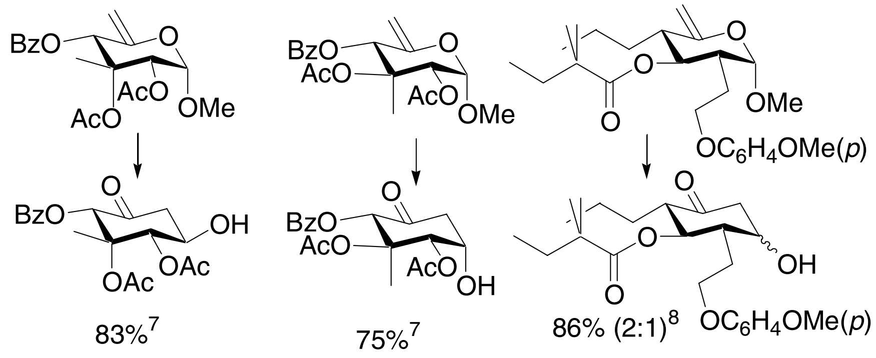
While attempting to find a route from carbohydrates to functionalized cyclopentanes (and hence prostaglandins), Robin Ferrier converted alkene **1** to the standard product of methoxymercuration, but was unable to proceed to cyclopentanes by causing C-6 of the C-6-mercurated product to displace the tosyloxy group from C-2. However, hydroxymercuration of **1** with mercury(II) chloride in refluxing aqueous acetone afforded the unstable hemiacetal **2** from which aldehydoketone **3** and hence the hydroxyketone **4** were formed spontaneously, the latter crystallizing in 83% yield on cooling of the solution.[3] The high yield can be increased to 89% by addition of a trace of acetic acid,[4] and even higher yields have been reported in similar examples. Catalytic amounts of mercury(II) trifluoroacetate[5] and sulfate[6] can promote the reaction, and chelation control has been held responsible for the high stereoselectivity usually observed, the favored epimers having the *trans*-relationship between the hydroxyl groups at the new chiral centers and the substituents at C-3.[1,2]

General examples:

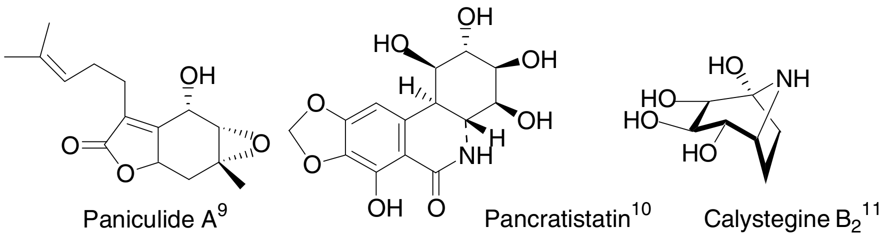




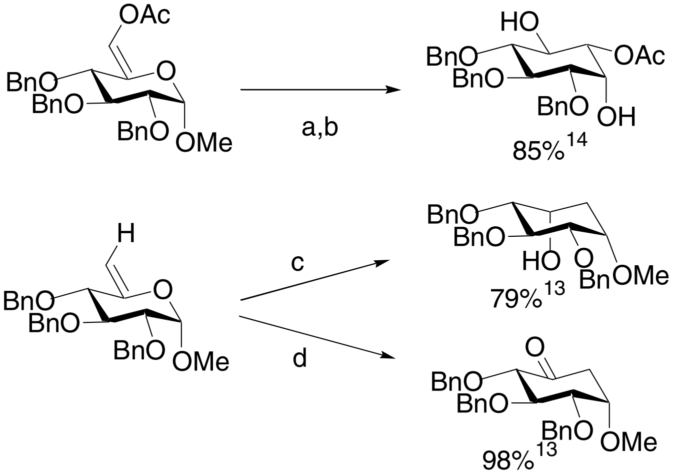
More complex products



Complex bioactive compounds made following the application of the reaction



Modified hex-5-enopyranosides and reactions



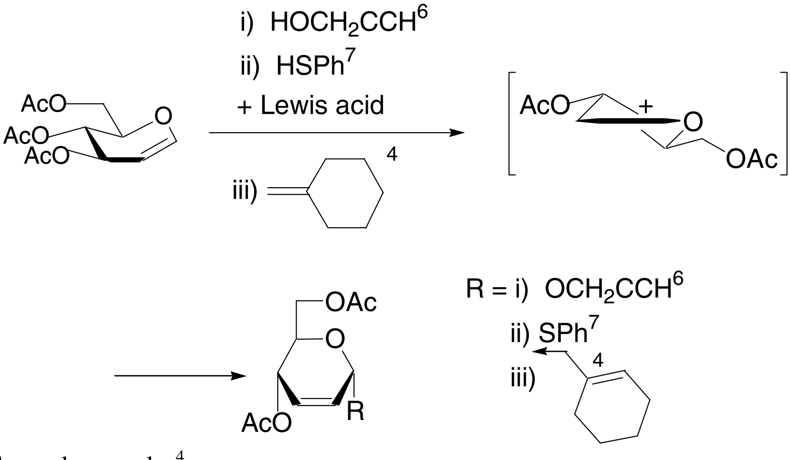
a, $Hg(OCOCF_3)_2$, Me_2CO, H_2O, 0 °C; b, $NaBH(OAc)_3$, AcOH, MeCN, rt; c, *i*-Bu_3Al, PhMe, 40 °C; d, Ti(O*i*-Pr)Cl_3, CH_2Cl_2, –78 °C, 15 min. (Note: The aglycon is retained in the Al- and Ti-induced reactions).

References

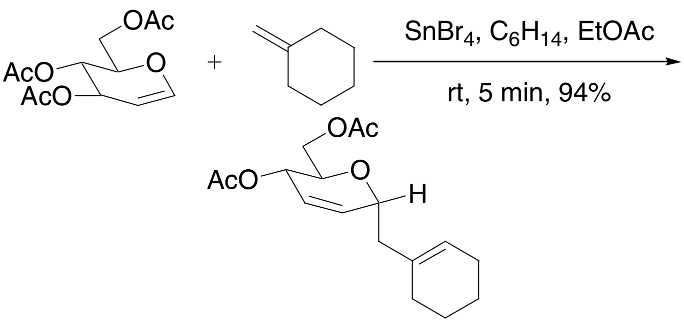
1. Ferrier, R. J.; Middleton, S. *Chem. Rev*. **1993**, *93*, 2779–2831. (Review).
2. Ferrier, R. J. *Top. Curr. Chem.* **2001**, *215*, 277–291 (Review).
3. Ferrier, R. J. *J. Chem. Soc., Perkin Trans. 1* **1979**, 1455. The discovery (1977) was made in the Pharmacology Department, University of Edinburgh, while R. J. Ferrier was on leave from Victoria University of Wellington, New Zealand where he was Professor of Organic Chemistry. He is now a consultant with Industrial Research Ltd., Lower Hutt, New Zealand.
4. Blattner, R.; Ferrier, R. J.; Haines, S. R. *J. Chem. Soc., Perkin Trans. 1*, **1985**, 2413.
5. Chida, N.; Ohtsuka, M.; Ogura, K.; Ogawa, S. *Bull. Chem. Soc. Jpn*. **1991**, *64*, 2118.
6. Machado, A. S.; Olesker, A.; Lukacs, G. *Carbohydr. Res*. **1985**, *135*, 231.
7. Sato, K.-i.; Sakuma, S.; Nakamura, Y.; Yoshimura, J.; Hashimoto, H. *Chem. Lett*. **1991**, 17.
8. Ermolenko, M. S.; Olesker, A.; Lukacs, G. *Tetrahedron Lett*. **1994**, *35*, 711.
9. Amano, S.; Takemura, N.; Ohtsuka, M.; Ogawa, S.; Chida, N. *Tetrahedron* **1999**, *55*, 3855.
10. Park, T. K.; Danishefsky, S. J. *Tetrahedron Lett.* **1995**, *36*, 195.
11. Boyer, F.-D.; Lallemand, J.-Y. *Tetrahedron* **1994**, *50*, 10443.
12. Das, S. K.; Mallet, J.-M.; Sinaÿ, P. *Angew. Chem. Int. Ed. Engl*. **1997**, *36*, 493.
13. Sollogoub, M.; Mallet, J.-M.; Sinaÿ, P. *Tetrahedron Lett.* **1998**, *39*, 3471.
14. Bender, S. L.; Budhu, R. J. *J. Am. Chem. Soc.* **1991**, *113*, 9883.
15. Estevez, V. A.; Prestwich, E. D. *J. Am. Chem. Soc.* **1991**, *113*, 9885.

Ferrier glycal allylic rearrangement

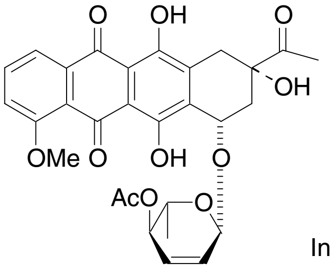
In the presence of Lewis acid catalysts *O*-substituted glycal derivatives can react with *O*-, *S*-, *C*- and, less frequently, *N*-, *P*- and halide nucleophiles to give 2,3-unsaturated glycosyl products.[1,2] This allylic transformation has been termed the "Ferrier Reaction" or, to avoid complications, the "Ferrier I Reaction" or the "Ferrier Rearrangement". However, the reaction was first noted by Emil Fischer when he heated tri-*O*-acetyl-D-glucal in water.[3] When carbon nucleophiles are involved, the term "Carbon Ferrier Reaction" has been used,[4] although the only contribution the Ferrier group made in this area was to find that tri-*O*-acetyl-D-glucal dimerizes under acid catalysis to give a *C*-glycosidic product.[5] The general reaction is illustrated by the separate conversions of tri-*O*-acetyl-D-glucal with *O*-, *S*- and *C*-nucleophiles to the corresponding 2,3-unsaturated glycosyl derivatives. Normally, Lewis acids are used as catalysts, boron trifluoride etherate being the most common. Allyloxycarbenium ions are involved as intermediates, high yields of products are obtained, and glycosidic compounds with quasi-axial bonds (as illustrated) predominate (commonly in the α,β-ratio of about 7:1). The examples illustrated[4,6,7] are typical of a very large number of literature reports.[1]



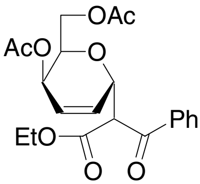
General examples[4]



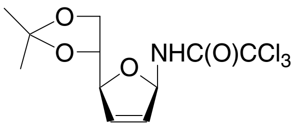
More complex products made directly from the corresponding glycols:



In benzene, $BF_3.OEt_2$, 5 °C, 10 min, (67%, α-anomer).[8]

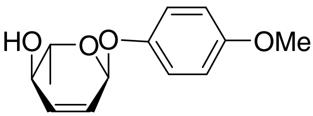


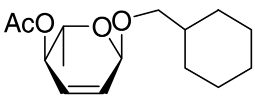
In $PhCOCH_2CO_2Et$, $BF_3.OEt_2$, rt, 15 min, (81% α-anomer).[9]



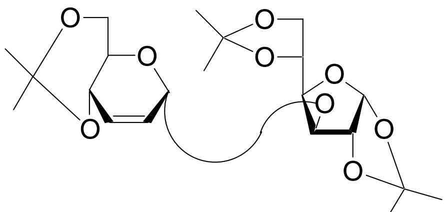
By spontaneous sigmatropic rearrangement of the glycal 3-trichloroacetimidate made with NaH, Cl_3CCN, (78% α–anomer).[10]

Products formed without acid catalysts



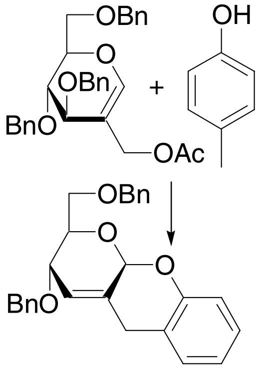


Promoter:	DEAD, Ph_3P (80%, α-anomer)[11]	DDQ (88%, mainly α)[12]
C-3 leaving group of glycal:	hydroxy	acetoxy

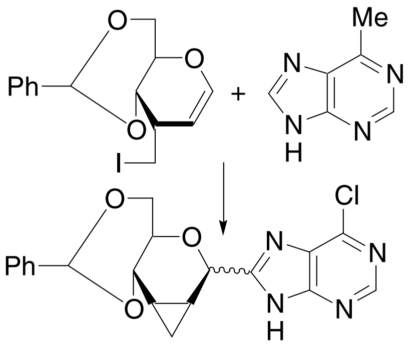


N-iodonium dicollidine perchlorate
(65%, mainly α)[13]
pent-4-enoyloxy

Modified glycals and their reactions:



$BF_3{\bullet}OEt_2$, CH_2Cl_2, 0 °C (70%, mainly α)[14]



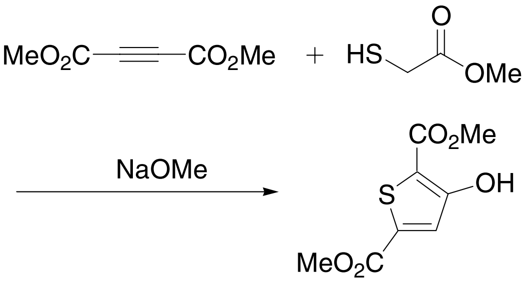
$AgNO_3$, Na_2CO_3, reflux $MeNO_2$, 6 h (58%, α,β 1:1).[15]

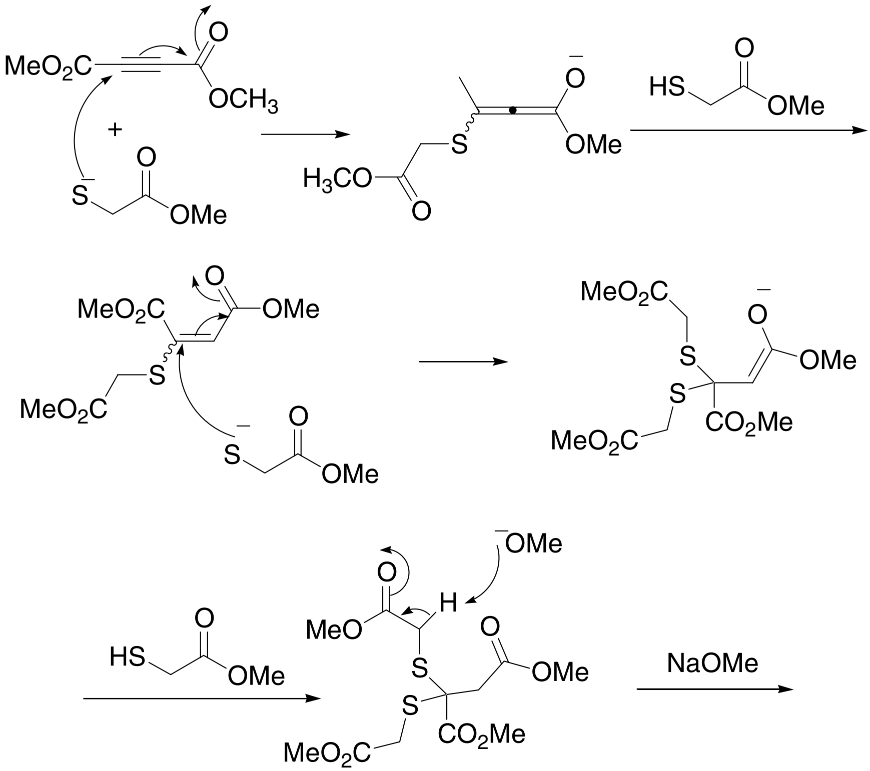
References

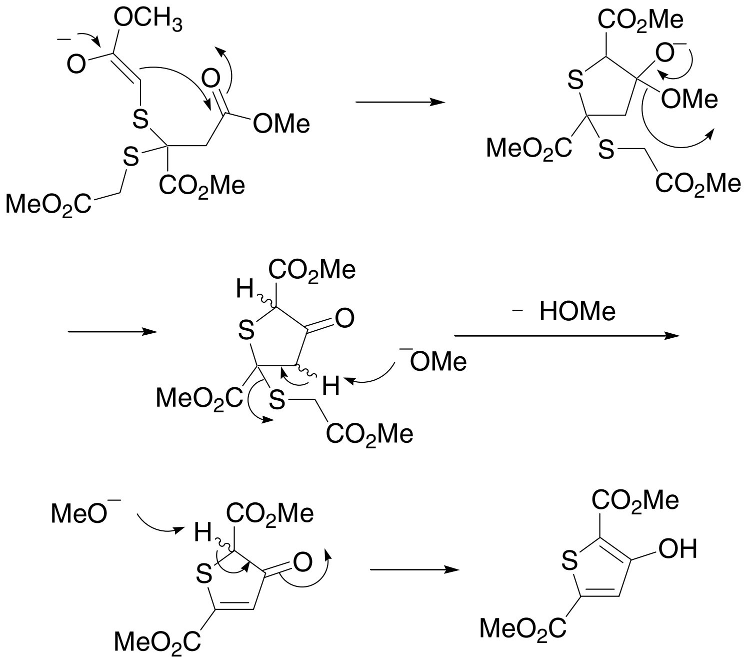
1. Ferrier, R. J.; Zubkov, O. A. Transformation of glycals into 2,3-unsaturated glycosyl derivatives, In *Org. React.* **2003**, *62*, 569–736. (Review). It was almost 50 years after Fischer's seminal finding that water took part in the reaction[3] that Ann Ryan, working in George Overend's Department in Birkbeck College, University of London, found, by chance, that *p*-nitrophenol likewise participates.[16] Robin Ferrier, her immediate supervisor, who suggested her experiment, then found that simple alcohols at high temperatures also take part,[17] and with other students, notably Nagendra Prasad and George Sankey, he explored the reaction extensively. They did not apply it to make the very important *C*-glycosides.
2. Ferrier, R. J. *Top. Curr. Chem.* **2001**, *215*, 175. (Review).
3. Fischer, E. *Chem. Ber.* **1914**, *47*, 196.
4. Herscovici, J.; Muleka, K.; Boumaïza, L.; Antonakis, K. *J. Chem. Soc., Perkin Trans. 1* **1990**, 1995.
5. Ferrier, R. J.; Prasad, N. *J. Chem. Soc. (C)* **1969**, 581.
6. Moufid, N.; Chapleur, Y.; Mayon, P. *J. Chem. Soc., Perkin Trans. 1* **1992**, 999.
7. Whittman, M. D.; Halcomb, R. L.; Danishefsky, S. J.; Golik, J.; Vyas, D. *J. Org. Chem.* **1990**, *55*, 1979.
8. Klaffke, W.; Pudlo, P.; Springer, D.; Thiem, J. *Liebigs Ann. Chem.* **1991**, 509.
9. Yougai, S.; Miwa, T. *J. Chem. Soc., Chem. Commun.* **1983**, 68.
10. Armstrong, P. L.; Coull, I. C.; Hewson, A. T.; Slater, M. J. *Tetrahedron Lett.* **1995**, *36*. 4311.
11. Sobti, A.; Sulikowski, G. A. *Tetrahedron Lett.* **1994**, *35*. 3661.
12. Toshima, K.; Ishizuka, T.; Matsuo, G.; Nakata, M.; Kinoshita, M. *J. Chem. Soc., Chem. Commun.* **1993**, 704.
13. López, J. C.; Gómez, A. M.; Valverde, S.; Fraser-Reid, B. *J. Org. Chem.* **1995**, *60*, 3851.
14. Booma, C.; Balasubramanian, K. K. *Tetraherdron Lett.* **1993**, *34*, 6757.
15. Tam, S. Y.-K.; Fraser-Reid, B. *Can. J. Chem.* **1977**, *55*, 3996.
16. Ferrier, R. J.; Overend, W. G.; Ryan, A. E. *J. Chem. Soc. (C)* **1962**, 3667.
17. Ferrier, R. J. *J. Chem. Soc.***1964**, 5443.

Fiesselmann thiophene synthesis

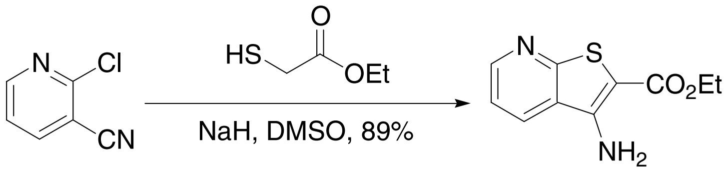
Condensation reaction of thioglycolic acid derivatives with α,β-acetylenic esters, which upon treatment with base result in the formation of 3-hydroxy-2-thiophenecarboxylic acid derivatives.



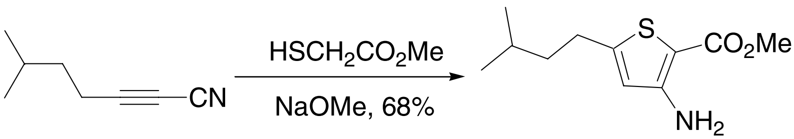




Example 1[6]



Example 2[8]



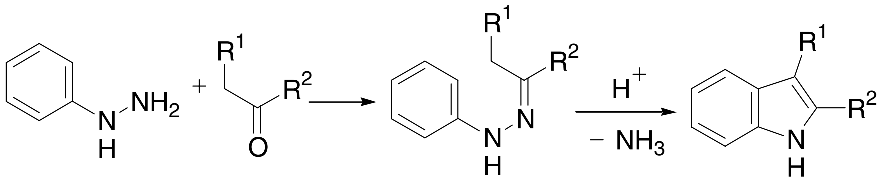
References

1. Fiesselmann, H.; Schipprak, P. *Chem. Ber.* **1954**, *87*, 835; Fiesselmann, H.; Schipprak, P.; Zeitler, L. *Chem. Ber.* **1954**, *87*, 841; Fiesselmann, H.; Pfeiffer, G. *Chem. Ber.* **1954**, *87*, 848; Fiesselmann, H.; Thoma, F. *Chem. Ber.* **1956**, *89*, 1907; Fiesselmann, H.; Schipprak, P. *Chem. Ber.* **1956**, *89*, 1897.
2. Gronowitz, S. In *Thiophene and Its Derivatives*, Part 1, Gronowitz, S., Ed.; Wiley & Sons: New York, **1985**, 88−125. (Review).

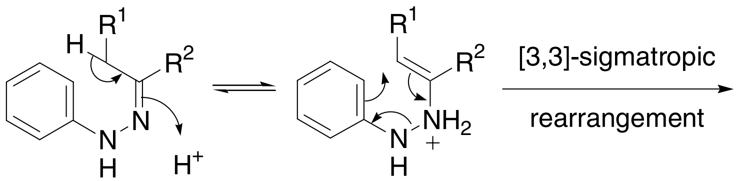
3. Nicolaou, K. C.; Skokotas, G.; Furuya, S.; Suemune, H.; Nicolaou, D. C. *Angew. Chem. Int. Ed. Engl.* **1990**, *29*, 1064.
4. Mullican, M. D.; Sorenson, R. J.; Connor, D. T.; Thueson, D. O.; Kennedy, J. A.; Conroy, M. C. *J. Med. Chem.* **1991**, *34*, 2186.
5. Ram, V. J.; Goel, A.; Shukla, P. K.; Kapil, A. *Bioorg. Med. Chem. Lett.* **1997**, *7*, 3101.
6. Showalter, H. D. H.; Bridges, A. J.; Zhou, H.; Sercel, A. D.; McMichael, A.; Fry, D. W. *J. Med. Chem.* **1999**, *42*, 5464.
7. Shkinyova, T. K.; Dalinger, I. L.; Molotov, S. I.; Shevelev, S. A. *Tetrahedron Lett.* **2000**, *41*, 4973
8. Redman, A. M.; Johnson, J. S.; Dally, R.; Swartz, S.; *et al. Bioorg. Med. Chem. Lett.* **2001**, *11*, 9.
9. Migianu, E.; Kirsch, G. *Synthesis*, **2002**, 1096.
10. Mullins, R. J.; Williams, D. R. *Fiesselmann Thiophene Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 184−192. (Review).

Fischer indole synthesis

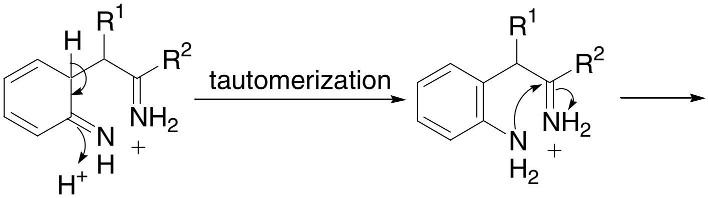
Cyclization of arylhydrazones to indoles.



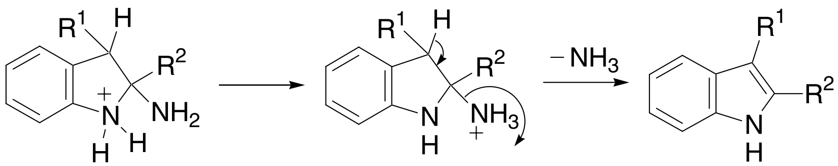
phenylhydrazine phenylhydrazone



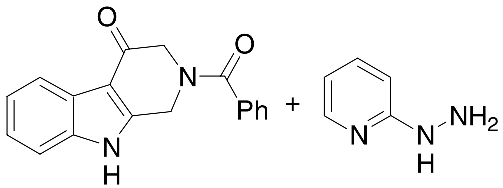
protonation ene-hydrazine

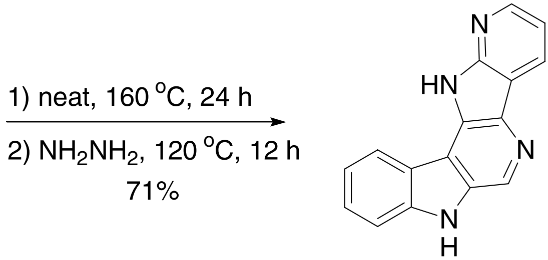


double imine

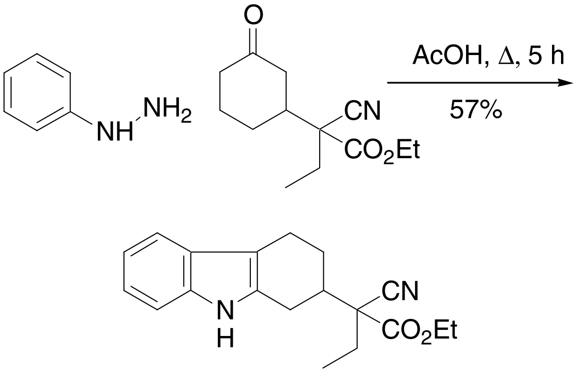


Example 1[8,12]





Example 2[13]

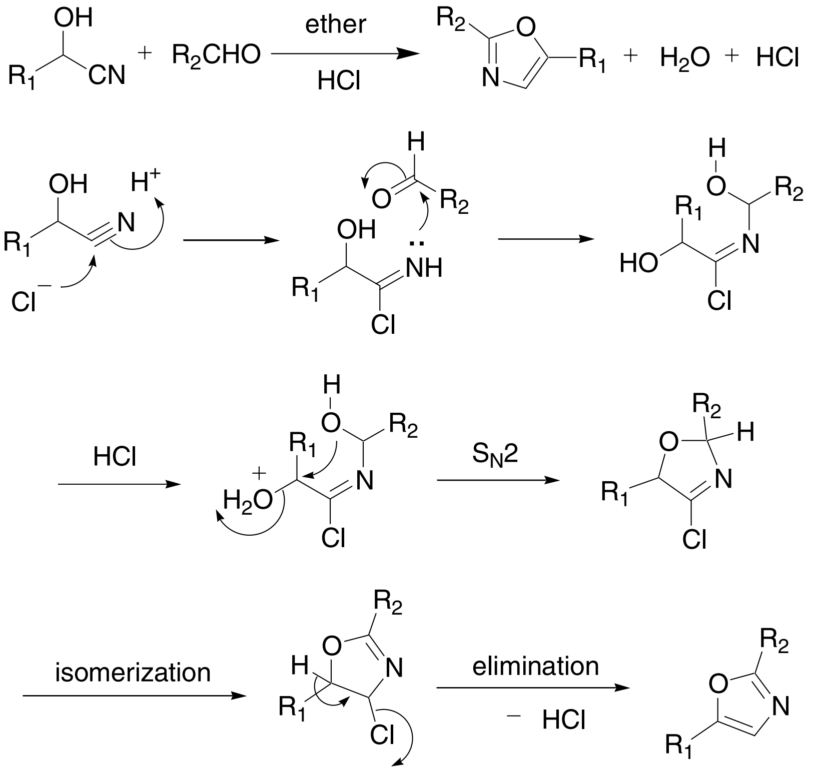


References

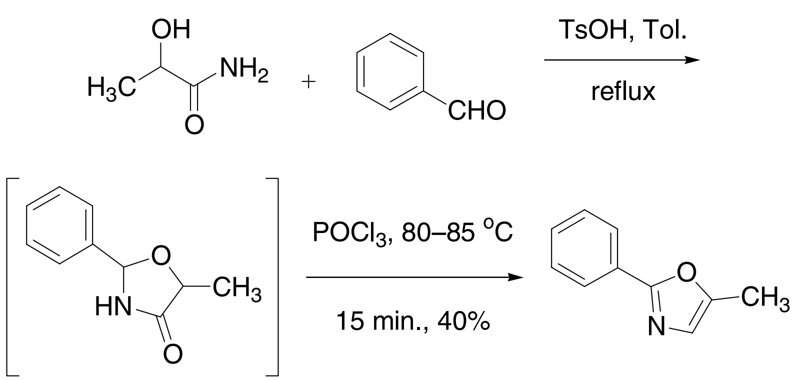
1. Fischer, E.; Jourdan, F. *Ber. Dtsch. Chem. Ges.* **1883**, *16*, 2241. H. Emil Fischer (1852−1919) is arguably the greatest organic chemist ever. He was born in Euskirchen, near Bonn, Germany. When he was a boy, his father, Lorenz, said about him: "The boy is too stupid to go in to business; so in God's name, let him study." Fischer studied at Bonn and then Strassburg under Adolf von Baeyer. Fischer won the Nobel Prize in Chemistry in 1902 (three years ahead of his master, von Baeyer) for his synthetic studies in the area of sugar and purine groups.
2. Fischer, E.; Hess, O. *Ber. Dtsch. Chem. Ges.* **1884**, *17*, 559.
3. Shriner, R. L.; Ashley, W. C.; Welch, E. *Org. Synth.* **1955***, Coll. Vol. 3*, 725.
4. Robinson, B. *Chem. Rev.* **1963***, 63*, 373−401. (Review).
5. Robinson, B. *Chem. Rev.* **1969**, *69*, 227−250. (Review).
6. Ishii, H. *Acc. Chem. Res.* **1981**, *14*, 275−283. (Review).
7. Robinson, B. *The Fisher Indole Synthesis,* John Wiley & Sons, New York, NY, **1982**. (Book).
8. Hughes, D. L. *Org. Prep. Proc. Int.* **1993**, *25*, 607-632. (Review).
9. Bosch, J.; Roca, T.; Armengol, M.; Fernández-Forner, D. *Tetrahedron* **2001***, 57*, 1041.
10. Pete, B.; Parlagh, G. *Tetrahedron Lett.* **2003**, *44*, 2537.
11. Li, J.; Cook, J. M. *Fischer Indole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 100−103. (Review).

Fischer oxazole synthesis

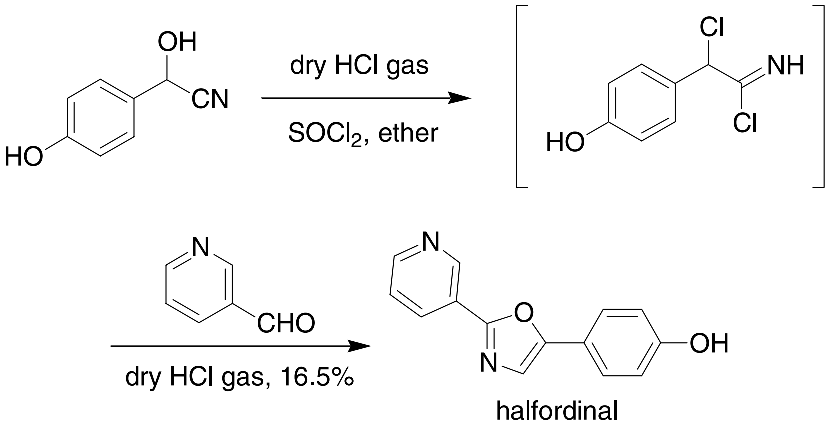
Oxazoles from the condensation of equimolar amounts of aldehyde cyanohydrins and aromatic aldehydes in dry ether in the presence of dry hydrochloric acid.



Example 1[6]



Example 2[10]

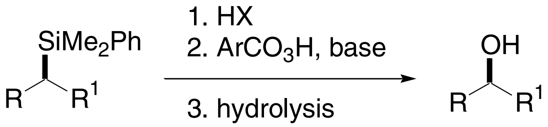


References

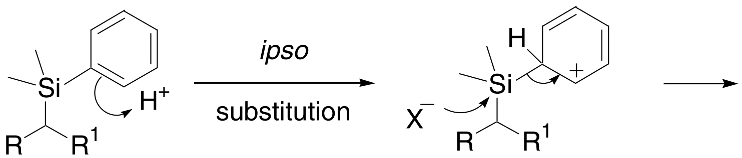
1. Fischer, E. *Ber.* **1896**, **29,** 205.
2. Ingham, B. H. *J. Chem. Soc.* **1927**, 692.
3. Minovici, S.; Nenitzescu, C. D.; Angelescu, B. *Bull Soc. Chem. Romania* **1928**, *10*, 149; *Chem. Abstracts* **1929**, *23*, 2716.
4. Ladenburg, K.; Folkers, K.; Major, R. T. *J. Am. Chem. Soc.* **1936**, *58*, 1292.
5. Wiley, R. H. *Chem. Rev.* **1945**, *37*, 401–442. (Review).
6. Cornforth, J. W.; Cornforth, R. H. *J. Chem. Soc.* **1949,** 1028.
7. Cornforth, J. W. In *Heterocyclic Compounds 5*; Elderfield, R. C. Ed.; Wiley & Sons: New York, **1957**, *5,* 309–312. (Review).
8. Crow, W. D.; Hodgkin, J. H. *Tetrahedron Lett.* **1963**, *2*, 85; *Austr. J. Chem.* **1964**, *17*, 119.
9. Brossi, A.; Wenis, E. *J. Heterocyclic Chem.* **1965**, *2*, 310.
10. Onaka, T. *Tetrahedron Lett.* **1971,** 4393.
11. Brooks, D. A. *Fisher Oxazole Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 234–236. (Review).

Fleming–Kumada oxidation

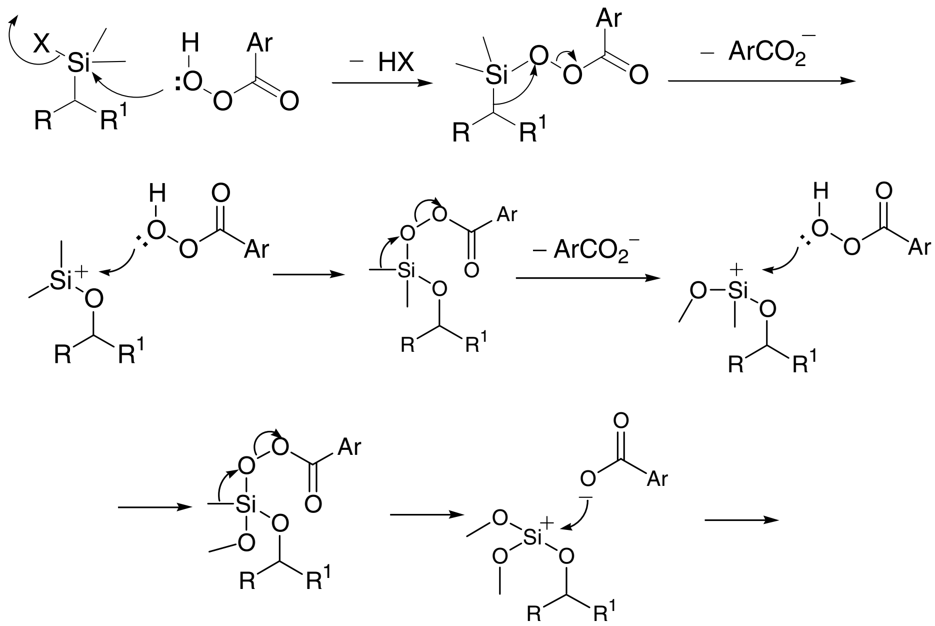
Stereoselective oxidation of alkyl-silanes into the corresponding alkyl-alcohols using peracids.

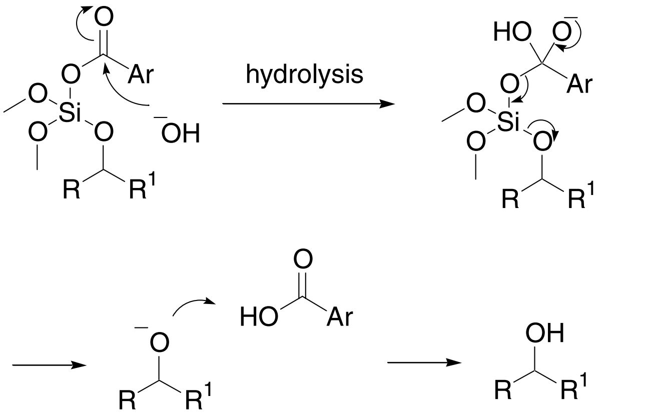


retention of configuration

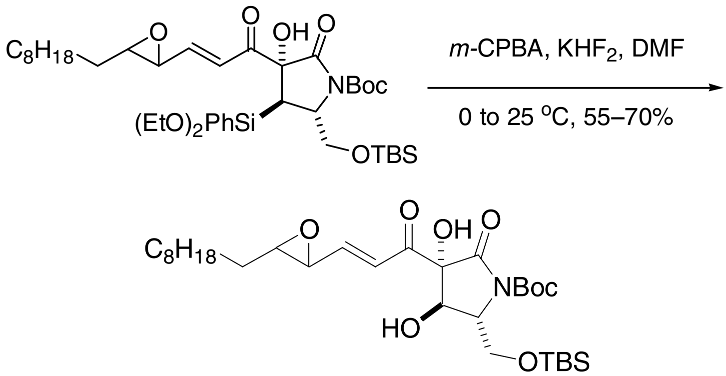


the β-carbocation is stabilized by the silicon group

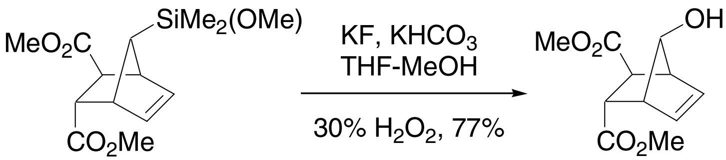




Example 1[7]

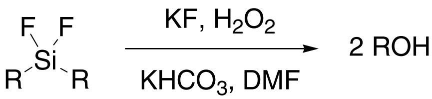


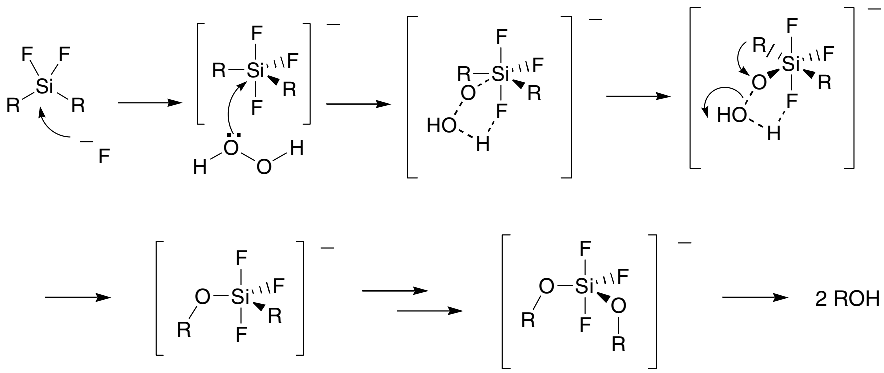
Example 2[12]



Tamao–Kumada oxidation[15]

Oxidation of alkyl fluorosilanes to the corresponding alcohols. A variant of the Fleming–Kumada oxidation.





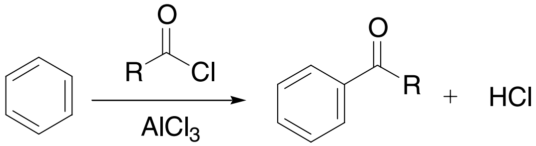
References

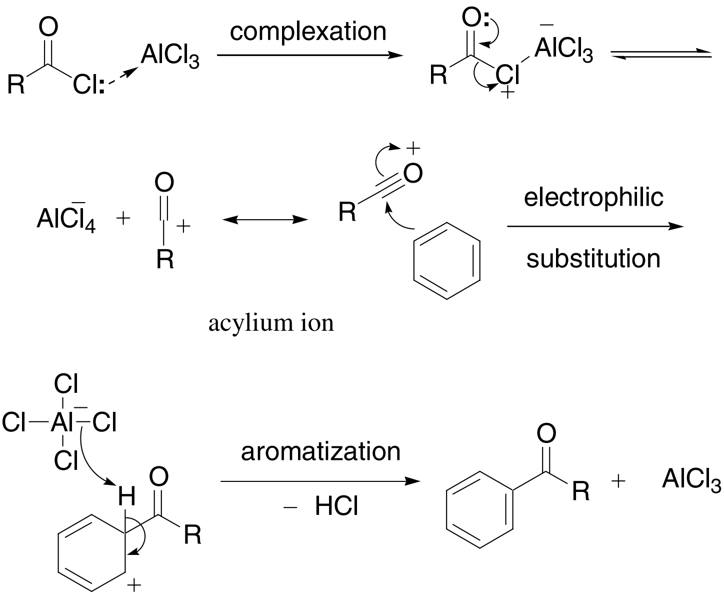
1. Fleming, I.; Henning, R.; Plaut, H. *J. Chem. Soc., Chem. Commun.* **1984**, 29.
2. Fleming, I.; Sanderson, P. E. J. *Tetrahedron Lett.* **1987**, *28*, 4229.
3. Fleming, I.; Dunoguès, J.; Smithers, R. *Org. React.* **1989**, *37*, 57–576. (Review).
4. Jones, G. R.; Landais, Y. *Tetrahedron* **1996**, *52*, 7599.
5. Hunt, J. A.; Roush, W. R. *J. Org. Chem.* **1997**, *62*, 1112.
6. Knölker, H.-J.; Jones, P. G.; Wanzl, G. *Synlett* **1997**, 613.
7. Barrett, A. G. M.; Head, J.; Smith, M. L.; Stock, N. S.; White, A. J. P.; Williams, D. J. *J. Org. Chem.* **1999**, *64*, 6005.
8. Lee, T. W.; Corey, E. J. *Org. Lett.* **2001**, *3*, 3337.
9. Rubin, M.; Schwier, T.; Gevorgyan, V. *J. Org. Chem.* **2002**, *67*, 1936.
10. Boulineau, F. P.; Wei, A. *Org. Lett.* **2002**, *4*, 2281.
11. Jung, M. E.; Piizzi, G. *J. Org. Chem.* **2003**, *68*, 2572.
12. Clive, D. L. J.; Cheng, H.; Gangopadhyay, P.; Huang, X.; Prabhudas, B. *Tetrahedron* **2004**, *60*, 4205.
13. Sanganee, M. J.; Steel, P. G.; Whelligan, D. K. *Org. Biomol. Chem.* **2004**, *2*, 2393.
14. Ko, C. H.; Jung, D. Y.; Kim, M. K.; Kim, Y. H. *Synlett* **2005**, 304.
15. Tamao, K.; Ishida, N.; Kumada, M. *J. Org. Chem.* **1983**, *48*, 2120.

Friedel–Crafts reaction

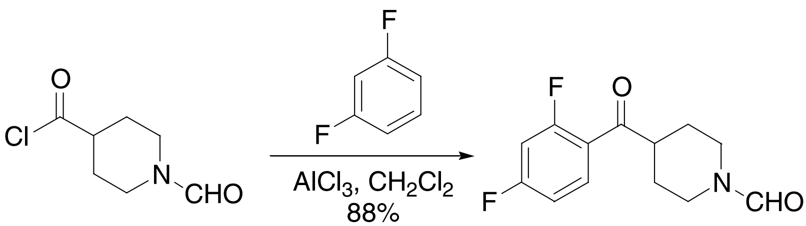
Friedel–Crafts *acylation* reaction:

Introduction of an acyl group onto an aromatic substrate by treating the substrate with an acyl halide or anhydride in the presence of a Lewis acid.



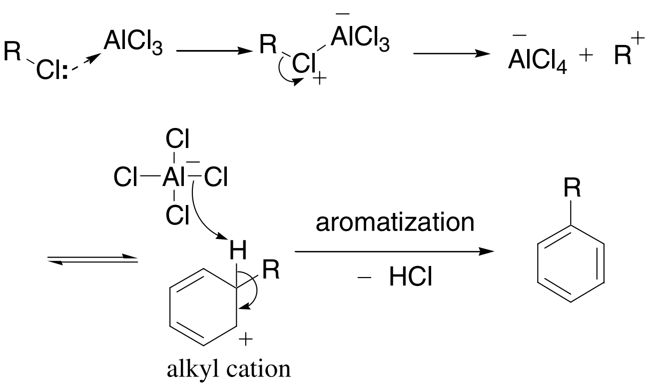


Example 1[16]

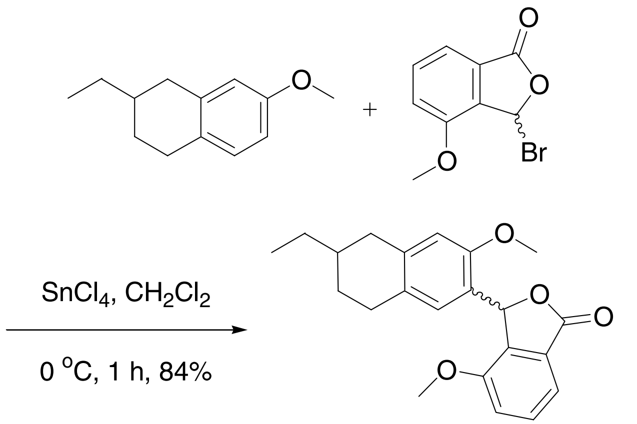


Friedel–Crafts *alkylation* reaction:

Introduction of an alkyl group onto an aromatic substrate by treating the substrate with an alkylating agent such as alkyl halide, alkene, alkyne and alcohol in the presence of a Lewis acid.



Example 2[7]



References

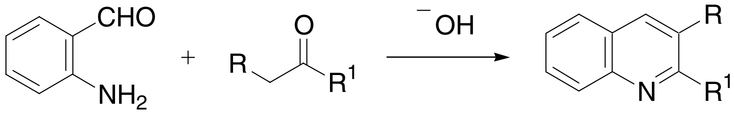
1. Friedel, C.; Crafts, J. M. *Compt. Rend.* **1877**, *84*, 1392. Charles Friedel (1832−1899) was born in Strasbourg, France. He earned his Ph.D. in 1869 under Wurtz at Sorbonne and became a professor and later chair (1884) of organic chemistry at Sorbonne. Friedel was one of the founders of the French Chemical Society and served as its president for four terms. James Mason Crafts (1839−1917) was born in Boston, Massachusetts. He studied under Bunsen and Wurtz in his youth and became a professor at Cornell and MIT. From 1874 to 1891, Crafts collaborated with Friedel at École de Mines in Paris, where they discovered the Friedel–Crafts reaction. He returned to MIT

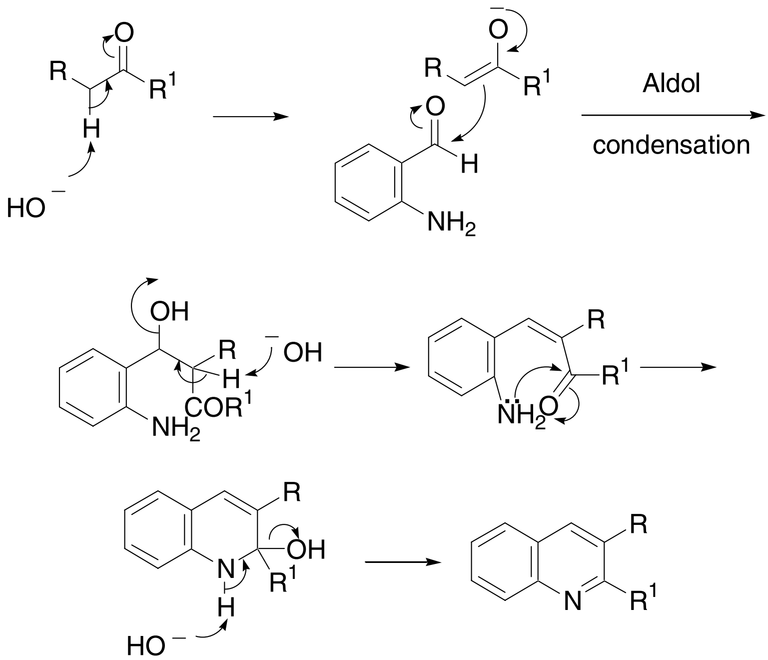
in 1892 and later served as its president. The discovery of the Friedel–Crafts reaction was the fruit of serendipity and keen observation. In 1877, both Friedel and Crafts were working in Charles A. Wurtz's laboratory. In order to prepare amyl iodide, they treated amyl chloride with aluminum and iodide using benzene as the solvent. Instead of amyl iodide, they ended up with amylbenzene! Unlike others before them who may have simply discarded the reaction, they thoroughly investigated the Lewis acid-catalyzed alkylations and acylations and published more than 50 papers and patents on the Friedel–Crafts reaction, which has become one of the most useful organic reactions.

2. Pearson, D. E.; Buehler, C. A. *Synthesis* **1972**, 533.
3. Gore, P. H. *Chem. Ind.* **1974**, 727.
4. Chevrier, B.; Weiss, R. *Angew. Chem., Int. Ed. Engl.* **1974**, *13*, 1.
5. Schriesheim, A.; Kirshenbaum, I. *Chemtech* **1978**, *8*, 310−314. (Review).
6. Hermecz, I.; Mészáros, Z. *Adv. Heterocyclic Chem.* **1983**, *33*, 241.
7. Patil, M. L.; Borate, H. B.; Ponde, D. E.; Bhawal, B. M.; Deshpande, V. H. *Tetrahedron Lett.* **1999**, *40*, 4437.
8. Ottoni, O.; Neder, A. de V. F.; Dias, A. K. B.; Cruz, R. P. A.; Aquino, L. B. *Org. Lett.* **2001**, *3*, 1005.
9. Fleming, I. *Chemtracts: Org. Chem.* **2001**, *14*, 405. (Review).
10. Metivier, P. *Friedel-Crafts Acylation* In *Friedel-Crafts Reaction* Sheldon, R. A.; Bekkum, H. eds., Wiley-VCH: New York. **2001**, pp161−172. (Review).
11. Meima, G. R.; Lee, G. S.; Garces, J. M. *Friedel-Crafts Alkylation* In *Friedel−Crafts Reaction* Sheldon, R. A.; Bekkum, H. eds. Wiley-VCH: New York. **2001**, pp550−556. (Review).
12. Le Roux, C.; Dubac, J. *Synlett* **2002**, 181.
13. Sefkow, M.; Buchs, J. *Org. Lett.* **2003**, *5*, 193.
14. Bandini, M.; Melloni, A.; Umani-Ronchi, A. *Angew. Chem., Int. Ed. Engl.* **2004**, *43*, 550−556. (Review).
15. Fakhraian, H.; Zarinehzad, M.; Ghadiri, H. *Org. Prep. Proced. Int.* **2005**, *37*, 377.
16. Ba Sappa; Mantelingu, K.; Sadashira, M. P.; Rangappa, K. S. *Indian J. Chem. B.* **2004**, *43*, 1954.

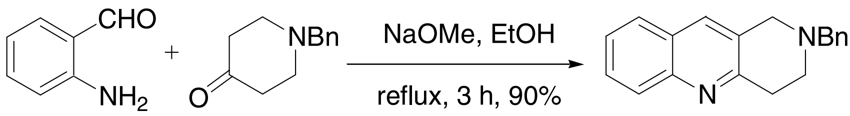
Friedländer quinoline synthesis

The Friedländer quinoline synthesis combines an α-amino aldehyde or ketone with another aldehyde or ketone with at least one methylene α adjacent to the carbonyl to furnish a substituted quinoline. The reaction can be promoted by acid, base, or heat.

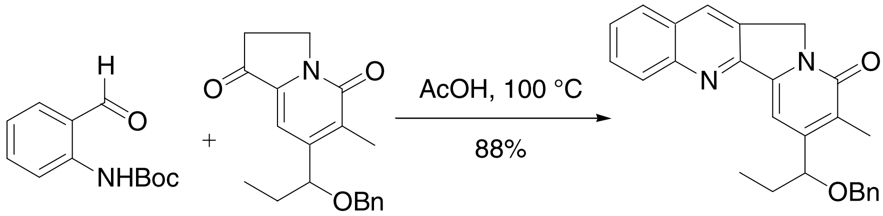




Example 1[5]



Example 2[15]

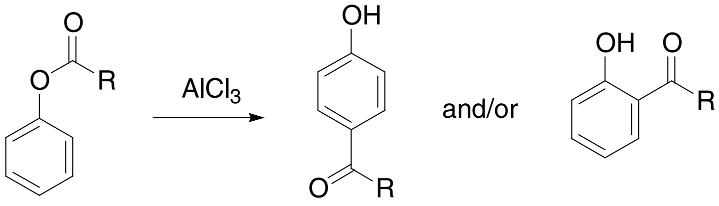


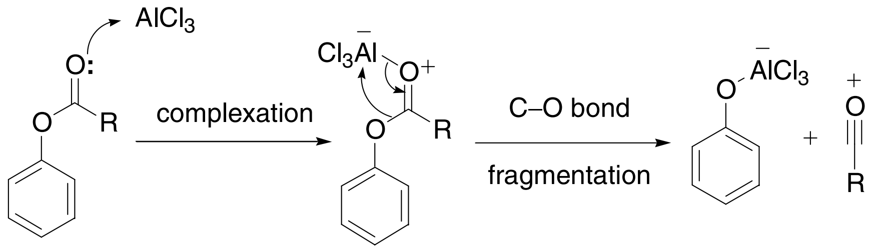
References

1. Friedländer, P. *Ber. Dtsch. Chem. Ges.* **1882**, *15*, 2572. Paul Friedländer (1857−1923), born in Königsberg, Prussia, apprenticed under Carl Graebe and Adolf von Baeyer. He was interested in music and was an accomplished pianist.
2. Elderfield, R. C. In *Heterocyclic Compounds*, Elderfield, R. C., ed.; Wiley & Sons,: New York, **1952**, *4*, Quinoline, Isoquinoline and Their Benzo Derivatives, 45–47. (Review).
3. Jones, G. in *Heterocyclic Compounds*, Quinolines, vol. 32, **1977**; Wiley & Sons: New York, 181–191. (Review).
4. Cheng, C.-C.; Yan, S.-J. *Org. React.* **1982**, *28*, 37. (Review).
5. Shiozawa, A.; Ichikawa, Y.-I.; Komuro, C.; Kurashige, S.; Miyazaki, H.; Yamanaka, H.; Sakamoto, T. *Chem. Pharm. Bull.* **1984**, *32*, 2522.
6. Thummel, R. P. *Synlett* **1992**, 1.
7. Riesgo, E. C.; Jin, X.; Thummel, R. P. *J. Org. Chem.* **1996**, *61*, 3017.
8. Mori, T.; Imafuku, K.; Piao, M.-Z.; Fujimori, K. *J. Heterocycl. Chem.* **1996**, *33*, 841.
9. Ubeda, J. I.; Villacampa, M.; Avendaño, C. *Synthesis* **1998**, 1176.
10. Bu, X.; Deady, L. W. *Synth. Commun.* **1999**, *29*, 4223.
11. Strekowski, L.; Czarny, A.; Lee, H. *J. Fluorine Chem.* **2000**, *104*, 281.
12. Chen, J.; Deady, L. W.; Desneves, J.; Kaye, A. J.; Finlay, G. J.; Baguley, B. C.; Denny, W. A. *Bioorg. Med. Chem.* **2000**, *8*, 2461.
13. Gladiali, S.; Chelucci, G.; Mudadu, M. S.; Gastaut, M.-A.; Thummel, R. P. *J. Org. Chem.* **2001**, *66*, 400.
14. Hsiao, Y.; Rivera, N. R.; Yasuda, N.; Hughes, D. L.; Reider, P. J. *Org. Lett.* **2001**, *3*, 1101; and **2002**, *4*, 1243.
15. Henegar, K. E.; Baughman, T. A. *J. Heterocycl. Chem.* **2003**, *40*, 601.
16. Dormer, P. G.; Eng, K. K.; Farr, R. N.; Humphrey, G. R.; McWilliams, J. C.; Reider, P. J.; Sager, J. W.; Volante, R. P. *J. Org. Chem.* **2003**, *68*, 467.
17. Pflum, D. A. *Friedländer Quinoline Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 411–415. (Review).

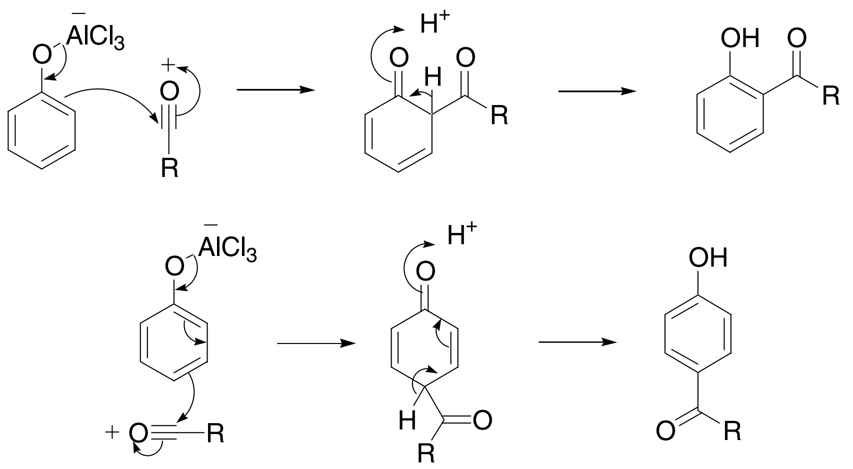
Fries rearrangement

Lewis acid-catalyzed rearrangement of phenol esters and lactams to 2- or 4-ketophenols. Also known as the Fries–Finck rearrangement.

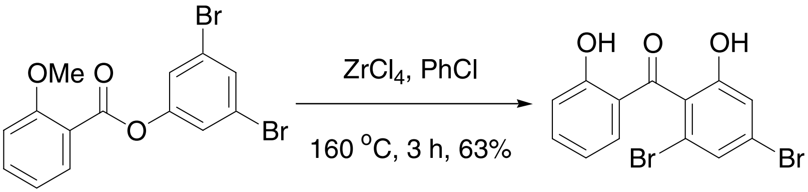




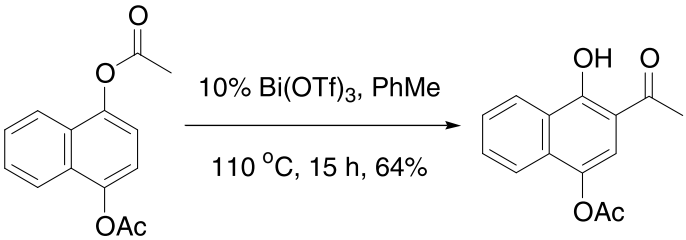
aluminum phenolate, acylium ion



Example 1[11]



Example 2[12]

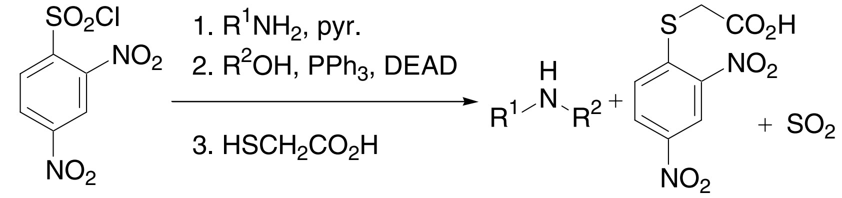


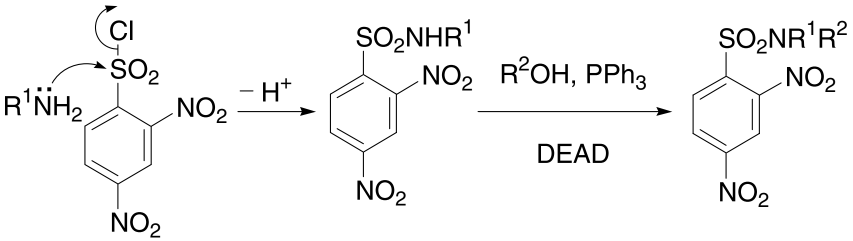
References

1. Fries, K.; Finck, G. *Ber. Dtsch. Chem. Ges.* **1908**, *41*, 4271. Karl Theophil Fries (1875−1962) was born in Kiedrich near Wiesbaden on the Rhine. He earned his doctorate under Theodor Zincke. Although G. Finck co-discovered the rearrangement of phenolic esters, somehow his name has been forgotten by history. In all fairness, the Fries rearrangement should really be the Fries−Finck rearrangement.
2. Martin, R. *Bull. Soc. Chim. Fr.* **1974**, 983–988. (Review).
3. Martin, R. *Org. Prep. Proced. Int.* **1992**, *24*, 369-435. (Review).
4. Trehan, I. R.; Brar, J. S.; Arora, A. K.; Kad, G. L. *J. Chem. Educ.* **1997**, *74*, 324.
5. Boyer, J. L.; Krum, J. E.; Myers, M. C.; Fazal, A. N.; Wigal, C. T. *J. Org. Chem.* **2000**, *65,* 4712.
6. Harjani, J. R.; Nara, S. J.; Salunkhe, M. M. *Tetrahedron Lett.* **2001**, *42,* 1979.
7. Focken, T.; Hopf, H.; Snieckus, V.; Dix, I.; Jones, P. G. *Eur. J. Org. Chem.* **2001**, 2221.
8. Kozhevnikova, E. F.; Derouane, E. G.; Kozhevnikov, I. V. *Chem. Commun.* **2002**, 1178.
9. Clark, J. H.; Dekamin, M. G.; Moghaddam, F. M. *Green Chem.* **2002**, *4,* 366.
10. Sriraghavan, K.; Ramakrishnan, V. T. *Tetrahedron* **2003**, *59,* 1791.
11. Tisserand, S.; Baati, R.; Nicolas, M.; Mioskowski, C. *J. Org. Chem.* **2004**, *69,* 8982.
12. Ollevier, T.; Desyroy, V.; Asim, M.; Brochu, M.-C. *Synlett* **2004**, 2794.
13. Easwaramurthy, M.; Ravikumar, R.; Lakshmanan, A. J.; Raju, G. J. *Indian J. Chem., Sect. B* **2005**, *44B*, 635.

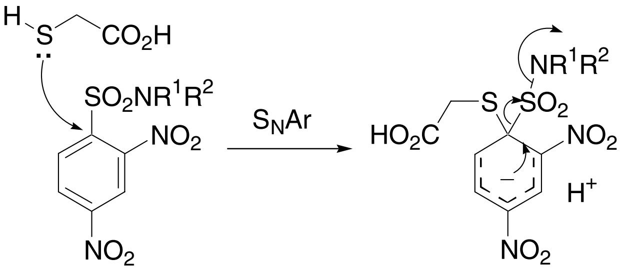
Fukuyama amine synthesis

Transformation of a primary amine to a secondary amine using 2,4-dinitrobenzenesulfonyl chloride and an alcohol. Also known as Fukuyama–Mitsunobu procedure.

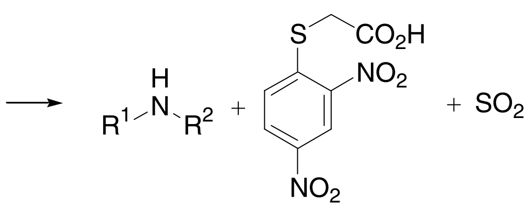




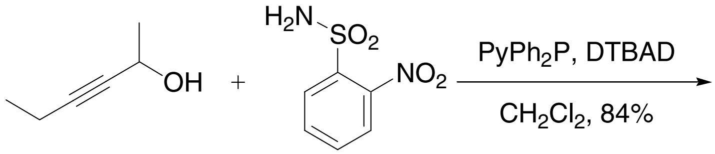
See page 390 for mechanism of the Mitsunobu reaction.



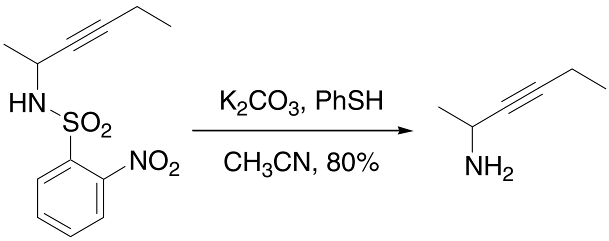
Meisenheimer complex



Example 1[9]



$PyPh_2P$ = diphenyl 2-pyridylphosphine; DTBAD = di-*tert*-butylazodicarbonate

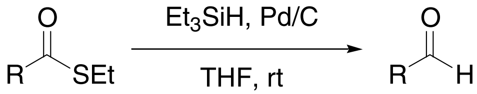


References

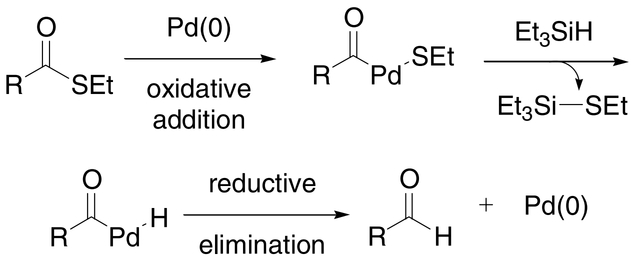
1. Fukuyama, T.; Jow, C.-K.; Cheung, M. *Tetrahedron Lett.* **1995**, *36*, 6373. Tohru Fukuyama moved to the University of Tokyo from Rice University in 1995.
2. Fukuyama, T.; Cheung, M.; Jow, C.-K.; Hidai, Y.; Kan, T. *Tetrahedron Lett.* **1997**, *38*, 5831.
3. Yang, L.; Chiu, K. *Tetrahedron Lett.* **1997**, *38*, 7307.
4. Piscopio, A. D.; Miller, J. F.; Koch, K. *Tetrahedron Lett.* **1998**, *39*, 2667.
5. Bolton, G. L.; Hodges, J. C. *J. Comb. Chem.* **1999**, *1*, 130.
6. Lin, X.; Dorr, H.; Nuss, J. M. *Tetrahedron Lett.* **2000**, *41*, 3309.
7. Amssoms, K.; Augustyns, K.; Yamani, A.; Zhang, M.; Haemers, A. *Synth. Commun.* **2002**, *32*, 319.
8. Olsen, C. A.; Jørgensen, M. R.; Witt, M.; Mellor, I. R.; Usherwood, P. N. R.; Jaroszewski, J. W.; Franzyk, H. *Eur. J. Org. Chem.* **2003**, 3288.
9. Guisado, C.; Waterhouse, J. E.; Price, W. S.; Jørgensen, M. R.; Miller, A. D. *Org. Biomol. Chem.* **2005**, *3*, 1049.
10. Olsen, C. A.; Witt, M.; Hansen, S. H.; Jaroszewski, J. W.; Franzyk, H. *Tetrahedron* **2005**, *61*, 6046.

Fukuyama reduction

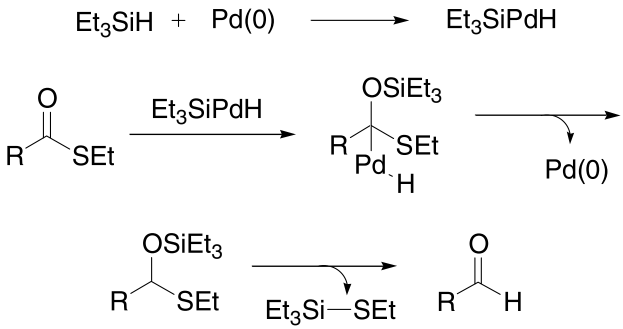
Aldehyde synthesis through reduction of thiol esters with Et_3SiH in the presence of Pd/C catalyst.



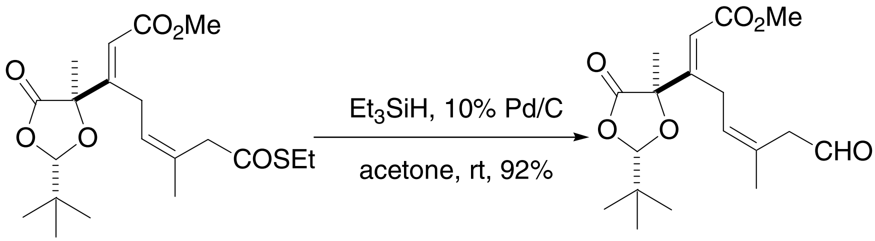
Path A:



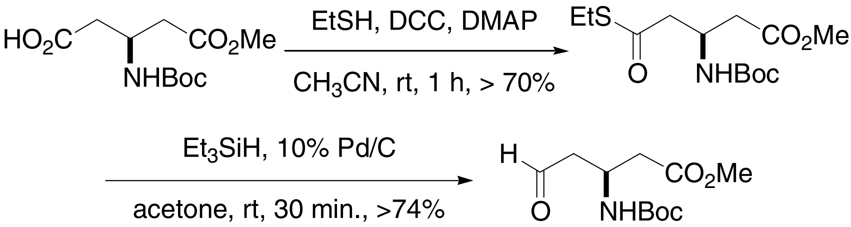
Path B:



Example 1[1]



Example 2[3]

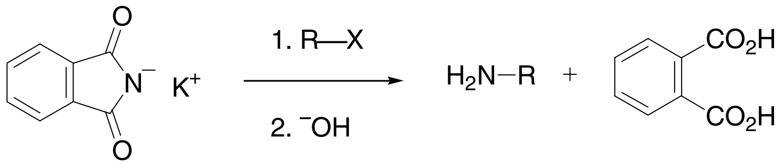


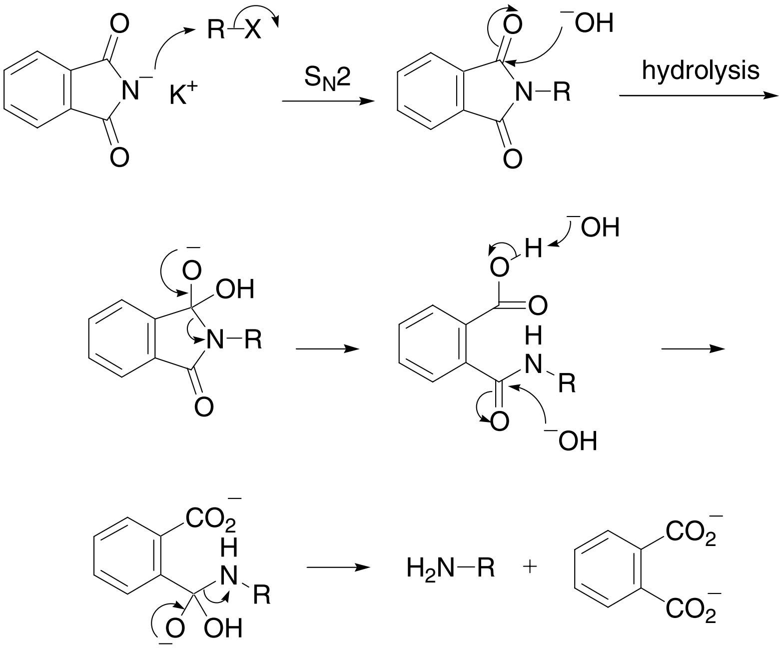
References

1. Fukuyama, T.; Lin, S.-C.; Li, L. *J. Am. Chem. Soc.* **1990**, *112*, 7050.
2. Kanda, Y.; Fukuyama, T. *J. Am. Chem. Soc.* **1993**, *115*, 8451.
3. Fujiwara, A.; Kan, T.; Fukuyama, T. *Synlett* **2000**, 1667.
4. Tokuyama, H.; Yokoshima, S.; Lin, S.-C.; Li, L.; Fukuyama, T. *Synthesis* **2002**, 1121.
5. Evans, D. A.; Rajapakse, H. A.; Stenkamp, D. *Angew. Chem., Int. Ed.* **2002**, *41*, 4569.
6. Shimada, K.; Kaburagi, Y.; Fukuyama, T. *J. Am. Chem. Soc.* **2003**, *125*, 4048.
7. Kimura, M.; Seki, M. *Tetrahedron Lett.* **2004**, *45*, 3219. (Possible mechanisms were proposed in this paper).
8. Miyazaki, T.; Han-ya, Y.; Tokuyama, H.; Fukuyama, T. *Synlett* **2004**, 477.

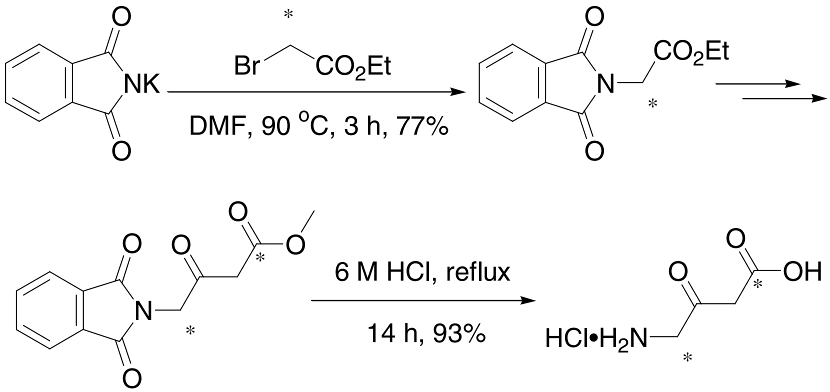
Gabriel synthesis

Synthesis of primary amines using potassium phthalimide and alkyl halides.





Example 1[10]

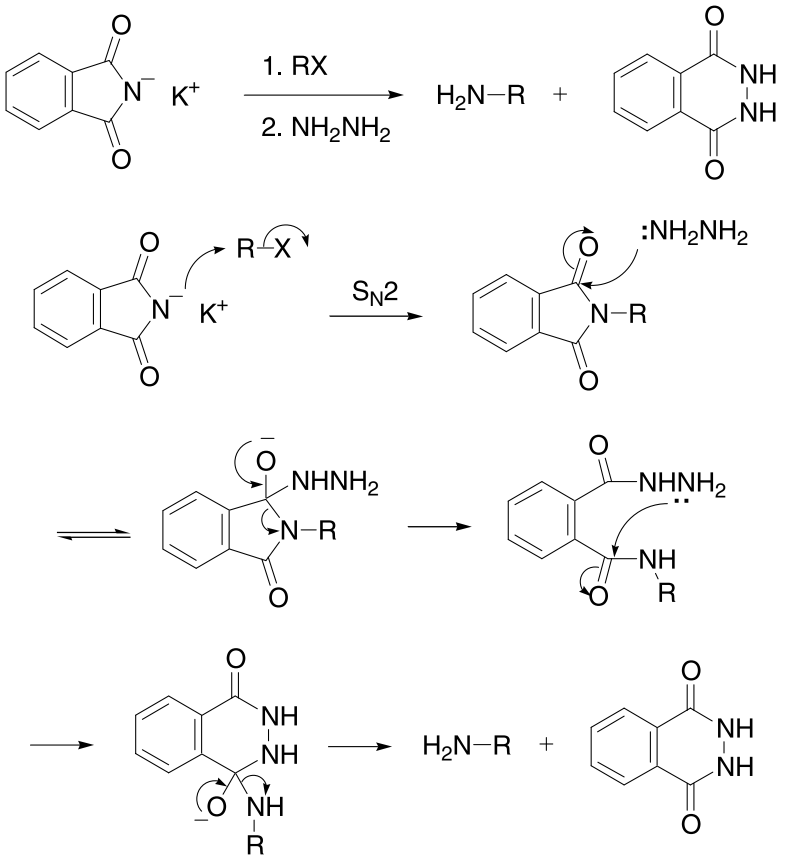


References

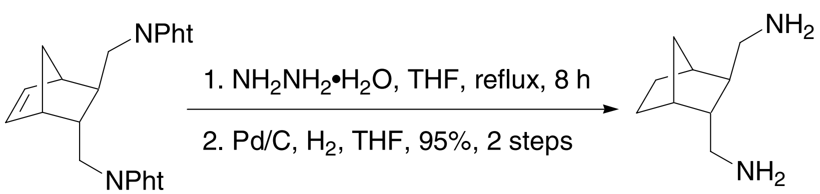
1. Gabriel, S. *Ber. Dtsch. Chem. Ges.* **1887**, *20*, 2224. Siegmund Gabriel (1851−1924), born in Berlin, Germany, studied under Hofmann at Berlin and Bunsen in Heidelberg. He taught at Berlin, where he discovered the Gabriel synthesis of amines. Gabriel, a good friend of Emil Fischer, often substituted for Fischer in his lectures.
2. Press, J. B.; Haug, M. F.; Wright, W. B., Jr. *Synth. Commun.* **1985**, *15*, 837.
3. Slusarska, E.; Zwierzak, A. *Justus Liebigs Ann. Chem.* **1986**, 402.
4. Han, Y.; Hu, H. *Synthesis* **1990**, 122.
5. Ragnarsson, U.; Grehn, L. *Acc. Chem. Res.* **1991**, *24*, 285–289. (Review).
6. Toda, F.; Soda, S.; Goldberg, I. *J. Chem. Soc., Perkin Trans. 1* **1993**, 2357.
7. Khan, M. N. *J. Org. Chem.* **1996**, *61*, 8063.
8. Lávová, M.; Chovancová, J.; Veverková, E.; Toma, Š. *Tetrahedron* **1996**, *52*, 14995.
9. Mamedov, V. A.; Tsuboi, S.; Mustakimova, L. V.; Hamamoto, H.; Gubaidullin, A. T.; Litvinov, I. A.; Levin, Y. A. *Chem. Heterocyclic Compd.* **2001**, *36*, 911.
10. Iida, K.; Tokiwa, S.; Ishii, T.; Kajiwara, M. *J. Labelled. Compd. Radiopharm.* **2002**, *45*, 569.

Ing–Manske procedure

A variant of Gabriel amine synthesis where hydrazine is used to release the amine from the corresponding phthalimide:



Example[6]

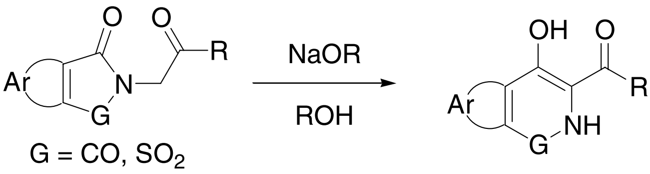


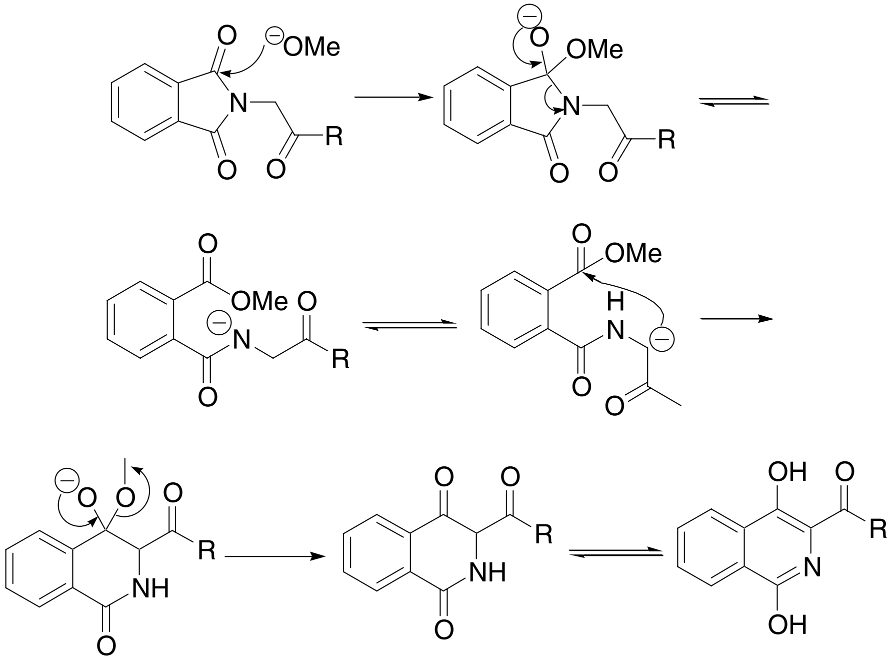
References

1. Ing, H. R.; Manske, R. H. F. *J. Chem. Soc.* **1926**, 2348. H. R. Ing was a professor of pharmacological chemistry at Oxford. R. H. F. Manske, Ing's collaborator at Oxford, was of German origin but trained in Canada before studying at Oxford. Manske left England to return to Canada, eventually to become director of research in the Union Rubber Company, Guelph, Ontario, Canada.
2. Ueda, T.; Ishizaki, K. *Chem. Pharm. Bull.* **1967**, *15*, 228.
3. Khan, M. N. *J. Org. Chem.* **1995**, *60*, 4536.
4. Hearn, M. J.; Lucas, L. E. *J. Heterocycl. Chem.* **1984**, *21*, 615.
5. Khan, M. N. *J. Org. Chem.* **1996**, *61*, 8063.
6. Tanyeli, C.; Özçubukçu, S. *Tetrahedron: Asymmetry* **2003**, *14*, 1167.
7. Ariffin, A.; Khan, M. N.; Lan, L. C.; May, F. Y.; Yun, C. S. *Synth. Commun.* **2004**, *34*, 4439.

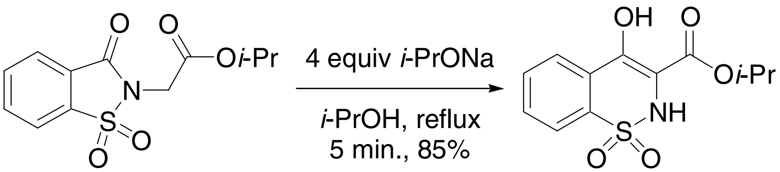
Gabriel–Colman rearrangement

Reaction of the enolate of a maleimidyl acetate to provide isoquinoline 1,4-diol.





Example[11]

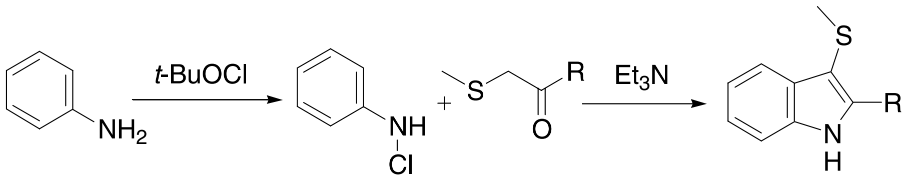


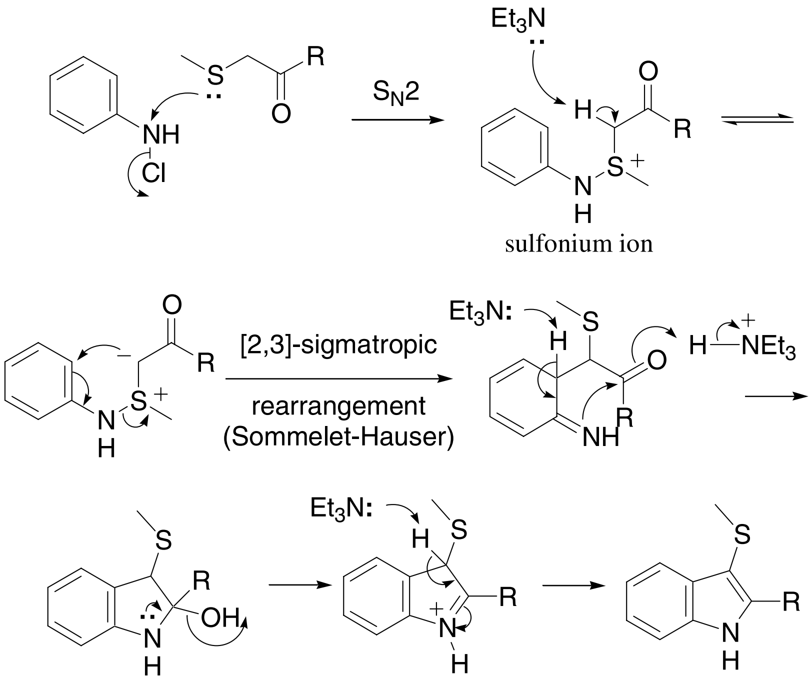
References

1. Gabriel, S.; Colman, J. *Chem. Ber*. **1900**, *33*, 980.
2. Gabriel, S.; Colman, J. *Chem. Ber*. **1900**, *33*, 2630.
3. Gabriel, S.; Colman, J. *Chem. Ber*. **1902**, *35*, 1358.
4. Allen, C. F. H. *Chem. Rev*. **1950**, *47*, 275–305. (Review).
5. Hauser, C.R. and Kantor, S. W. *J. Am. Chem. Soc*. **1951**, *73*, 1437.
6. Gensler, W. J. *Heterocyclic Compounds*, Vol. 4, R. C. Elderfield, Ed., Wiley & Sons., New York, N.Y., **1952**, 378. (Review).
7. Albert, A. and Hampton, A. *J. Chem. Soc*. **1952**, 4985.
8. Koelsch, C. F.; Lindquist, R. M. *J. Org. Chem.* **1956**, *21*, 657.
9. Hill, J. H. M.; *J. Org. Chem.* **1965**, *30*, 620. (Mechanism).
10. Lombardino, J. G.; Wiseman, E. H.; McLamore, W. M. *J. Med. Chem.* **1971**, *14*, 1171.
11. Schapira, C. B.; Perillo, I. A.; Lamdan, S. *J. Heterocycl. Chem.* **1980**, *17*, 1281.
12. Schapira, C. B.; Abasolo, M. I.; Perillo, I. A. *J. Heterocycl. Chem.* **1985**, *22*, 577.
13. Groutas, W. C.; Chong, L. S.; Venkataraman, R.; Epp, J. B.; Kuang, R.; Houser-Archield, N.; Hoidal, J. R. *Bioorg. Med. Chem.* **1995**, *3*, 187.
14. Lazer, E. S.; Miao, C. K.; Cywin, C. L.; *et al. J. Med. Chem.* **1997**, *40*, 980.
15. Pflum, D. A. *Gabriel–Colman Rearrangement* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 416–422. (Review).

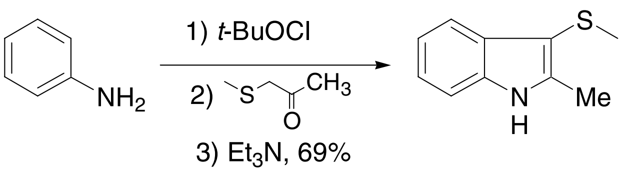
Gassman indole synthesis

The Gassman indole synthesis involves a one-pot process in which a hypohalite, a β-carbonyl sulfide derivative, and a base are added sequentially to an aniline or a substituted aniline to provide 3-thioalkoxyindoles. The sulfur can be easily removed by hydrogenolysis or Raney nickel.

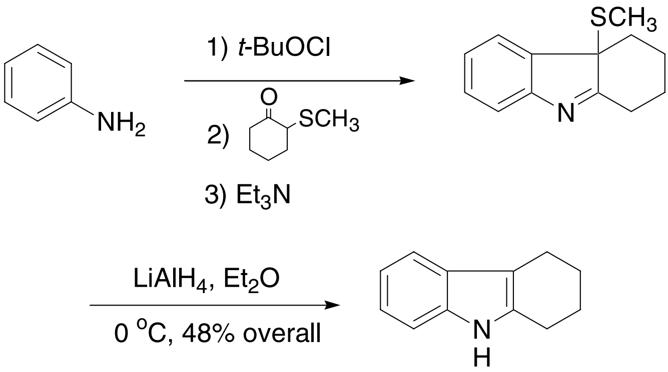




Example 1[1]



Example 2[1]

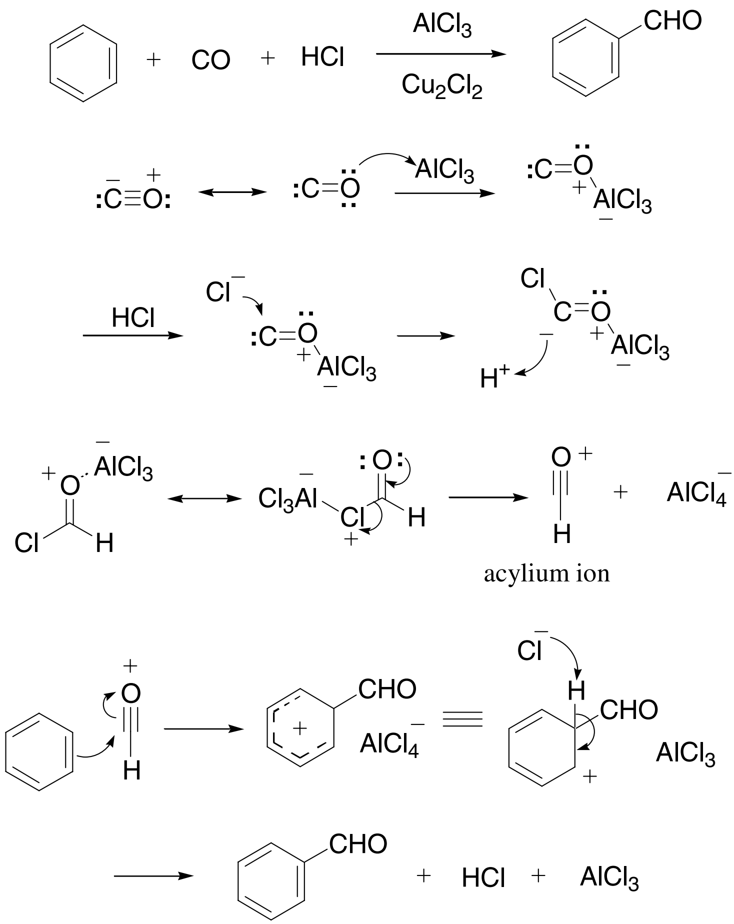


References

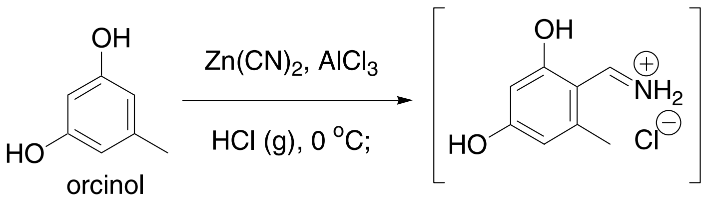
1. Gassman, P. G.; van Bergen, T. J.; Gilbert, D. P.; Cue, B. W., Jr. *J. Am. Chem. Soc.* **1974**, *96*, 5495. Paul G. Gassman (1935−1993) was a professor at the University of Minnesota (1974−1993).
2. Gassman, P. G.; van Bergen, T. J. *J. Am. Chem. Soc.* **1974**, *96*, 5508.
3. Gassman, P. G.; Gruetzmacher, G.; van Bergen, T. J. *J. Am. Chem. Soc.* **1974**, *96*, 5512.
4. Wierenga, W. *J. Am. Chem. Soc.* **1981**, *103*, 5621.
5. Ishikawa, H.; Uno, T.; Miyamoto, H.; Ueda, H.; Tamaoka, H.; Tominaga, M.; Nakagawa, K. *Chem. Pharm. Bull.* **1990**, *38*, 2459.
6. Smith, A. B., III; Sunazuka, T.; Leenay, T. L.; Kingery-Wood, J. *J. Am. Chem. Soc.* **1990**, *112*, 8197.
7. Smith, A. B., III; Kingery-Wood, J.; Leenay, T. L.; Nolen, E. G.; Sunazuka, T. *J. Am. Chem. Soc.* **1992**, *114*, 1438.
8. Savall, B. M.; McWhorter, W. W.; Walker, E. A. *J. Org. Chem.* **1996**, *61*, 8696.
9. Li, J.; Cook, J. M. *Gassman Indole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 128−131. (Review).

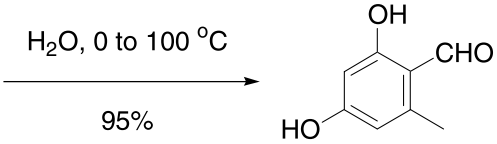
Gattermann–Koch reaction

Formylation of arenes using carbon monoxide and hydrogen chloride in the presence of aluminum chloride under high pressure.



Example, a more practical variant[4]



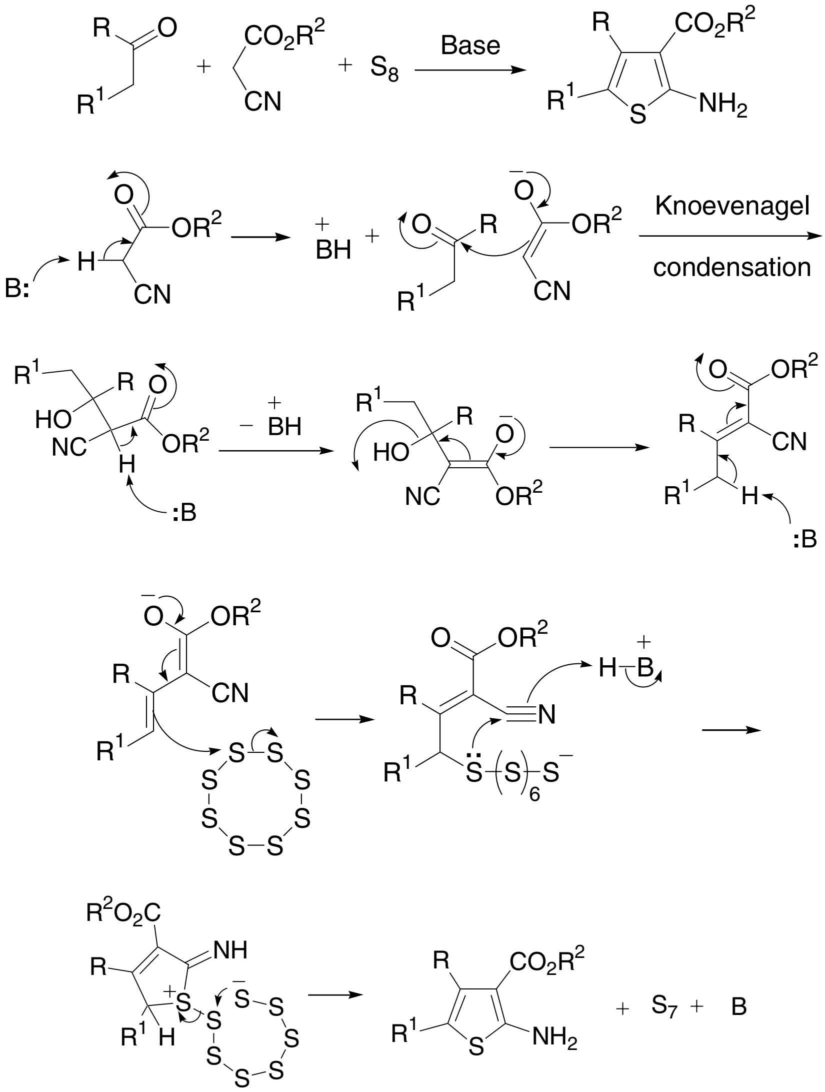


References

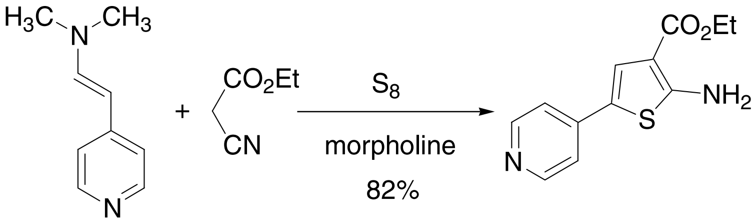
1. Gattermann, L.; Koch, J. A. *Ber.***1897**, *30*, 1622. Ludwig Gattermann (1860−1920) was born in Freiburg, Germany. His textbook, "*Die Praxis de organischen Chemie*" (1894) was one of his major contributions to organic chemistry.
2. Crounse, N. N. *Org. React.* **1949**, *5,* 290−300. (Review).
3. Truce, W. E. *Org. React.* **1957**, *9,* 37−72. (Review).
4. Solladié, G.; Rubio, A.; Carreño, M. C.; García Ruano, J. L. *Tetrahedron: Asymmetry* **1990**, *1*, 187.
5. Tanaka, M.; Fujiwara, M.; Ando, H. *J. Org. Chem.* **1995**, *60*, 2106.
6. Tanaka, M.; Fujiwara, M.; Ando, H.; Souma, Y. *Chem. Commun.* **1996**, 159.
7. Tanaka, M.; Fujiwara, M.; Xu, Q.; Souma, Y.; Ando, H.; Laali, K. K. *J. Am. Chem. Soc.* **1997**, *119*, 5100.
8. Tanaka, M.; Fujiwara, M.; Xu, Q.; Ando, H.; Raeker, T J. *J. Org. Chem.* **1998**, *63*, 4408.
9. Kantlehner, W.; Vettel, M.; Gissel, A; Haug, E.; Ziegler, G.; Ciesielski, M.; Scherr, O.; Haas, R. *J. Prakt. Chem.* **2000**, *342*, 297.
10. Doana, M. I.; Ciuculescu, A.; Bruckner, A.; Pop, M.; Filip, P. *Rev. Roum. Chim.* **2002**, *46*, 345.

Gewald aminothiophene synthesis

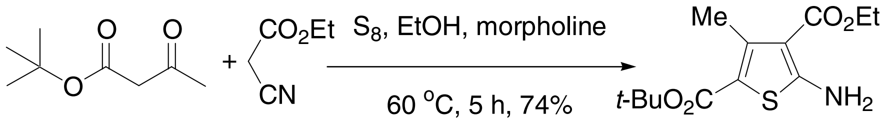
Base-promoted aminothiophene formation from ketone, α-active methylene nitrile and elemental sulfur.



Example 1[8]



Example 2[13]

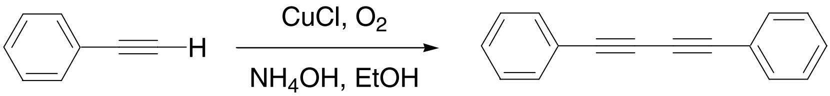


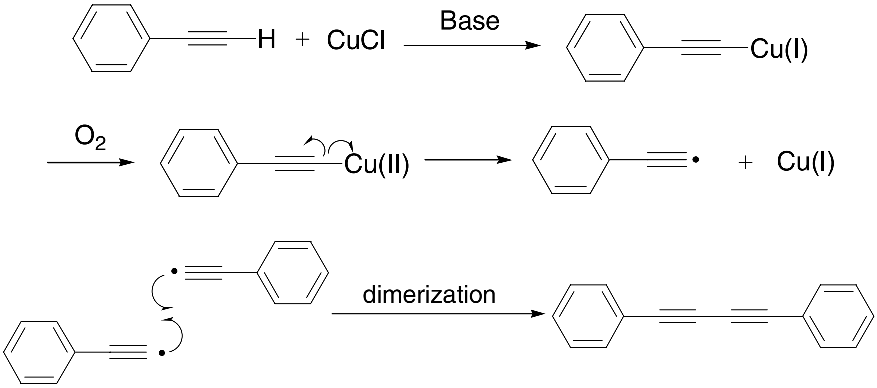
References

1. Gewald, K. *Z. Chem.* **1962**, *2*, 305.
2. Gewald, K.; Schinke, E.; Böttcher, H. *Chem. Ber.* **1966**, *99*, 94.
3. Gewald, K.; Neumann, G.; Böttcher, H. *Z. Chem.* **1966**, *6*, 261.
4. Gewald, K.; Schinke, E. *Chem. Ber.* **1966**, *99*, 2712.
5. Mayer, R.; Gewald, K. *Angew. Chem., Int. Ed. Engl.* **1967**, *6*, 294–306. (Review).
6. Gewald, K. *Chimia* **1980**, *34*, 101–110. (Review).
7. Peet, N. P.; Sunder, S.; Barbuch, R. J.; Vinogradoff, A. P. *J. Heterocycl. Chem.* **1986**, *23*, 129.
8. Bacon, E. R.; Daum, S. J. *J. Heterocycl. Chem.* **1991**, *28*, 1953.
9. Sabnis, R. W. *Sulfur Reports* **1994**, *16*, 1. (Review).
10. Guetschow, M.; Schroeter, H.; Kuhnle, G.; Eger, K. *Monatsh. Chem.* **1996**, *127*, 297.
11. Zhang, M.; Harper, R. W. *Bioorg. Med. Chem. Lett.* **1997**, *7*, 1629.
12. Sabnis, R. W.; Rangnekar, D. W.; Sonawane, N. D. *J. Heterocycl. Chem.* **1999**, *36*, 333. (Review).
13. Gütschow, M.; Kuerschner, L.; Neumann, U.; Pietsch, M.; Löser, R.; Koglin, N.; Eger, K. *J. Med. Chem.* **1999**, *42*, 5437.
14. Baraldi, P. G.; Zaid, A. N.; Lampronti, I.; Fruttarolo, F.; Pavani, M. G.; Tabrizi, M. A.; Shryock, J. C.; Leung, E.; Romagnoli, R. *Bioorg. Med. Chem. Lett.* **2000**, *10*, 1953.
15. Pinto, I. L.; Jarvest, R. L.; Serafinowska, H. T. *Tetrahedron Lett.* **2000**, *41*, 1597.
16. Buchstaller, H.-P.; Siebert, C. D.; Lyssy, R. H.; Frank, I.; Duran, A.; Gottschlich, R.; Noe, C. R. *Monatsh. Chem.* **2001**, *132*, 279.
17. Hoener, A. P. F.; Henkel, B.; Gauvin, J.-C. *Synlett* **2003**, 63.
18. Tinsley, J. M. *Gewald Aminothiophene Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 193–198. (Review).

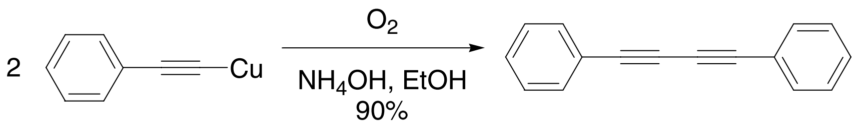
Glaser coupling

Oxidative homo-coupling of terminal alkynes using copper catalyst in the presence of oxygen.

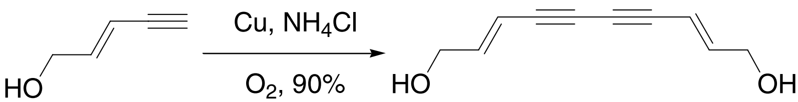




Example 1[1]



Example 2, homo-coupling[2]



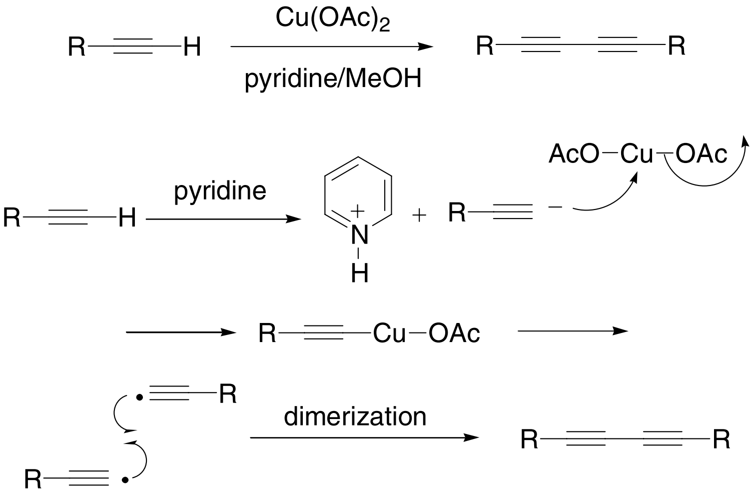
References

1. Glaser, C. *Ber. Dtsch. Chem. Ges.* **1869**, *2*, 422.
2. Bowden, K.; Heilbron, I.; Jones, E. R. H.; Sondheimer, F. *J. Chem. Soc.* **1947**, 1583.
3. Hoeger, S.; Meckenstock, A.-D.; Pellen, H. *J. Org. Chem.* **1997**, *62*, 4556.
4. Li, J.; Jiang, H. *Chem. Commun.* **1999**, 2369.
5. Siemsen, P.; Livingston, R. C.; Diederich, F. *Angew. Chem., Int. Ed.* **2000**, *39*, 2632. (Review).
6. Setzer, W. N.; Gu, X.; Wells, E. B.; Setzer, M. C.; Moriarity, D. M. *Chem. Pharm. Bull.* **2001**, *48*, 1776.

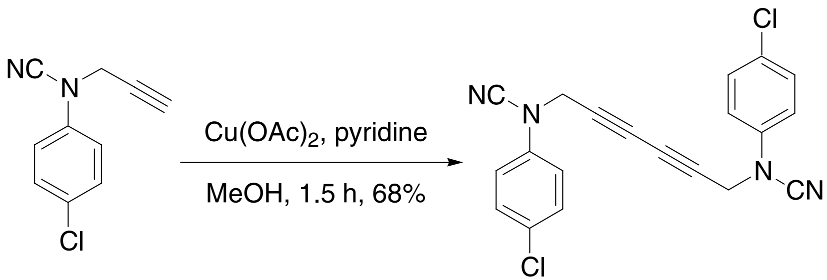
7. Kabalka, G. W.; Wang, L.; Pagni, R. M. *Synlett* **2001**, 108.
8. Youngblood, W. J.; Gryko, D. T.; Lammi, R. K.; Bocian, D. F.; Holten, D.; Lindsey, J. S. *J. Org. Chem.* **2002**, *67*, 2111.
9. Yadav, J. S.; Reddy, B. V. S.; Reddy, K. B.; Gayathri, K. U.; Prasad, A. R. *Tetrahedron Lett*. **2003**, *44*, 6493.
10. Moriarty, R. M.; Pavlovic, D. *J. Org. Chem*. **2004**, *69*, 5501.
11. Wang, L.; Yan, J.; Li, P.; Wang, M.; Su, C. *J. Chem. Res.* **2005**, 112.

Eglinton coupling

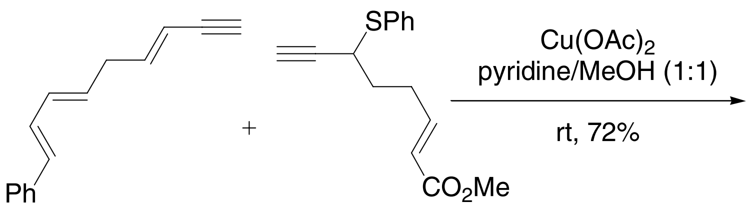
Oxidative homo-coupling of terminal alkynes mediated by stoichiometric (or often excess) $Cu(OAc)_2$. A variant of the Glaser coupling reaction.

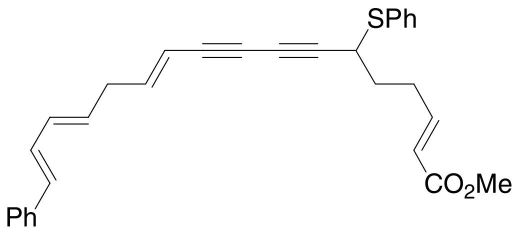


Example 1, homo-coupling[6]



Example 2, cross-coupling[4]



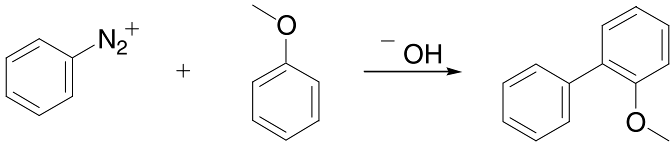


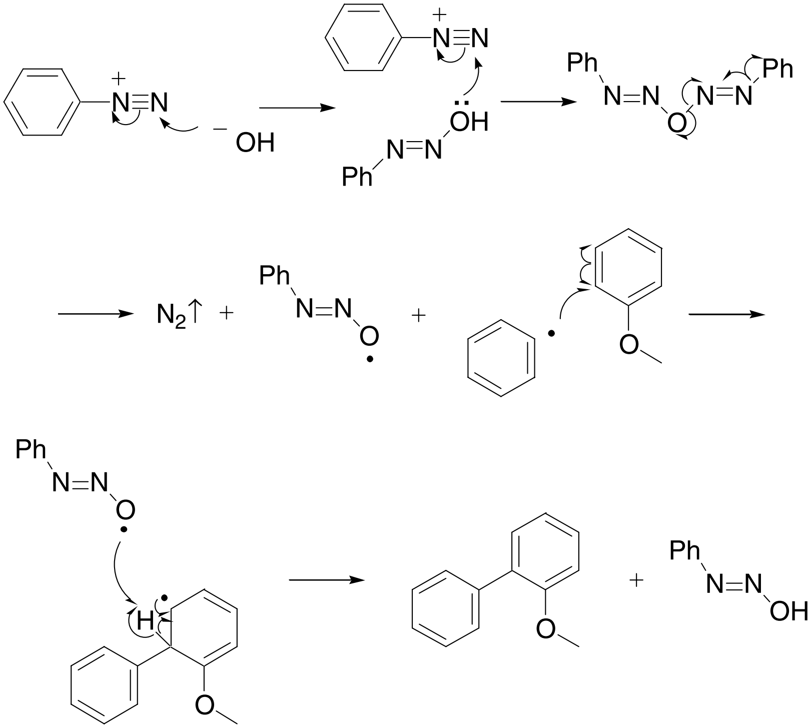
References

1. Eglinton, G.; Galbraith, A. R. *Chem. Ind.* **1956**, 737. Geoffrey Eglinton (1927−) was born in Cardiff, Wales.
2. Behr, O. M.; Eglinton, G.; Galbraith, A. R.; Raphael, R. A. *J. Chem. Soc.* **1960**, 3614.
3. Eglinton, G.; McRae, W. *Adv. Org. Chem.* **1963**, *4*, 225. (Review).
4. Nicolaou, K. C.; Petasis, N. A.; Zipkin, R. E.; Uenishi, J. *J. Am. Chem. Soc.* **1982**, *104*, 5558.
5. Altmann, M.; Friedrich, J.; Beer, F.; Reuter, R.; Enkelmann, V.; Bunz, U. H. F. *J. Am. Chem. Soc.* **1997**, *119*, 1472.
6. Srinivasan, R.; Devan, B.; Shanmugam, P.; Rajagopalan, K. *Indian J. Chem., Sect. B* **1997**, *36B*, 123.
7. Nakanishi, H.; Sumi, N.; Aso, Y.; Otsubo, T. *J. Org. Chem.* **1998**, *63*, 8632.
8. Müller, T.; Hulliger, J.; Seichter, W.; Weber, E.; Weber, T.; Wübbenhorst, M. *Chem. Eur. J.* **2000**, *6*, 54.
9. Märkl, G.; Zollitsch, T.; Kreimeier, P.; Prinzhorn, M.; Reithinger, S.; Eibler, E. *Chem. Eur. J.* **2000**, *6*, 3806.
10. Kaigtti-Fabian, K. H. H.; Lindner, H.-J.; Nimmerfroh, N.; Hafner, K. *Angew. Chem., Int. Ed.* **2001**, *40*, 3402.
11. Siemsen, P.; Livingston, R. C.; Diederich, F. *Angew. Chem., Int. Ed.* **2000**, *39*, 2632. (Review).
12. Inouchi, K.; Kabashi, S.; Takimiya, K.; Aso, Y.; Otsubo, T. *Org. Lett.* **2002**, *4*, 2533.
13. Xu, G.-L.; Zou, G.; Ni, Y.-H.; DeRosa, M. C.; Crutchley, R. J.; Ren, T. *J. Am. Chem. Soc.* **2003**, *125*, 10057.

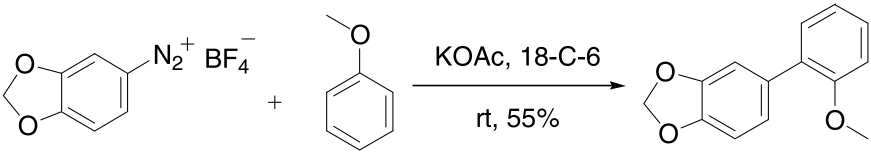
Gomberg–Bachmann reaction

Base-promoted radical coupling between an aryl diazonium salt and an arene to form a diaryl compound.

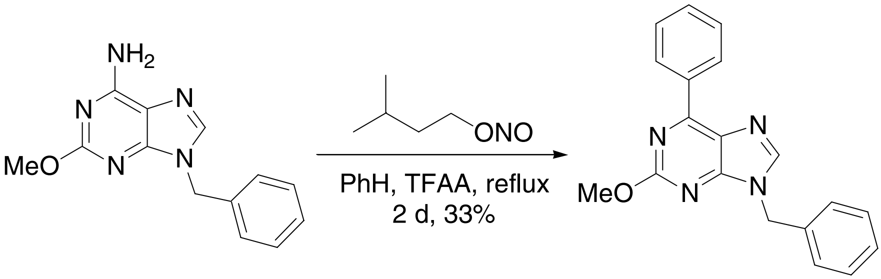




Example 1[4]



Example 2[5]

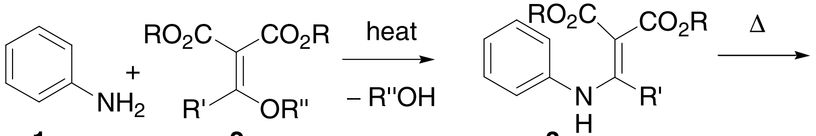


References

1. Gomberg, M.; Bachmann, W. E. *J. Am. Chem. Soc.* **1924**, *46*, 2339. Moses Gomberg (1866−1947) was born in Elizabetgrad, Russia. He discovered the triphenylmethyl stable radical at the University of Michigan in Ann Arbor, Michigan. In this article, Gomberg declared that he had reserved the field of radical chemistry for himself! Werner Bachmann (1901−1951), Gomberg's Ph.D. student, was born in Detroit, Michigan. After his postdoctoral trainings in Europe Bachmann returned to the University of Michigan as the Moses Gomberg Professor of Chemistry.
2. DeTar, D. F.; Kazimi, A. A. *J. Am. Chem. Soc.* **1955**, *77,* 3842.
3. Eliel, E. L.; Saha, J. G.; Meyerson, S. *J. Org. Chem.* **1965**, *30*, 2451.
4. Beadle, J. R.; Korzeniowski, S. H.; Rosenberg, D. E.; Garcia-Slanga, B. J.; Gokel, G. W. *J. Org. Chem.* **1984**, *49*, 1594.
5. McKenzie, T. C.; Rolfes, S. M. *J. Heterocycl. Chem.* **1987**, *24*, 859.
6. Gurczynski, M.; Tomasik, P. *Org. Prep. Proced. Int.* **1991**, *23*, 438.
7. Hales, N. J.; Heaney, H.; Hollinshead, J. H.; Sharma, R. P. *Tetrahedron* **1995**, *51*, 7403.
8. Lai, Y.-H.; Jiang, J. *J. Org. Chem.* **1997**, *62*, 4412.

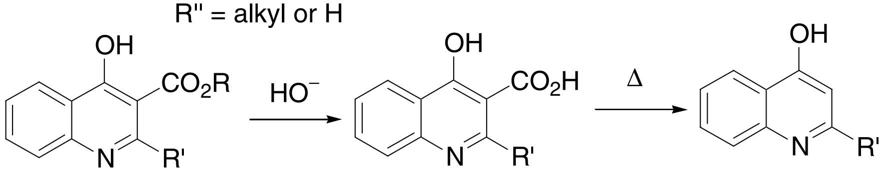
Gould–Jacobs reaction

The Gould–Jacobs reaction is a sequence of the following reactions: a. condensation of an aniline **1** with either alkoxy methylenemalonic ester or acyl malonic ester **2** providing the anilidomethylenemalonic ester **3**; b. cyclization of **3** to the 4-hydroxy-3-carboalkoxyquinoline **4**; c. saponification to form acid **5**, and d. decarboxylation to give the 4-hydroxyquinoline **6**.

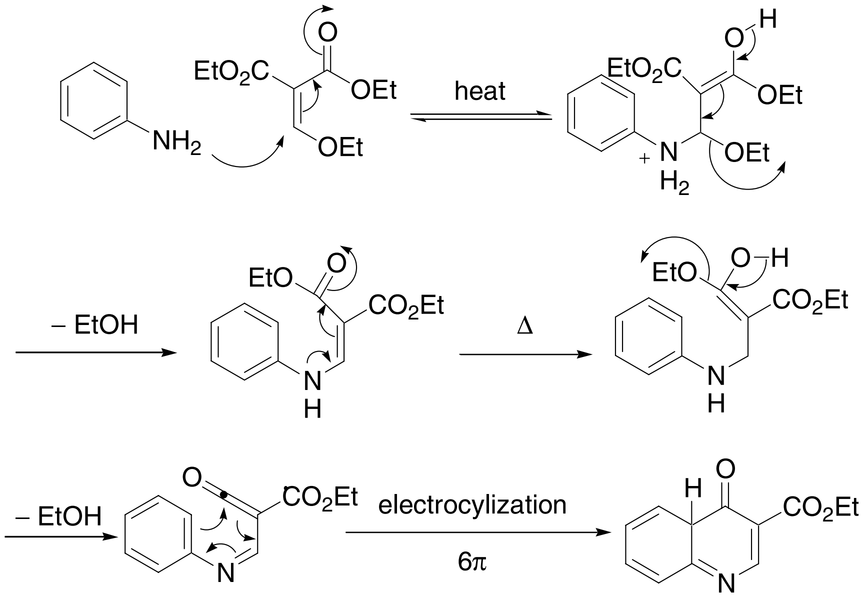


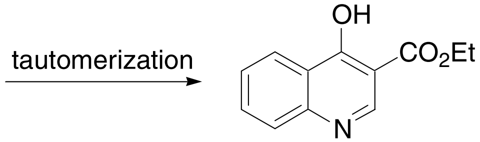
1 **2** **3**

R = alkyl
R' = alkyl, aryl, or H
R'' = alkyl or H

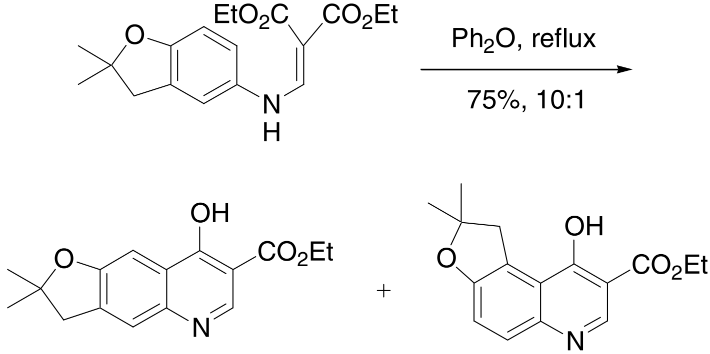


4 **5** **6**





Example 1[13]

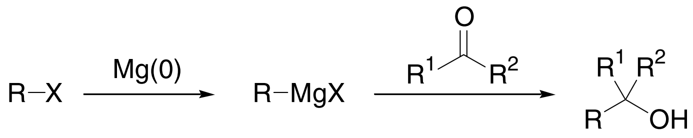


References

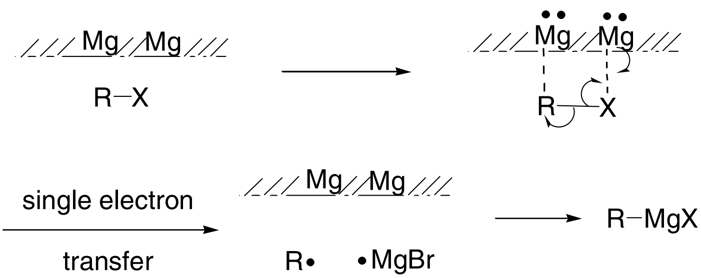
1. Gould, R. G.; Jacobs, W. A. *J. Am. Chem. Soc.* **1939**, *61*, 2890. R. Gordon Gould was born in Chicago in 1909. He earned his Ph.D. at Harvard University in 1933. After serving as an instructor at Harvard and Iowa, Gould worked at Rockefeller Institute for Medical Research where he discovered the Gould–Jacobs reaction with his colleague Walter A. Jacobs.
2. Baker, R. H., Lappin, G. R., Albisetti, C. J., Riegel, B. *J. Am. Chem. Soc.* **1946**, *68*, 1267.
3. Jones, G. In *Heterocyclic Compounds*, *Quinolines* Vol. 32, chapter 2, pp 146−150, 158, 159. (Review).
4. Reitsema, R. H. *Chem. Rev.* **1948**, *53*, 43. (Review).
5. Elderfield, R. C. In *Heterocyclic Compounds*, Elderfield, R. C., Wiley & Sons, New York, 1952, vol. 4, pps. 38−41. (Review).
6. Price, C. C., Snyder, H. R., Bullitt, O. H., Kovacic, P. *J. Am. Chem. Soc.* **1947**, 69, 374.
7. Briehl, H., Lukosch, A., Wentrup, C. *J. Org. Chem.* **1984**, *49*, 2772.
8. Ouali, M. S., Vaultier, M., Carrie, R. *Tetrahedron* **1980**, *36*, 1821.
9. Horvath, G., Hermecz, I., Gorvath, A., Pongor-Csakvari, M., Pusztay, L. *J. Heterocycl. Chem.* **1985**, *22*, 481.
10. Agui, H., Komatsu, T., Nakagome, T. *J. Heterocycl. Chem.* **1975,** *12*, 557.
11. Sabnis, R. W., Rangnekar, D. W. *J. Heterocycl. Chem.* **1991**, *28*, 1105.
12. Suzuki, N., Tanaka, Y., Dohmori, R. *Chem. Pharm. Bull.* **1979**, *27*, 1.
13. Cruickshank, P. A., Lee, F. T., Lupichuk, A. *J. Med. Chem.* **1970**, *13*, 1110.
14. Hayakawa, I., Suzuki, N., Suzuki, K., Tanaka, Y. *Chem. Pharm. Bull.* **1984**, *32*, 4914.
15. Wang, C. G., Langer, T., Kiamath, P. G., Gu, Z. Q., Skolnick, P., Fryer, R. I. *J. Med. Chem.* **1995**, *38*, 950.
16. Leyva, E., Monreal, E., Hernandez, A. *J. Fluorine Chem.* **1999**, *94*, 7.
17. Dave, C. G.; Joshipura, H. M. *Indian J. Chem., Sect. B* **2002**, *41B*, 650.
18. Curran, T. T. *Gould–Jacobs REaction* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 423−436. (Review).

Grignard reaction

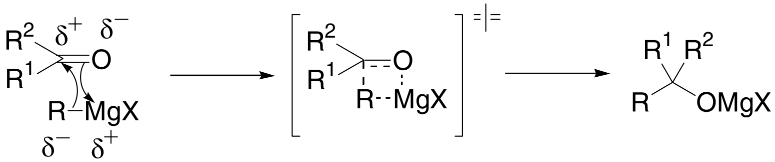
Addition of organomagnesium compounds (Grignard reagents), generated from organohalides and magnesium metal, to electrophiles.



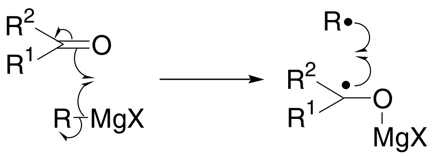
Formation of the Grignard reagent:

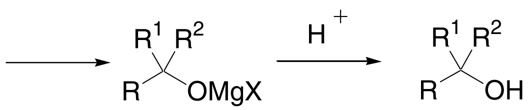


Grignard reaction, ionic mechanism:

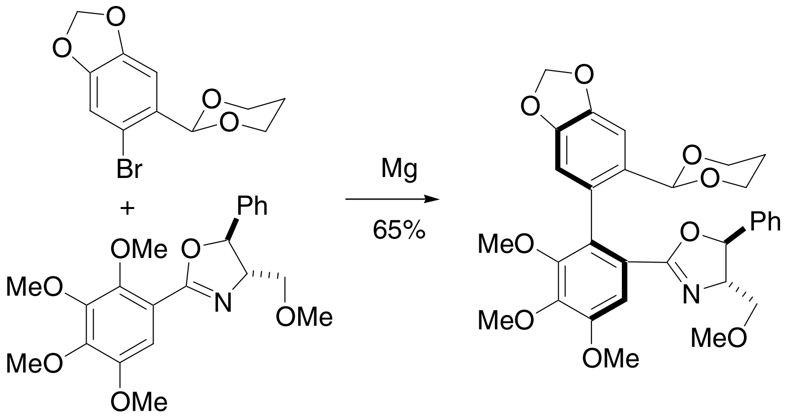


Radical mechanism,

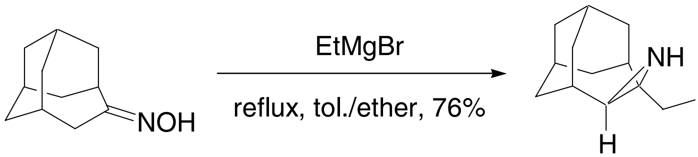




Example 1[6]



Example 2[4]



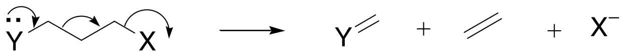
This reaction is known as the **Hoch–Campbell aziridine synthesis**, which entails treatment of ketoximes with excess Grignard reagents and subsequent hydrolysis of the organometallic complex to produce aziridines.

References

1. Grignard, V. *C. R. Acad. Sci.* **1900**, *130*, 1322. Victor Grignard (France, 1871−1935) won the Nobel Prize in Chemistry in 1912 for his discovery of the Grignard reagent.
2. Ashby, E. C.; Laemmle, J. T.; Neumann, H. M. *Acc. Chem. Res.* **1974**, *7*, 272. (Review).
3. Ashby, E. C.; Laemmle, J. T. *Chem. Rev.* **1975**, *75*, 521. (Review).
4. Sasaki, T.; Eguchi, S.; Hattori, S. *Heterocycles* **1978**, *11*, 235.
5. Lasperas, M.; Perez-Rubalcaba, A.; Quiroga-Feijoo, M. L. *Tetrahedron* **1980**, *36*, 3403.
6. Meyers, A. I.; Flisak, J. R.; Aitken, R. A. *J. Am. Chem. Soc.* **1987**, *109*, 5446.
7. *Grignard Reagents* Richey, H. G., Jr., Ed.; Wiley: New York, 2000. (Book).
8. Holm, T.; Crossland, I. In *Grignard Reagents* Richey, H. G., Jr., Ed.; Wiley: New York, **2000**, Chapter 1, pp 1−26. (Review).
9. Toda, N.; Ori, M.; Takami, K.; Tago, K.; Kogen, H. *Org. Lett.* **2003**, *5*, 269.
10. Shinokubo, H.; Oshima, K. *Eur. J. Org. Chem.* **2004**, 2081−2091. (Review).
11. Graden, H.; Kann, N. *Cur. Org. Chem.* **2005**, *9*, 733−763. (Review).

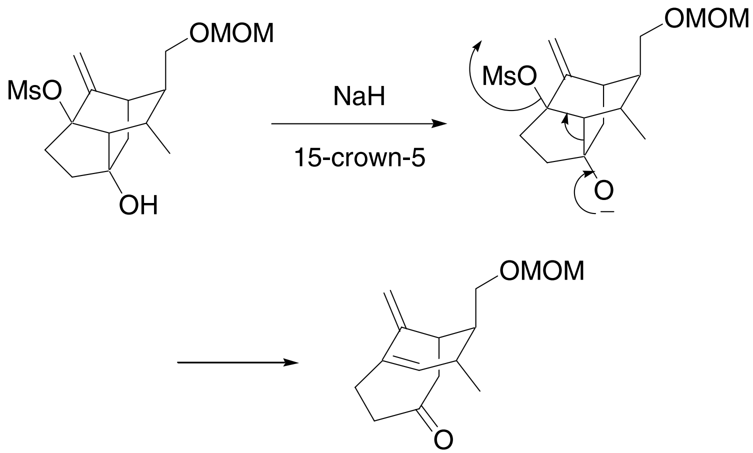
Grob fragmentation

C–C bond cleavage primarily via a concerted process involving a five atom system. General scheme:

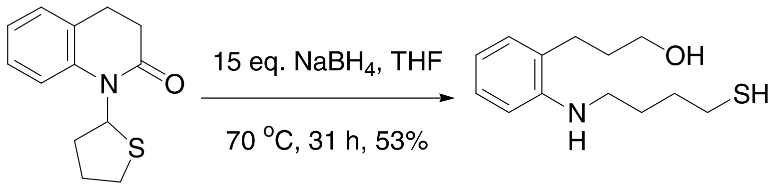


$X = OH_2^+$, OTs, I, Br, Cl; $Y = O^-$, NR_2

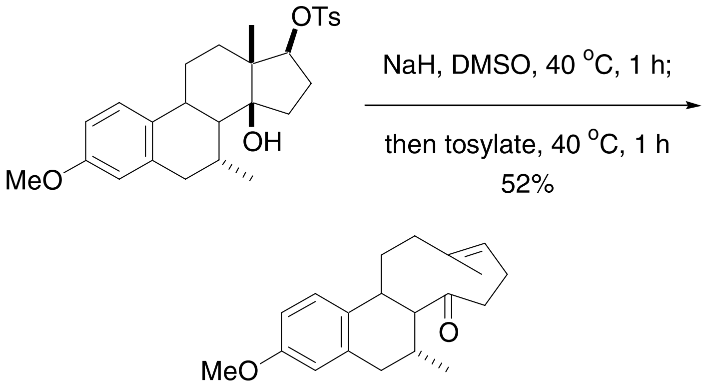
Example 1



Example 2, aza-Grob fragmentation[7]



Example 3[12]

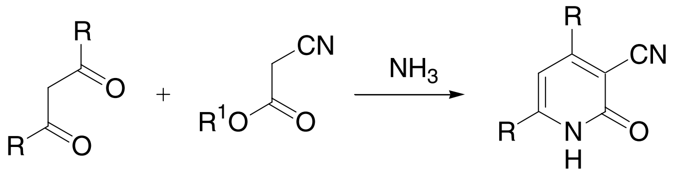


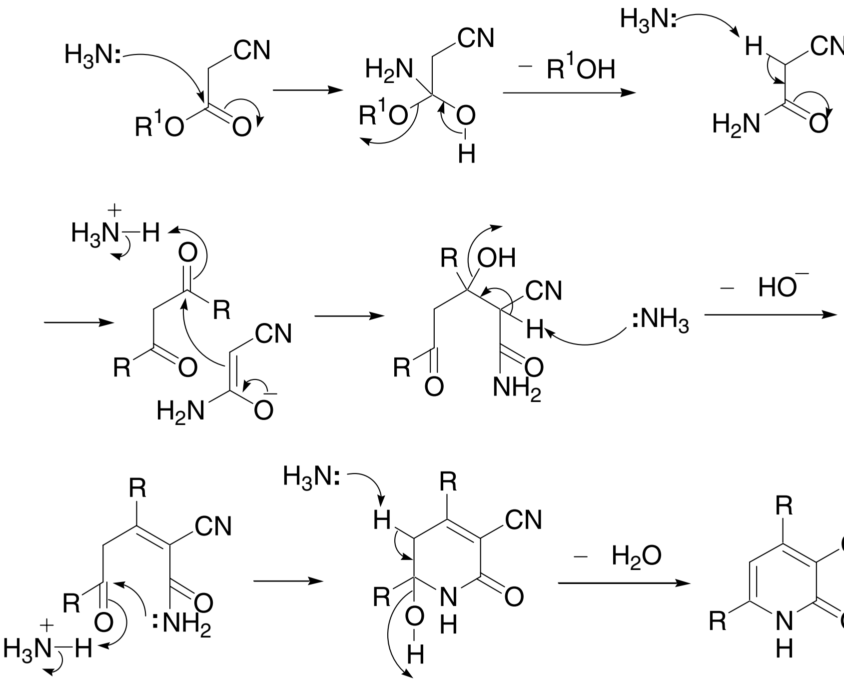
References

1. Grob, C. A.; Baumann, W. *Helv. Chim. Acta* **1955**, *38*, 594.
2. Grob, C. A.; Schiess, P. W. *Angew. Chem., Int. Ed. Engl.* **1967**, *6,* 1.
3. French, L. G.; Charlton, T. P. *Heterocycles* **1993**, *35*, 305.
4. Harmata, M.; Elahmad, S. *Tetrahedron Lett.* **1993**, *34*, 789.
5. Armesto, X. L.; Canle L., M.; Losada, M.; Santaballa, J. A. *J. Org. Chem.* **1994**, *59*, 4659.
6. Yoshimitsu, T.; Yanagiya, M.; Nagaoka, H. *Tetrahedron Lett*. **1999**, *40*, 5215.
7. Hu, W.-P.; Wang, J.-J.; Tsai, P.-C. *J. Org. Chem*. **2000**, *65*, 4208.
8. Molander, G. A.; Le Huerou, Y.; Brown, G. A. *J. Org. Chem*. **2001**, *66*, 4511.
9. Paquette, L. A.; Yang, J.; Long, Y. O. *J. Am. Chem. Soc*. **2002**, *124*, 6542.
10. Barluenga, J.; Alvarez-Perez, M.; Wuerth, K.; Rodriguez, F.; Fananas, F. J. *Org. Lett*. **2003**, *5*, 905.
11. Tada, N.; Miyamoto, K.; Ochiai, M. *Chem. Pharm. Bull.* **2004**, *52*, 1143.
12. Khripach, V. A.; Zhabinskii, V. N.; Fando, G. P.; *et al*. *Steroids* **2004**, *69*, 495.

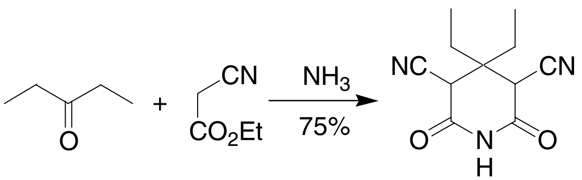
Guareschi–Thorpe condensation

2-Pyridone formation from the condensation of cyanoacetic ester with diketone in the presence of ammonia.





Example[7]



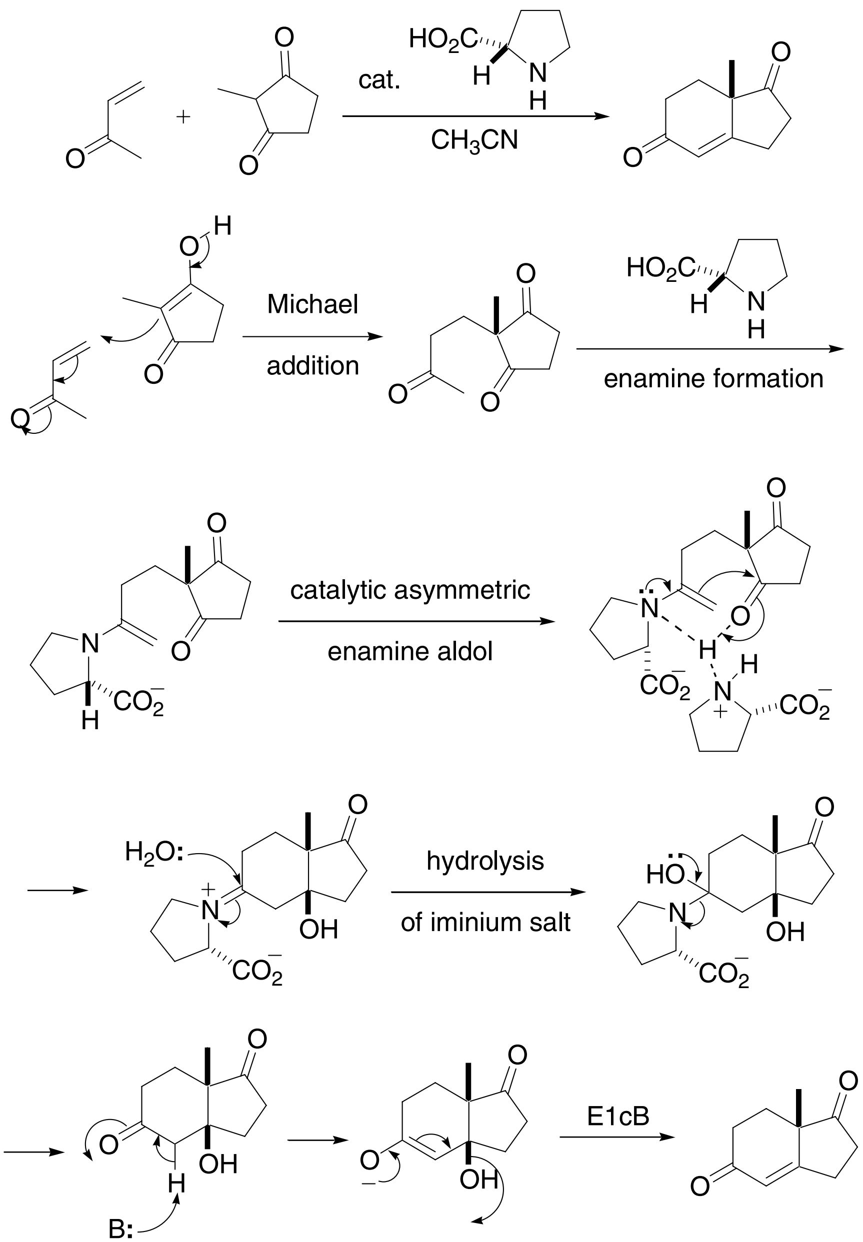
Guareschi imide

References

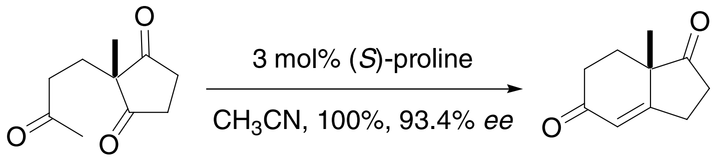
1. Guareschi, I. *Mem. Reale Accad. Sci. Torino* **1896**, *II*, 7, 11, 25.
2. Baron, H.; Renfry, F. G. P.; Thorpe, J. F. *J. Chem. Soc.* **1904**, *85*, 1726. Jocelyn F. Thorpe spent two years in Germany where he worked in the laboratory of a dyestuff manufacturer before taking a post as a lecturer at Manchester. Thorpe later became FRS (Fellow of the Royal Society) and professor of organic chemistry at Imperial College.
3. Vogel, A. I. *J. Chem. Soc.* **1934**, 1758.
4. McElvain, S. M.; Lyle, R. E. Jr. *J. Am. Chem. Soc.* **1950**, *72*, 384.
5. Brunskill, J. S. A. *J. Chem. Soc. (C)* **1968**, 960.
6. Brunskill, J. S. A. *J. Chem. Soc., Perkin Trans. 1* **1972**, 2946.
7. Holder, R. W.; Daub, J. P.; Baker, W. E.; Gilbert, R. H. III; Graf, N. A. *J. Org. Chem.* **1982**, *47*, 1445.
8. Collins, D. J.; Jones, A. M. *Aust. J. Chem.* **1989**, *42*, 215.
9. Krstic, V.; Misic-Vukovic, M.; Radojkovic-Velickovic, M. *J. Chem. Res. (S)* **1991**, 82.
10. Narsaiah, B.; Sivaprasad, A.; Venkataratnam, R. V. *Org. Prep. Proced. Int.* **1993**, *25*, 116.
11. Mijin, D. Z.; Misic-Vukovic, M. M. *Indian J. Chem., Sect. B* **1995**, *34B*, 348.
12. Mijin, D. Z.; Misic-Vukovic, M. M. *Indian J. Chem., Sect. B* **1998**, *37B*, 988.
13. Al-Omran, F.; El-Khair, A. A. Mijin, D. Z.; Misic-Vukovic, M. M. *Indian J. Chem., Sect. B* **2001**, *40B*, 608.
14. Galatsis, P. *Guareschi–Thorpe Pyridine Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 307–308. (Review).

Hajos–Wiechert reaction

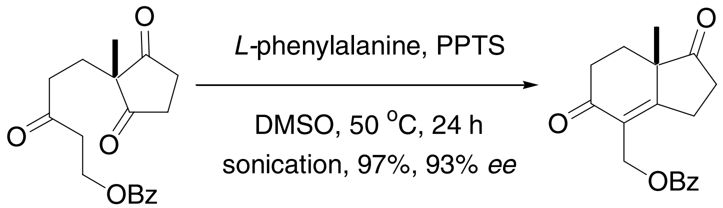
Asymmetric Robinson annulation catalyzed by (*S*)-(−)-proline.



Example 1[1]



Example 2[9]

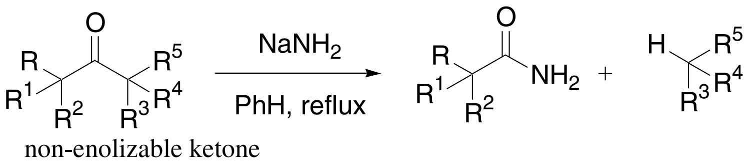


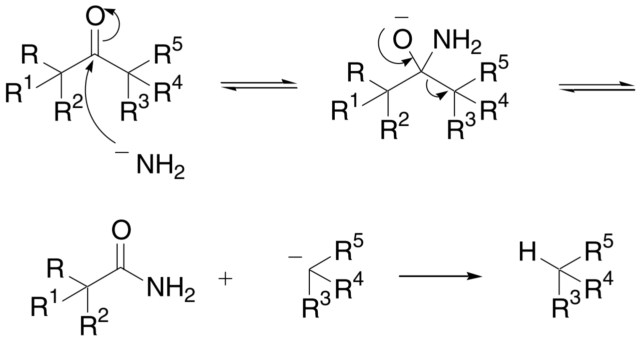
References

1. Hajos, Z. G.; Parrish, D. R. *J. Org. Chem.* **1974**, *39*, 1615. Hajos and Parrish were chemists at Hoffmann-La Roche.
2. Eder, U.; Sauer, G.; Wiechert, R. *Angew. Chem., Int. Ed. Engl.* **1971**, *10*, 496.
3. Brown, K. L.; Dann, L.; Duntz, J. D.; Eschenmoser, A.; Hobi, R.; Kratky, C. *Helv. Chim. Acta* **1978**, *61*, 3108.
4. Agami, C. *Bull. Soc. Chim. Fr.* **1988**, 499.
5. Nelson, S. G. *Tetrahedron: Asymmetry* **1998**, *9*, 357.
6. List, B.; Lerner, R. A.; Barbas, C. F., III. *J. Am. Chem. Soc.* **2000**, *122*, 2395.
7. List, B.; Pojarliev, P.; Castello, C. *Org. Lett.* **2001**, *3*, 573.
8. Hoang, L.; Bahmanyar, S.; Houk, K. N.; List, B. *J. Am. Chem. Soc.* **2003**, *125*, 16.
9. Shigehisa, H.; Mizutani, T.; Tosaki, S.-y.; Ohshima, T.; Shibasaki, M. *Tetrahedron* **2005**, *61*, 5057.

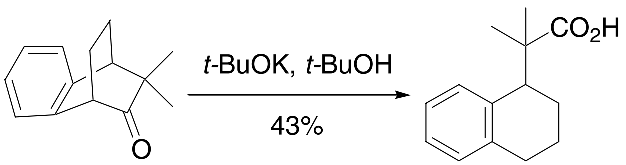
Haller–Bauer reaction

Base-induced cleavage of non-enolizable ketones leading to carboxylic amide derivative and a neutral fragment in which the carbonyl group is replaced by a hydrogen.

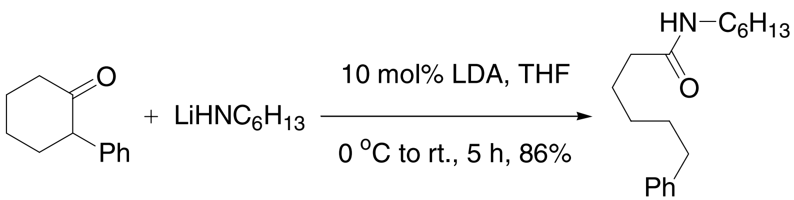




Example 1[4]



Example 2[12]

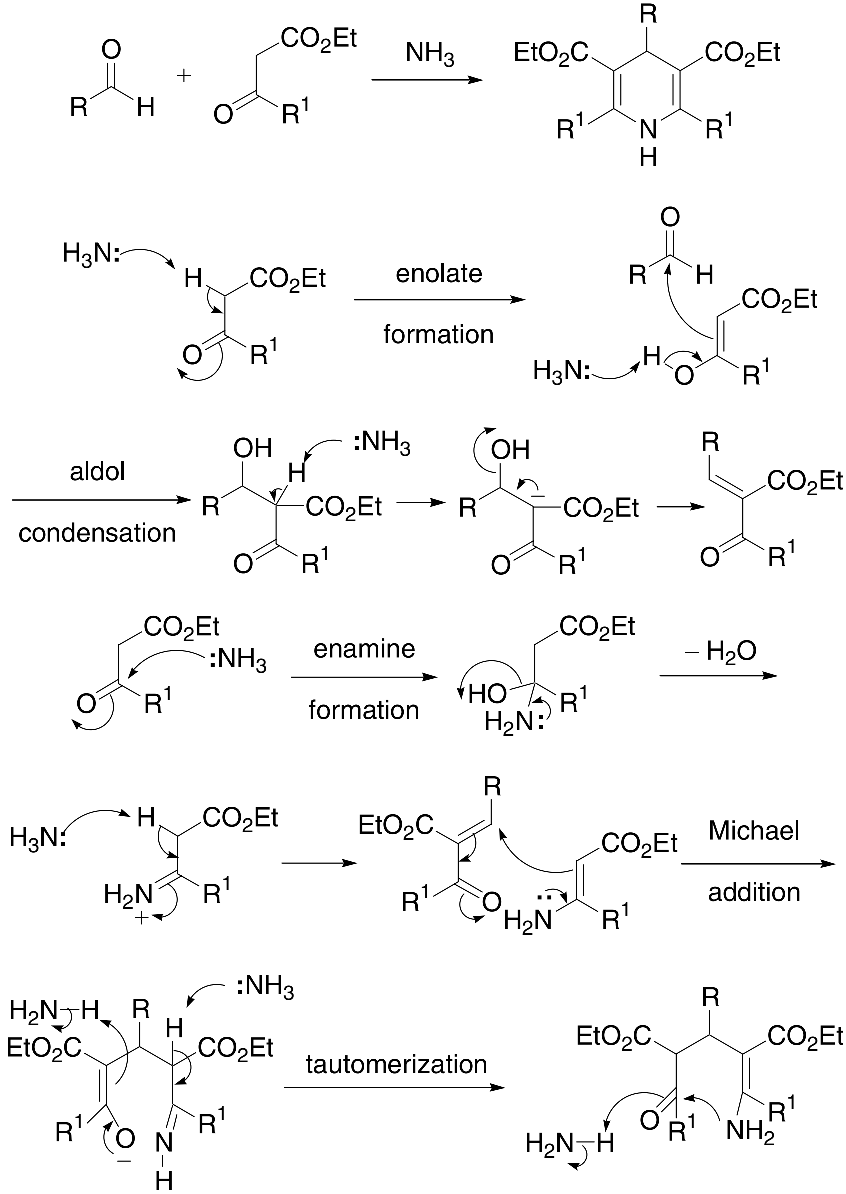


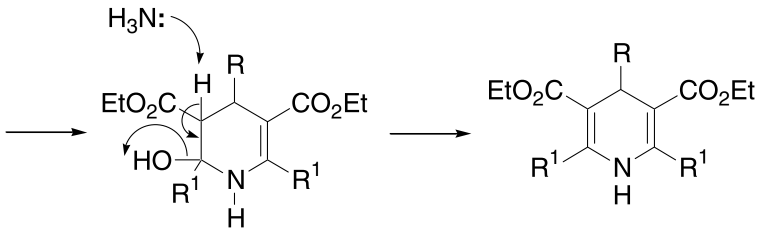
References

1. Haller, A.; Bauer, E. *Compt. Rend.* **1908**, *147*, 824.
2. Gilday, J. P.; Gallucci, J. C.; Paquette, L. A. *J. Org. Chem.* **1989**, *54*, 1399.
3. Paquette, L. A.; Gilday, J. P.; Maynard, G. D. *J. Org. Chem.* **1989**, *54*, 5044.
4. Paquette, L. A.; Gilday, J. P. *Org. Prep. Proc. Int.* **1990**, *22*, 167.
5. Muir, D. J.; Stothers, J. B. *Can. J. Chem.* **1993**, *71*, 1290.
6. Mehta, G.; Praveen, M. *J. Org. Chem*. **1995**, *60*, 279.
7. Mehta, G.; Reddy, K. S.; Kunwar, A. C. *Tetrahedron Lett*. **1996**, *37,* 2289.
8. Mehta, G.; Reddy, K. S. *Synlett* **1996**, 229.
9. Mittra, A.; Bhowmik, D. R.; Venkateswaran, R. V. *J. Org. Chem*. **1998**, *63*, 9555.
10. Mehta, G.; Venkateswaran, R. V. *Tetrahedron* **2000**, *56*, 1399−1422. (Review).
11. Arjona, O.; Medel, R.; Plumet, J. *Tetrahedron Lett*. **2001**, *42*, 1287.
12. Ishihara, K.; Yano, T. *Org. Lett*. **2004**, *6*, 1983.

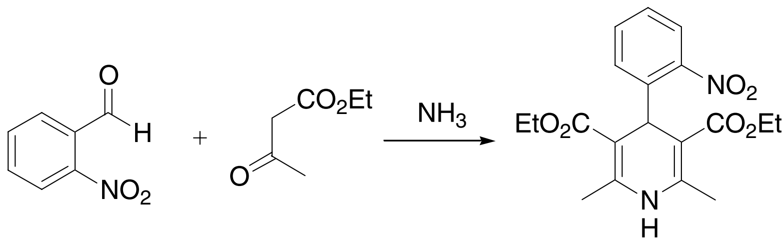
Hantzsch dihydropyridine synthesis

Dihydropyridine from the condensation of aldehyde, β-ketoester and ammonia.





Example 1[6]



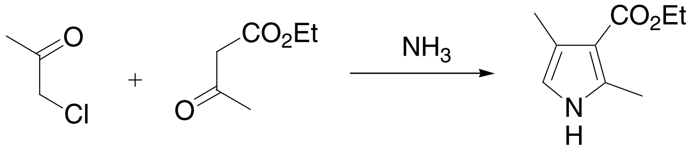
nifedipine

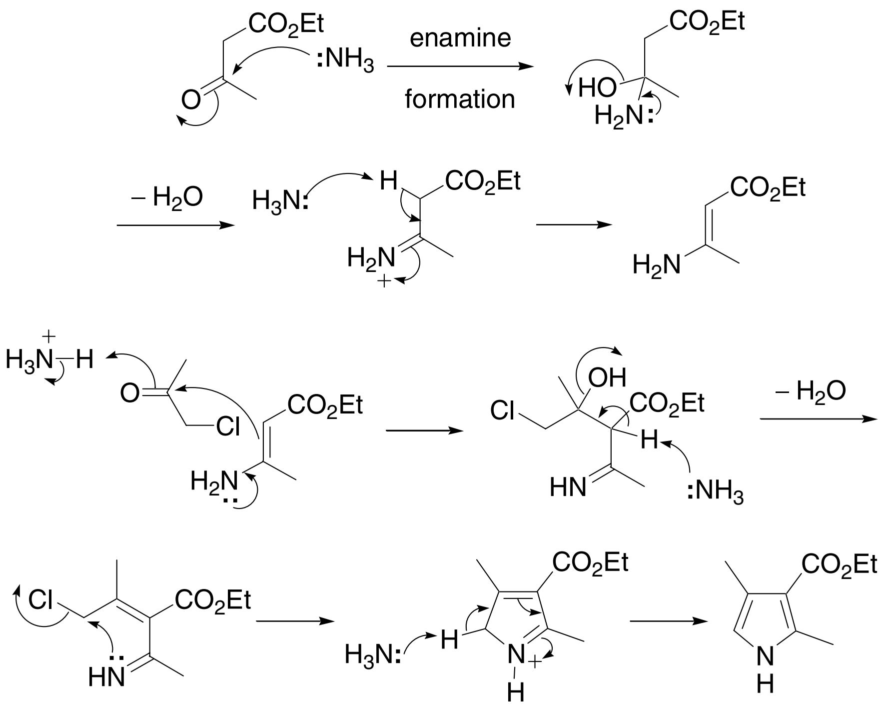
References

1. Hantzsch, A. *Justus Liebigs Ann. Chem.* **1882**, *215*, 1–83.
2. Bottorff, E. M.; Jones, R. G.; Kornfeld, E. C.; Mann, M. J. *J. Am. Chem. Soc*. **1951**, *73*, 4380.
3. Berson, J. A.; Brown, E. *J. Am. Chem. Soc*. **1955**, *77*, 444.
4. Marsi, K. L.; Torre, K. *J. Org. Chem*. **1964**, *29*, 3102.
5. Meyers, A. I.; Sircar, J. C.; Singh, S. *J. Heterocycl. Chem*. **1967**, *4*, 461.
6. Bossert, F.; Vater, W. *Naturwissinschaften* **1971**, *58*, 578.
7. Balogh, M.; Hermecz, I.; Naray-Szabo, G.; Simon, K.; Meszaros, Z. *J. Chem. Soc., Perkin Trans. 1* **1986**, 753.
8. Katritzky, A. R.; Ostercamp, D. L.; Yousaf, T. I. *Tetrahedron* **1986**, *42*, 5729.
9. Katritzky, A. R.; Ostercamp, D. L.; Yousaf, T. I. *Tetrahedron* **1987**, *43*, 5171.
10. Sainai, J. B.; Shah, A. C.; Arya, V. P. *Indian J. Chem. B.* **1995**, *34B(1),* 17.
11. Menconi, I.; Angeles, E.; Martinez, L.; Posada, M. E.; Toscano, R. A.; Martinez, R. *J. Heterocycl. Chem*. **1995**, *32*, 831.
12. Goerlitzer, K.; Heinrici, C.; Ernst, L. *Pharmazie* **1999**, *54*, 35.
13. Raboin, J.-C.; Kirsch, G.; Beley, M. *J. Heterocycl. Chem*. **2000**, *37*, 1077.
14. Sambongi, Y.; Nitta, H.; Ichihashi, K.; Futai, M.; Ueda, I. *J. Org. Chem*. **2002**, *67*, 3499.
15. Galatsis, P. *Hantzsch Dihydro-Pyridine Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 304–307. (Review).

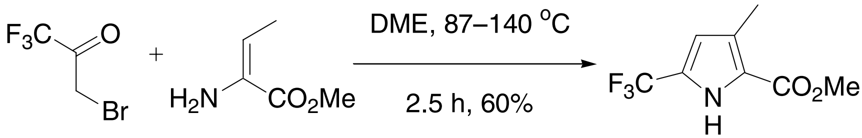
Hantzsch pyrrole synthesis

Reaction of α-chloromethyl ketones with β-ketoesters and ammonia to assemble pyrroles.

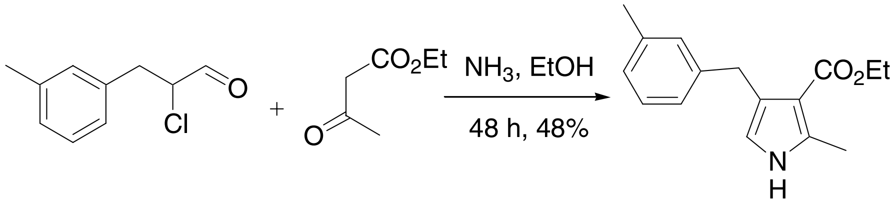




Example 1[5]



Example 2[8]

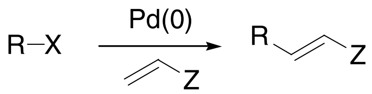


References

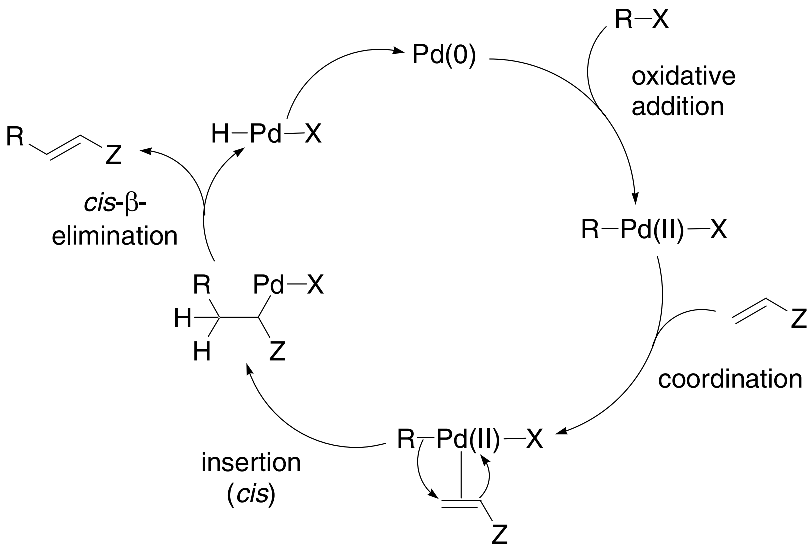
1. Hantzsch, A. *Ber. Dtsch. Chem. Ges.* **1890**, *23*, 1474.
2. Hort, E. V.; Anderson, L. R. *Kirk-Othmer Encycl. Chem. Technol.*; 3rd Ed.; **1982**, *19*, 499. (Review).
3. Katritzky, A. R.; Ostercamp, D. L.; Yousaf, T. I. *Tetrahedron* **1987**, *43*, 5171.
4. Kirschke, K.; Costisella, B.; Ramm, M.; Schulz, B. *J. Prakt. Chem.* **1990**, *332*, 143.
5. Kameswaran, V.; Jiang, B. *Synthesis* **1997**, 530.
6. Trautwein, A. W.; Süβmuth, R. D.; Jung, G. *Bioorg. Med. Chem. Lett.* **1998**, *8*, 2381.
7. Ferreira, V. F.; De Souza, M. C. B. V.; Cunha, A. C.; Pereira, L. O. R.; Ferreira, M. L. G. *Org. Prep. Proced. Int.* **2001**, *33*, 411−454. (Review).
8. Matiychuk, V. S.; Martyak, R. L.; Obushak, N. D.; Ostapiuk, Yu. V.; Pidlypnyi, N. I. *Chem. Heterocyclic Compounds* **2004**, *40*, 1218.

Heck reaction

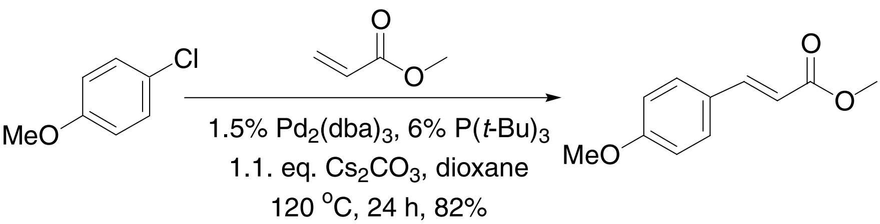
Palladium-catalyzed coupling between organohalides or triflates with olefins.



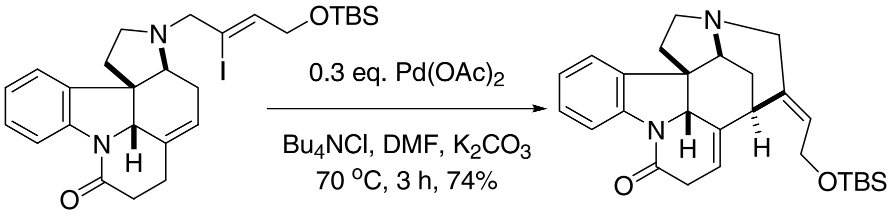
X = I, Br, OTf, Cl, *etc.*
Z = H, R, Ar, CN, CO_2R, OR, OAc, NHAc, *etc.*



Example 1[7]



Example 2[6]

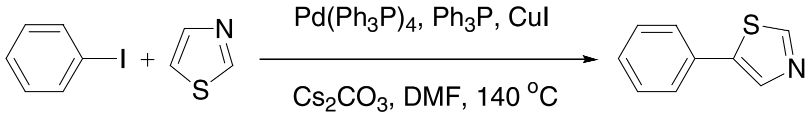


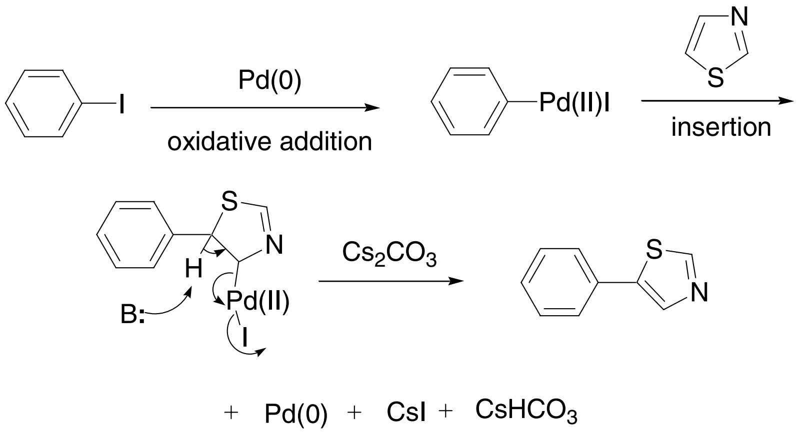
References

1. Heck, R. F.; Nolley, J. P., Jr. *J. Am. Chem. Soc.* **1968**, *90*, 5518. Richard Heck discovered the Heck reaction when he was an assistant professor at the University of Delaware. Despite having discovered a novel methodology that would see ubiquitous utility in organic chemistry and having published a popular book,[4] Heck had difficulties in securing funding for his research, he left chemistry and moved to Asia. Now he is retired in Florida.
2. Heck, R. F. *Acc. Chem. Res.* **1979**, *12*, 146. (Review).
3. Heck, R. F. *Org. React.* **1982**, *27*, 345. (Review).
4. Heck, R. F. *Palladium Reagents in Organic Synthesis,* Academic Press, London, **1985**. (Book).
5. Hegedus, L. S. *Transition Metals in the Synthesis of Complex Organic Molecule* **1994**, University Science Books: Mill Valley, CA, pp 103−113. (Book).
6. Rawal V. H.; Iwasa, H. *J. Org. Chem.* **1994**, *59*, 2685.
7. Littke, A. F.; Fu, G. C. *J. Org. Chem.* **1999**, *64*, 10.
8. Beletskaya, I. P.; Cheprakov, A. V. *Chem. Rev.* **2000**, *100*, 3009−3066. (Review).
9. Amatore, C.; Jutand, A. *Acc. Chem. Res.* **2000**, *33*, 314. (Review).
10. Link, J. T. *Org. React.* **2002**, *60*, 157−534. (Review).
11. Dounay, A. B.; Overman, L. E. *Chem. Rev.* **2003**, *103*, 2945−2963. (Review).
12. Beller, M.; Zapf, A.; Riermeier, T. H. *Transition Metals for Organic Synthesis* (2nd edn.) **2004**, *1*, 271−305. (Review).
13. Oestreich, M. *Eur. J. Org. Chem.* **2005**, 783−792. (Review).

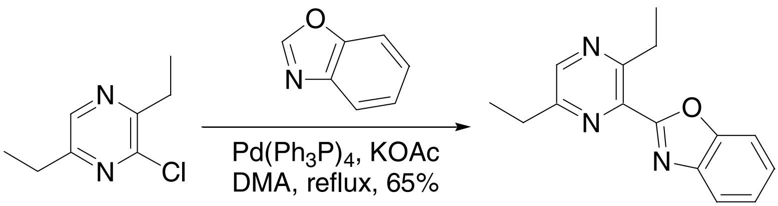
Heteroaryl Heck reaction

Intermolecular or intramolecular Heck reaction that occurs onto a heteroaryl recipient.

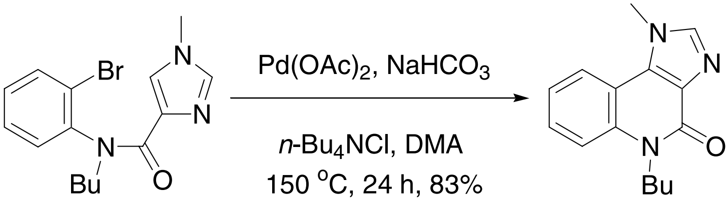




Example 1[3]



Example 2[2]

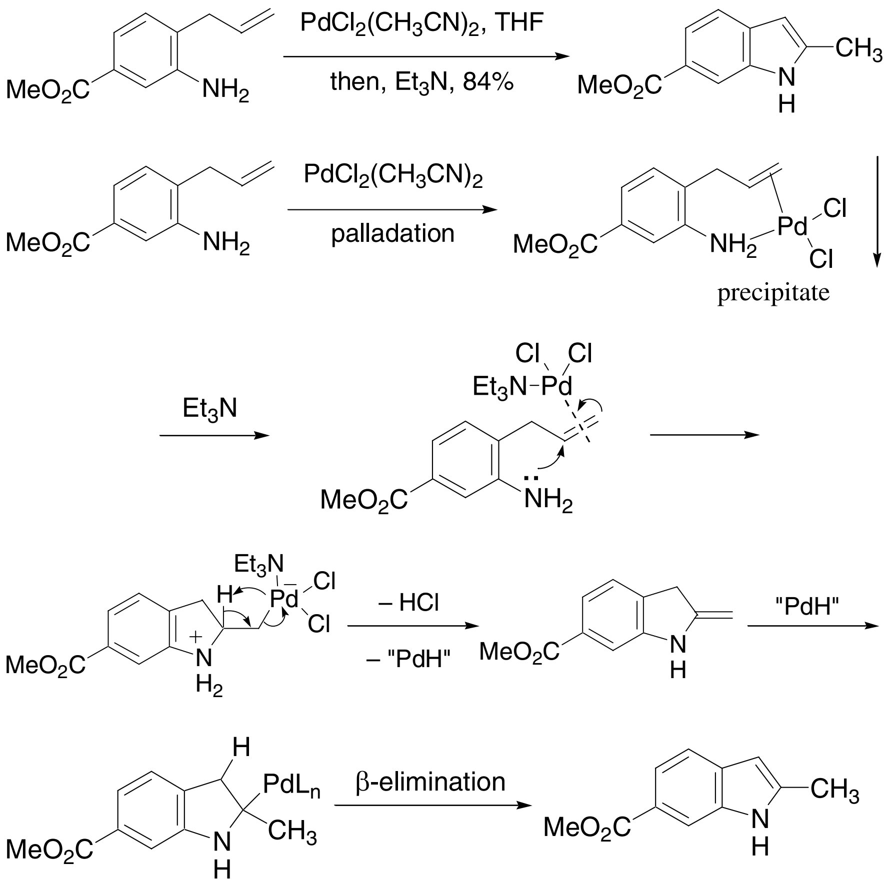


References

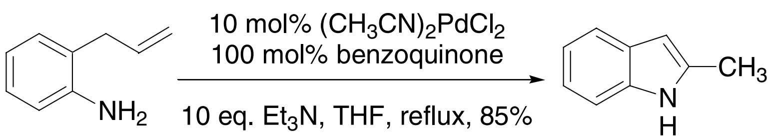
1. Ohta, A.; Akita, Y.; Ohkuwa, T.; Chiba, M.; Fukunaka, R.; Miyafuji, A.; Nakata, T.; Tani, N. Aoyagi, Y. *Heterocycles* **1990**, *31*, 1951.
2. Kuroda, T.; Suzuki, F. *Tetrahedron Lett.* **1991**, *32*, 6915
3. Aoyagi, Y.; Inoue, A.; Koizumi, I.; Hashimoto, R.; Tokunaga, K.; Gohma, K.; Komatsu, J.; Sekine, K.; Miyafuji, A.; Kunoh, J. Honma, R. Akita, Y.; Ohta, A. *Heterocycles* **1992**, *33*, 257.
4. Proudfoot, J. R. *et al. J. Med. Chem.* **1995**, *38*, 1406.
5. Pivsa-Art, S.; Satoh, T.; Kawamura, Y.; Miura, M.; Nomura, M. *Bull. Chem. Soc. Jpn.* **1998**, *71*, 467.
6. Li, J. J.; Gribble, G. W. In *Palladium in Heterocyclic Chemistry;* **2000**, Pergamon: Oxford, p16. (Review).

Hegedus indole synthesis

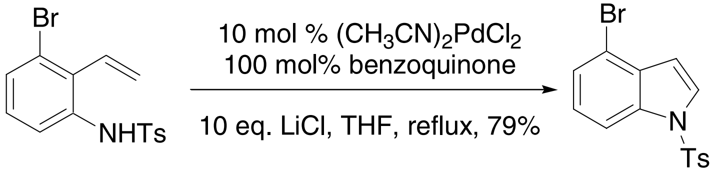
Stoichiometric Pd(II)-mediated oxidative cyclization of alkenyl anilines to indoles. *Cf.* Wacker oxidation.



Example 1[1]



Example 2[4]

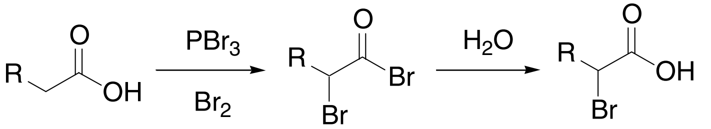


References

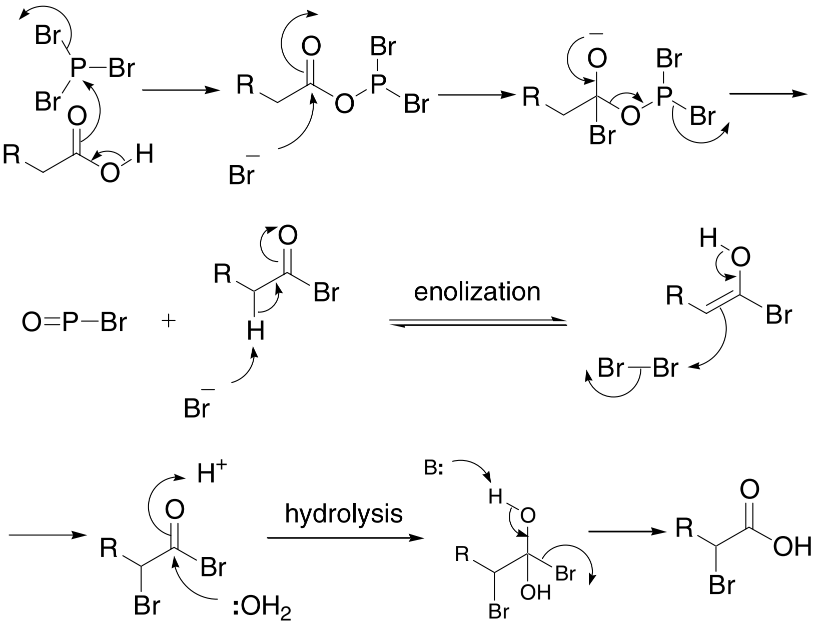
1. Hegedus, L. S.; Allen, G. F.; Waterman, E. L. *J. Am. Chem. Soc.* **1976**, *98,* 2674. Lou Hegedus is a professor at Colorado State University.
2. Hegedus, L. S.; Allen, G. F.; Bozell, J. J.; Waterman, E. L. *J. Am. Chem. Soc.* **1978**, *100,* 5800.
3. Hegedus, L. S.; Winton, P. M.; Varaprath, S. *J. Org. Chem.* **1981**, *46*, 2215.
4. Harrington, P. J.; Hegedus, L. S. *J. Org. Chem.* **1984**, *49*, 2657.
5. Hegedus, L. S. *Angew. Chem., Int. Ed. Engl.* **1988**, *27,* 1113. (Review).
6. Brenner, M.; Mayer, G.; Terpin, A.; Steglich, W. *Chem. Eur. J.* **1997**, *3*, 70.
7. Osanai, Y. Y.; Kondo, K.; Murakami, Y. *Chem. Pharm. Bull.* **1999**, *47*, 1587.
8. A ruthenium variant: Kondo, T.; Okada, T.; Mitsudo, T. *J. Am. Chem. Soc.* **2002**, *124*, 186.
9. Johnston, J. N. *Hegedus Indole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 135–139. (Review).

Hell–Volhard–Zelinsky reaction

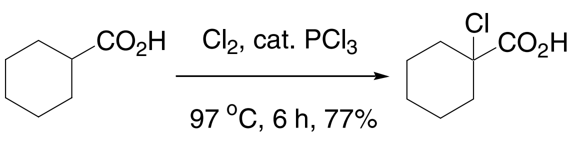
α-Bromination of carboxylic acids using Br_2/PBr_3.



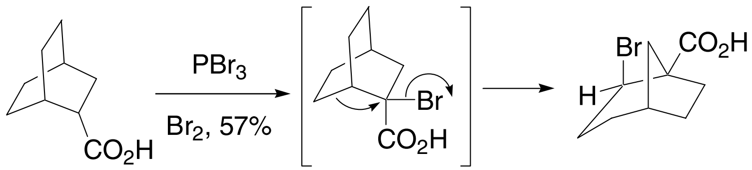
α-bromoacid



Example 1[7]



Example 2[8]

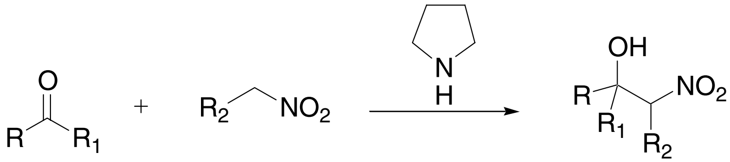


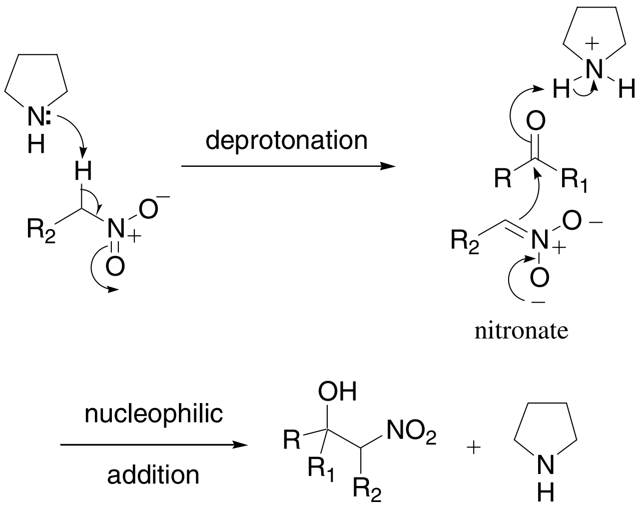
References

1. Hell, C. *Ber. Dtsch. Chem. Ges.* **1881**, *14*, 891. Carl M. von Hell (1849−1926) was born in Stuttgart, Germany. He studied under Fehling and Erlenmeyer. After serving in the war of 1870, he became very ill. Hell became a professor at Stuttgart in 1883 where he discovered the Hell–Volhard–Zelinsky reaction.
2. Volhard, J. *Justus Liebigs Ann. Chem.* **1887**, *242*, 141. Jacob Volhard (1849−1909) was born in Darmstadt, Germany. He apprenticed under Liebig, Will, Bunsen, Hofmann, Kolbe, and von Baeyer. He improved Hell's original procedure in preparing α-bromo-acid during his research in thiophenes.
3. Zelinsky, N. A. *Ber. Dtsch. Chem. Ges.* **1887**, *20,* 2026. Nikolai D. Zelinsky (1861−1953) was born in Tyaspol, Russia. He studied at Göttingen under Victor Meyer, receiving his Ph.D. in 1889. Zelinsky returned to Russia and became a professor at the University of Moscow. On his ninetieth birthday in 1951, he was awarded the Order of Lenin.
4. Watson, H. B. *Chem. Rev.* **1930**, *7,* 173−201. (Review).
5. Sonntag, N. O. V. *Chem. Rev.* **1953**, *52,* 237−246. (Review).
6. Harwood, H. J. *Chem. Rev.* **1962**, *62,* 99−154. (Review).
7. Jason, E. F.; Fields, E. K. US Patent 3,148,209 (**1964**).
8. Chow, A. W.; Jakas, D. R.; Hoover, J. R. E. *Tetrahedron Lett.* **1966**, *5427.*
9. Little, J. C.; Sexton, A. R.; Tong, Y.-L. C.; Zurawic, T. E. *J. Am. Chem. Soc.* **1969**, *91*, 7098.
10. Chatterjee, N. R. *Indian J. Chem., Sect. B* **1978**, *16B*, 730.
11. Kortylewicz, Z. P.; Galardy, R. E. *J. Med. Chem.* **1990**, *33*, 263.
12. Kolasa, T.; Miller, M. J. *J. Org. Chem.* **1990**, *55*, 4246.
13. Liu, H.-J.; Luo, W. *Synth. Commun.* **1991**, *21*, 2097.
14. Krasnov, V. P.; Bukrina, I. M.; Zhdanova, E. A.; Kodess, M. I.; Korolyova, M. A. *Synthesis* **1994**, 961.
15. Zhang, L. H.; Duan, J.; Xu, Y.; Dolbier, W. R., Jr. *Tetrahedron Lett.* **1998**, *39,* 9621.
16. Sharma, A.; Chattopadhyay, S. *J. Org. Chem.* **1999**, *64*, 8059.
17. Stack, D. E.; Hill, A. L.; Diffendaffer, C. B.; Burns, N. M. *Org. Lett.* **2002**, *4*, 4487.

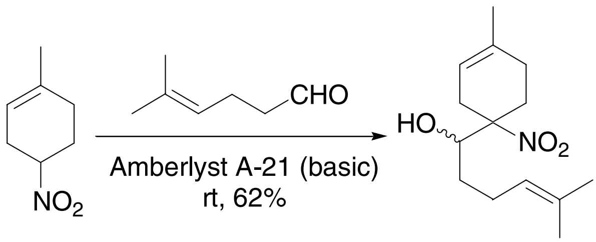
Henry nitroaldol reaction

The nitroaldol condensation reaction involving aldehydes and nitronates, derived from deprotonation of nitroalkanes by bases.

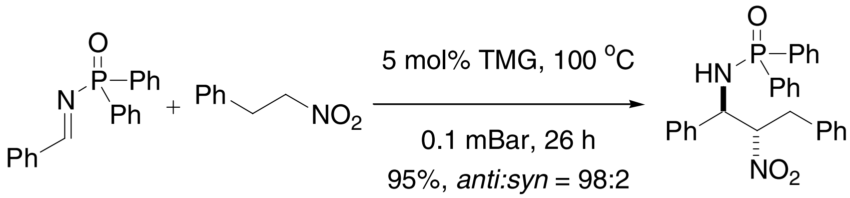




Example 1[6]



Example 2, aza-Henry reaction[14]

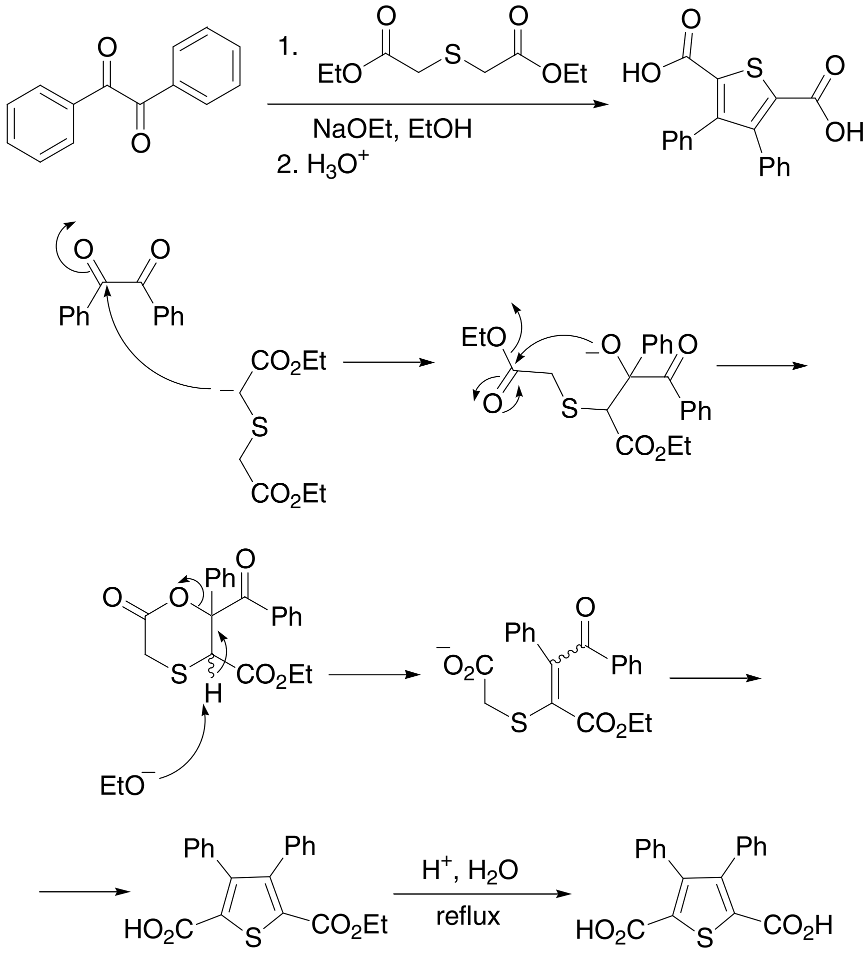


References

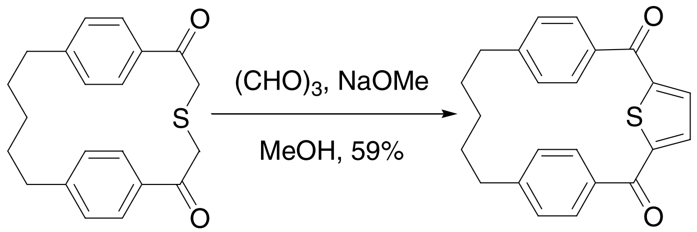
1. Henry, L. *Compt. Rend.* **1895**, *120*, 1265.
2. Matsumoto, K. *Angew. Chem.* **1984**, *96*, 599.
3. Sakanaka, O.; Ohmori, T.; Kozaki, S.; Suami, T.; Ishii, T.; Ohba, S.; Saito, Y. *Bull. Chem. Soc. Jpn.* **1986**, *59*, 1753.
4. Barrett, A. G. M.; Robyr, C.; Spilling, C. D. *J. Org. Chem.* **1989**, *54*, 1233.
5. Rosini, G. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *2*, 321–340. (Review).
6. Chen, Y.-J.; Lin, W.-Y. *Tetrahedron Lett.* **1992**, *33*, 1749.
7. Bandgar, B. P.; Uppalla, L. S. *Synth. Commun.* **2000**, *30*, 2071.
8. Luzzio, F. A. *Tetrahedron* **2001**, *57*, 915. (Review).
9. Trost, B. M.; Yeh, V. S. C. *Angew. Chem., Int. Ed.* **2002**, *41,* 861.
10. Ma, D.; Pan, Q.; Han, F. *Tetrahedron Lett.* **2002**, *43*, 9401.
11. Westermann, B. *Angew. Chem., Int. Ed.* **2003**, *42,* 151. (Review on aza-Henry reaction).
12. Risgaard, T.; Gothelf, K. V.; Jøgensen, K. A. *Org. Biomol. Chem.* **2003**, *1*, 153.
13. Ballini, R.; Bosica, G.; Livi, D.; Palmieri, A.; Maggi, R.; Sartori, G. *Tetrahedron Lett.* **2003**, *44*, 2271.
14. Bernardi, L.; Bonini, B. F.; Capito, E.; Dessole, G.; Comes-Franchini, M.; Fochi, M.; Ricci, A. *J. Org. Chem.* **2004**, *69*, 8168.
15. Chung, W. K.; Chiu, P. *Synlett* **2005**, 55.
16. Palomo, C.; Oiarbide, M.; Laso, A. *Angew. Chem. Int. Ed. Engl.* **2005**, *44*, 3881.

Hinsberg synthesis of thiophene derivatives

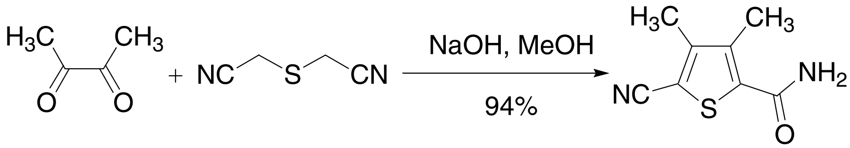
Condensation of diethyl thiodiglycolate and α-diketones under basic conditions, which provides 3,4-disubstituted thiophene-2,5-dicarboxylic acids upon hydrolysis of the crude ester product with aqueous acid.



Example 1[11]



Example 2[15]

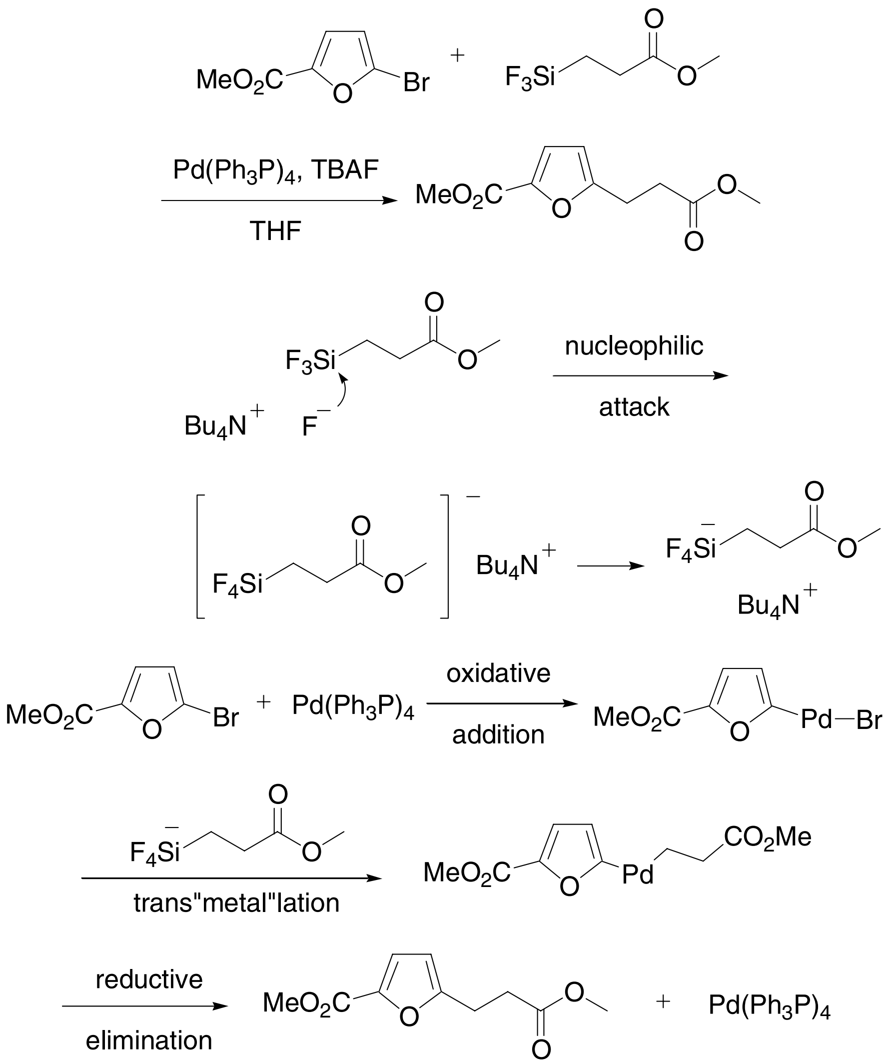


References

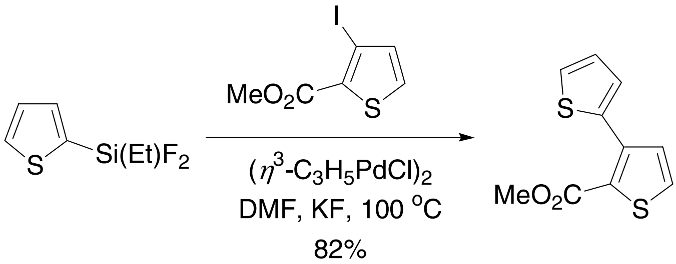
1. Hinsberg, O. *Ber. Dtsch. Chem. Ges.* **1910**, *43*, 901.
2. Gronowitz, S. In *Thiophene and Its Derivatives*, Part 1, Gronowitz, S., ed.; Wiley-Interscience: New York, 1985, 34–41. (Review).
3. Wynberg, H.; Zwanenburg, D. J. *J. Org. Chem.* **1964**, *29*, 1919.
4. Wynberg, H.; Kooreman, H. J. *J. Am. Chem. Soc.* **1965**, *87*, 1739.
5. Chadwick, D. J.; Chambers, J.; Meakins, G. D.; Snowden, R. L. *J. Chem. Soc., Perkin I,* **1972**, 2079.
6. Kumar, A.; Tilak, B. D. *Indian J. Chem.***1986**, *25B*, 880.
7. Miyahara, Y.; Inazu, T.; Yoshino, T. *Chem. Lett.* **1980**, 397.
8. Miyahara, Y.; Inazu, T.; Yoshino, T. *Bull. Chem. Soc. Jpn.* **1980**, *53*, 1187.
9. Huybrechts, L.; Buffel, D.; Freyne, E.; Hoornaert, G. *Tetrahedron* **1984**, *40*, 2479.
10. Miyahara, Y.; Inazu, T.; Yoshino, T. *Tetrahedron Lett.* **1984**, *25*, 415.
11. Miyahara, Y.; Inazu, T.; Yoshino, T. *J. Org. Chem.* **1984**, *49*, 1177.
12. Vogel, E. *Pure Appl. Chem.* **1990**, *62*, 557.
13. Christl, M.; Krimm, S.; Kraft, A. *Angew. Chem. Int. Ed. Engl.* **1990**, *29*, 675.
14. Rangnekar, D. W.; Mavlankar, S. V. *J. Heterocycl. Chem.* **1991**, *28*, 1455.
15. Beye, N.; Cava, M. P. *J. Org. Chem.* **1994**, *59*, 2223.
16. Vogel, E.; Pohl, M.; Herrmann, A.; Wiss, T.; König, C.; Lex, J.; Gross, M.; Gisselbrecht, J. P. *Angew. Chem. Int. Ed. Engl.* **1996**, *35*, 1520.
17. Mullins, R. J.; Williams, D. R. *Hinsberg Synthesis of Thiophene Derivatives* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 199–206. (Review).

Hiyama cross-coupling reaction

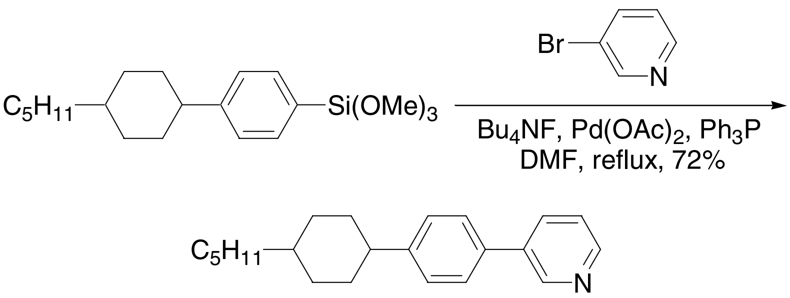
Palladium-catalyzed cross-coupling reaction of organosilicons with organic halides, triflates, *etc*. in the presence of an activating agent such as fluoride or hydroxide (transmetalation is reluctant to occur without the effect of an activating agent). For the catalytic cycle, see the Kumada coupling on page 345.



Example 1[1]



Example 2[5]



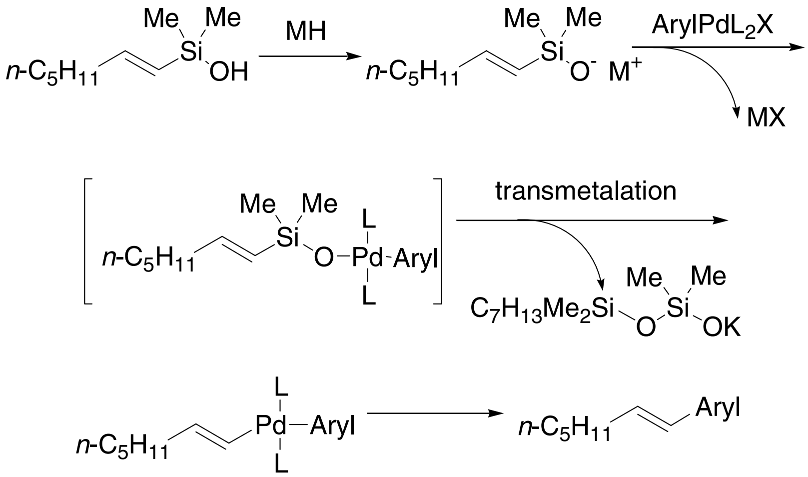
References

1. Hatanaka, Y.; Fukushima, S.; Hiyama, T. *Heterocycles* **1990**, *30*, 303.
2. Hiyama, T.; Hatanaka, Y. *Pure Appl. Chem.* **1994**, *66*, 1471.
3. Matsuhashi, H.; Kuroboshi, M.; Hatanaka, Y.; Hiyama, T. *Tetrahedron Lett.* **1994**, *35,* 6507.
4. Mateo, C.; Fernandez-Rivas, C.; Echavarren, A. M.; Cardenas, D. J. *Organometallics* **1997**, *16*, 1997.
5. Shibata, K.; Miyazawa, K.; Goto, Y. *Chem. Commun.* **1997**, 1309.
6. Hiyama, T. In *Metal-Catalyzed Cross-Coupling Reactions;* **1998**, Diederich, F.; Stang, P. J., Eds.; Wiley–VCH: Weinheim, Germany, 421–53. (Review).
7. Denmark, S. E.; Wang, Z. *J. Organomet. Chem*. **2001**, *624*, 372.
8. Hiyama, T. *J. Organomet. Chem.* **2002**, *653*, 58.
9. Pierrat, P.; Gros, P.; Fort, Y. *Org. Lett*. **2005**, *7*, 697.
10. Clarke, M. L. *Adv. Synth. Cat*. **2005**, *347*, 303.
11. Domin, D.; Benito-Garagorri, D.; Mereiter, K.; Froehlich, J.; Kirchner, K. *Organometallics* **2005**, *24*, 3957.

Hiyama–Denmark cross-coupling reaction

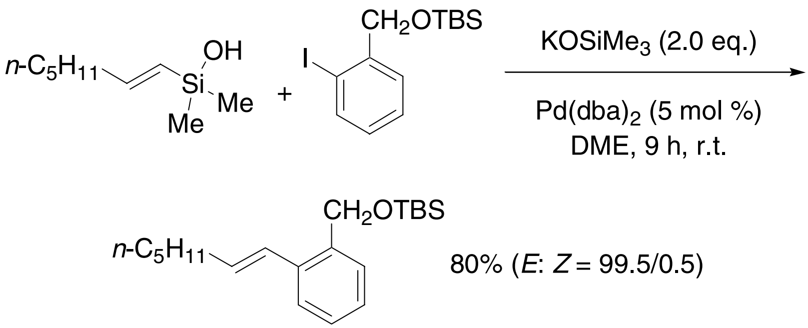
A synthetically important and mechanistically distinct cross-coupling process of organosilanols has been developed. Unlike the Hiyama cross-coupling reaction of polychloro- and fluorosilanes that requires activation by fluoride ion, the Denmark process involves the simple deprotonation of an organosilanol to initiate the coupling. This variant has obvious advantages of avoiding incompatibility with fluoride (silicon protective groups and large-scale reactors).

Mechanistic study[5]

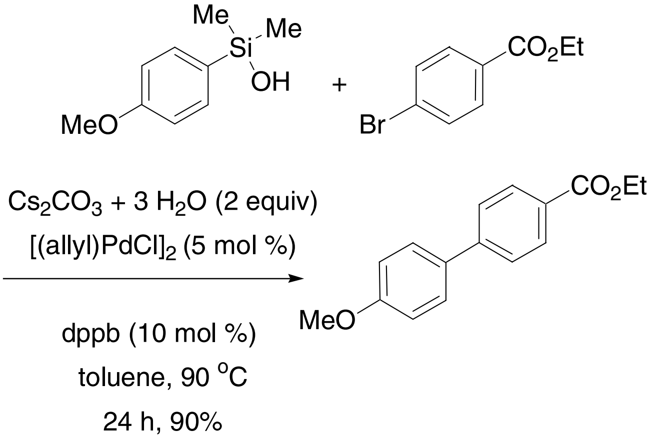


Many organosilanol substrates and different bases have been demonstrated.

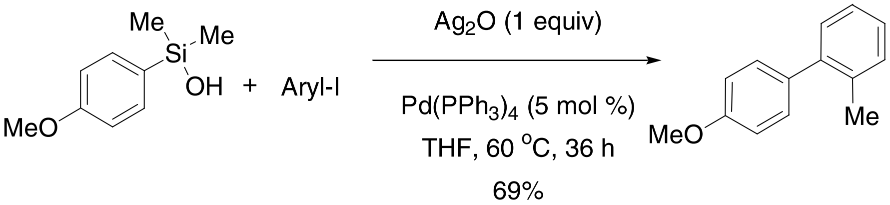
1. Alkenylsilanol ($KOSiMe_3$)[6]



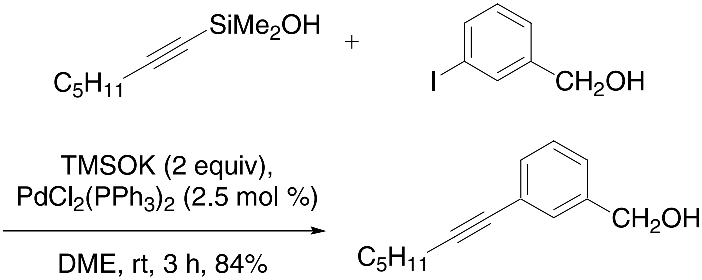
2. Arylsilanol (Cs_2CO_3)[7]



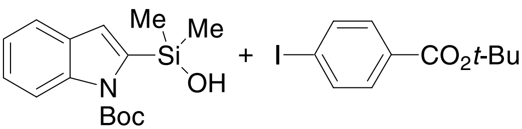
3. Arylsilanol (Ag_2O)[8]

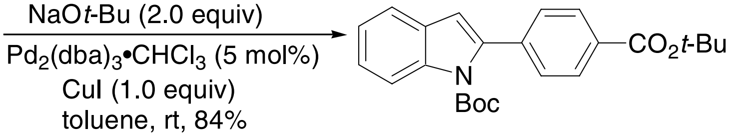


4. Alkynylsilanol ($KOSiMe_3$)[9]

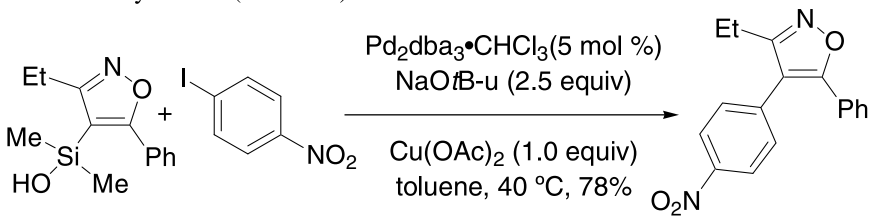


5. 2-Indolylsilanol (KO*t*-Bu)[10]

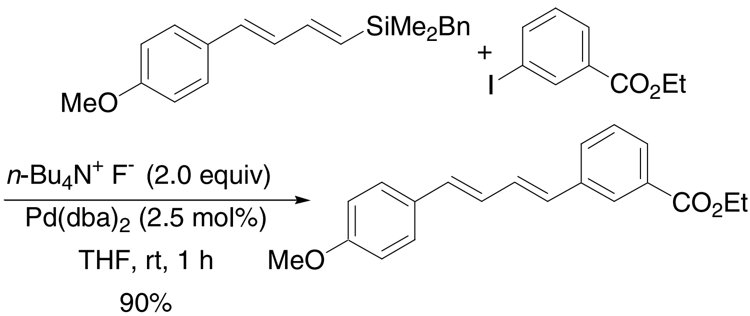




6. 4-Isoxazolylsilanol (NaO*t*-Bu)[11]



7. 1,4-Bis-silyl-1,3-butadienes ($KOSiMe_3$)[12]

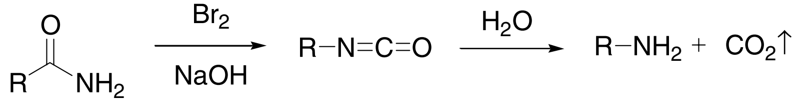


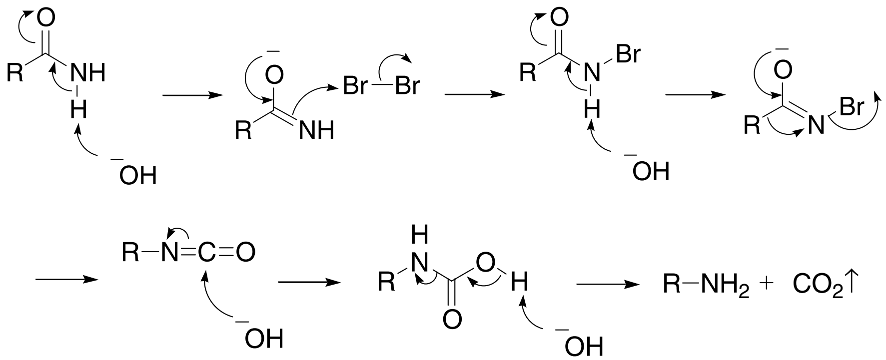
References

1. Denmark, S. E.; Sweis, R. F. *Acc. Chem. Res.* **2002**, *35*, 835. Scott Denmark is a professor at the University of Illinois at Urbana-Champaign.
2. Denmark, S. E.; Sweis, R. F. *Chem. Pharm. Bull.* **2002**, *50*, 1531.
3. Denmark, S. E.; Ober, M. H. *Aldrichimica Acta* **2003**, *36*, 75.
4. Denmark, S. E.; Sweis, R. F. *Organosilicon Compounds in Cross-Coupling Reactions* In *Metal-Catalyzed C-C and C-N Cross-Coupling Reactions;* F. Diederich, A. deMeijere, Eds. Wiley-VCH, 2004; Vol. 1; Chapt. 4.
5. Denmark, S. E.; Sweis, R. F. *J. Am. Chem. Soc.* **2004**, *126*, 4876.
6. Denmark, S. E.; Sweis, R. F. *J. Am. Chem. Soc.* **2001,** *123*, 6439.
7. Denmark, S. E.; Ober, M. H. *Adv. Synth. Catal.*, **2004**, *346*, 1703.
8. Hirabayashi K.; Mori A.; Kawashima J.; Suguro M.; Nishihara Y.; Hiyama T. *J. Org. Chem.* **2000**, *65,* 5342.
9. Denmark, S. E.; Tymonko, S. A. *J. Org. Chem.* **2003**. *68*, 9151.
10. Denmark, S. E.; Baird, J. D. *Org. Lett.* **2004**, *6*(20), 3649.
11. Denmark, S. E.; Kallemeyn, J. *J. Org. Chem.* **2005**, *70*, 2839.
12. Denmark, S. E.; Tymonko, S. A. *J. Am. Chem. Soc.* **2005**, *127*, 8004.

Hofmann rearrangement

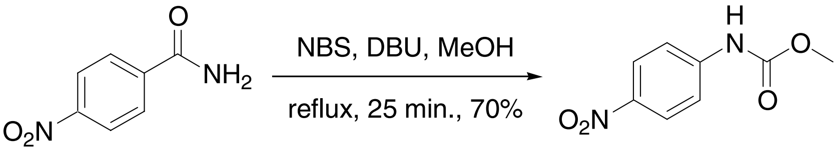
Upon treatment of primary amides with hypohalites, primary amines with one less carbon are obtained *via* the intermediacy of isocyanate. Also know as the Hofmann degradation reaction.



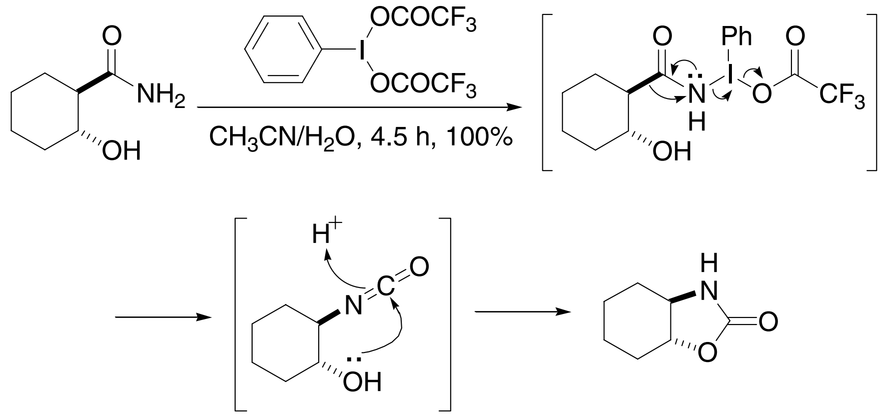


isocyanate intermediate

Example 1[4]



Example 2[9]

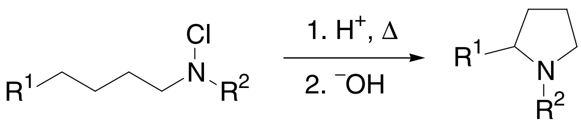


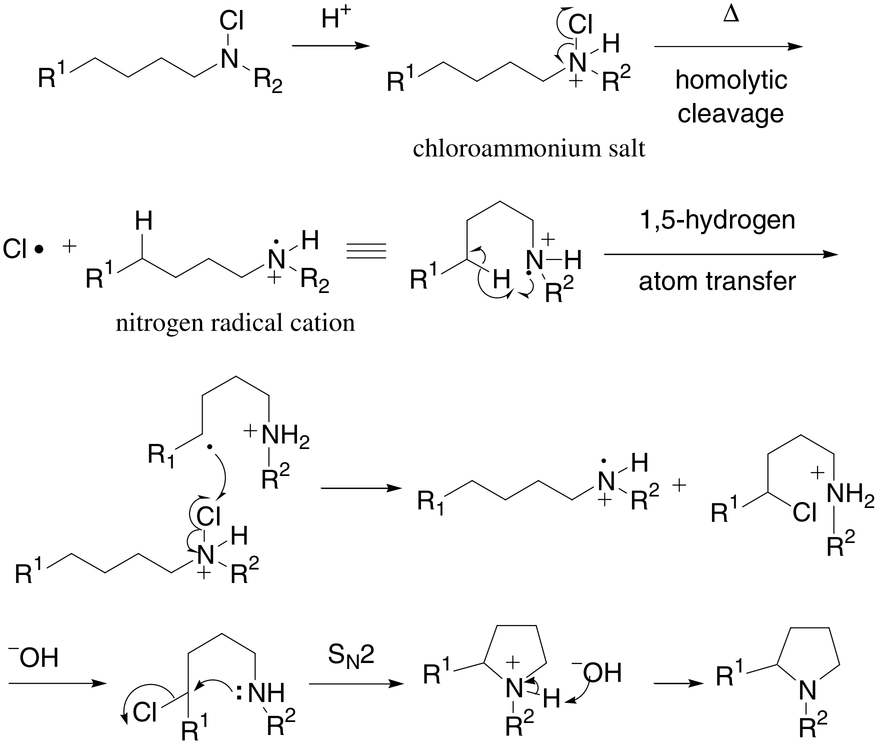
References

1. Hofmann, A. W. *Ber. Dtsch. Chem. Ges.* **1881**, *14*, 2725.
2. Grillot, G. F. *Mech. Mol. Migr.* **1971**, 237. (Review).
3. Jew, S. S.; Park, H. G.; Park, H. J.; Park, M. S.; Cho, Y. S. *Ind. Chem. Library* **1991**, *3*, 147–53. (Review).
4. Jew, S.-s.; Kang, M.-h. *Arch. Pharmacal Res*. **1994**, *17*, 490.
5. Huang, X.; Seid, M.; Keillor, J. W. *J. Org. Chem*. **1997**, *62*, 7495.
6. Spanggord, R. J.; Clizbe, L. A. *J. Labelled Compd. Radiopharm.* **1998**, *41*, 615.
7. Monk, K. A.; Mohan, R. S. *J. Chem. Educ*. **1999**, *76*, 1717. (Review).
8. Togo, H.; Nabana, T.; Yamaguchi, K. *J. Org. Chem*. **2000**, *65*, 8391.
9. Yu, C.; Jiang, Y.; Liu, B.; Hu, L. *Tetrahedron Lett*. **2001**, *42*, 1449.
10. Keillor, J. W.; Huang, X. *Org. Synth.* **2002**, *78*, 234.
11. Lopez-Garcia, M.; Alfonso, I.; Gotor, V. *J. Org. Chem*. **2003**, *68*, 648.
12. Moriarty, R. M. *J. Org. Chem*. **2005**, *70*, 2893–2903. (Review).

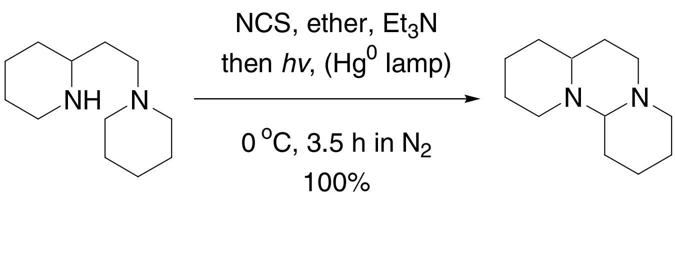
Hofmann–Löffler–Freytag reaction

Formation of pyrrolidines or piperidines by thermal or photochemical decomposition of protonated *N*-haloamines.

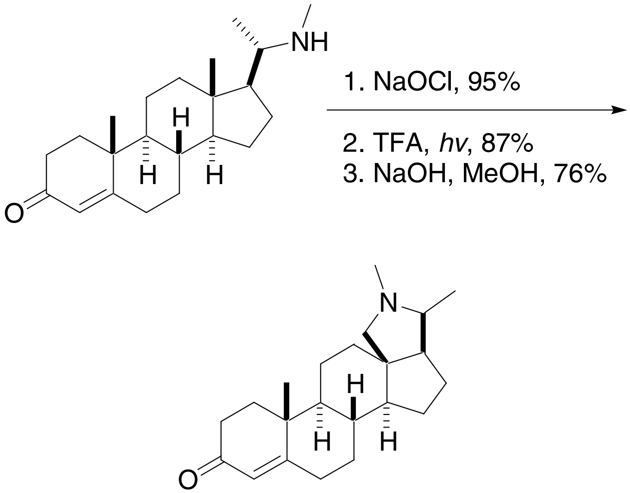




Example 1[6]



Example 2[3]

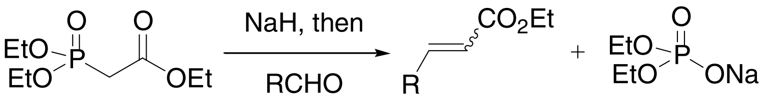


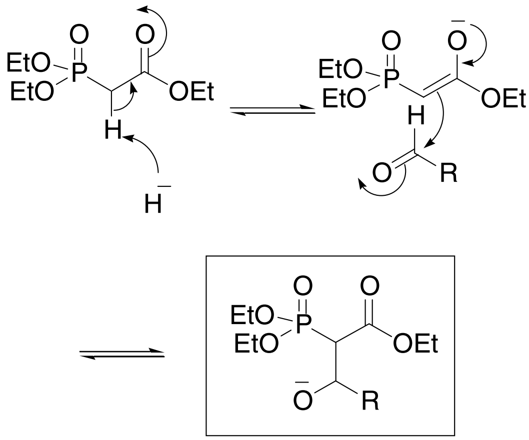
References

1. Hofmann, A. W. *Ber. Dtsch. Chem. Ges.* **1879**, *12*, 984.
2. Löffler, K.; Freytag, C. *Ber. Dtsch. Chem. Ges.* **1909**, *42*, 3727.
3. Kerwin, J. F.; Wolff, M. E.; Owings, F. F.; Lewis, B. B.; Blank, B.; Magnani, A.; Karash, C.; Georgian, V. *J. Am. Chem. Soc*. **1960**, *82*, 4117.
4. Wolff, M. E. *Chem. Rev.* **1963**, *63,* 55. (Review).
5. Furstoss, R.; Teissier, P.; Waegell, B. *Tetrahedron Lett.* **1970**, *11,* 1263.
6. Kimura, M.; Ban, Y. *Synthesis* **1976**, 201.
7. Deshpande, R. P.; Nayak, U. R. *Indian J. Chem., Sect. B* **1979**, *17B*, 310.
8. Hammerum, S. *Tetrahedron Lett.* **1981**, *22*, 157.
9. Uskokovic, M. R.; Henderson, T.; Reese, C.; Lee, H. L.; Grethe, G.; Gutzwiller, J. *J. Am. Chem. Soc*. **1978**, *100*, 571.
10. Stella, L. *Angew. Chem., Int. Ed. Engl.* **1983**, *22*, 337–422. (Review).
11. Majetich, G.; Wheless, K. *Tetrahedron* **1995**, *51*, 7095. (Review).
12. Madsen, J.; Viuf, C.; Bols, M. *Chem. Eur. J*. **2000**, *6*, 1140.
13. Togo, H.; Katohgi, M. *Synlett* **2001**, 565. (Review).
14. Pellissier, H.; Santelli, M. *Org. Prep. Proced. Int*. **2001**, *33*, 455. (Review).
15. Li, J. J. *Hofmann–Löffler–Freytag Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 80–97. (Review).

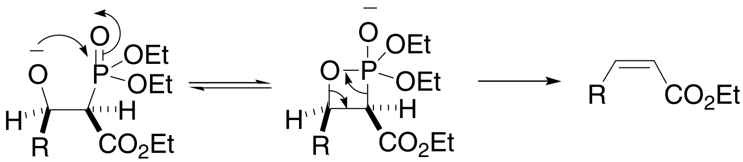
Horner–Wadsworth–Emmons reaction

Olefin formation from aldehydes and phosphonates. Workup is more advantageous than the corresponding Wittig reaction because the phosphate by-product can be washed away with water.

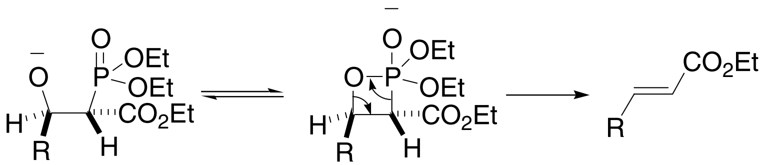




erythro (kinetic) or *threo* (thermodynamic)

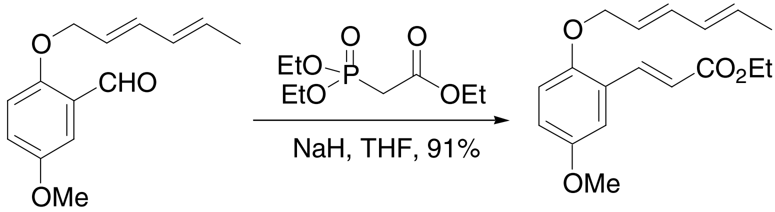


erythro, kinetic adduct

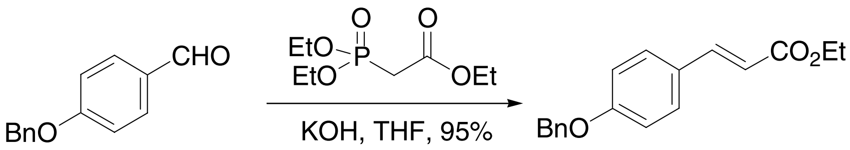


threo, thermodynamic adduct

Example 1[5]



Example 2[8]

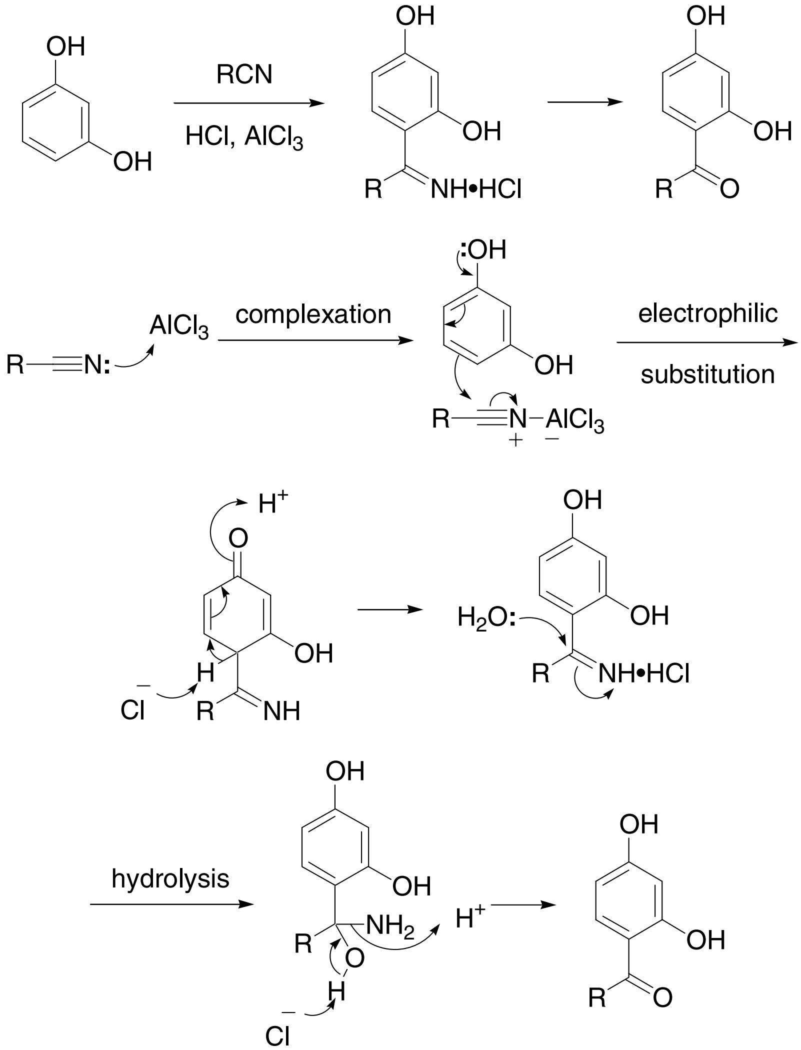


References

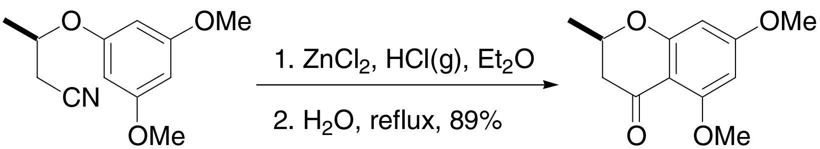
1. Horner, L.; Hoffmann, H.; Wippel, H. G.; Klahre, G. *Chem. Ber.* **1959**, *92*, 2499.
2. Wadsworth, W. S., Jr.; Emmons, W. D. *J. Am. Chem. Soc.* **1961**, *83*, 1733.
3. Wadsworth, D. H.; Schupp, O. E.; Seus, E. J.; Ford, J. A., Jr. *J. Org. Chem.* **1965**, *30*, 680.
4. Maryanoff, B. E.; Reitz, A. B. *Chem. Rev.* **1989**, *89*, 863−927. (Review).
5. Shair, M. D.; Yoon, T. Y.; Mosny, K. K.; Chou, T. C.; Danishefsky, S. J. *J. Am. Chem. Soc.* **1996**, *118*, 9509.
6. Ando, K. *J. Org. Chem.* **1997**, *62*, 1934.
7. Ando, K. *J. Org. Chem.* **1999**, *64*, 6815.
8. Nicolaou, K. C.; Boddy, C. N. C.; Li, H.; Koumbis, A. E.; Hughes, R. J.; Natarajan, S.; Jain, N. F.; Ramajulu, J. M.; Bräse, S.; Solomon, M. E. *Chem. Eur. J.* **1999**, *5*, 2602.
9. Reiser, U.; Jauch, J. *Synlett* **2001**, 90.
10. Comins, D. L.; Ollinger, C. G. *Tetrahedron Lett.* **2001**, *42*, 4115.
11. Harusawa, S.; Koyabu, S.; Inoue, Y.; Sakamoto, Y.; Araki, L.; Kurihara, T. *Synthesis* **2002**, 1072.
12. Lattanzi, A.; Orelli, L. R.; Barone, P.; Massa, A.; Iannece, P.; Scettri, A. *Tetrahedron Lett.* **2003**, *44*, 1333.
13. Blasdel, L. K.; Myers, A. G. *Org. Lett.* **2005**, *7*, 4281.

Houben–Hoesch reaction

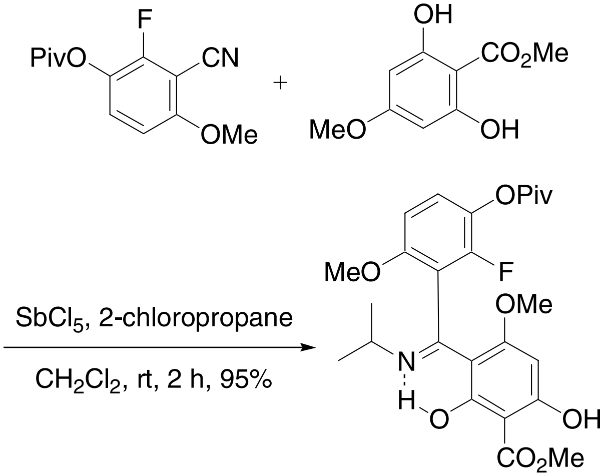
Acid-catalyzed acylation of phenols as well as phenolic ethers using nitriles.



Example 1, intramolecular Houben–Hoesch reaction[5]



Example 2[8]

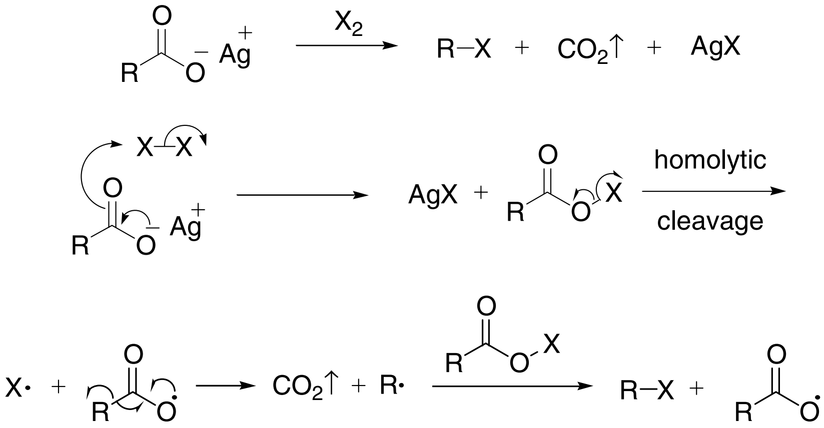


References

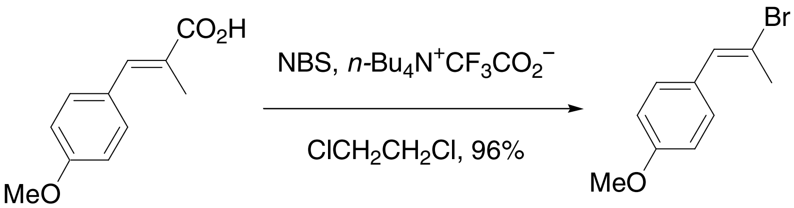
1. Hoesch, K. *Ber. Dtsch. Chem. Ges.* **1915**, *48,* 1122. Kurt Hoesch (1882−1932) was born in Krezau, Germany. He studied at Berlin under Emil Fischer. During WWI, Hoesch was Professor of Chemistry at the University of Istanbul, Turkey. After the war he gave up his scientific activities to devote himself to the management of a family business.
2. Houben, J. *Ber. Dtsch. Chem. Ges.* **1926**, *59,* 2878.
3. Amer, M. I.; Booth, B. L.; Noori, G. F. M.; Proenca, M. F. J. R. P. *J. Chem. Soc., Perkin Trans. 1* **1983**, 1075.
4. Yato, M.; Ohwada, T.; Shudo, K. *J. Am. Chem. Soc*. **1991**, *113*, 691.
5. Rao, A. V. R.; Gaitonde, A. S.; Prakash, K. R. C.; Rao, S. P. *Tetrahedron Lett.* **1994**, *35*, 6347.
6. Sato, Y.; Yato, M.; Ohwada, T.; Saito, S.; Shudo, K. *J. Am. Chem. Soc*. **1995**, *117*, 3037.
7. Kawecki, R.; Mazurek, A. P.; Kozerski, L.; Maurin, J. K. *Synthesis* **1999**, 751.
8. Udwary, D. W.; Casillas, L. K.; Townsend, C. A. *J. Am. Chem. Soc*. **2002**, *124*, 5294.
9. Sanchez-Viesca, F.; Gomez, M. R.; Berros, M. *Org. Prep. Proc. Int.* **2004**, *36*, 135.

Hunsdiecker–Borodin reaction

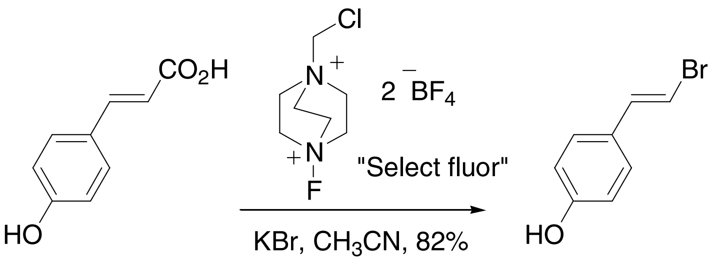
Conversion of silver carboxylate to halide by treatment with halogen.



Example 1[6]



Example 2[10]



References

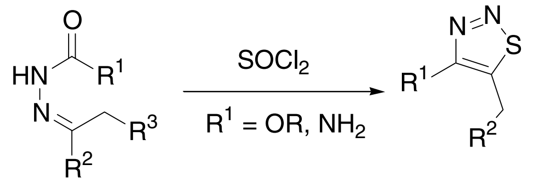
1. Borodin, A. *Justus Liebigs Ann. Chem.* **1861**, *119*, 121. Aleksandr Porfirevič Borodin (1833–1887) was born in St Petersburg, the illegitimate son of a prince. He prepared methyl bromide from silver acetate in 1861, but another eighty years elapsed before

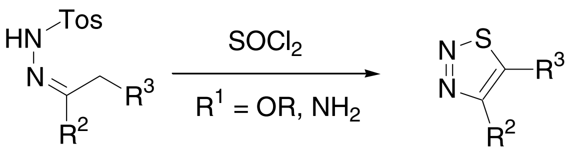
Heinz and Cläre Hunsdiecker converted Borodin's synthesis into a general method, the Hunsdiecker or Hunsdiecker–Borodin reaction. Borodin was also an accomplished composer and is now best known for his musical masterpiece, opera Prince Egor. He kept a piano outside his laboratory.

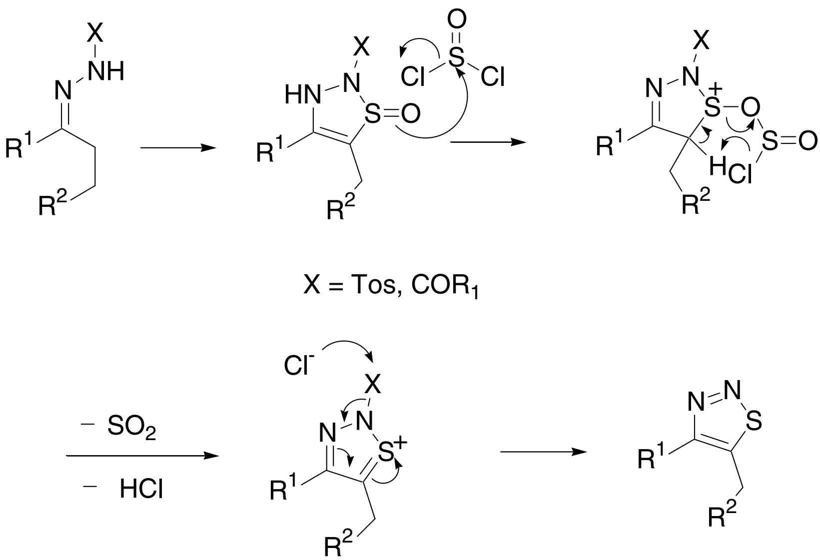
2. Hunsdiecker, H.; Hunsdiecker, C. *Ber. Dtsch. Chem. Ges.* **1942**, *75,* 291. Cläre Hunsdiecker was the only woman to give a name reaction in this book. I hope there will be many more in future editions. Cläre Hunsdiecker was born in 1903 and educated in Cologne. She developed the bromination of silver carboxylate alongside her husband, Heinz.
3. Sheldon, R. A.; Kochi, J. K. *Org. React.* **1972**, *19*, 326. (Review).
4. Barton, D. H. R.; Crich, D.; Motherwell, W. B. *Tetrahedron Lett.* **1983**, *24,* 4979.
5. Crich, D. In *Comprehensive Organic Synthesis;* Trost, B. M.; Steven, V. L., Eds.; Pergamon, **1991**, *Vol. 7*, 723–734. (Review).
6. Naskar, D.; Chowdhury, S.; Roy, S. *Tetrahedron Lett.* **1998**, *39*, 699.
7. Camps, P.; Lukach, A. E.; Pujol, X.; Vazquez, S. *Tetrahedron* **2000**, *56*, 2703.
8. De Luca, L.; Giacomelli, G.; Porcu, G.; Taddei, M. *Org. Lett.* **2001**, *3*, 855.
9. Das, J. P.; Roy, S. *J. Org. Chem.* **2002**, *67*, 7861.
10. Ye, C.; Shreeve, J. M. *J. Org. Chem.* **2004**, *69*, 8561.

Hurd–Mori 1,2,3-thiadiazole synthesis

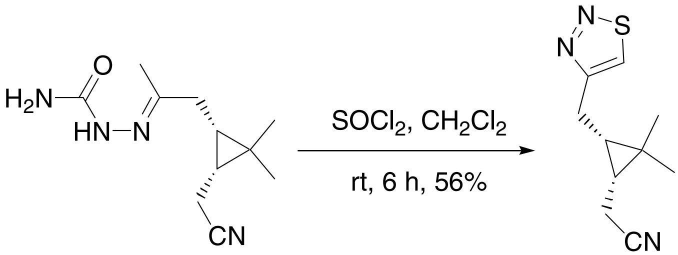
Reaction of thionyl chloride with the *N*-acylated or tosyl hydrazone derivatives to provide the 1,2,3-thiadiazole in one step.







Example[17]

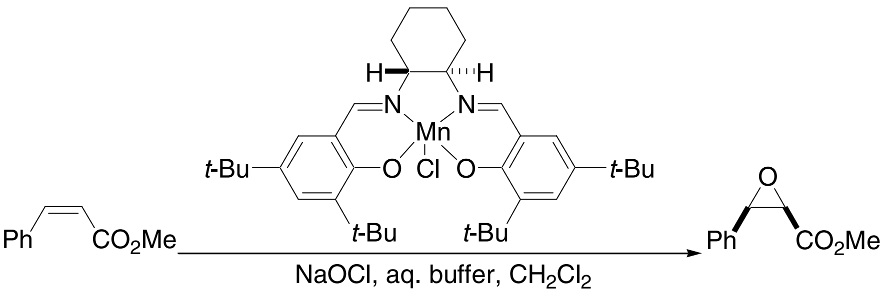


References

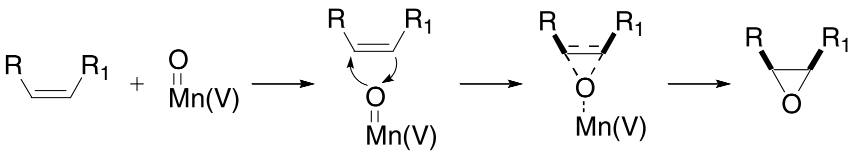
1. Hurd, C. D.; Mori, R. I. *J. Am. Chem. Soc.* **1955**, *77*, 5359.
2. Meier, H.; Hanold, N. In *Methoden der Organischen Chemie*: Houben−Weyl, Georg Thieme: Stuttgart – New York, **1994**; Vol. E8d, p.60. (Review).
3. Thomas, E. W. In *Comprehensive Heterocyclic Chemistry;* Potts, K. T., Vol. Ed.; Katrizky, A. R.; Rees, C. W.; Series Eds.; Pergamon Press: London, **1984**; Vol. 6, Part 4B, p. 447. (Review).
4. Thomas, E. W. In *Comprehensive Heterocyclic Chemistry II*; Storr, R. C., Vol. Ed.; Katrizky, A. R.; Rees, C. W.; Scriven, E. F.; Series Eds.; Pergamon Press: London, **1996**; Vol. 4, p. 289. (Review).
5. Stanetty, P.; Turner, M.; Mihovilovic, M. D. In *Targets in Heterocyclic Systems* **1999**, *3*, 265–299. (Review).
6. Thomas, E. W.; Nishizawa, E. E.; Zimmermann, D. C.; Williams, D. J. *J. Med. Chem.* **1985**, *28*, 442.
7. Lewis, G. S.; Nelson, P. H. *J. Med. Chem.* **1979**, *22*, 1214.
8. Fujita, M.; Nimura, K.; Kobori, T.; Hiyama, T.; Kondo, K. *Heterocycles* **1995**, *41*, 2413.
9. Peet, N. P.; Sunder, S. *J. Heterocycl. Chem.* **1975**, *12*, 1191.
10. Zimmer, O.; Meier, H. *Chem. Ber.* **1981**, *114*, 2938.
11. Britton, T. C.; Lobl, T. J.; Chidester, C. G. *J. Org. Chem.* **1984**, *49*, 4773.
12. Fujita, M.; Kobori, T.; Hiyama, T.; Kondo, K. *Heterocycles* **1993**, *36*, 33.
13. D'Hooge, B.; Smeets, S.; Toppet, S.; Dehaen, W. *Chem. Commun.* **1997**, 1753.
14. Stanetty, P.; Kremslehner, M.; Vollenkle, H. *J. Chem. Soc., Perkin Trans. 1* **1998**, 853; Stanetty, P.; Kremslehner, M.; Jaksits, M. *Pest. Sci.* **1998**, *54*, 316.
15. Hu, Y.; Baudart, S.; Porco, J. A., Jr. *J. Org. Chem.* **1999**, *64*, 1049.
16. Abramov, M. A.; Dehaen, W. *Synthesis* **2000**, 1529.
17. Morzherin, Y. Y.; Glukhareva, T. V.; Mokrushin, V. S.; Tkachev, A. V.; Bakulev, V. A. *Heterocyclic Commun.* **2001**, *7*, 173.
18. Hameurlaine, A.; Abramov, M. A.; Dehaen, W. *Tetrahedron Lett.* **2002**, *43*, 1015.
19. Sakya, S. M. *Hurd–Mori 1,2,3-Thiadiazole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Eds, Li, J. J.; Corey, E. J. Wiley & Sons: Hoboken, NJ, **2005**, 199−206. (Review).

Jacobsen–Katsuki epoxidation

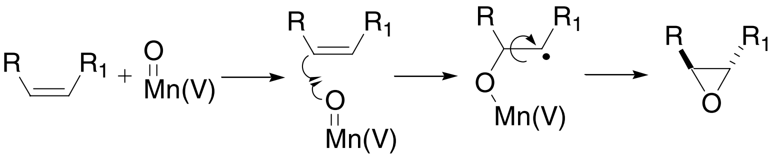
Manganese-catalyzed asymmetric epoxidation of (Z)-olefins.



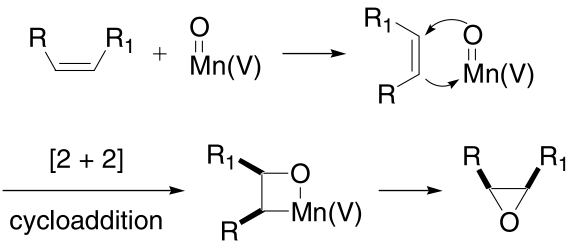
1. Concerted oxygen transfer (*cis*-epoxide):



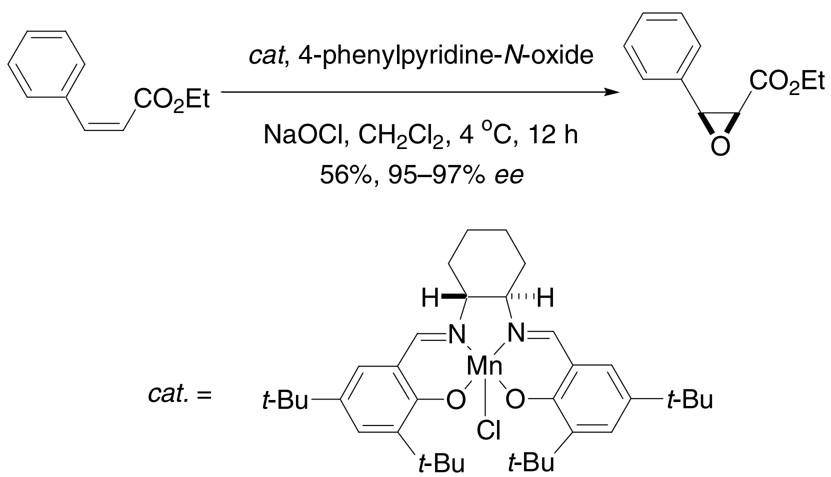
2. Oxygen transfer *via* radical intermediate (*trans*-epoxide):



3. Oxygen transfer *via* manganaoxetane intermediate (*cis*-epoxide):



Example[5]

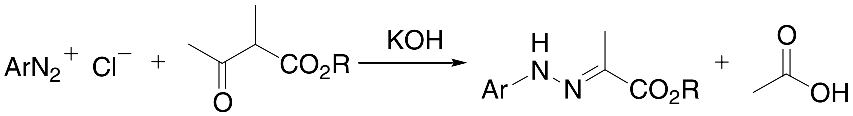


References

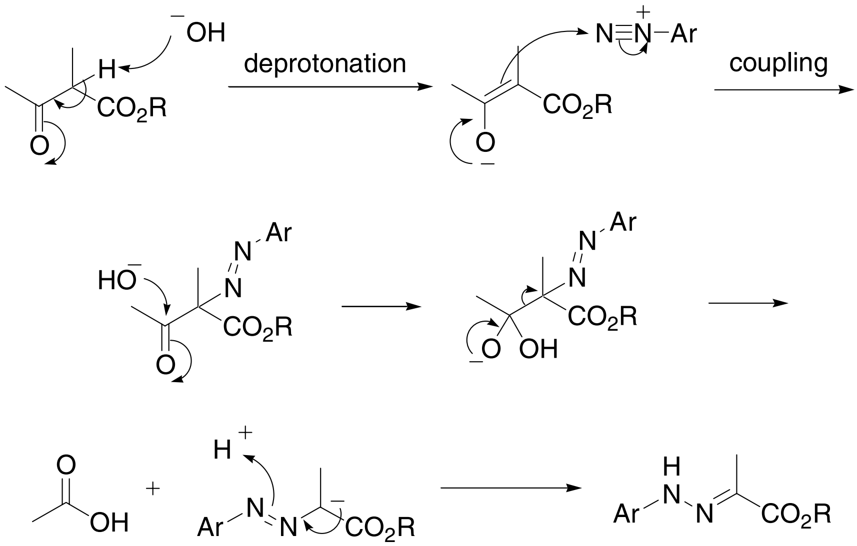
1. Zhang, W.; Loebach, J. L.; Wilson, S. R.; Jacobsen, E. N. *J. Am. Chem. Soc.* **1990**, *112,* 2801.
2. Irie, R.; Noda, K.; Ito, Y.; Matsumoto, N.; Katsuki, T. *Tetrahedron Lett.* **1990**, *31*, 7345.
2. Irie, R.; Noda, K.; Ito, Y.; Katsuki, T. *Tetrahedron Lett.* **1991**, *32*, 1055.
3. Zhang, W.; Jacobsen, E. N. *J. Org. Chem.* **1991**, *56*, 2296.
4. Schurig, V.; Betschinger, F. *Chem. Rev.* **1992**, *92*, 873. (Review).
5. Deng, Li; Jacobsen, E. N. *J. Org. Chem.* **1992**, 57, 4320.
6. Jacobsen, E. N. In *Catalytic Asymmetric Synthesis;* Ojima, I., Ed.; VCH: Weinheim, New York, **1993**, Ch. 4.2. (Review).
7. Katsuki, T. *Coord. Chem. Rev.* **1995**, *140*, 189–214. (Review).
8. E. N. Jacobsen, in *Comprehensive Organometallic Chemistry II*, Eds. G. W. Wilkinson, G. W.; Stone, F. G. A.; Abel, E. W.; Hegedus, L. S., Pergamon, New York, **1995**, vol 12, Chapter 11.1. (Review).
9. Palucki, M.; McCormick, G. J.; Jacobsen, E. N. *Tetrahedron Lett.* **1995**, *36*, 5457.
10. Senananyake, C. H. *Aldrichimica Acta* **1998**, *31*, 3. (Review).
11. Jacobsen, E. N.; Wu, M. H. in *Comprehensive Asymmetric Catalysis*, Jacobsen, E. N.; Pfaltz, A.; Yamamoto, H. Eds.; Springer: New York; 1999, Chapter 18.2. (Review).
12. Katsuki, T. In *Catalytic Asymmetric Synthesis;* 2nd edn.; Ojima, I., Ed.; Wiley-VCH: New York, **2000**, 287. (Review).
13. Katsuki, T. *Synlett* **2003**, 281. (Review).
14. Palucki, M. *Jacobsen–Katsuki epoxidation* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 29–43. (Review).

Japp–Klingemann hydrazone synthesis

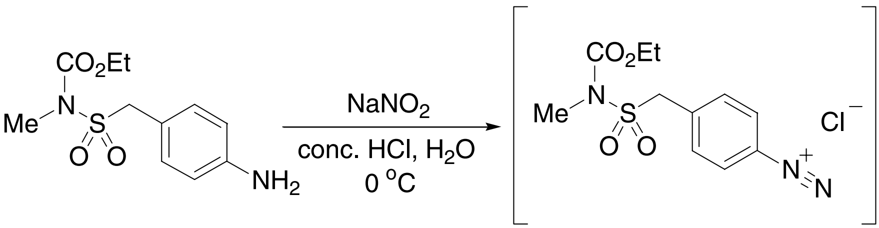
Hydrazones from α-ketoesters and diazonium salts with the acid of base.

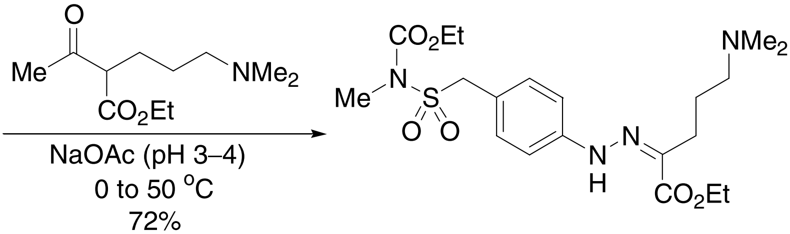


Diazonium salt β-keto-ester hydrazone

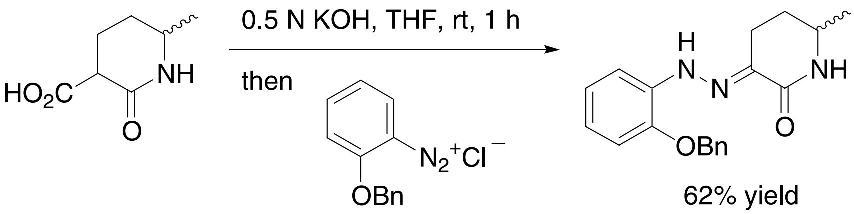


Example 1[6]





Example 2[9]

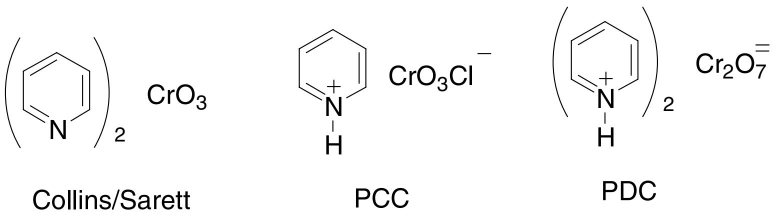


References

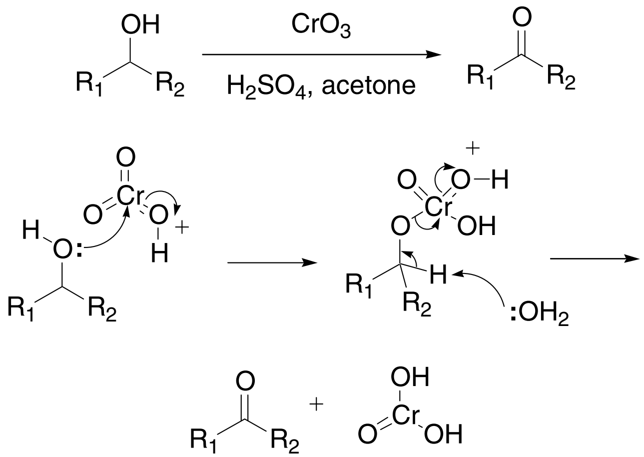
1. Japp, F. R.; Klingemann, F. *Justus Liebigs Ann. Chem.* **1888**, *247*, 190.
2. Laduree, D.; Florentin, D.; Robba, M. *J. Heterocycl. Chem.* **1980**, *17*, 1189.
3. Strandtmann, M. v.; Cohen, Marvin P.; Shavel, J. Jr. *J. Med. Chem.* **1963**, *6*, 719.
4. Loubinoux, B.; Sinnes, J.-L.; O'Sullivan, A. C.; Winkler, T. *J. Org. Chem.* **1995**, *60*, 953.
5. Saha, C., Miss; Chakraborty, A.; Chowdhury, B. K. *Indian J. Chem.* **1996**, *35B*, 677.
6. Pete, B.; Bitter, I.; Harsanyi, K.; Toke, L. *Heterocycles* **2000**, *53*, 665.
7. Atlan, V.; Kaim, L. E.; Supiot, C. *Chem. Commun.* **2000**, 1385.
8. Shawali, A. S.; Abdallah, M. A.; Mosselhi, M. A. N.; Farghaly, T. A. *Heteroatom Chem.* **2002**, *13*, 136.
9. Dubash, N. P.; Mangu, N. K.; Satyam, A. *Synth. Commun.* **2004**, *34*, 1791.

Jones oxidation

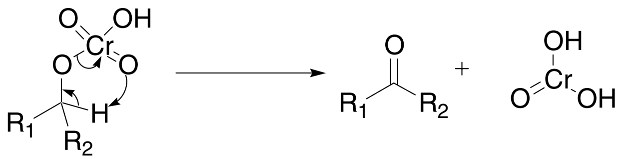
The **Collins/Sarett oxidation** (chromium trioxide-pyridine complex), and **Corey´s PCC** (pyridinium chlorochromate) and **PDC** (pyridinium dichromate) **oxidations** follow a similar pathway as the **Jones oxidation**. All these oxidants have a chromium (VI), normally yellow, which is reduced to Cr(IV), often green.



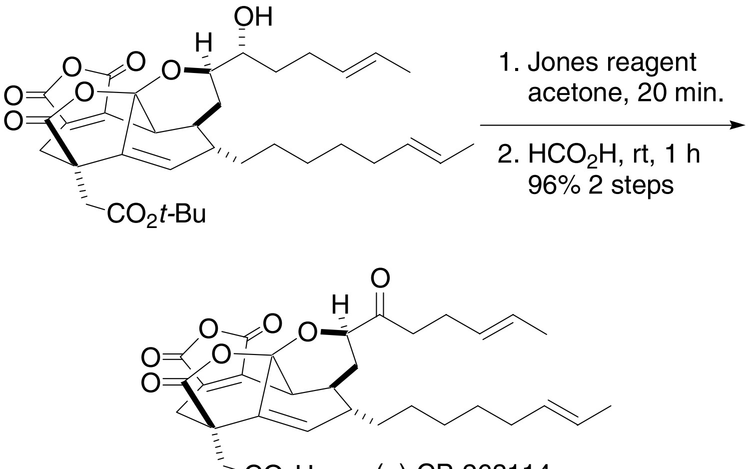
Jones oxidation



The intramolecular mechanism is also operative:

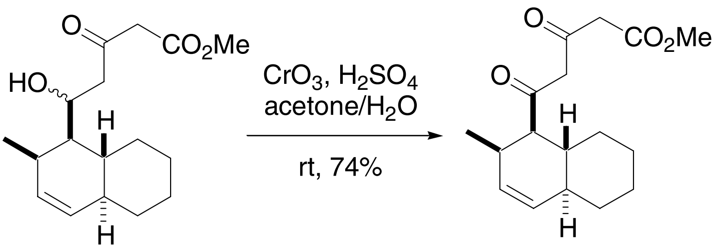


Example 1[14]

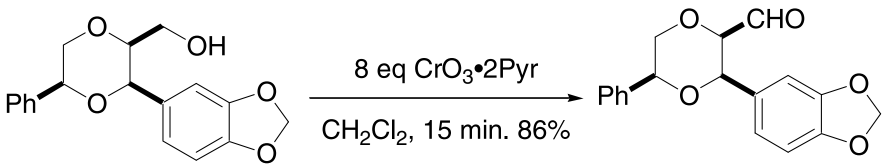


(–)-CP-263114

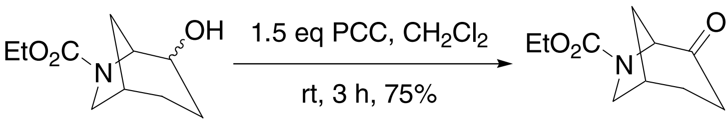
Example 2[15]



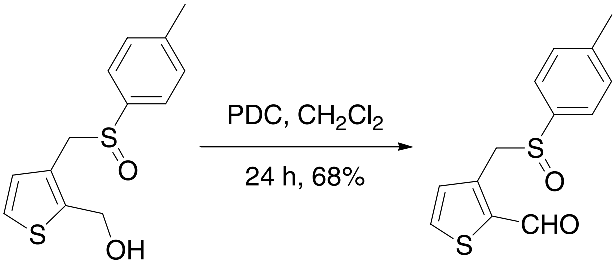
Collins/Sarett oxidation[5]



PCC oxidation[6]



PDC oxidation[7]

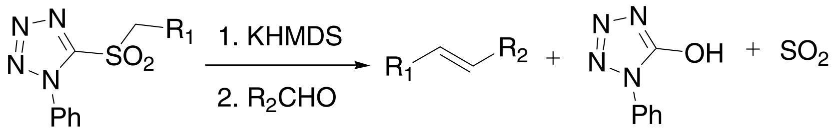


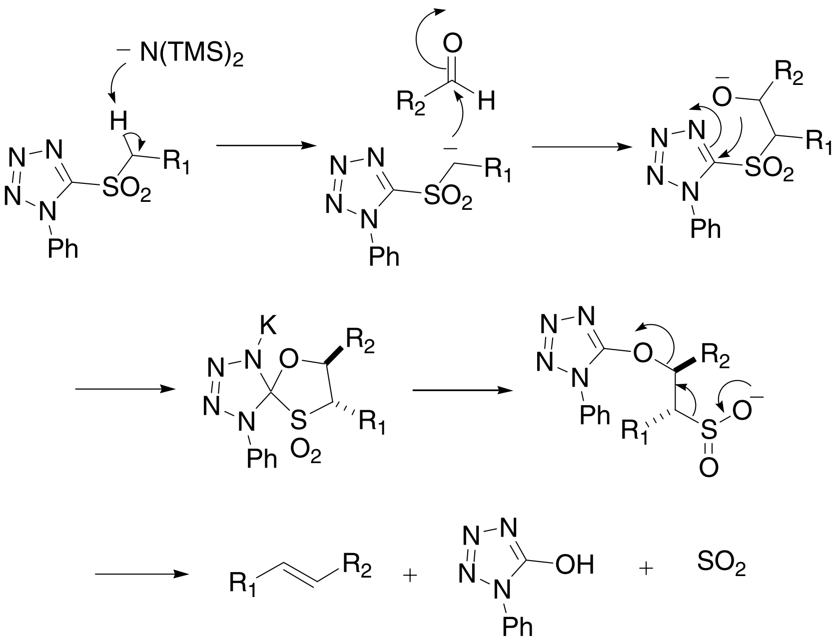
References

1. Bowden, K.; Heilbron, I. M., Jones, E. R. H.; Weedon, B. C. L. *J. Chem. Soc.* **1946**, 39-45. Ewart R. H. (Tim) Jones worked with Ian M. Heilbron at Imperial College. Jones later succeeded Robert Robinson to become the prestigious Chair of Organic Chemistry at Manchester. *The recipe for the Jones reagent: 25 g CrO_3, 25 mL conc. H_2SO_4, and 70 mL H_2O.*
2. Poos, G. I.; Arth, G. E.; Beyler, R. E.; Sarett, L. H. *J. Am. Chem. Soc.* **1953**, *75*, 422.
3. Ratcliffe, R. W. *Org. Syn.* **1973**, *53*, 1852.
4. Andrieux, J.; Bodo, B.; Cunha, H.; Deschamps-Vallet, C.; Meyer-Dayan, M.; Molho, D. *Bull. Soc. Chim. Fr.* **1976**, 1975.
5. Vanmaele, L.; De Clerq, P.; Vandewalle, M. *Tetrahedron Lett.* **1982**, *23*, 995.
6. Krow, G. R.; Shaw, D. A.; Szczepanski, S.; Ramjit, H. *Synth. Commun.* **1984**, *14*, 429.
7. Terpstra, J. W.; Van Leusen, A. M. *J. Org. Chem.* **1986**, *51*, 230.
8. Gomez-Garibay, F.; Quijano, L.; Pardo, J. S. C.; Aguirre, G.; Rios, T. *Chem. Ind.* **1986**, 827.
9. Glinski, J. A.; Joshi, B. S.; Jiang, Q. P.; Pelletier, S. W. *Heterocycles* **1988**, *27*, 185.
10. Turjak-Zebic, V.; Makarevic, J.; Skaric, V. *J. Chem. Soc. (S)* **1991**, 132.
11. Luzzio, F. A. *Org. React.* **1998**, *53*, 1–222. (Review).
12. Zhao, M.; Li, J.; Song, Z.; Desmond, R. J.; Tschaen, D. M.; Grabowski, E. J. J.; Reider, P. J. *Tetrahedron Lett.* **1998**, *39*, 5323. (Catalytic CrO_3 oxidation).
13. Caamano, O.; Fernandez, F.; Garcia-Mera, X.; Rodriguez-Borges, J. E. *Tetrahedron Lett.* **2000**, *41*, 4123.
14. Waizumi, N.; Itoh, T.; Fukuyama, T. *J. Am. Chem. Soc.* **2000**, *122*, 7825.
15. Hagiwara, H.; Kobayashi, K.; Miya, S.; Hoshi, T.; Suzuki, T.; Ando, M. *Org. Lett.* **2001**, *3*, 251.
16. Arumugam, N.; Srinivasan, P. C. *Synth. Commun.* **2003**, *33*, 2313.
17. Fernandes, R. A.; Kumar, P. *Tetrahedron Lett.* **2005**, *44*, 1275.
18. Xu, L.; Cheng, J.; Trudell, M. L. *J. Org. Chem.* **2005**, *68*, 5388.

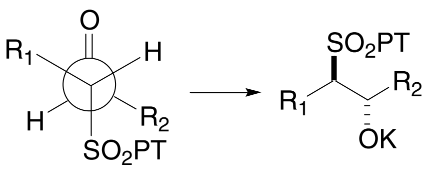
Julia–Kocienski olefination

Modified one-pot Julia olefination to give predominantly (*E*)-olefins from heteroarylsulfones and aldehydes. A sulfone reduction step is *not* required.

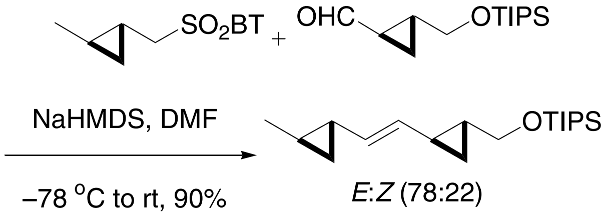




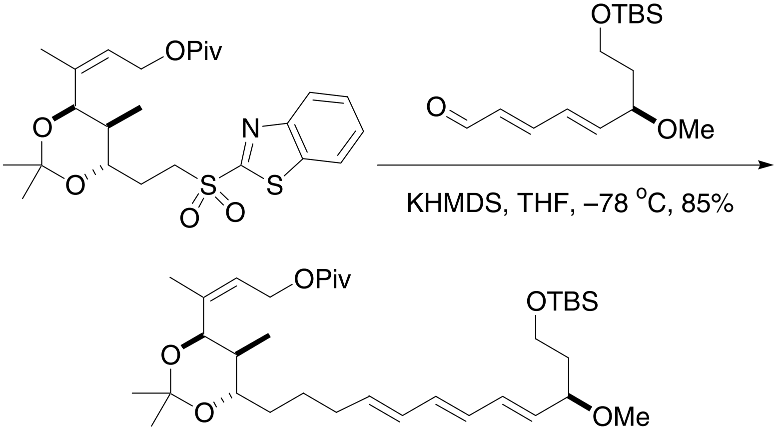
The use of larger counterion (such as K^+) and polar solvents (such as DME) favors an open transition state (PT = phenyltetrazolyl):



Example 1, (BT = benzotriazole)[4]



Example 2[6]

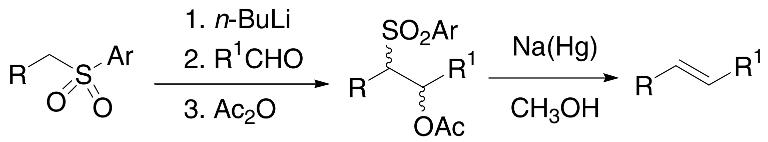


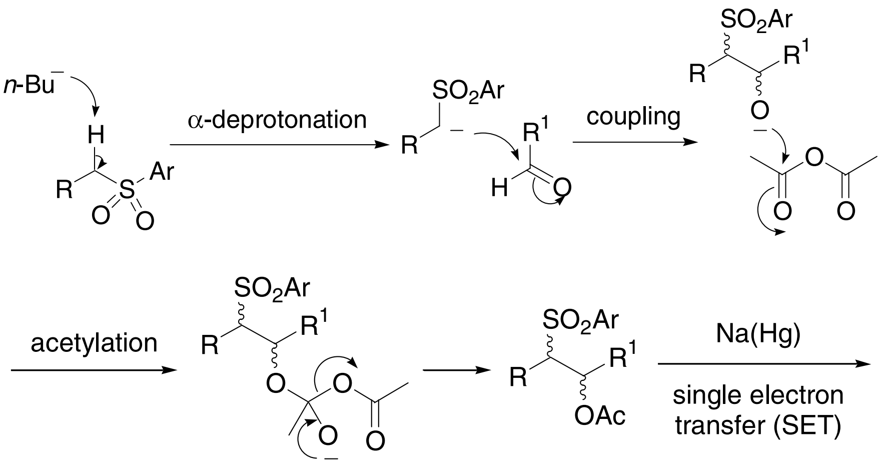
References

1. Baudin, J. B.; Hareau, G.; Julia, S. A.; Ruel, O. *Tetrahedron Lett.* **1991**, *32*, 1175.
2. Baudin, J. B.; Hareau, G.; Julia, S. A.; Ruel, O. *Bull. Soc. Chim. Fr.* **1993**, *130*, 336.
3. Baudin, J. B.; Hareau, G.; Julia, S. A.; Loene, R.; Ruel, O. *Bull. Soc. Chim. Fr.* **1993**, *130*, 856.
4. Charette, A. B.; Lebel, H. *J. Am. Chem. Soc.* **1996**, *118*, 10327.
5. Blakemore, P. R.; Cole, W. J.; Kocienski, P. J.; Morely, A. *Synlett* **1998**, 26.
6. Blakemore, P. R.; Kocienski, P. J.; Morley, A.; Muir, K. *J. Chem. Soc., Perkin Trans. 1* **1999**, 955.
7. Williams, D. R.; Brooks, D. A.; Berliner, M. P. *J. Am. Chem. Soc.* **1999**, *121*, 4924.
8. Kocienski, P. J.; Bell, A.; Blakemore, P. R. *Synlett* **2000**, 365.
9. Smith, A. B., III; Wan, Z. *J. Org. Chem.* **2000**, *65*, 3738.
10. Liu, P.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2001**, *123*, 10772.
11. Compostella, F.; Franchin, L.; Panza, L.; Prosperi, D.; Ronchetti, F. *Tetrahedron* **2002**, *58*, 4425.
12. Meyers, C.; Carreira, E. M. *Angew. Chem., Int. Ed.* **2003**, *42*, 694.
13. Furuichi, N.; Hara, H.; Osaki, T.; Nakano, M.; Mori, H.; Katsumura, S. *J. Org. Chem.* **2004**, *69*, 7949.
14. Bedel, O.; Haudrechy, A.; Langlois, Y. *Eur. J. Org. Chem.* **2004**, 3813.
15. Alonso, D. A.; Najera, C.; Varea, M. *Tetrahedron Lett.* **2004**, *45*, 573.
16. Alonso, D. A.; Fuensanta, M.; Najera, C.; Varea, M. *J. Org. Chem.* **2005**, *70*, 6404.

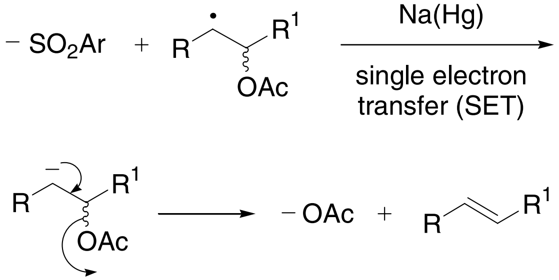
Julia–Lythgoe olefination

(*E*)-Olefins from sulfones and aldehydes.

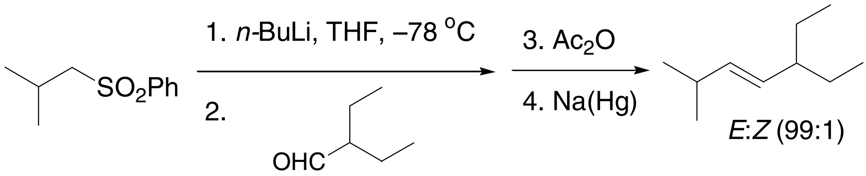




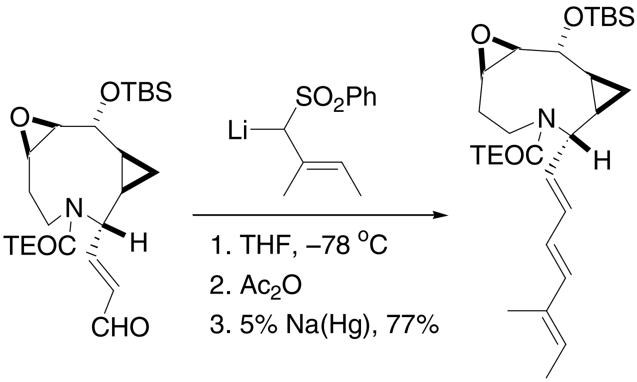
4 possible diastereomers



Example 1[3]



Example 2[4]

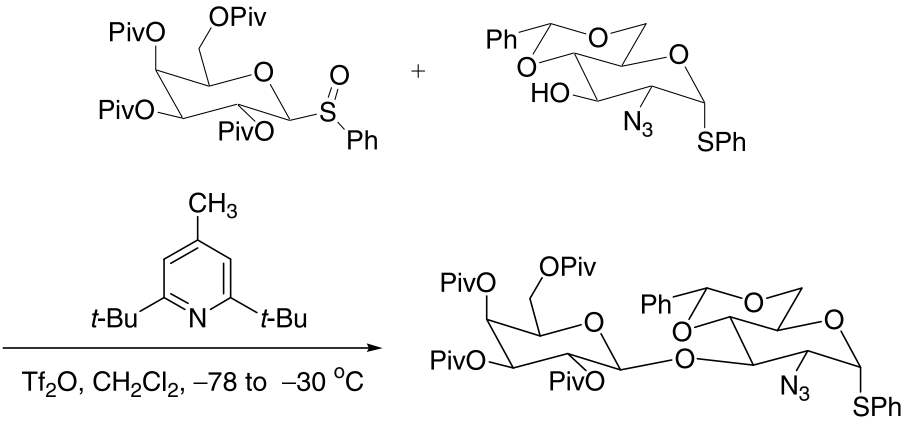


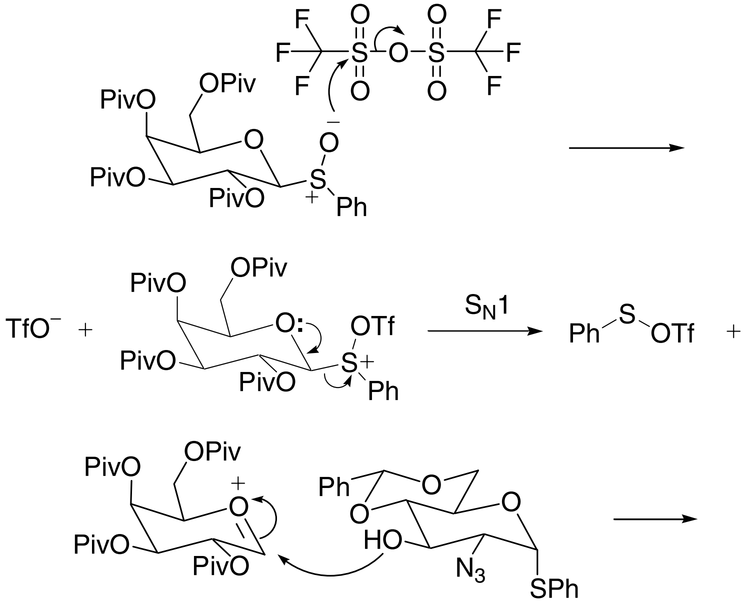
References

1. Julia, M.; Paris, J. M. *Tetrahedron. Lett.* **1973**, 4833.
2. Lythgoe, B. *J. Chem. Soc., Perkin Trans. 1* **1978**, 834.
3. Kocienski, P. J.; Lythgoe, B. *J. Chem. Soc., Perkin Trans. 1* **1980**, 1045.
4. Kim, G.; Chu-Moyer, M. Y.; Danishefsky, S. J. *J. Am. Chem. Soc.* **1990**, *112*, 2003.
5. Keck, G. E.; Savin, K. A.; Weglarz, M. A. *J. Org. Chem.* **1995**, *60*, 3194.
6. Marko, I. E.; Murphy, F.; Dolan, S. *Tetrahedron Lett.* **1996**, *37*, 2089.
7. Satoh, T.; Hanaki, N.; Yamada, N.; Asano, T. *Tetrahedron* **2000**, *56*, 6223.
8. Charette, A. B.; Berthelette, C.; St-Martin, D. *Tetrahedron Lett.* **2001**, *42*, 5149.
9. Marko, I. E.; Murphy, F.; Kumps, L.; Ates, A.; Touillaux, R.; Craig, D.; Carballares, S.; Dolan, S. *Tetrahedron* **2001**, *57*, 2609.
10. Breit, B. *Angew. Chem., Int. Ed.* **1998**, 37, 453.
11. Zanoni, G.; Porta, A.; Vidari, G. *J. Org. Chem.* **2002**, *67*, 4346.
12. Marino, J. P.; McClure, M. S.; Holub, D. P.; Comasseto, J. V.; Tucci, F. C. *J. Am. Chem. Soc.* **2002**, *124*, 1664.
13. D’herde, J. N. P.; De Clercq, P. J. *Tetrahedron Lett.* **2003**, *44*, 6657.
14. Bernard, A. M.; Frongia, A.; Piras, P. P.; Secci, F. *Synlett* **2004**, 1064.
15. Pospisil, J.; Pospisil, T.; Marko, I. E. *Org. Lett.* **2005**, *7*, 2373.

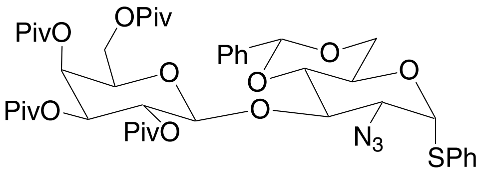
Kahne–Crich glycosidation

Diastereoselective glycosidation of a sulfoxide at the anomeric center as the glycosyl acceptor. The sulfoxide activation is achieved using Tf_2O.

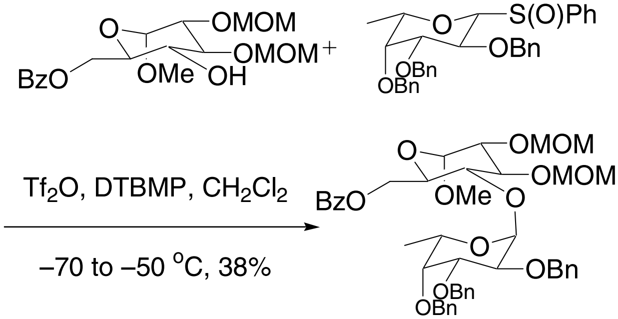




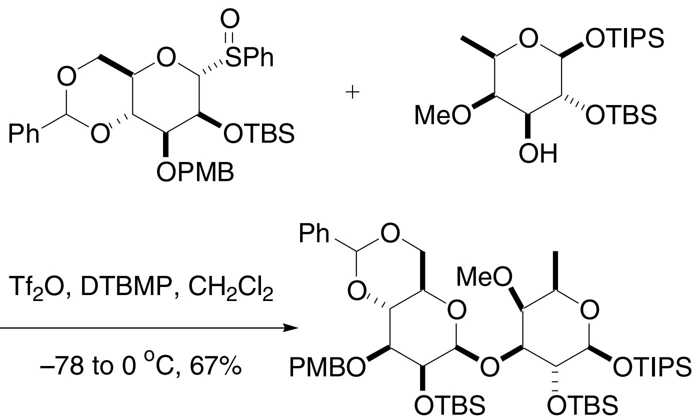
oxonium ion



Example 1[2]



Example 2[6]

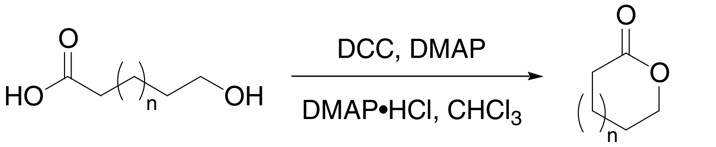


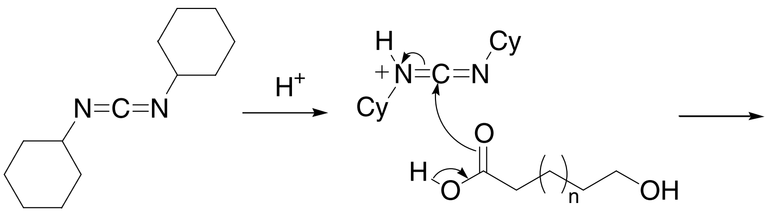
References

1. Kahne, D.; Walker, S.; Cheng, Y.; Van Engen, D. *J. Am. Chem. Soc.* **1989**, *111*, 6881.
2. Yan, L.; Taylor, C. M.; Goodnow, R., Jr.; Kahne, D. *J. Am. Chem. Soc.* **1994**, *116*, 6953.
3. Yan, L.; Kahne, D. *J. Am. Chem. Soc.* **1996**, *118*, 9239.
4. Gildersleeve, J.; Pascal, R. A.; Kahne, D. *J. Am. Chem. Soc.* **1998**, *120*, 5961.
5. Crich, D.; Sun, S. *J. Am. Chem. Soc.* **1998**, *120*, 435.
6. Crich, D.; Li, H. *J. Org. Chem.* **2000**, *65*, 3095.
7. Nicolaou, K. C.; Rodríguez, R. M.; Mitchell, H. J.; Suzuki, H.; Fylaktakidou, K. C.; Baudoin, O.; van Delft, F. L. *Chem. Eur. J.* **2000**, *6*, 801.
8. Crich, D.; Li, H.; Yao, Q.; Wink, D. J.; Sommer, R. D.; Rheingold, A. L. *J. Am. Chem. Soc.* **2001**, *123*, 5826.
9. Berkowitz, D. B.; Choi, S.; Bhuniya, D.; Shoemaker, R. K. *Org. Lett.* **2000**, *2*, 1149.
10. Crich, D.; Lim, L. B. L. *Org. React.* . **2004**, *64*, 115−251. (Review).

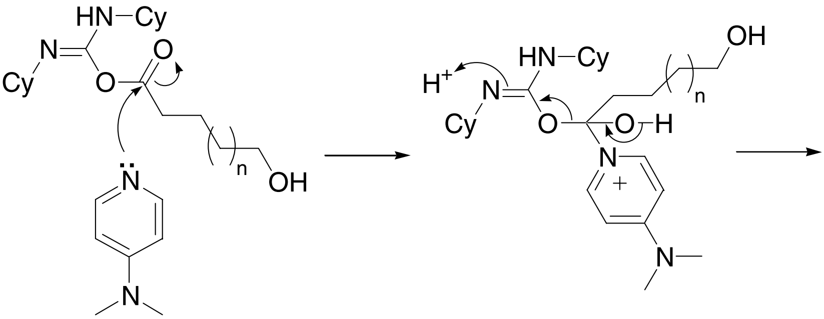
Keck macrolactonization

Macrolactonization of ω-hydroxyl acids using a combination of DCC, DMAP and DMAP•HCl.

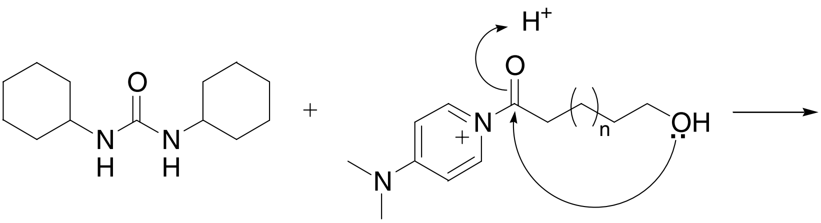




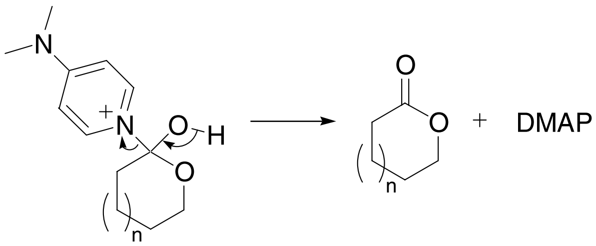
1,3-dicyclohexylcarbodiimide (DCC)



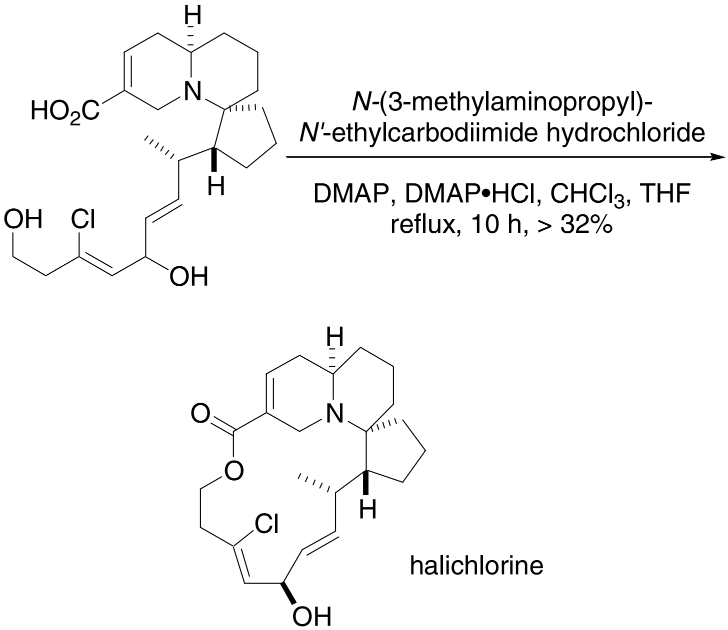
dimethylaminopyridine (DMAP)



1,3-dicyclohexylurea



Example 1[7]

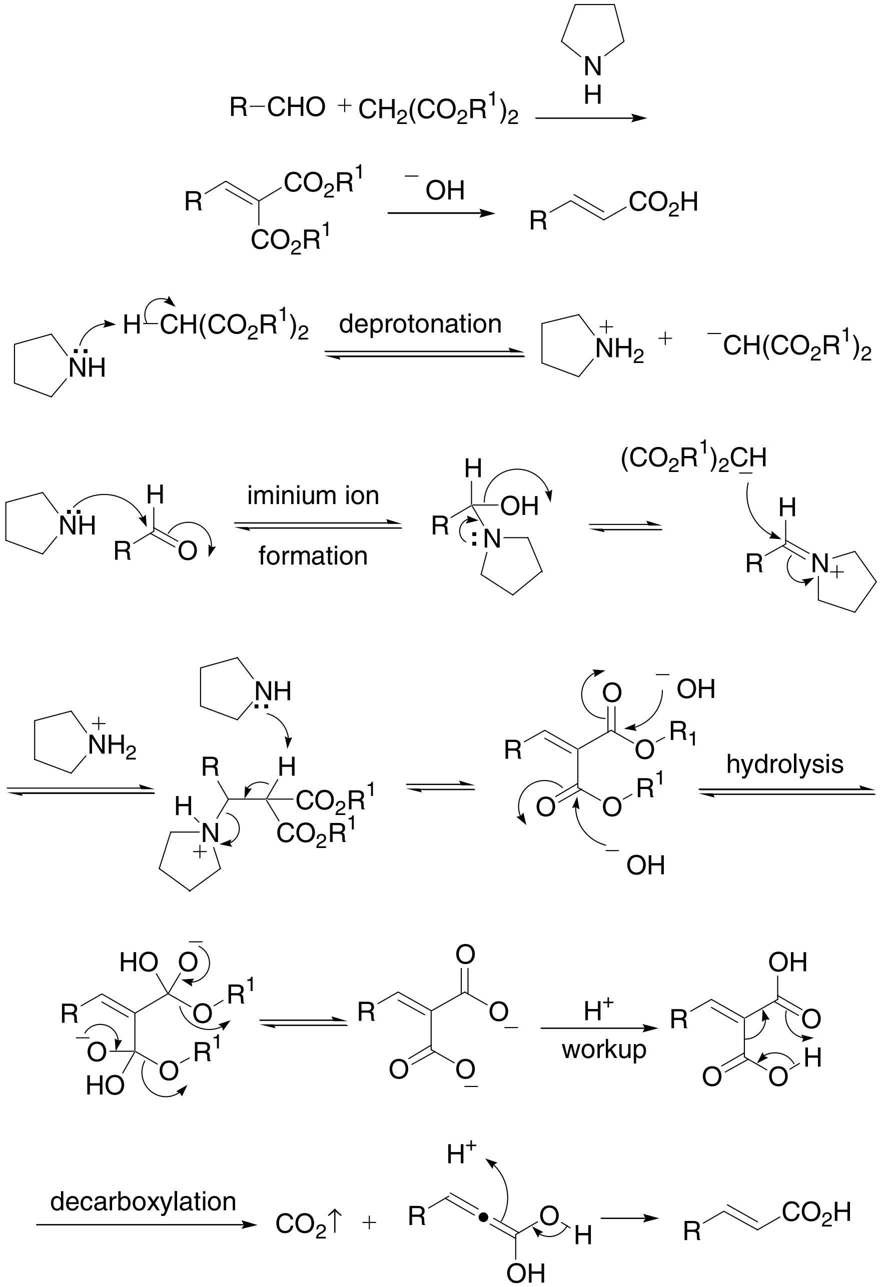


References

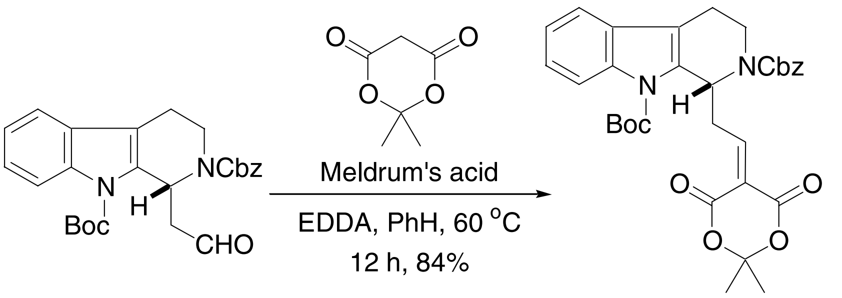
1. Boden, E. P.; Keck, G. E. *J. Org. Chem.* **1985**, *50*, 2394.
2. Paterson, I.; Yeung, K.-S.; Ward, R. A.; Cumming, J. G.; Smith, J. D. *J. Am. Chem. Soc.* **1994**, *116*, 9391.
3. Keck, G. E.; Sanchez, C.; Wager, C. A. *Tetrahedron Lett*. **2000**, *41*, 8673.
4. Tsai, C.-Y.; Huang, X.; Wong, C.-H. *Tetrahedron Lett*. **2000**, *41*, 9499.
5. Hanessian, S.; Ma, J.; Wang, W. *J. Am. Chem. Soc*. **2001**, *123*, 10200.
6. Lewis, A.; Stefanuti, I.; Swain, S. A.; Smith, S. A.; Taylor, R. J. K. *Org. Biomol. Chem*. **2003**, *1*, 104.
7. Christie, H. S.; Heathcock, C. H. *PNAS* **2004**, *101*, 12079.

Knoevenagel condensation

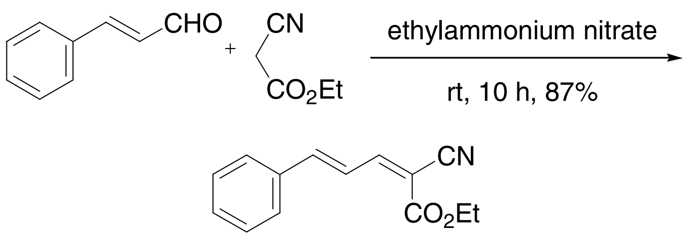
Condensation between carbonyl compounds and activated methylene compounds catalyzed by amines.



Example 1[7]



Example 2, using ionic liquid ethylammonium nitrate (EAN) as solvent[13]

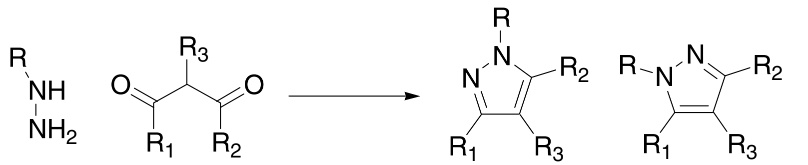


References

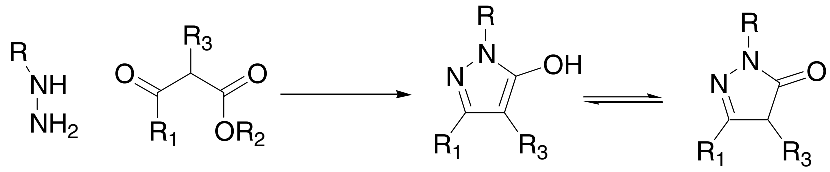
1. Knoevenagel, E. *Ber. Dtsch. Chem. Ges.* **1898**, *31*, 2596. Emil Knoevenagel (1865-1921) was born in Hannover, Germany. He studied at Göttingen under Victor Meyer and Gattermann, receiving a Ph.D. in 1889. He became a full professor at Heidelberg in 1900. When WWI broke out in 1914, Knoevenagel was one of the first to enlist and rose to the rank of staff officer. After the war, he returned to his academic work until his sudden death during an appendectomy.
2. Jones, G. *Org. React.* **1967**, *15*, 204. (Review).
3. Van der Baan, J. L.; Bickelhaupt, F. *Tetrahedron* **1974**, *30*, 2447.
4. Green, B.; Khaidem, I. S.; Crane, R. I.; Newaz, S. S. *Tetrahedron* **1976**, *31*, 2997.
5. Angeletti, E.; Canepa, C.; Martinetti, G.; Venturello, P. *J. Chem. Soc., Perkin Trans. 1* **1989**, 105.
6. Paquette, L. A.; Kern, B. E.; Mendez-Andino, J. *Tetrahedron Lett.* **1999**, *40*, 4129.
7. Tietze, L. F.; Zhou, Y. *Angew. Chem., Int. Ed.* **1999**, *38*, 2045.
8. Balalaie, S.; Nemati, N. *Synth. Commun.* **2000**, *30*, 869.
9. Pearson, A. J.; Mesaros, E. F. *Org. Lett.* **2002**, *4*, 2001.
10. Curini, M.; Epifano, F.; Marcotullio, M. C.; Rosati, O.; Tsadjout, A. *Synth. Commun.* **2002**, *32*, 355.
11. Kourouli, T.; Kefalas, P.; Ragoussis, N.; Ragoussis, V. *J. Org. Chem.* **2002**, *67,* 4615.
12. Wada, S.; Suzuki, H. *Tetrahedron Lett.* **2003**, *44*, 399.
13. Hu, Yi; Chen, J.; Le, Z.-G.; Zheng, Q.-G. *Synth. Comm.* **2005**, *35*, 739.

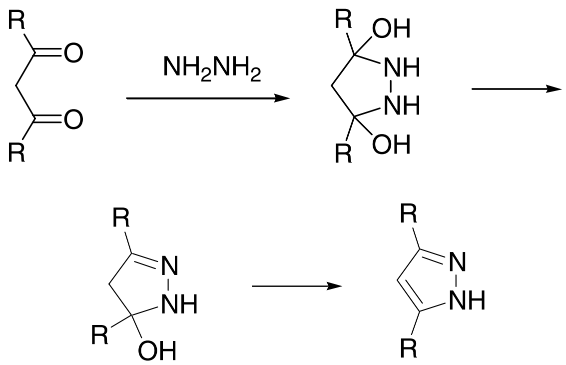
Knorr pyrazole synthesis

Reaction of hydrazine or substituted hydrazine with 1,3-dicarbonyl compounds to provide the pyrazole or pyrazolone ring system. *Cf.* Paal–Knorr pyrrole synthesis (page 333).

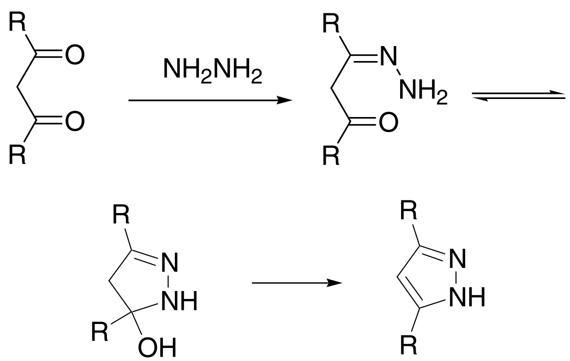


R = H, Alkyl, Aryl, Het-aryl, Acyl, *etc*.

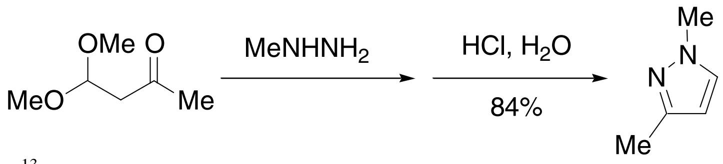




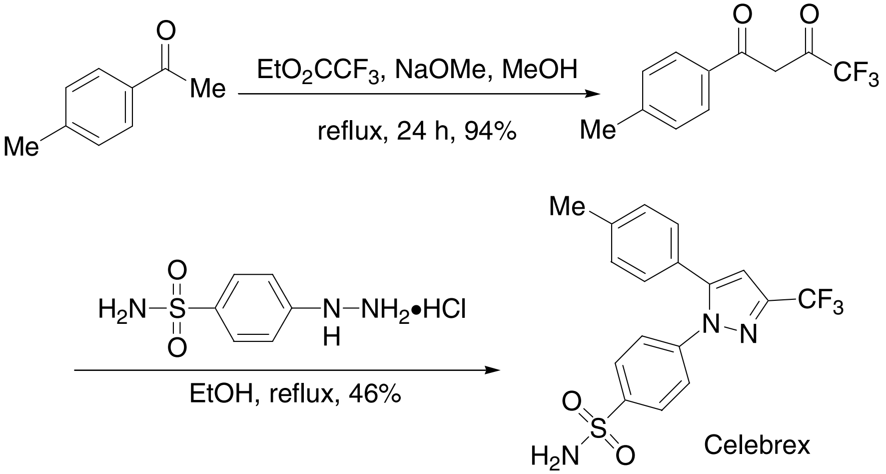
Alternatively,



Example 1[5]



Example 2[13]

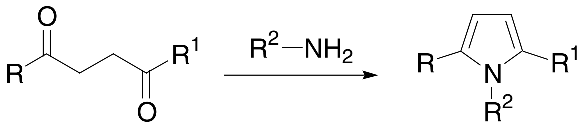


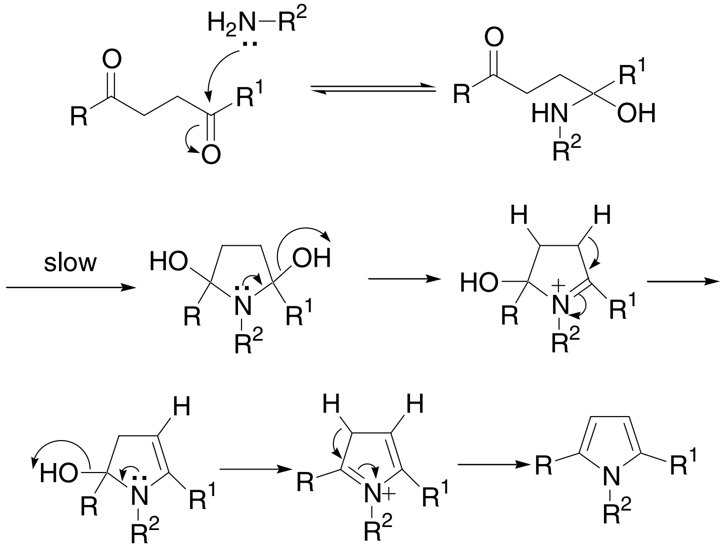
References

1 Knorr, L. *Ber Dtsch. Chem. Ges.* **1883**, *16*, 2597. Ludwig Knorr (1859–1921) was born near Munich, Germany. After studying under Volhard, Emil Fischer, and Bunsen, he was appointed professor of chemistry at Jena. Knorr made tremendous contributions in the synthesis of heterocycles in addition to discovering the important pyrazolone drug, pyrine.
2 Knorr, L. *Ber Dtsch. Chem. Ges.* **1884**, *17*, 546, 2032.
3 Knorr, L. *Ber Dtsch. Chem. Ges.* **1885**, *18*, 311.
4 Knorr, L., *Justus Liebigs Ann. Chem.* **1887**, *238*, 137.
5 Burness, D. M. *J. Org. Chem.* **1956**, *21*, 97.
6 Jacobs, T. L., in *Heterocyclic Compounds*, Elderfield, R. C., Ed.; Wiley: New York, **1957**, *5*, 45. (Review).
7 *Houben-Weyl*, **1967**, *10/2*, 539, 587, 589, 590. (Review).
8 Marzinzik, A. L.; Felder, E. R. *Tetrahedron Lett.* **1996**, *37*, 1003.
9 Elguero, J., In *Comprehensive Heterocyclic Chemistry II*, Katrizky, A. R.; Rees, C. W.: Scriven, E. F. V., Eds; Elsevier: Oxford, **1996**, *3*, 1. (Review).
10 Penning, T. D.; Talley, J. J.; *et al. J. Med. Chem.* **1997,** *40*, 1347.
11 Shen, D-M.; Shu, M.; Chapman, K. T. *Org. Lett.* **2000**, *2*, 2789.
12 Stanovnik, E.; Svete, J. in *Science Of Synthesis*, **2002**, *12*, 15; Ed. by Neier, R.; Thieme. (Review).
13 Carpino, P. A.; Lefker, B. A.; Toler, S. M.; *et al. Bioorg. Med. Chem.* **2003**,*11*, 581.
14 Sakya, S. M. *Knorr Pyrazole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Eds, Li, J. J.; Corey, E. J. Wiley & Sons: Hoboken, NJ, **2005**, 292–300. (Review).

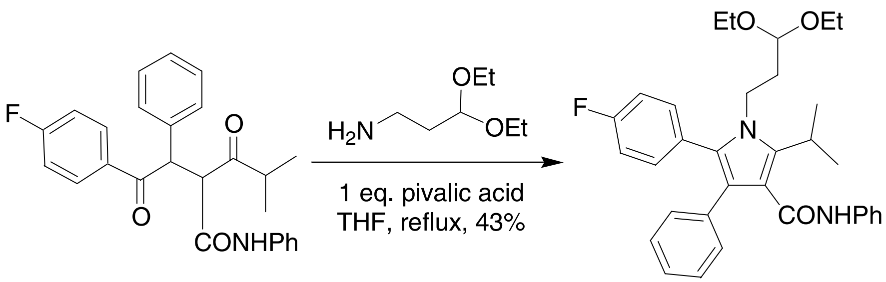
Paal–Knorr pyrrole synthesis

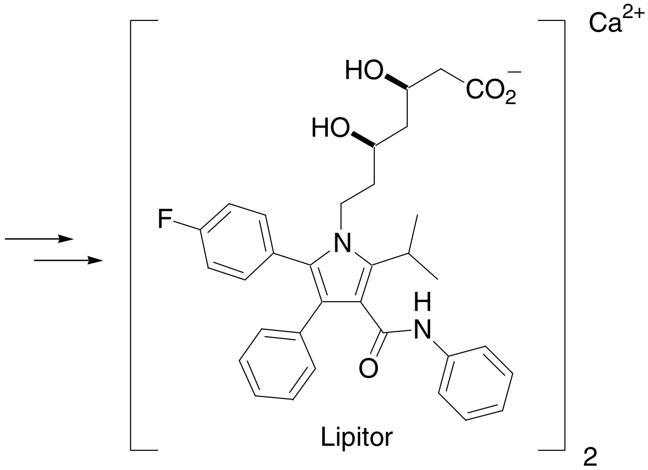
Reaction between 1,4-ketones and primary amines (or ammonia) to give pyrroles. A variation of the Knorr pyrazole synthesis (page 331).



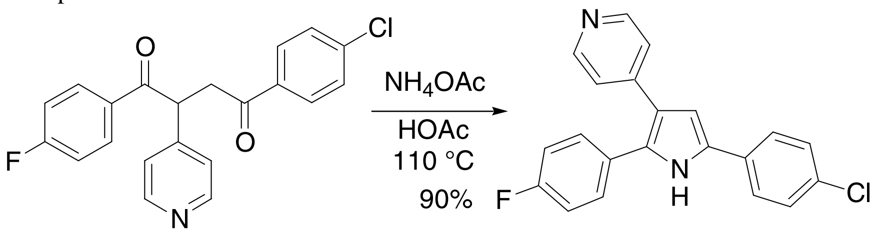


Example 1[5]





Example 2[7]

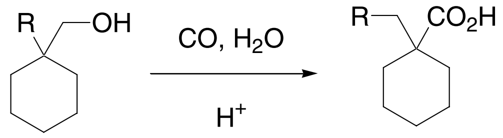


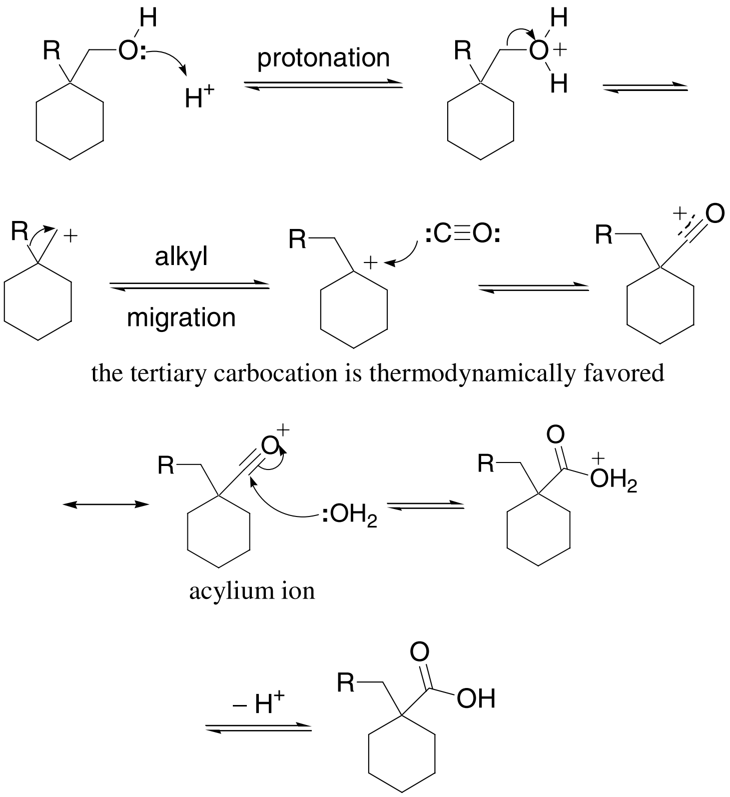
References

1. Paal, C. *Ber. Dtsch. Chem. Ges.* **1885**, *18*, 367.
2. Corwin, A. H. *Heterocyclic Compounds* Vol. 1, Wiley, NY, **1950**; Chapter 6. (Review).
3. Jones, R. A.; Bean, G. P. *The Chemistry of Pyrroles*, Academic Press, London, **1977**, pp 51–57, 74–79. (Review).
4. Chiu, P. K.; Sammes, M. P. *Tetrahedron* **1990**, *46*, 3439.
5. Browner, P. L.; Butler, D. E.; Deering, C. F.; Le, T. V.; Millar, A.; Nanninga, T. N.; Roth, B. D. *Tetrahedron Lett.* **1992**, *33*, 2279, 2283.
6. Yu, S.-X.; Le Quesne, P. W. *Tetrahedron Lett*. **1995**, *36*, 6205.
7. de Laszlo, S. E.; Visco, D.; Agarwal, L.; *et al. Bioorg. Med. Chem. Lett.* **1998**, *8*, 2689.
8. Robertson, J.; Hatley, R. J. D.; Watkin, D. J. *J. Chem. Soc., Perkin 1* **2000**, 3389.
9. Braun, R. U.; Zeitler, K.; Mueller, T. J. J. *Org. Lett*. **2001**, *3*, 3297.
10. Gorlitzer, K.; Fabian, J.; Frohberg, P.; Drutkowski, G. *Pharmazie* **2002**, *57*, 243.
11. Quiclet-Sire, B.; Quintero, L.; Sanchez-Jimenez, G.; Zard, Z. *Synlett* **2003**, 75.
12. Gribble, G. W. *Knorr and Paal–Knorr Pyrrole Syntheses* In *Name Reactions in Heterocyclic Chemistry*, Eds, Li, J. J.; Corey, E. J. Wiley & Sons: Hoboken, NJ, **2005**, 79–88. (Review).

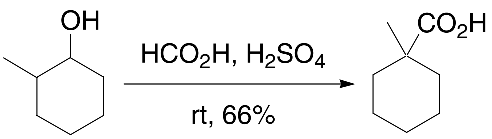
Koch–Haaf carbonylation

Strong acid-catalyzed tertiary carboxylic acid formation from alcohols or olefins and CO.

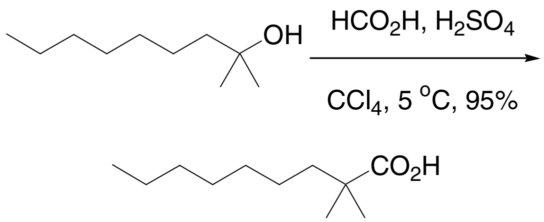




Example 1[5]



Example 2[7]

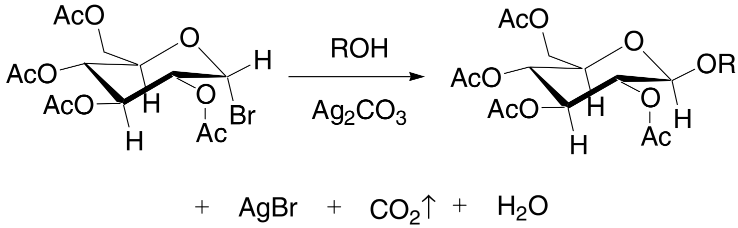


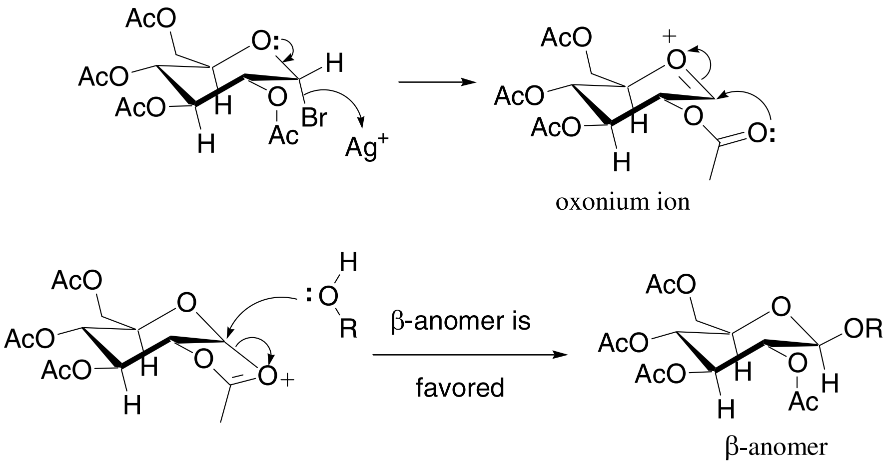
References

1. Koch, H.; Haaf, W. *Justus Liebigs Ann. Chem.* **1958**, *618*, 251.
2. Kell, D. R.; McQuillin, F. J. *J. Chem. Soc., Perkin Trans. 1* **1972**, 2096.
3. Norell, J. R. *J. Org. Chem.* **1972**, *37*, 1971.
4. Booth, B. L.; El-Fekky, T. A. *J. Chem. Soc., Perkin Trans. 1* **1979**, 2441.
5. Langhals, H.; Mergelsberg, I.; Rüchardt, C. *Tetrahedron Lett.* **1981**, *22*, 2365.
6. Farooq, O.; Marcelli, M.; Prakash, G. K. S.; Olah, G. A. *J. Am. Chem. Soc.* **1988**, *110*, 864.
7. Takahashi, Y. *Synth. Commun.* **1989**, *19*, 1945.
8. Stepanov, A. G.; Luzgin, M. V.; Romannikov, V. N.; Zamaraev, K. I. *J. Am. Chem. Soc.* **1995**, *117*, 3615.
9. Olah, G. A.; Prakash, G. K. S.; Mathew, T.; Marinez, E. R. *Angew. Chem., Int. Ed.* **2000**, *39*, 2547.
10. Xu, Q.; Inoue, S.; Tsumori, N.; Mori, H.; Kameda, M.; Tanaka, M.; Fujiwara, M.; Souma, Y. *J. Mol. Catal. A: Chem.* **2001**, *170*, 147.
11. Tsumori, N.; Xu, Q.; Souma, Y.; Mori, H. *J. Mol. Catalysis A: Chem.* **2002**, *179*, 271.
12. Mori, H.; Mori, A.; Xu, Q.; Souma, Y. *Tetrahedron Lett.* **2002**, *43*, 7871.
13. Li, T.; Tsumori, N.; Souma, Y.; Xu, Q. *Chem. Commun.* **2003**, 2070.
14. Haubein, N. C.; Broadbelt, L. J.; Schlosberg, R. H. *Ind. Eng. Chem. Res.* **2004**, *43*, 18.

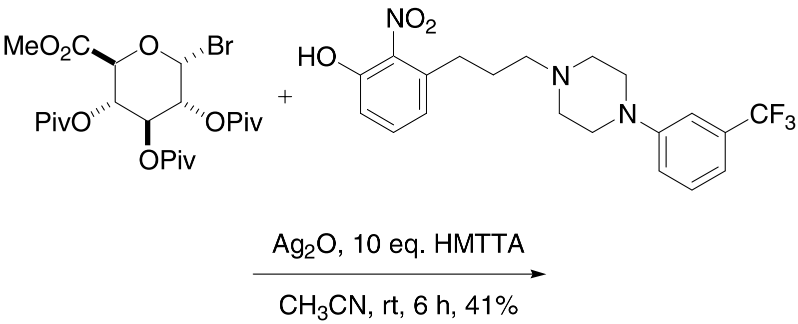
Koenig–Knorr glycosidation

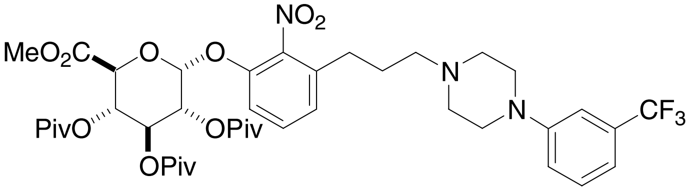
Formation of the β-glycoside from α-halocarbohydrate under the influence of silver salt.



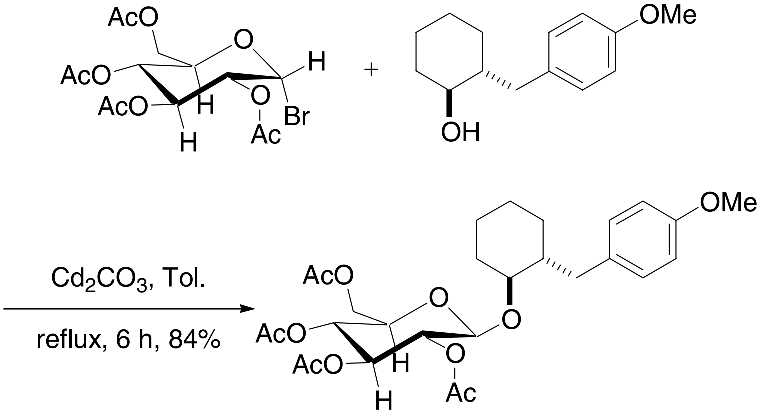


Example 1[13]





Example 2[15]

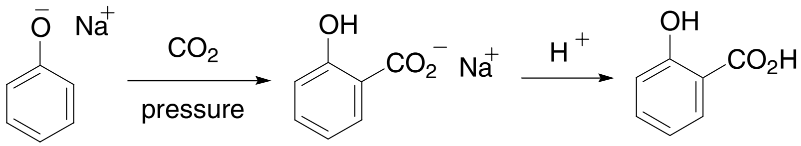


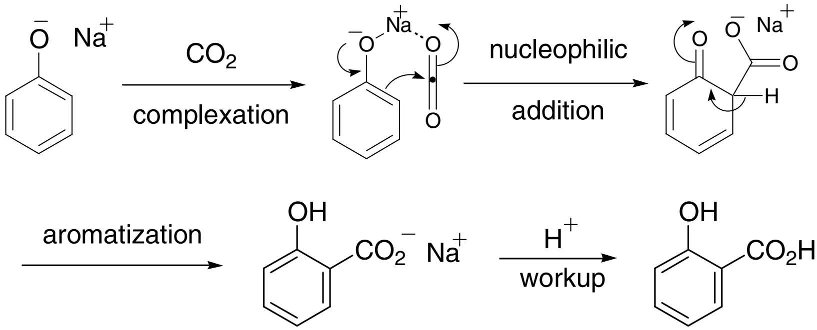
References

1. Koenig, W.; Knorr, E. *Ber. Dtsch. Chem. Ges.* **1901**, *34*, 957.
2. Igarashi, K. *Adv. Carbohydr. Chem. Biochem.* **1977**, *34,* 243–83. (Review).
3. Schmidt, R. R. *Angew. Chem.* **1986**, *98*, 213.
4. Greiner, J.; Milius, A.; Riess, J. G. *Tetrahedron Lett*. **1988**, *29,* 2193.
5. Smith, A. B., III; Rivero, R. A.; Hale, K. J.; Vaccaro, H. A. *J. Am. Chem. Soc*. **1991**, *113*, 2092.
6. Li, H.; Li, Q.; Cai, M.-S.; Li, Z.-J. *Carbohydr. Res*. **2000**, *328*, 611.
7. Fürstner, A.; Radkowski, K.; Grabowski, J.; Wirtz, C.; Mynott, R. *J. Org. Chem*. **2000**, *65*, 8758.
8. Josien-Lefebvre, D.; Desmares, G.; Le Drian, C. *Helv. Chim. Acta* **2001**, *84*, 890.
9. Seebacher, W.; Haslinger, E.; Weis, R. *Monatsh. Chem.* **2001**, *132*, 8397.
10. Yashunsky, D. V.; Tsvetkov, Y. E.; Ferguson, M. A. J.; Nikolaev, A. V. *J. Chem. Soc., Perkin Trans. 1* **2002**, 242.
11. Kroger, L.; Thiem, J. *J. Carbohydrate Chem*. **2003**, *22*, 9.
12. Somsak, L.; Kovacs, L.; Gyollai, V.; Osz, E. *Chem. Commun*. **1999**, 591.
13. Stazi, F.; Palmisano, G.; Turconi, M.; Clini, S.; Santagostino, M. *J. Org. Chem*. **2004**, *69*, 1097.
14. Claffey, D. J.; Casey, M. F.; Finan, P. A. *Carbohydrate Res*. **2004**, *339*, 2433.
15. Wimmer, Z.; Pechova, L.; Saman, D. *Molecules* **2004**, *9*, 902.

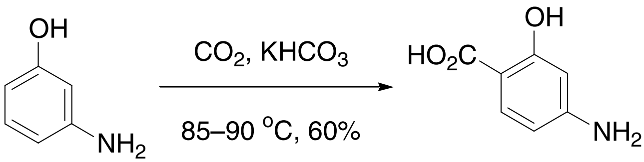
Kolbe–Schmitt reaction

Carboxylation of sodium phenoxides with carbon dioxide, to give salicylic acid, the precursor to the synthesis of aspirin.

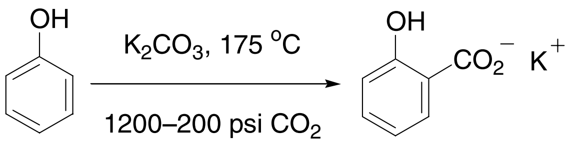




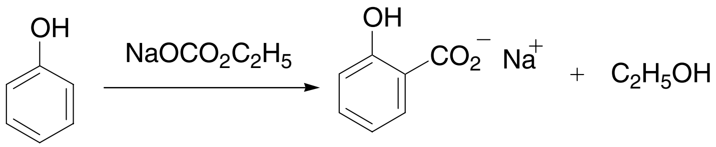
Example 1[3]



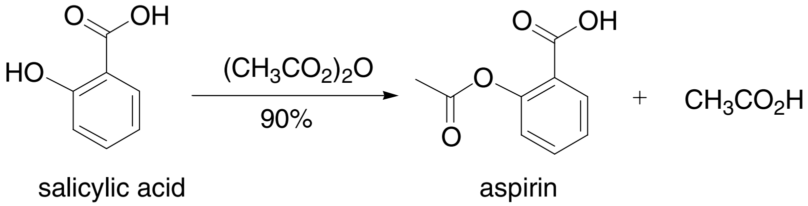
Example 2, the **Marasse modification** of the Kolbe–Schmitt reaction uses excess of anhydrous potassium carbonate in place of carbon dioxide[4]



Example 3, the Jones modification of the Kolbe–Schmitt reaction employs sodium ethyl carbonate[5]



Salicylic acid is the precursor to the synthesis of aspirin:

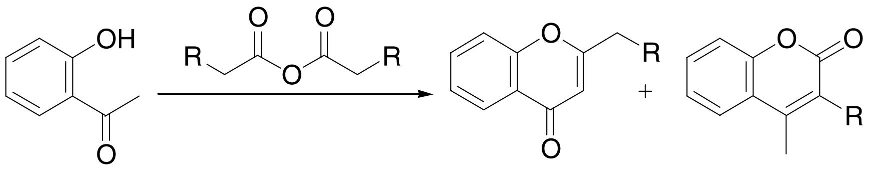


References

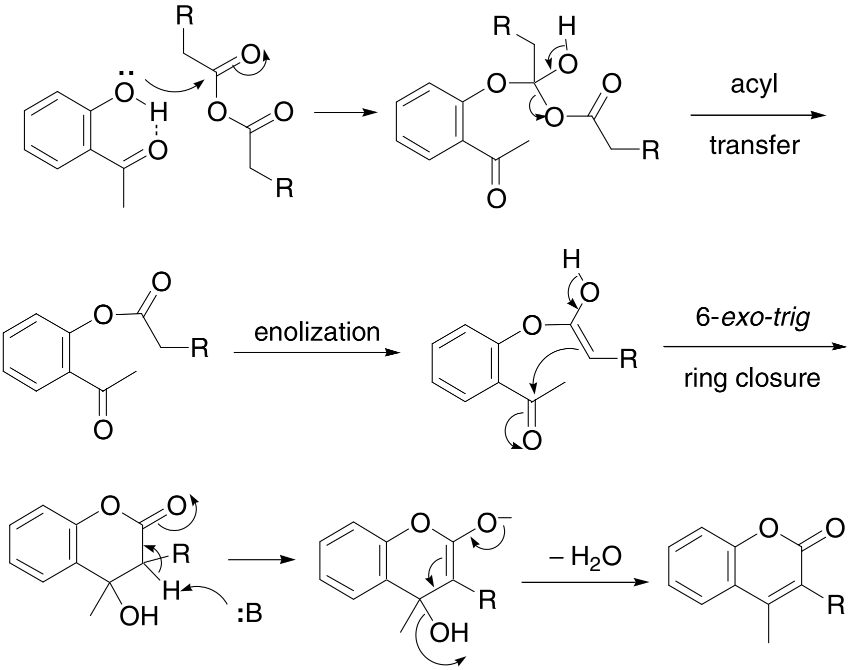
1. Kolbe, H. *Justus Liebigs Ann. Chem.* **1860**, *113*, 1125. Hermann Kolbe (1818–1884) was born in Elliehausen, Germany. In 1860, at Marburg University, he developed a reaction to synthesize salicylic acid by simply treating phenol with carbon dioxide under high pressure at 180–200 °C. Like Wöhler's urea synthesis, Kolbe's synthesis of acetic acid by treating trichloroacetic acid with potassium amalgam is considered one of the first total syntheses in organic chemistry. One of his students, Friedrich von Heyden, founded a company to profit from the Kolbe reaction with much financial success.
2. Schmitt, R. *J. Prakt. Chem.* **1885**, *31*, 397.
3. Erlenmeyer, H.; Prijs, B.; Sorkin, E.; Suter, E. *Helv. Chim. Acta* **1948**, *31*, 988.
4. Marasse, S. German Patent 73,279, **1893**.
5. Jones, J. I. *Chem. Ind.* **1957**, 889.
6. Lindsey, A. S.; Jeskey, H. *Chem. Rev.* **1957**, *57*, 583. (Review).
7. Kunert, M.; Dinjus, E.; Nauck, M.; Sieler, J. *Ber.* **1997**, *130*, 1461.
8. Kosugi, Y.; Takahashi, K. *Stud. Surf. Sci. Catal.* **1998**, *114*, 487.
9. Kosugi, Y.; Rahim, M. A.; Takahashi, K.; Imaoka, Y.; Kitayama, M. *Appl. Organomet. Chem.* **2000**, *14*, 841.
10. Rahim, M. A.; Matsui, Y.; Kosugi, Y. *Bull. Chem. Soc. Jpn.* **2002**, *75*, 619.

Kostanecki reaction

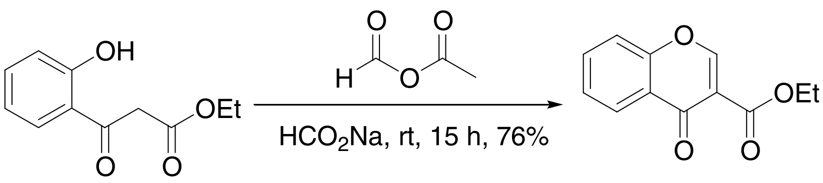
Also known as **Kostanecki–Robinson reaction**. Transformation **1**→**2** represents an **Allan–Robinson reaction** (see page 8), whereas **1**→**3** is a **Kostanecki (acylation) reaction**:



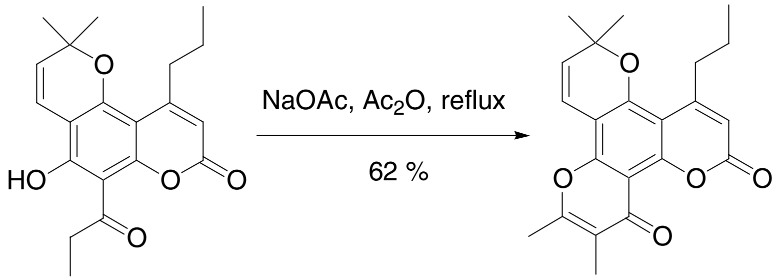
1 **2** **3**



Example 1[5]



Example 2[13]

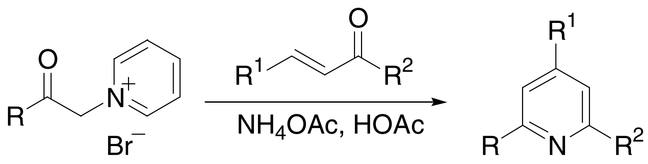


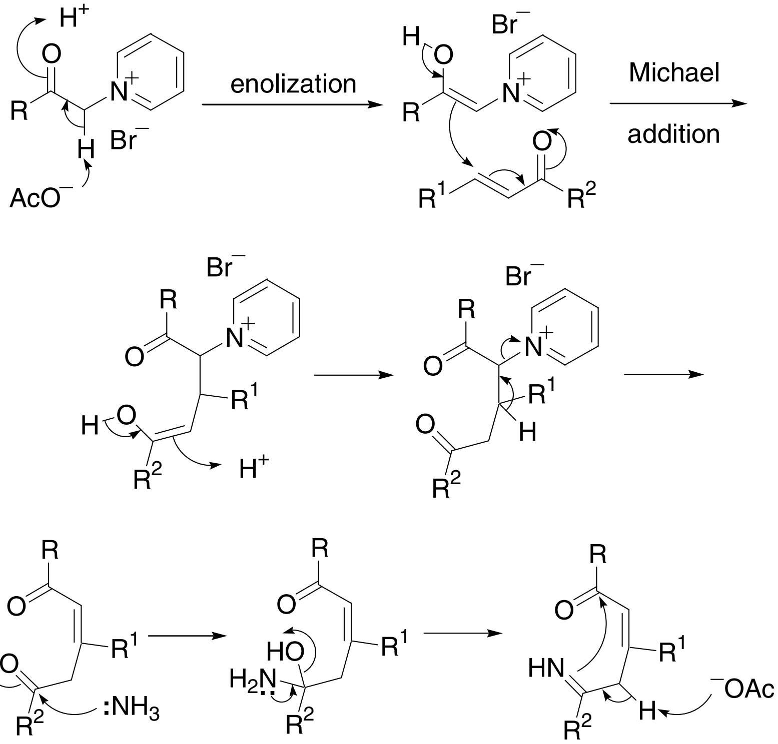
References

1. von Kostanecki, S.; Rozycki, A. *Ber. Dtsch. Chem. Ges.* **1901**, *34*, 102.
2. Hauser, C. R.; Swamer, F. W.; Adams, J. T. *Org. React.* **1954**, *8*, 59. (Review).
3. Cook, D.; McIntyre, J. S. *J. Org. Chem.* **1968**, *33*, 1746.
4. Széll, T.; Dózsai, L.; Zarándy, M.; Menyhárth, K. *Tetrahedron* **1969**, *25*, 715.
5. Pardanani, N. H.; Trivedi, K. N. *J. Indian Chem. Soc.* **1972**, *49*, 599.
6. Okumura, K.; Kondo, K.; Oine, T.; Inoue, I. *Chem. Pharm. Bull.* **1974**, *22*, 331.
7. Wagner, H.; Farkas, L. In *The Flavanoids*; Harborne, J. B.; Mabry, T. J.; Mabry H., eds.; Academic Press: New York, **1975**; p 127. (Review).
8. Ahluwalia, V. K. *Indian J. Chem., Sect. B* **1976**, *14B*, 682.
9. Ellis, G. P., *Chromenes, Chromanones, and Chromones from The Chemistry of Heterocyclic Compounds*, Weissberger, A. and Taylor, E. C., eds.; Wiley & Sons: New York, **1977**, vol. 31, p.495. (Review).
10. Looker, J. H.; McMechan, J. H.; Mader, J. W. *J. Org. Chem.* **1978**, *43*, 2344.
11. Stanton, J. In *Comprehensive Organic Chemistry-The Synthesis and Reactions of Organic Compounds*; Sammes, P. G., ed.; Pergamon Press: New York, **1979**, vol.4; p. 659. (Review).
12. Iyer, P. R.; Iyer, C. S. R.; Prasad, K. J. R. *Indian J. Chem., Sect. B* **1983**, *22B*, 1055.
13. Flavin, M. T.; Rizzo, J. D.; Khilevich, A.; *et al. J. Med. Chem.* **1996**, *39*, 1303.
14. Mamedov, V. A.; Kalinin, A. A.; Gubaidullin, A. T.; Litvinov, I. A.; Levin, Ya. A. *Chemistry of Heterocyclic Compounds* **2003**, *39*, 96.
15. Limberakis, C. *Kostanecki–Robinson Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 521–535. (Review).

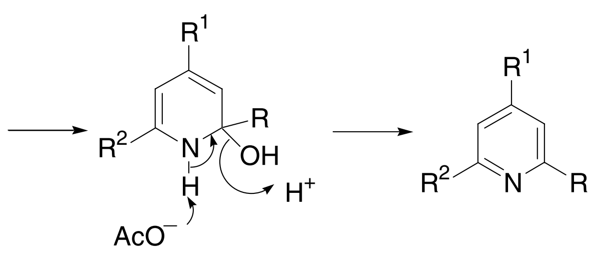
Kröhnke pyridine synthesis

Pyridines from α-pyridinium methyl ketone salts and α,β-unsaturated ketones.

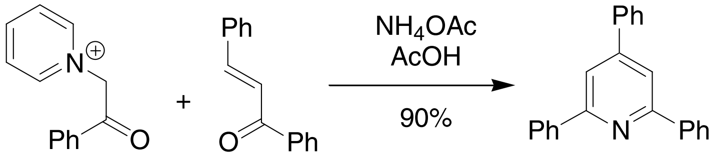




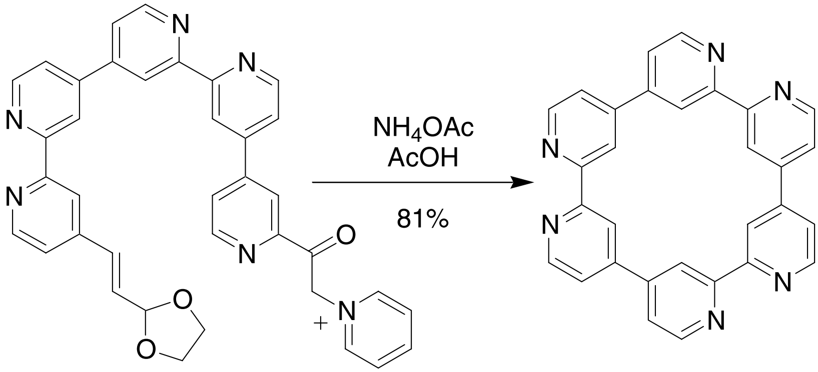
The ketone is more reactive than the enone



Example 1[2]



Example 2[10]

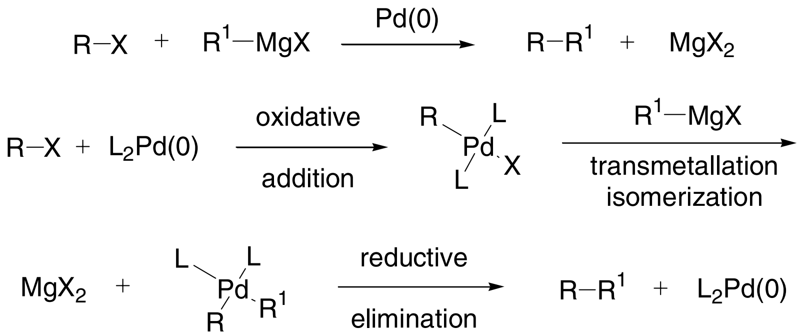


References

1. Zecher, W.; Kröhnke, F. *Ber.* **1961**, *94*, 690.
2. Kröhnke, F.; Zecher, W. *Angew. Chem. Intl. Ed.* **1962**, *1*, 626.
3. Kröhnke, F. *Synthesis* **1976**, 1–24. (Review).
4. Chatterjea, J. N.; Shaw, S. C.; Singh, J. N.; Singh, S. N. *Indian J. Chem., Sect. B* **1977**, *15B*, 430.
5. Potts, K. T.; Cipullo, M. J.; Ralli, P.; Theodoridis, G. *J. Am. Chem. Soc.* **1981**, *103*, 3584, 3585.
6. Newkome, G. R.; Hager, D. C.; Kiefer, G. E. *J. Org. Chem.* **1986**, *51*, 850.
7. Constable, E. C.; Ward, M. D.; Tocher, D. A. *J. Chem. Soc., Dalton Trans.* **1991**, 1675.
8. Constable, E. C.; Chotalia, R. *J. Chem. Soc., Chem. Commun.* **1992**, 65.
9. Markovac, A.; Ash, A. B.; Stevens, C. L.; Hackley, B. E., Jr.; Steinberg, G. M. *J. Heterocycl. Chem.* **1977**, *14*, 19.
10. Kelly, T. R.; Lee, Y.-J.; Mears, R. J. *J. Org. Chem.* **1997**, *62*, 2774.
11. Bark, T.; Von Zelewsky, A. *Chimia* **2000**, *54*, 589.
12. Malkov, A. V.; Bella, M.; Stara, I. G.; Kocovsky, P. *Tetrahedron Lett.* **2001**, *42*, 3045.
13. Cave, G. W. V.; Raston, C. L. *J. Chem. Soc. Perkin Trans. 1* **2001**, 3258.
14. Galatsis, P. *Kröhnke Pyridine Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 311–313. (Review).

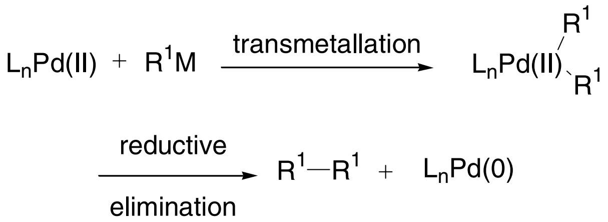
Kumada cross-coupling reaction

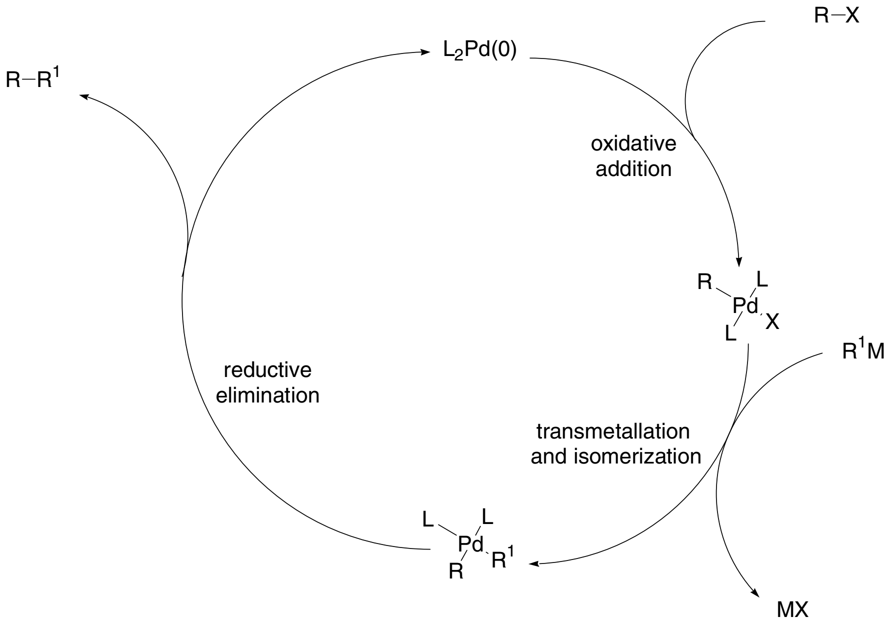
The Kumada cross-coupling reaction (also occasionally known as the Kharasch cross-coupling reaction) is a nickel- or palladium-catalyzed cross-coupling reaction of a Grignard reagent with an organic halide, triflate, *etc*.



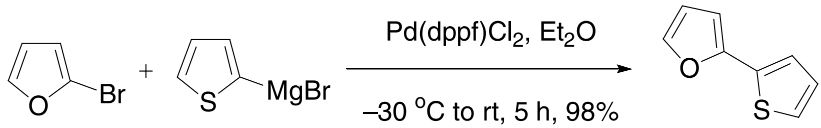
The Kumada cross-coupling reaction, as well as the Negishi, Stille, Hiyama, and Suzuki cross-coupling reactions, belong to the same category of Pd-catalyzed cross-coupling reactions of organic halides, triflates and other electrophiles with organometallic reagents. These reactions follow a general mechanistic cycle as shown on the next page. There are slight variations for the Hiyama and Suzuki reactions, for which an additional activation step is required for the transmetalation to occur.

The catalytic cycle:

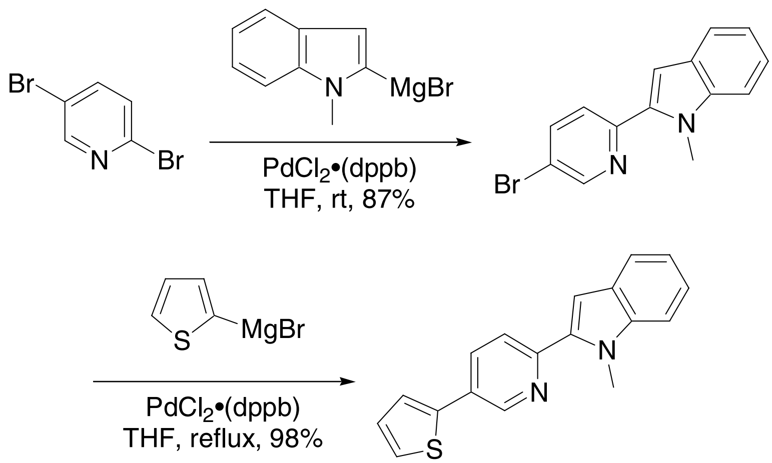




Example 1[2]



Example 2[4]

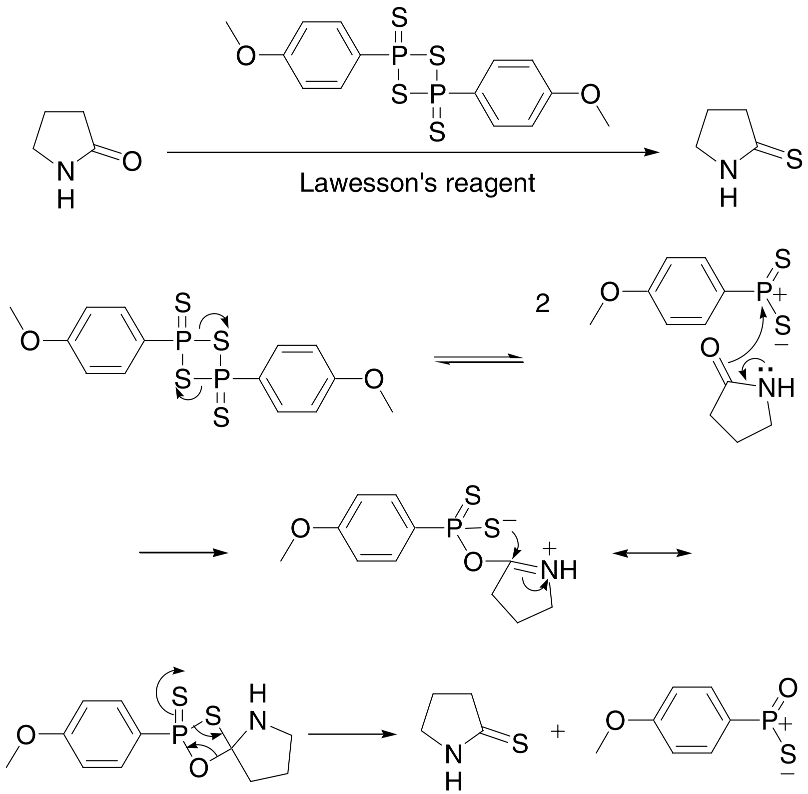


References

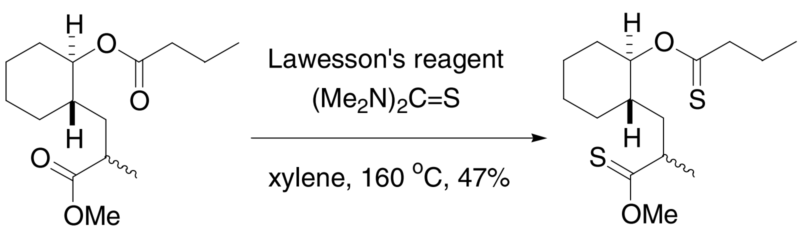
1. Tamao, K.; Sumitani, K.; Kiso, Y.; Zembayashi, M.; Fujioka, A.; Kodma, S.-i.; Nakajima, I.; Minato, A.; Kumada, M. *Bull. Chem. Soc. Jpn.* **1976**, *49*, 1958.
2. Carpita, A.; Rossi, R.; Veracini, C. A. *Tetrahedron* **1985**, *41*, 1919.
3. Kalinin, V. N. *Synthesis* **1992**, 413.
4. Meth-Cohn, O.; Jiang, H. *J. Chem. Soc., Perkin Trans. 1* **1998**, 3737.
5. Stanforth, S. P. *Tetrahedron* **1998**, *54,* 263. (Review).
6. Park, M.; Buck, J. R.; Rizzo, C. J. *Tetrahedron* **1998**, *54*, 12707.
7. Huang, J.; Nolan, S. P. *J. Am. Chem. Soc*. **1999**, *121*, 9889.
8. Uenishi, J.; Matsui, K. *Tetrahedron Lett*. **2001**, *42*, 4353.
9. Li, G. Y. *J. Organomet. Chem.* **2002**, *653*, 63.
10. Anctil, E. J.-G.; Snieckus, V. *J. Organomet. Chem.* **2002**, *653*, 150.
11. Banno, T.; Hayakawa, Y.; Umeno, M. *J. Organomet. Chem.* **2002**, *653*, 288.
12. Tasler, S.; Lipshutz, B. H. *J. Org. Chem.* **2003**, *68*, 1190.
13. Phan, N. T. S.; Brown, D. H.; Styring, P. *Green Chem*. **2004**, *6*, 526.
14. Mans, D. M.; Pearson, W. H. *J. Org. Chem.* **2004**, *69*, 6419.
15. Shao, L.-X.; Shi, M. *Org. Biomol. Chem*. **2005**, *3*, 1828.
16. Semeril, D.; Lejeune, M.; Jeunesse, C.; Matt, D. *J. Mol. Cat. A: Chem.* **2005**, *239*, 257.

Lawesson's reagent

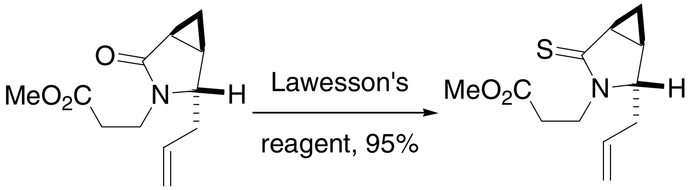
2,4-Bis-(4-methoxyphenyl)-[1,3,2,4]dithiadiphosphetane 2,4-disulfide, transforms the carbonyl groups of ketones, amides and esters into the corresponding thiocarbonyl compounds. *Cf.* Knorr thiophene synthesis.



Example 1[4]



Example 2[4]

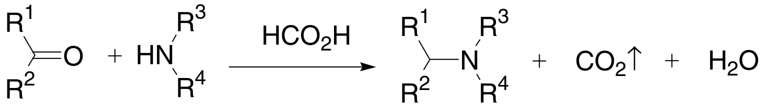


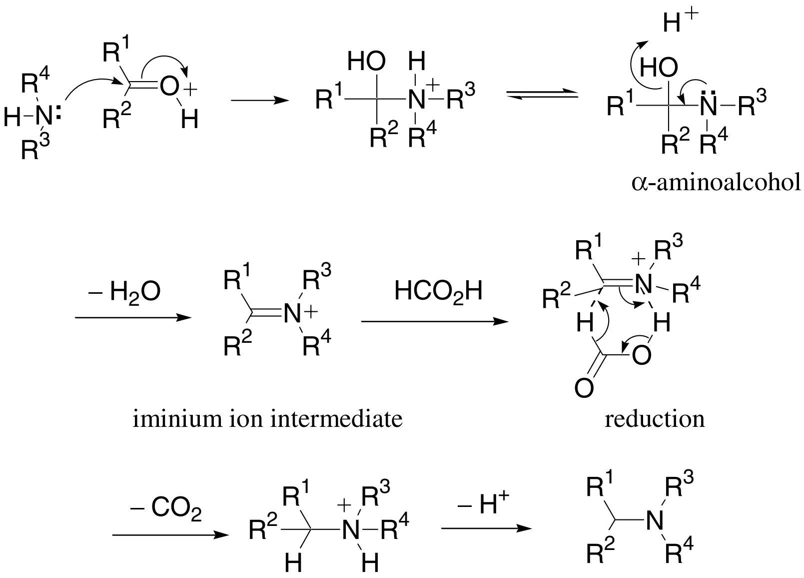
References

1. Lawesson, S. O.; Perregaad, J.; Scheibye, S.; Meyer, H. J.; Thomsen, I. *Bull. Soc. Chim. Belg*. **1977**, *86,* 679.
2. Navech, J.; Majoral, J. P.; Kraemer, R. *Tetrahedron Lett.* **1983**, *24*, 5885.
3. Cava, M. P.; Levinson, M. I. *Tetrahedron* **1985**, *41*, 5061. (Review).
4. Nicolaou, K. C.; Hwang, C.-K.; Nugiel, D. A. *Angew. Chem., Int. Ed. Engl.* **1989**, *27*, 1362.
5. Kim, G.; Chu-Moyer, M. Y.; Danishefsky, S. J. *J. Am. Chem. Soc.* **1990**, *112*, 2003.
6. Luheshi, A. B. N.; Smalley, R. K.; Kennewell, P. D.; Westwood, R. *Tetrahedron Lett.* **1990**, *31*, 123.
7. Luo, Y.; He, L.; Ding, M.; Yang, G.; Luo, A.; Liu, X.; Wu, T. *Heterocycl. Commun*. **2001**, *7*, 37.
8. He, L.; Luo, Y.; Li, K.; Ding, M.; Luo, A.; Liu, X.; Wu, T.; Cai, F. *Synth. Commun.* **2002**, *32*, 1415.
9. Ishii, A.; Yamashita, R.; Saito, M.; Nakayama, J. *J. Org. Chem.* **2003**, *68*, 1555.

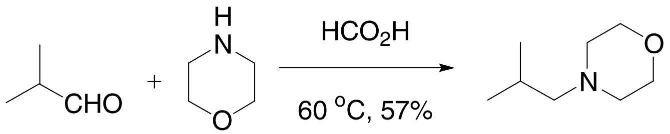
Leuckart–Wallach reaction

Amine synthesis from reductive amination of a ketone and an amine in the presence of excess formic acid, which serves as the reducing reagent by delivering a hydride. When the ketone is replaced by formaldehyde, it becomes Eschweiler–Clarke reductive alkylation of amines.

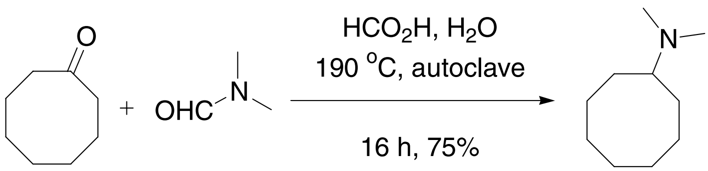




Example 1[5]



Example 2[7]

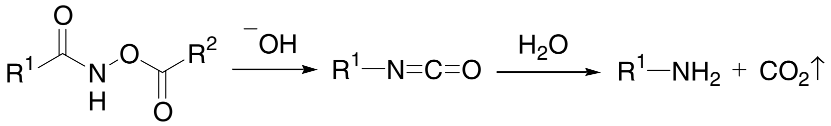


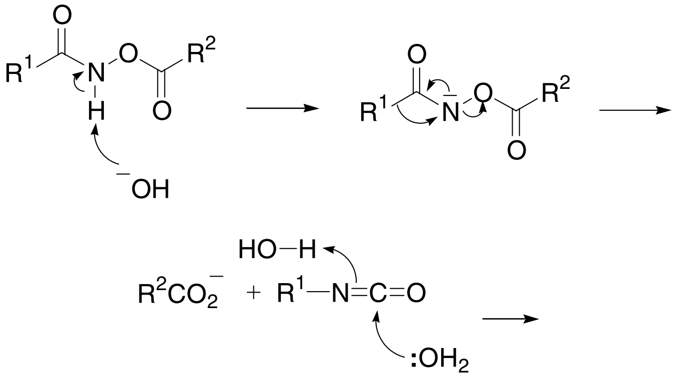
References

1. Leuckart, R. *Ber. Dtsch. Chem. Ges.* **1885**, *18*, 2341. Carl L. R. A. Leuckart (1854–1889) was born in Giessen, Germany. After studying under Bunsen, Kolbe, and von Baeyer, he became an assistant professor at Göttingen. Unfortunately, chemistry lost a brilliant contributor by his sudden death at age 35 as a result of a fall in his parent's house.
2. Wallach, O. *Justus Liebigs Ann. Chem.* **1892**, *272*, 99. Otto Wallach (1847–1931), born in Königsberg, Prussia, studied under Wöhler and Hofmann. He was the director of the Chemical Institute at Göttingen from 1889 to 1915. His book "Terpene und Kampfer" served as the foundation for future work in terpene chemistry. Wallach was awarded the Nobel Prize in Chemistry in 1910 for his work on alicyclic compounds.
3. Moore, M. L. *Org. React.* **1948**, *5*, 301. (Review).
4. Staple, Ezra; Wagner, E. C. *J. Org. Chem.* **1949**, *14,* 559.
5. DeBenneville, P. L.; Macartney, J. H. *J. Am. Chem. Soc.* **1950**, *72,* 3073.
6. Lukasiewiecz, A. *Tetrahedron* **1963**, *19,* 1789. (Mechanism).
7. Bach, R. D. *J. Org. Chem.* **1968**, *33,* 1647.
8. Doorenbos, N. J.; Solomons, W. E. *Chem. Ind.* **1970**, 1322.
9. Ito, K.; Oba, H.; Sekiya, M. *Bull. Chem. Soc. Jpn.* **1976**, *49*, 2485.
10. Musumarra, G.; Sergi, C. *Heterocycles* **1994**, *37*, 1033.
11. Kitamura, M.; Lee, D.; Hayashi, S.; Tanaka, S.; Yoshimura, M. *J. Org. Chem.* **2002**, *67,* 8685.

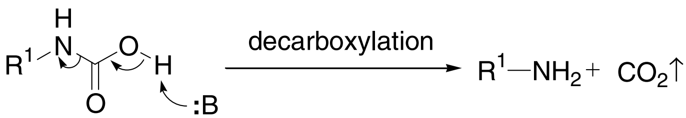
Lossen rearrangement

Treatment of *O*-acylated hydroxamic acids with base provides isocyanates.

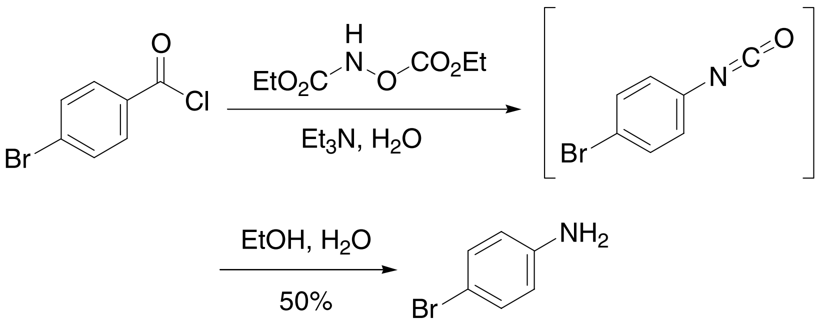




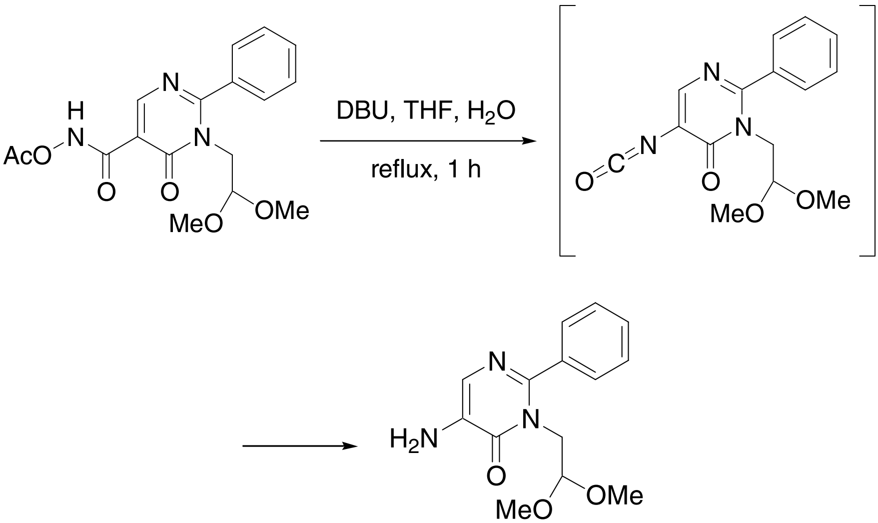
isocyanate intermediate



Example 1[6]



Example 2[8]

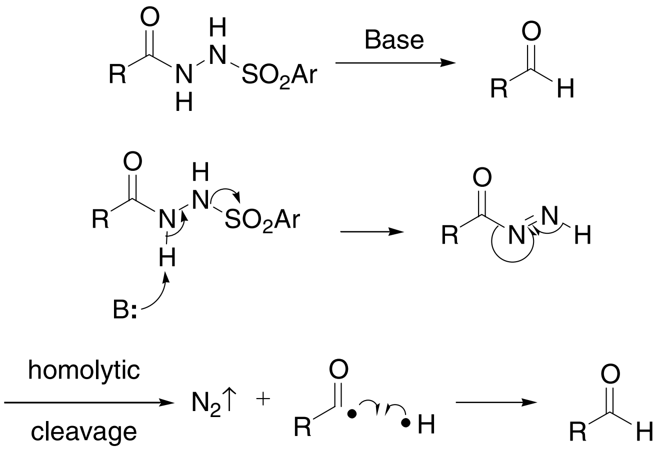


References

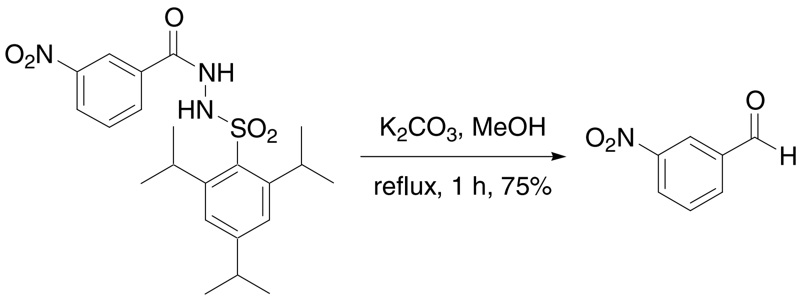
1. Lossen, W. *Ann.* **1872**, *161*, 347. Wilhelm C. Lossen (1838–1906) was born in Kreuznach, Germany. After his Ph.D. studies at Göttingen in 1862, he embarked on his independent academic career, and his interests centered on hydroxyamines.
2. Bauer, L.; Exner, O. *Angew. Chem.* **1974**, *86*, 419.
3. Lipczynska-Kochany, E. *Wiad. Chem.* **1982**, *36*, 735.
4. Casteel, D. A.; Gephart, R. S.; Morgan, T. *Heterocycles* **1993**, *36*, 485.
5. Zalipsky, S. *Chem. Commun.* **1998**, 69.
6. Anilkumar, R.; Chandrasekhar, S.; Sridhar, M. *Tetrahedron Lett.* **2000**, *41*, 5291.
7. Needs, P. W.; Rigby, N. M.; Ring, S. G.; MacDougall, A. J. *Carbohydr. Res.* **2001**, *333*, 47.
8. Ohmoto, K.; Yamamoto, T.; Horiuchi, T.; Kojima, T.; Hachiya, K.; Hashimoto, S.; Kawamura, M.; Nakai, H.; Toda, M. *Synlett* **2001**, 299.

McFadyen–Stevens reduction

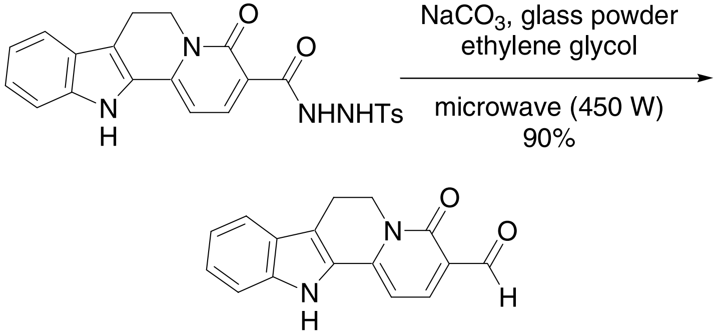
Treatment of acylbenzenesulfonylhydrazines with base delivers the corresponding aldehydes.



Example 1[9]



Example 2[11]

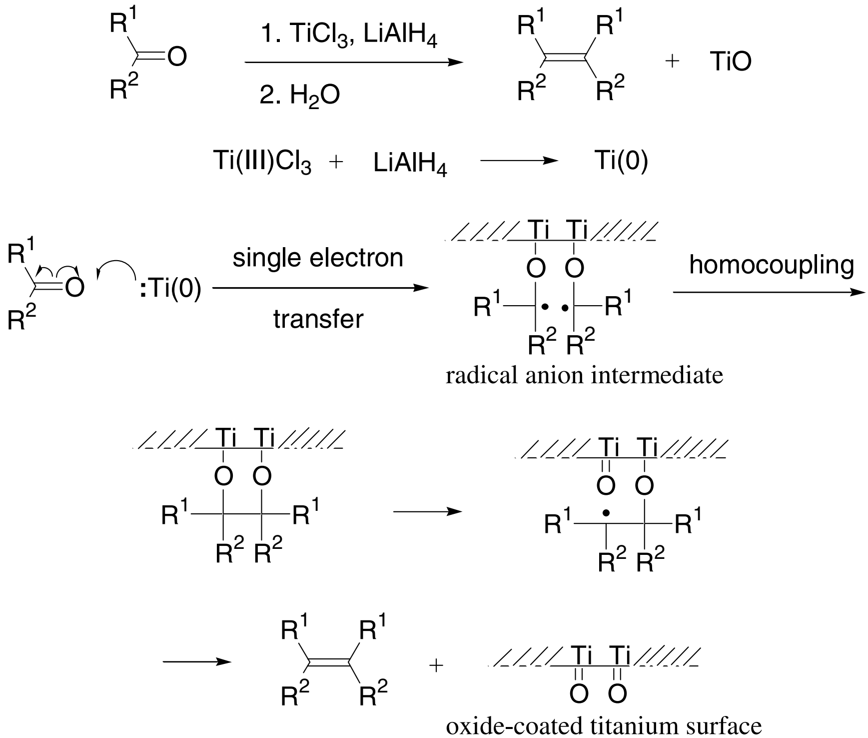


References

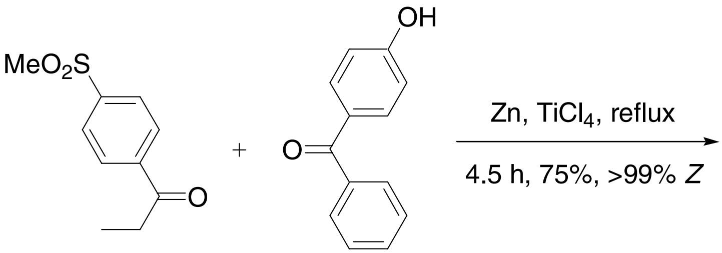
1. McFadyen, J. S.; Stevens, T. S. *J. Chem. Soc.* **1936,** 584. Thomas S. Stevens (1900–) was born in Renfrew, Scotland. After earning his Ph.D. under W. H. Perkin at Oxford University, he became a reader at the University of Sheffield. J. S. McFadyen (1908-) was born in Toronto, Canada. After studying under Stevens at the University of Glasgow, he worked for ICI for 15 years before returning to Canada where he worked for the Canadian Industries, Ltd., Montreal.
2. Newman, M. S.; Caflisch, E. G., Jr. *J. Am. Chem. Soc*. **1958**, *80,* 862.
3. Sprecher, M.; Feldkimel, M.; Wilchek, M. *J. Org. Chem*. **1961**, *26,* 3664.
4. Jensen, K. A.; Holm, A. *Acta. Chem. Scand*. **1961**, *15,* 1787.
5. Babad, H.; Herbert, W.; Stiles, A. W. *Tetrahedron Lett*. **1966**, 2927.
6. Graboyes, H.; Anderson, E. L.; Levinson, S. H.; Resnick, T. M. *J. Heterocycl. Chem*. **1975**, *12*, 1225.
7. Eichler, E.; Rooney, C. S.; Williams, H. W. R. *J. Heterocycl. Chem*. **1976**, *13*, 841.
8. Nair, M.; Shechter, H. *J. Chem. Soc., Chem. Commun*. **1978**, 793.
9. Dudman, C. C.; Grice, P.; Reese, C. B. *Tetrahedron Lett*. **1980**, *21*, 4645.
10. Manna, R. K.; Jaisankar, P.; Giri, V. S. *Synth. Commun*. **1998**, *28*, 9.
11. Jaisankar, P.; Pal, B.; Giri, V. S. *Synth. Commun*. **2002**, *32,* 2569.

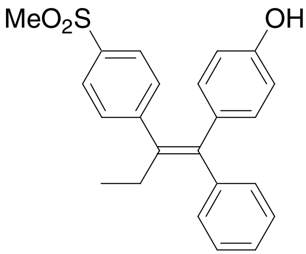
McMurry coupling

Olefination of carbonyls with low-valent titanium such as Ti(0) derived from $TiCl_3/LiAlH_4$. Single-electron process.

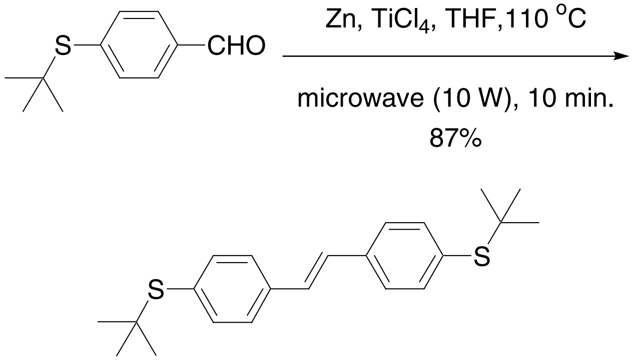


Example 1[12]





Example 2[13]

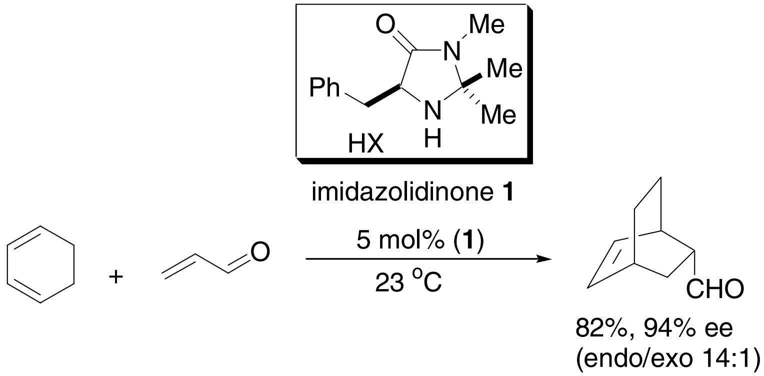


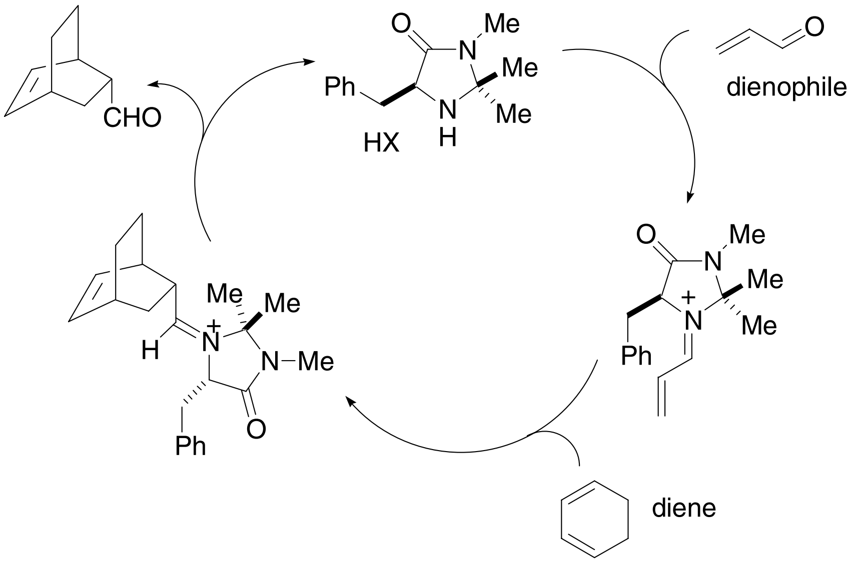
References

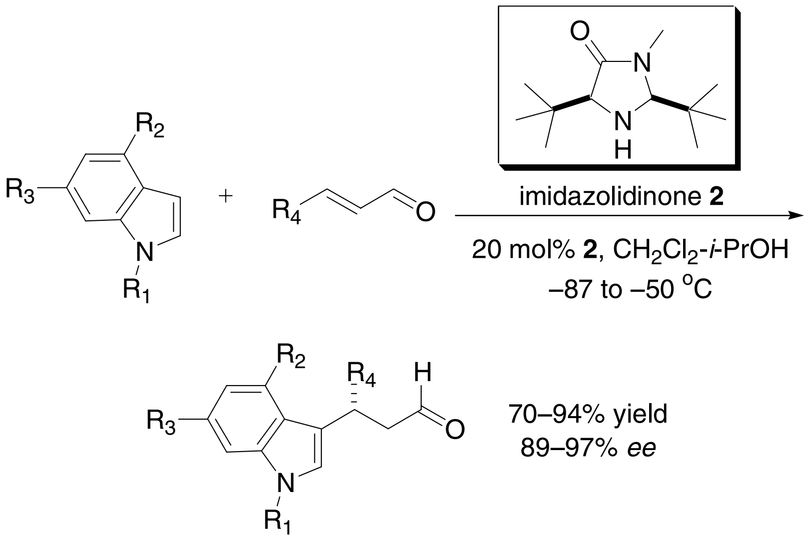
1. McMurry, J. E.; Fleming, M. P. *J. Am. Chem. Soc.* **1974**, *96*, 4708.
2. McMurry, J. E. *Chem. Rev.* **1989**, *89*, 1513–1524. (Review).
3. Ephritikhine, M. *Chem. Commun.* **1998**, 2549.
4. Hirao, T. *Synlett* **1999**, 175.
5. Yamato, T.; Fujita, K.; Tsuzuki, H. *J. Chem. Soc., Perkin Trans. 1* **2001**, 2089.
6. Sabelle, S.; Hydrio, J.; Leclerc, E.; Mioskowski, C.; Renard, P.-Y. *Tetrahedron Lett.* **2002**, *43*, 3645.
7. Williams, D. R.; Heidebrecht, R. W., Jr. *J. Am. Chem. Soc.* **2003**, *125*, 1843.
8. Kowalski, K.; Vessieres, A.; Top, S.; Jaouen, G.; Zakrzewski, J. *Tetrahedron Lett.* **2003**, *44*, 2749.
9. Honda, T.; Namiki, H.; Nagase, H.; Mizutani, H. *Tetrahedron Lett.* **2003**, *44*, 3035.
10. Ephritikhine, M.; Villiers, C. in *Modern Carbonyl Olefination* Takeda, T. ed., Wiley-VCH: Weinheim, Germany, **2004**, 223–285. (Review).
11. Rajakumar, P.; Gayatri Swaroop, M. *Tetrahedron Lett.* **2004**, *45*, 6165.
12. Uddin, M. J.; Rao, P. N. P.; Knaus, E. E. *Synlett* **2004**, 1513.
13. Stuhr-Hansen, N. *Tetrahedron Lett.* **2005**, *46*, 5491.

MacMillan catalyst

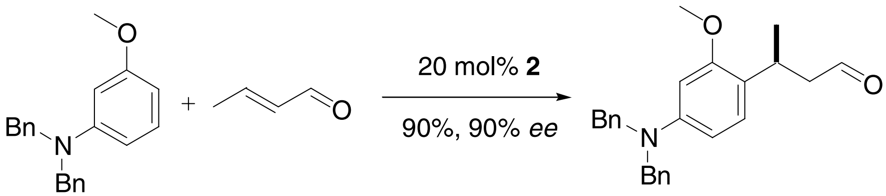
Highly enantioselective and general asymmetric organocatalytic Diels-Alder reaction using α-amino acid-derived imidazolidinones (of type **1**) as catalysts. The first generation of MacMillan catalyst (**1**) has been employed in a variety of organocatalytic enantioselective reactions. Typical examples are: Diels-Alder reaction;[1] nitrone cycloaddition,[2] pyrrole Friedel–Crafts reaction,[3] indole addition,[4] vinylogous Michael addition;[5] α-chlorination;[6] hydride addition;[7] cyclopropanation;[8] α-fluorination.[9] The second generation of MacMillan catalyst (**2**) was used to catalyze 1,4-addition of *C*-nucleophiles employing various indoles.



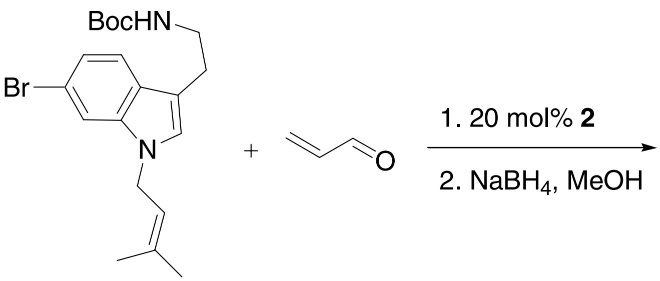


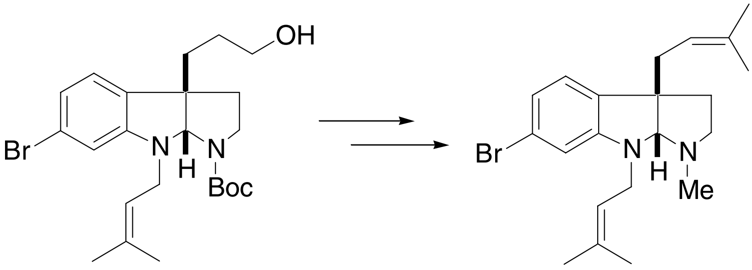


Example 1[11]



Example 2[10]





78% yield
90% ee

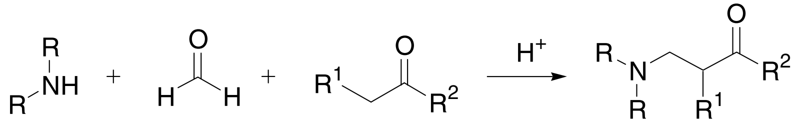
(–)-flustramine B

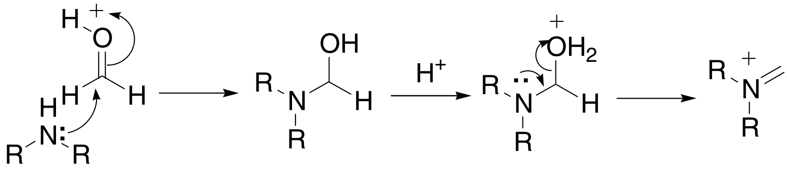
References

1. Ahrendt, K.; Borths, C.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2000**, *122*, 4243.
2. Jen, W.; Wiener, J.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2000**, *122*, 9874.
3. Paras, N.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2001**, *123*, 4370.
4. Austin, J. F.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2002**, *124*, 1172.
5. Brown, S. P.; Goodwin, N. C.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2003**, *125*, 1192.
6. Brochu, M. P.; Brown, S. P.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2004**, *126*, 4108.
7. Ouellet, S. G.; Tuttle, J. B.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2005**, *127*, 32.
8. Kunz, R. K; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2005**, *127*, 3240.
9. Beeson, T. D.; MacMillan, D. W. C. *J. Am. Chem. Soc*. **2005**, *127*, 8826.
10. Austin, J. F.; Kim, S.-G.; Sinz, C. J.; Xiao, W.-J.; MacMillan, D. W. C. *Proc. Nat. Acad. Sci. USA*, **2004**, *101*, 5482.
11. Kim, S.-G.; Kim, J.; Jung, H. *Tetrahedron Lett.* **2005**, *46*, 2437.

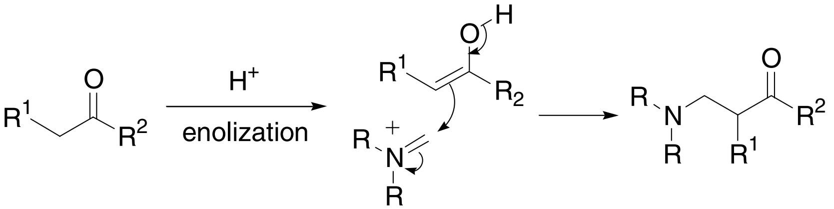
Mannich reaction

Three-component aminomethylation from amine, formaldehyde and a compound with an acidic methylene moiety.

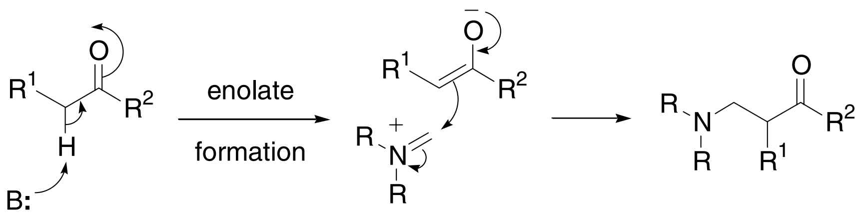




When R = H, the $^{+}Me_2N{=}CH_2$ salt is known as **Eschenmoser's salt**

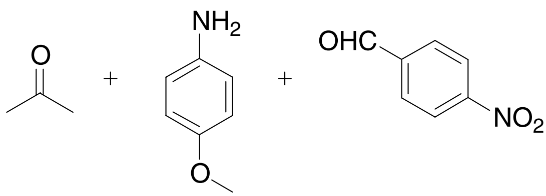


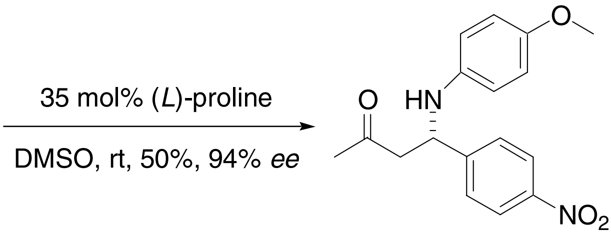
The Mannich reaction can also operate under basic conditions:



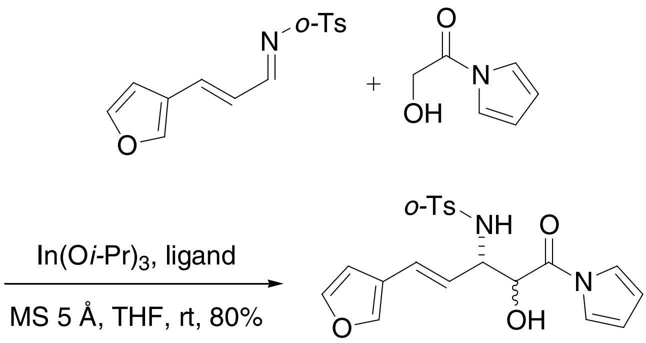
Mannich Base

Example 1, asymmetric Mannich reaction[4]





Example 2, asymmetric aza-Mannich reaction[13]

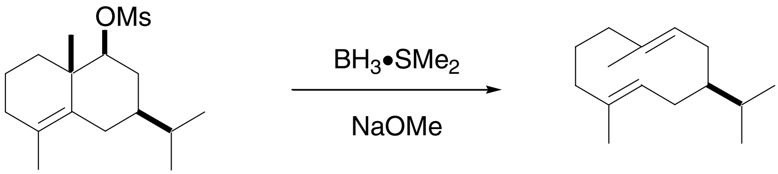


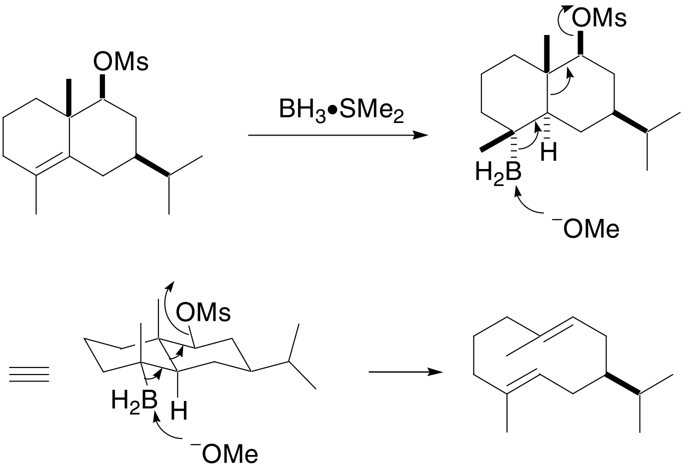
References

1. Mannich, C.; Krosche, W. *Arch. Pharm.* **1912**, *250*, 647. Carl U. F. Mannich (1877–1947) was born in Breslau, Germany. After receiving a Ph.D. at Basel in 1903, he served on the faculties of Göttingen, Frankfurt and Berlin. Mannich synthesized many esters of *p*-aminobenzoic acid as local anesthetics.
2. Arend, M.; Westermann, B.; Risch, N. *Angew. Chem., Int. Ed.* **1998**, *37*, 1045.
3. Padwa, A.; Waterson, A. G. *J. Org. Chem.* **2000**, *65*, 235.
4. List, B. *J. Am. Chem. Soc.* **2000**, *122*, 9336.
5. Schlienger, N.; Bryce, M. R.; Hansen, T. K. *Tetrahedron* **2000**, *56*, 10023.
6. Bur, S. K.; Martin, S. F. *Tetrahedron* **2001**, *57*, 3221. (Review).
7. Vicario, J. L.; Badía, D.; Carrillo, L. *Org. Lett.* **2001**, *3*, 773.
8. Martin, S. F. *Acc. Chem. Res.* **2002**, *35*, 895–904. (Review).
9. Padwa, A.; Bur, S. K.; Danca, D. M.; Ginn, J. D.; Lynch, S. M. *Synlett* **2002**, 851–862. (Review).
10. Padwa, A.; Bur, S. K.; Danca, D. M.; Ginn, J. D.; Lynch, S. M. *Synlett* **2002**, 851–862. (Review).
11. Notz, W.; Tanaka, F.; Barbas, C. F., III. *Acc. Chem. Res.* **2004**, *37*, 580–591. (Review).
12. Córdova, A. *Acc. Chem. Res.* **2004**, *37*, 102–112. (Review).
13. Harada, S.; Handa, S.; Matsunaga, S.; Shibasaki, M. *Angew. Chem., Int. Ed.* **2005**, *44*, 4365.

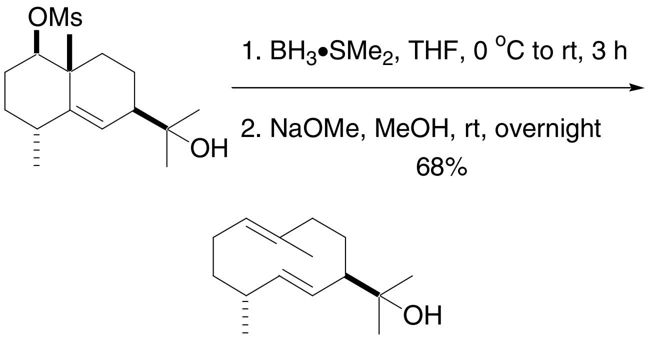
Marshall boronate fragmentation

Marshall boronate fragmentation is a variation of the Grob fragmentation (page 273) category.

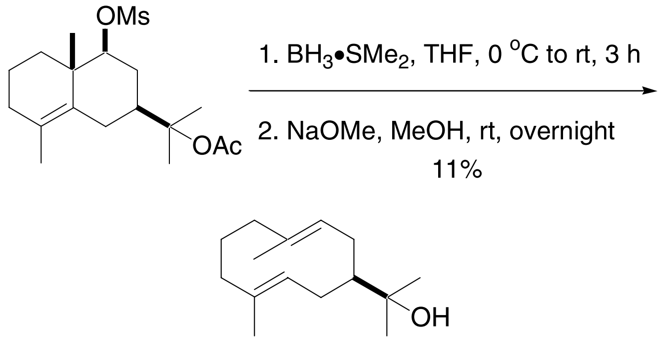




Example 1[5]



Example 2[6]

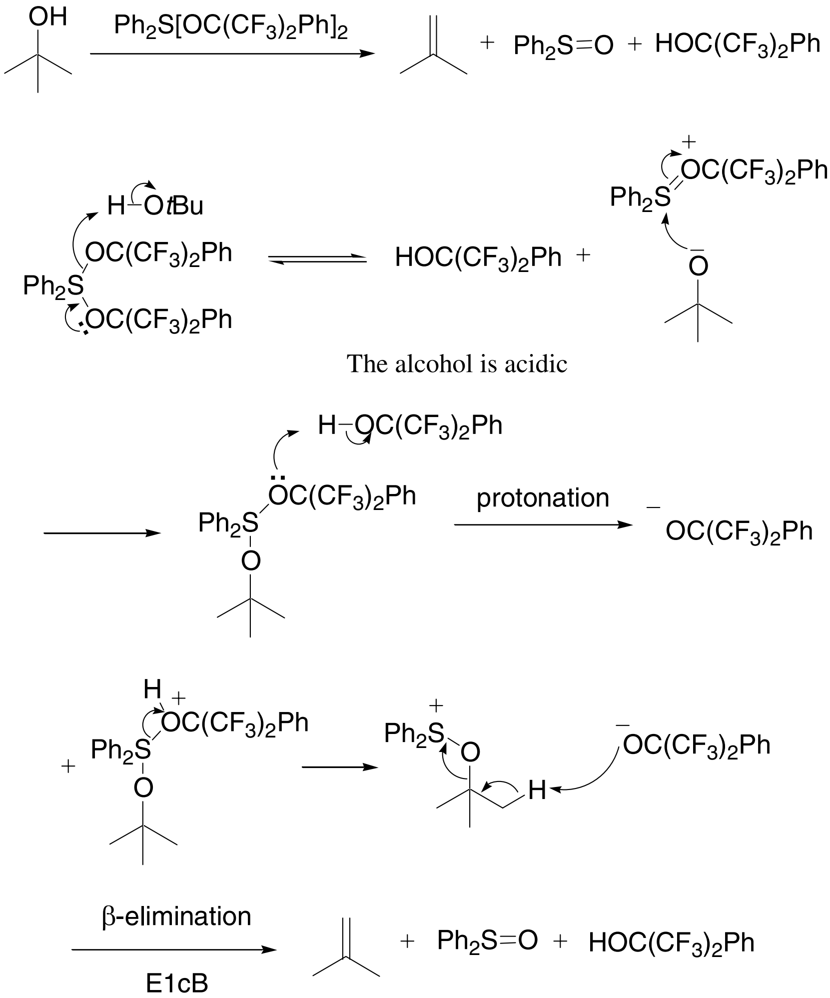


References

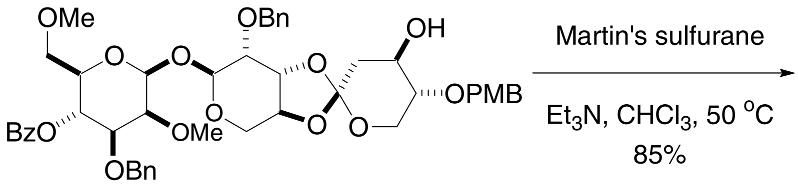
1. Marshall, J. A.; Huffman, W. F. *J. Am. Chem. Soc.* **1970**, *92*, 6358.
2. Marshall, J. A. *Synthesis* **1971**, 229. (Review).
3. Wharton, P. S.; Sundin, C. E.; Johnson, D. W.; Kluender, H. C. *J. Org. Chem.* **1972**, *37*, 34.
4. Minnaard, A. J.; Wijnberg, J. B. P. A.; de Groot, A. *Tetrahedron* **1994**, *50*, 4755.
5. Zhabinskii, V. N.; Minnard, A. J.; Wijnberg, J. B. P. A.; de Groot, A. *J. Org. Chem.* **1996**, *61*, 4022.
6. Minnard, A. J.; Stork, G. A.; Wijnberg, J. B. P. A.; de Groot, A. *J. Org. Chem.* **1997**, *62*, 2344.

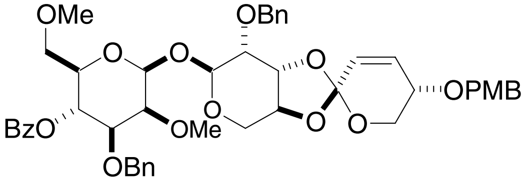
Martin's sulfurane dehydrating reagent

Dehydrates secondary and tertiary alcohols to give olefins, but forms ethers with primary alcohols. *Cf.* Burgess dehydrating reagent.

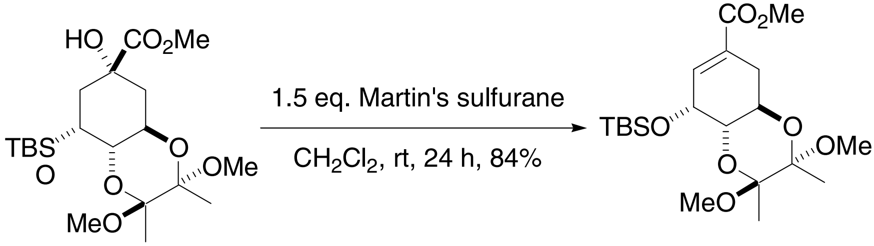


Example 1[9]





Example 2[10]

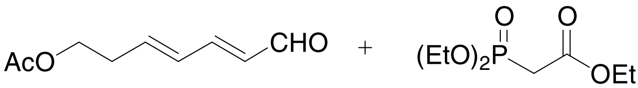


References

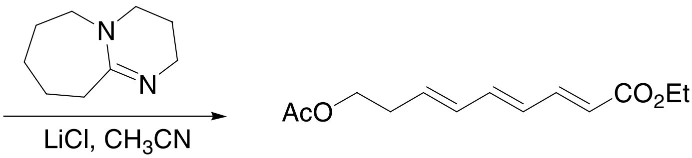
1. Martin, J. C.; Arhart, R. J. *J. Am. Chem. Soc.* **1971**, *93*, 2339, 2341. J. C. Martin was a professor at the University of Illinois at Urbana, where he discovered the Martin's sulfurane dehydrating reagent. Martin also developed the Dess–Martin periodinane oxidation (page 195) with his student Daniele Dess.
2. Martin, J. C.; Arhart, R. J. *J. Am. Chem. Soc.* **1971**, *93*, 4327.
3. Martin, J. C.; Arhart, R. J.; Franz, J. A.; Perozzi, E. F.; Kaplan, L. J. *Org. Synth.* **1977**, *57*, 22.
4. Bartlett, P. D.; Aida, T.; Chu, H.-K.; Fang, T.-S. *J. Am. Chem. Soc.* **1980**, *102*, 3515.
5. Gallagher, T. F.; Adams, J. L. *J. Org. Chem.* **1992**, *57*, 3347.
6. Tse, B.; Kishi, Y. *J. Org. Chem.* **1994**, *59*, 7807.
7. Winkler, J. D.; Stelmach, J. E.; Axten, J. *Tetrahedron Lett.* **1996**, *37*, 4317.
8. Rao, P. N.; Wang, Z. *Steroids* **1997**, *62*, 487.
9. Nicolaou, K. C.; Rodríguez, R. M.; Fylaktakidou, K. C.; Suzuki, H.; Mitchell, H. J. *Angew. Chem., Int. Ed. Engl.* **1999**, *38*, 3340.
10. Box, J. M.; Harwood, L. M.; Humphreys, J. L.; Morris, G. A.; Redon, P. M.; Whitehead, R. C. *Synlett* **2002**, 358.
11. Yokokawa, F.; Shioiri, T. *Tetrahedron Lett.* **2002**, *43*, 8679.
12. Myers, A. G.; Glatthar, R.; Hammond, M.; Harrington, P. M.; Kuo, E. Y.; Liang, J.; Schaus, S. E.; Wu, Y.; Xiang, J.-N. *J. Am. Chem. Soc.* **2002**, *124*, 5380.
13. Begum, L.; Box, J. M.; Drew, M. G. B.; Harwood, L. M.; Humphreys, J. L.; Lowes, D. J.; Morris, G. A.; Redon, P. M.; Walker, F. M.; Whitehead, R. C. *Tetrahedron* **2003**, *59*, 4827.

Masamune–Roush conditions

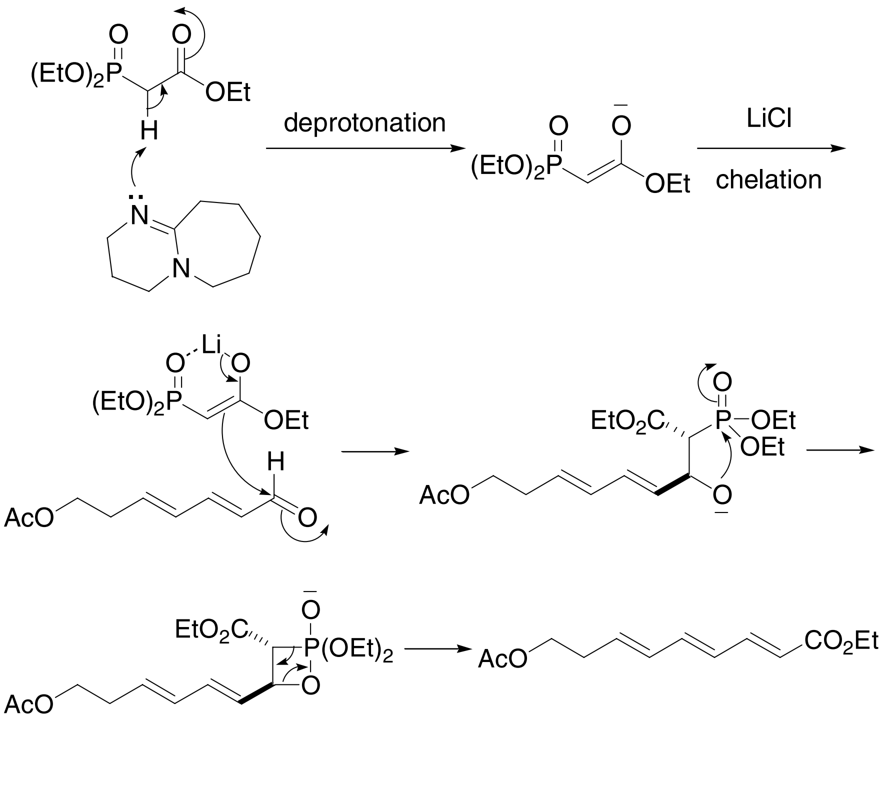
Applicable to base-sensitive aldehydes and phosphonates for the Horner–Wadsworth–Emmons reaction



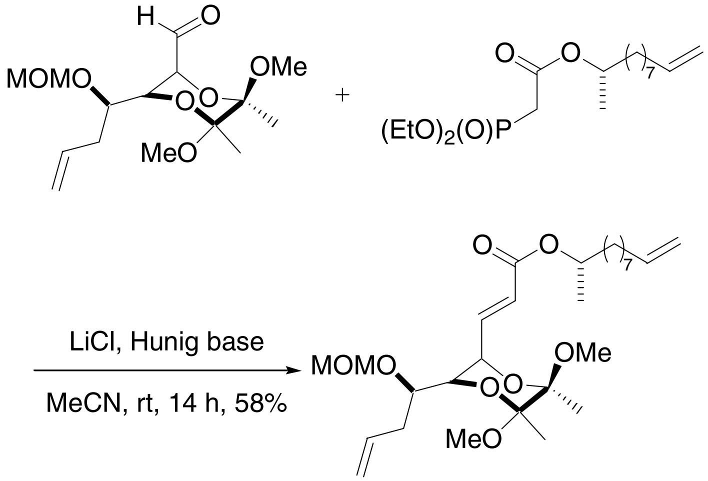
α-keto or α-alkoxycarbonyl phosphonate required



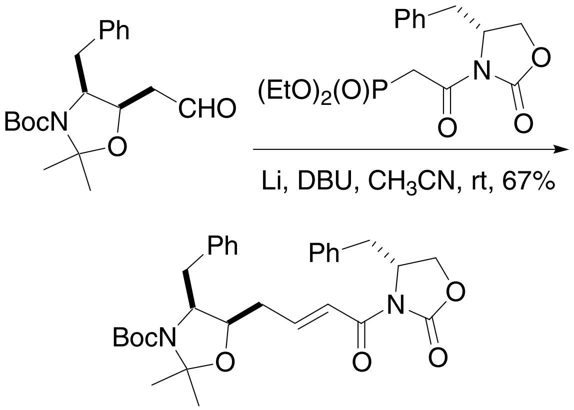
1,8-diazabicyclo[5.4.0]undec-7-ene (DBU)



Example 1[6]



Example 2[7]

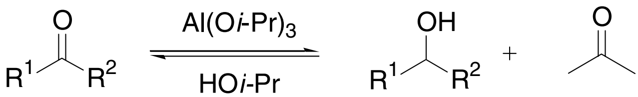


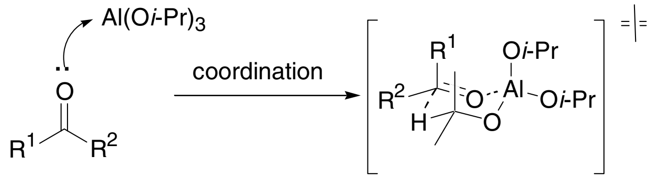
References

1. Blanchette, M. A.; Choy, W.; Davis, J. T.; Essenfeld, A. P.; Masamune, S.; Roush, W. R.; Sakai, T. *Tetrahedron Lett.* **1984**, *25*, 2183.
2. Marshall, J. A.; DuBay, W. J. *J. Org. Chem.* **1994**, *59*, 1703.
3. Tius, M. A.; Fauq, A. H. *J. Am. Chem. Soc*. **1986**, *108*, 1035.
4. Tius, M. A.; Fauq, A. H. *J. Am. Chem. Soc*. **1986**, *108*, 6389.
5. Rychnovsky, S. D.; Khire, U. R.; Yang, G. *J. Am. Chem. Soc*. **1997**, *119*, 2058.
6. Dixon, D. J.; Foster, A. C.; Ley, S. V. *Org. Lett*. **2000**, *2*, 123.
7. Crackett, P.; Demont, E.; Eatherton, A.; Frampton, C. S.; Gilbert, J.; Kahn, I.; Redshaw, S.; Watson, W. *Synlett* **2004**, 679.

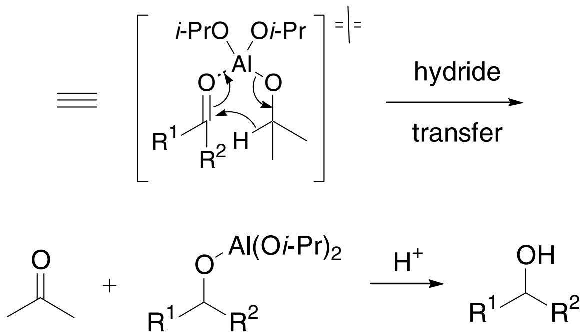
Meerwein–Ponndorf–Verley reduction

Reduction of ketones to the corresponding alcohols using Al(O*i*-Pr)$_3$ in isopropanol.

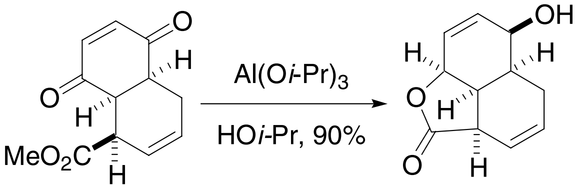




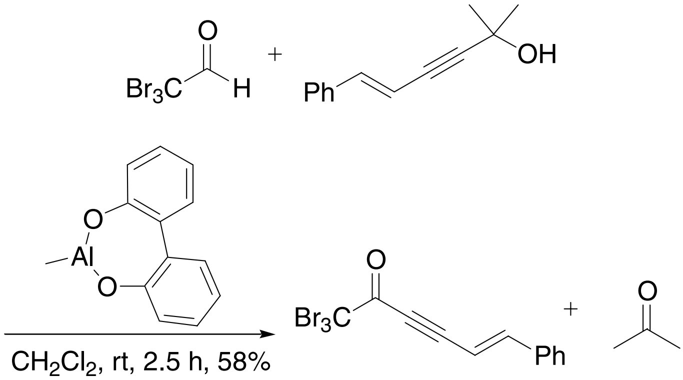
cyclic transition state



Example 1[2]



Example 2[12]

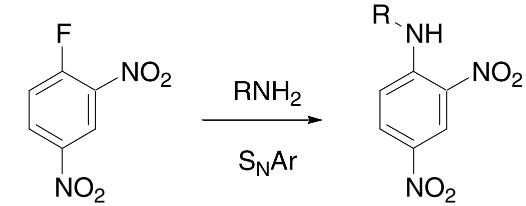


References

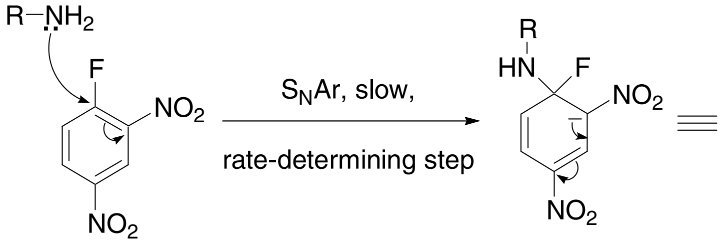
1. Meerwein, H.; Schmidt, R. *Justus Liebigs Ann. Chem.* **1925**, *444*, 221. Hans L. Meerwein, born in Hamburg Germany in 1879, received his Ph.D. at Bonn in 1903. In his long and productive academic career, Meerwein made many notable contributions in organic chemistry.
2. Woodward, R. B.; Bader, F. E.; Bickel, H.; Frey, A. J.; Kierstead, R. W. *Tetrahedron* **1958**, *2*, 1.
3. Ashby, E. C. *Acc. Chem. Res.* **1988**, *21*, 414. (Review).
4. de Graauw, C. F.; Peters, J. A.; van Bekkum, H.; Huskens, J. *Synthesis* **1994**, 1007. (Review).
5. Aremo, N.; Hase, T. *Tetrahedron Lett*. **2001**, *42*, 3637.
6. Campbell, E. J.; Zhou, H.; Nguyen, S. T. *Angew. Chem., Int. Ed. Engl*. **2002**, *41*, 1020.
7. Faller, J. W.; Lavoie, A. R. *Organometallics* **2002**, *21*, 2010.
8. Nishide, K.; Node, M. *Chirality* **2002**, *14*, 759.
9. Jerome, J. E.; Sergent, R. H. *Chem. Ind*. **2003**, *89*, 97. (Review).
10. Sominsky, L.; Rozental, E.; Gottlieb, H.; Gedanken, A.; Hoz, S. *J. Org. Chem.* **2004**, *69*, 1492.
11. Fukuzawa, S.-i.; Nakano, N.; Saitoh, T. *Eur. J. Org. Chem.* **2004**, 2863.
12. Ooi, T.; Miura, T.; Ohmatsu, K.; Saito, A.; Maruoka, K. *Org. Biomol. Chem.* **2004**, *2*, 3312.

Meisenheimer complex

Also known as Meisenheimer–Jackson salt, the stable intermediate for certain S_NAr reactions.

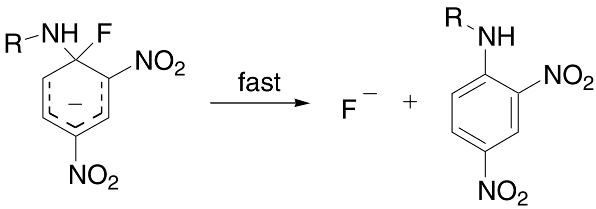


Sanger's reagent



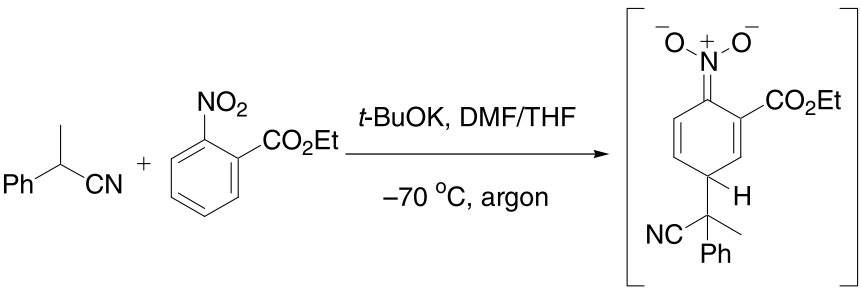
ipso attack

ipso substitution

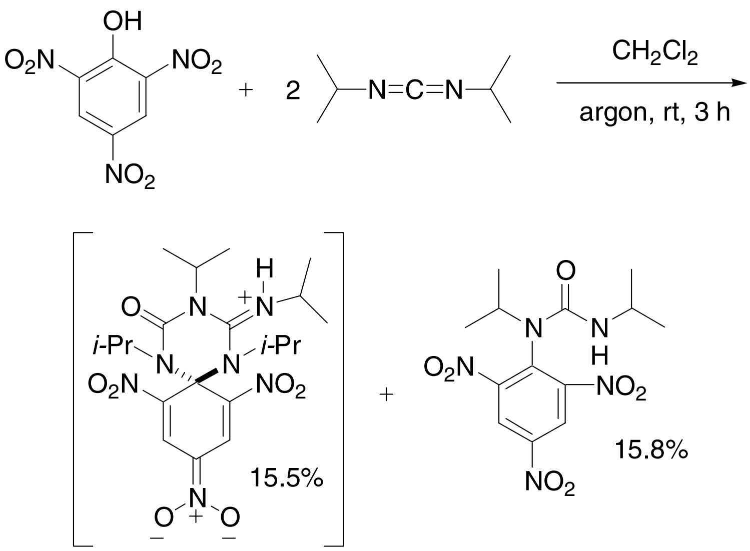


Meisenheimer complex (**Meisenheimer–Jackson salt**)

Example 1[10]



Example 2[13]



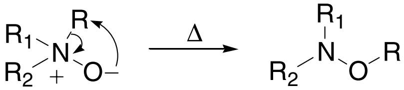
The reaction using Sanger's reagent is faster than using the corresponding chloro-, bromo-, and iodo-dinitrobenzene—the fluoro-Meisenheimer complex is the most stabilized because F is the most electron-withdrawing. The reaction rate does not depend upon the capacity of the leaving group.

References

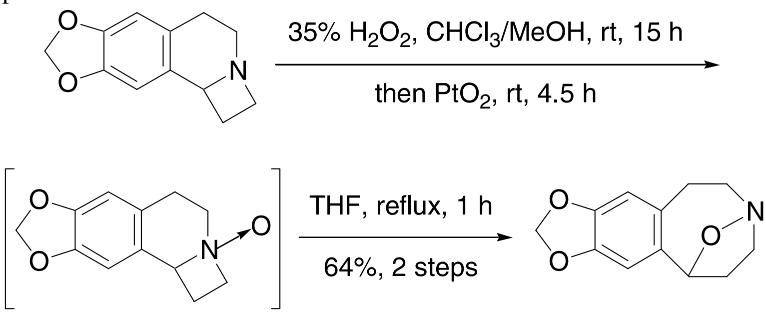
1. Meisenheimer, J. *Justus Liebigs Ann. Chem.* **1902**, *323*, 205.
2. Strauss, M. J. *Acc. Chem. Res.* **1974**, *7*, 181. (Review).
3. Bernasconi, C. F. *Acc. Chem. Res.* **1978**, *11*, 147. (Review).
4. Terrier, F. *Chem. Rev.* **1982**, *82*, 77. (Review).
5. Buncel, E.; Dust, J. M.; Manderville, R. A. *J. Am. Chem. Soc.* **1996**, *118*, 6072.
6. Sepulcri, P.; Goumont, R.; Hallé, J.-C.; Buncel, E.; Terrier, F. *Chem. Commun.* **1997**, 789.
7. Manderville, R. A.; Buncel, E. *J. Org. Chem.* **1997**, *62*, 7614.
8. Weiss, R.; Schwab, O.; Hampel, F. *Chem. Eur. J.* **1999**, *5*, 968.
9. Hoshino, K.; Ozawa, N.; Kokado, H.; Seki, H.; Tokunaga, T.; Ishikawa, T. *J. Org. Chem.* **1999**, *64*, 4572.
10. Adam, W.; Makosza, M.; Zhao, C.-G.; Surowiec, M. *J. Org. Chem.* **2000**, *65*, 1099.
11. Gallardo, I.; Guirado, G.; Marquet, J. *J. Org. Chem.* **2002**, *67*, 2548.
12. Kim, H.-Y.; Song, H.-G. *Appl. Microbiol. Biotech.* **2003**, *61*, 150.
13. Al-Kaysi, R. O.; Guirado, G.; Valente, E. J. *Eur. J. Org. Chem.* **2004**, 3408.

[1,2]-Meisenheimer rearrangement

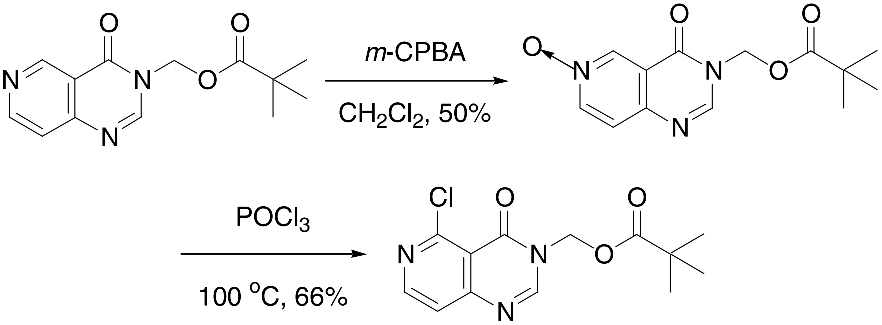
[1,2]-Sigmatropic rearrangement of tertiary amine *N*-oxides to hydroxylamines:



Example 1[5]



Example 2[6]

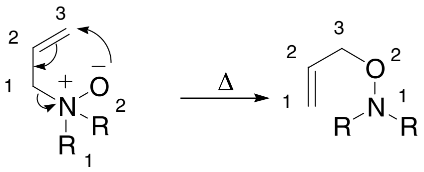


References

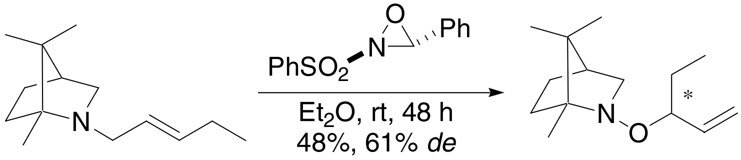
1. Meisenheimer, J. *Ber. Dtsch. Chem. Ges.* **1919**, *52*, 1667.
2. [1,2]-Sigmatropic rearrangement, Castagnoli, N., Jr.; Craig, J. C.; Melikian, A. P.; Roy, S. K. *Tetrahedron* **1970**, *26*, 4319.
3. Johnstone, R. A. W. *Mech. Mol. Migr.* **1969**, *2*, 249. (Review).
4. Molina, J. M.; El-Bergmi, R.; Dobado, J. A.; Portal, D. *J. Org. Chem.* **2000**, *65*, 8574.
5. Yoneda, R.; Sakamoto, Y.; Oketo, Y.; Harusawa, S.; Kurihara, T. *Tetrahedron* **1996**, *52*, 14563.
6. Williams, E. J.; Kenny, P. W.; Kettle, J. G.; Mwashimba, P. G. *Tetrahedron Lett.* **2004**, *45*, 3737.

[2,3]-Meisenheimer rearrangement

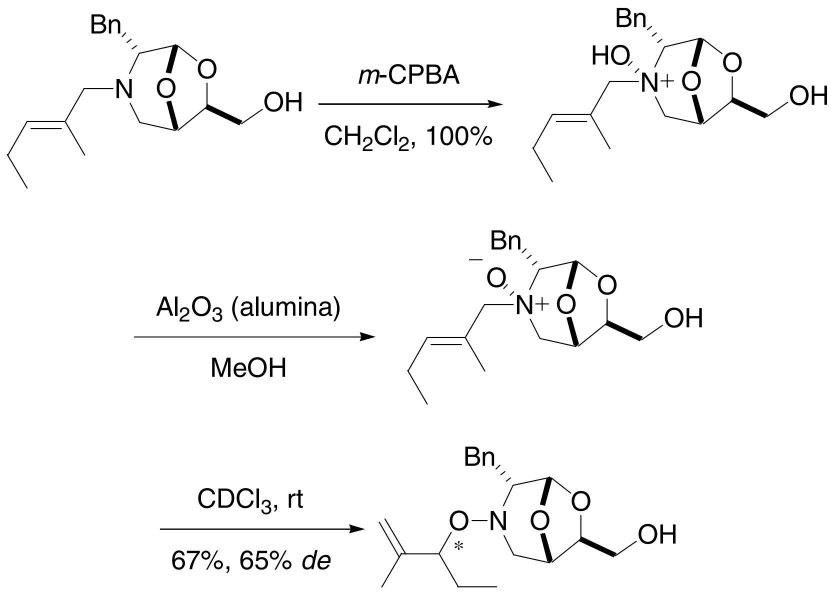
[2,3]-Sigmatropic rearrangement of allylic tertiary amine-*N*-oxides to give *O*-allyl hydroxylamines:



Example 1[7]



Example 2[8]

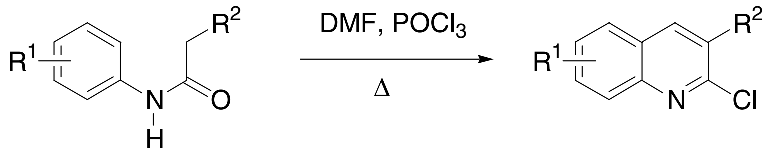


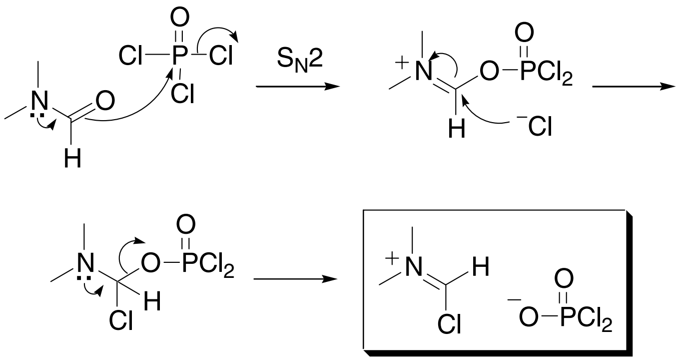
References

1. Meisenheimer, J. *Ber. Dtsch. Chem. Ges.* **1919**, *52*, 1667.
2. [2,3]-Sigmatropic rearrangement, Yamamoto, Y.; Oda, J.; Inouye, Y. *J. Org. Chem.* **1976**, *41*, 303.
3. Johnstone, R. A. W. *Mech. Mol. Migr.* **1969**, *2*, 249. (Review).
4. Kurihara, T.; Sakamoto, Y.; Matsumoto, H.; Kawabata, N.; Harusawa, S.; Yoneda, R. *Chem. Pharm. Bull.* **1994**, *42*, 475.
5. Blanchet, J.; Bonin, M.; Micouin, L.; Husson, H.-P. *Tetrahedron Lett*. **2000**, *41*, 8279.
6. Enders, D.; Kempen, H. *Synlett* **1994**, 969.
7. Buston, J. E. H.; Coldham, I.; Mulholland, K. R. *Synlett* **1997**, 322.
8. Guarna, A.; Occhiato, E. G.; Pizzetti, M.; Scarpi, D.; Sisi, S.; van Sterkenburg, M. *Tetrahedron: Asymmetry* **2000**, *11*, 4227.
9. Mucsi, Z.; Szabó, A.; Hermecz, I.; Kucsman, Á.; Csizmadia, I. G. *J. Am. Chem. Soc.* **2005**, *127*, 7615.

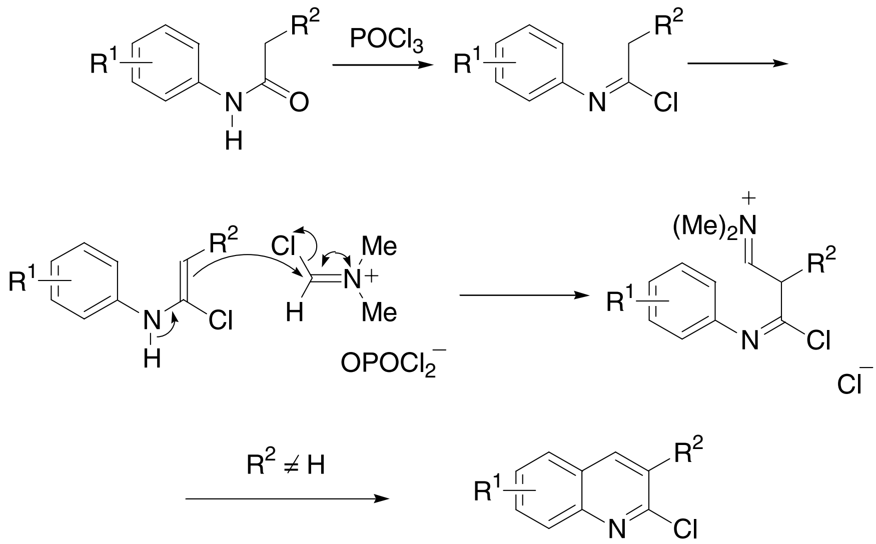
Meth–Cohn quinoline synthesis

Conversion of acylanilides into 2-chloro-3-substituted quinolines by the action of Vilsmeier's reagent in warmed phosphorus oxychloride ($POCl_3$) as solvent.

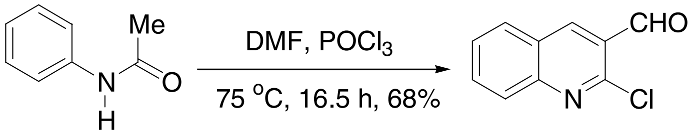




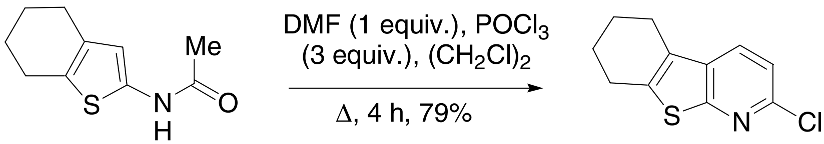
Vilsmeier–Haack reagent



Example 1[5]



Example 2[5]

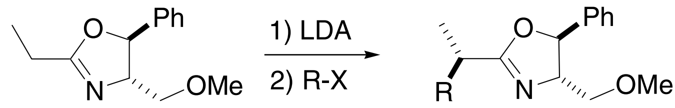


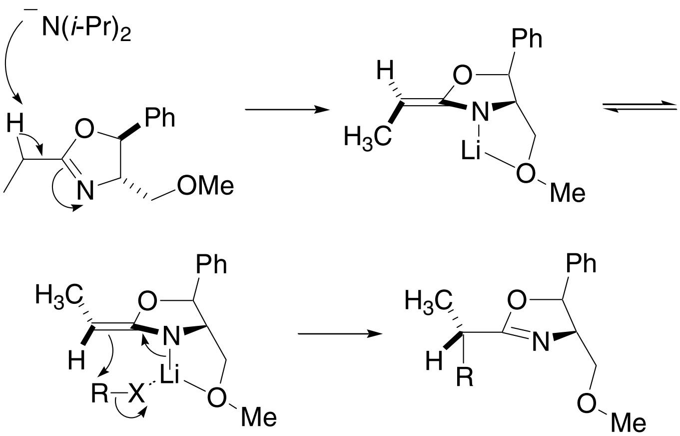
References

1. Meth-Cohn, O.; Narine, B. *Tetrahedron Lett.* **1978**, 2045;
2. Meth-Cohn, O.; Narine, B.; Tarnowski, B. *Tetrahedron Lett.* **1979**, 3111.
3. Meth-Cohn, O.; Tarnowski, B. *Tetrahedron Lett.* **1980**, *21*, 3721.
4. Meth-Cohn, O; Rhouati, S.; Tarnowski, B.; Robinson, A. *J. Chem. Soc., Perkin Trans. 1* **1981**, 1537.
5. Meth-Cohn, O; Narine, B.; Tarnowski, B. *J. Chem. Soc., Perkin Trans. 1* **1981**, 1520.
6. Meth-Cohn, O.; Tarnowski, B. *Adv. Heterocycl. Chem.* **1982**, *31*, 207. (Review).
7. Marson, C. M. *Tetrahedron* **1992**, *48*, 3659. (Review).
8. Meth-Cohn, O. *Heterocycles* **1993**, *35*, 539. (Review).
9. Swahn, B.-M.; Claesson, A.; Pelcman, B.; Besidski, Y.; Molin, H.; Sandberg, M. P.; Berge, O.-G. *Bioorg. Med. Chem. Lett.* **1996**, *6*, 1635.
10. Swahn, B.-M.; Andersson, F.; Pelcman, B.; Söderberg, J.; Claesson, A. *J. Labelled. Compd. Radiopharm.* **1997**, *39*, 259.
11. Ali, M. M.; Sana, S.; Tasneem; Rajanna, K. C.; Saiprakash, P. K. *Synth. Comm.* **2002**, *32*, 1351.
12. Moore, A. J. *Meth–Cohn quinoline synthesis* In *Name Reactions in Heterocycl. Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 443–450. (Review).

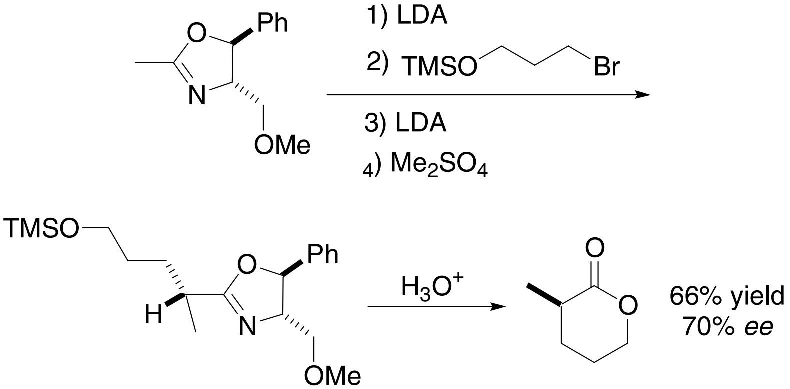
Meyers oxazoline method

Chiral oxazolines employed as activating groups and/or chiral auxiliaries in nucleophilic addition and substitution reactions that lead to the asymmetric construction of carbon-carbon bonds.

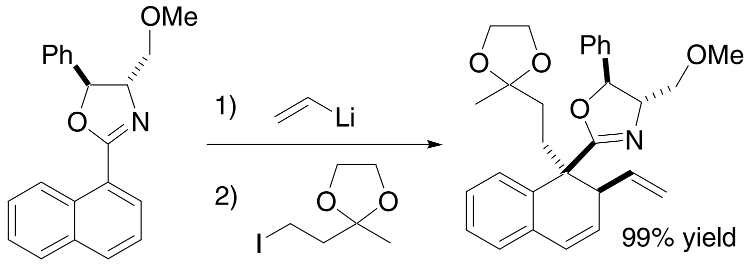




Example 1[8]



Example 2[12]

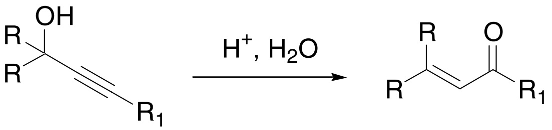


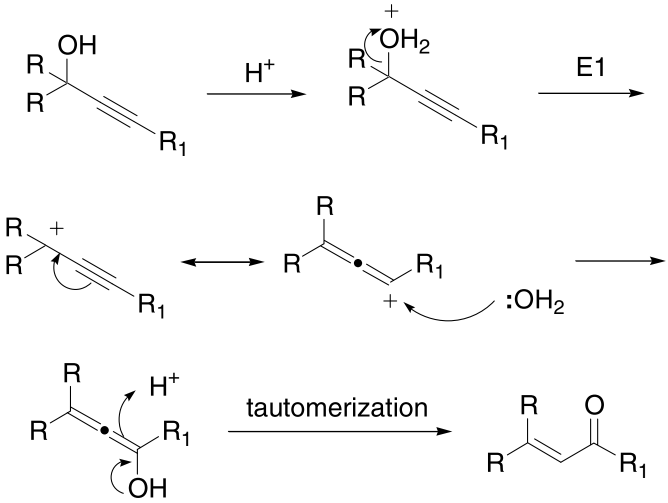
References

1. Meyers, A. I.; Knaus, G.; Kamata, K. *J. Am. Chem. Soc.* **1974**, *96*, 268. While Albert I. Meyers was an assistant professor at Wayne State University, neighboring pharmaceutical firm Parke-Davis (Drs. George Moersch and Harry Crooks) donated several kilograms of (1*S*, 2*S*)-(+)-2-amino-1-phenyl-1,3-propanediol (Meyers referred to it as the Parke-Davis diol), from which his chemistry with chiral oxazolines began. Meyers is currently Professor Emeritus at Colorado State University.
2. Meyers, A. I.; Knaus, G. *J. Am. Chem. Soc.* **1974**, *96*, 6508.
3. Meyers, A. I.; Knaus, G. *Tetrahedron Lett.* **1974**, 1333.
4. Meyers, A. I.; Whitten, C. E. *J. Am. Chem. Soc.* **1975**, *97*, 6266.
5. Meyers, A. I.; Mihelich, E. D. *J. Org. Chem.* **1975**, *40,* 1186.
6. Meyers, A. I.; Mihelich, E. D. *Angew. Chem. Int. Ed.* **1976**, *15*, 270. (Review).
7. Meyers, A, I. *Acc. Chem. Res.* **1978**, *11*, 375–381. (Review).
8. Meyers, A. I.; Yamamoto, Y.; Mihelich, E. D.; Bell, R. A. *J. Org. Chem.* **1980**, *45*, 2792.
9. Meyers, A. I., Lutomski, K. A. in *Asymmetric Synthesis*, Morrison, J. D. ed. Vol III, part B, Chapter 3, Academic Press, **1983**. (Review).
10. Reuman, M.; Meyers, A. I. *Tetrahedron* **1985**, *41*, 837–860. (Review).
11. Meyers, A. I.; Barner, B. A. *J. Org. Chem.* **1986**, *51*, 120.
12. Robichaud, A. J.; Meyers, A. I. *J. Org. Chem.* **1991**, *56*, 2607.
13. Gant, T. G.; Meyers, A. I. *Tetrahedron* **1994**, *50*, 2297–2360. (Review).
14. Meyers, A. I. *J. Heterocycl. Chem.* **1998**, *35*, 991–1002. (Review).
15. Wolfe, J. P. *Meyers Oxazoline Method* In *Name Reactions in Heterocycl. Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 237–248. (Review).

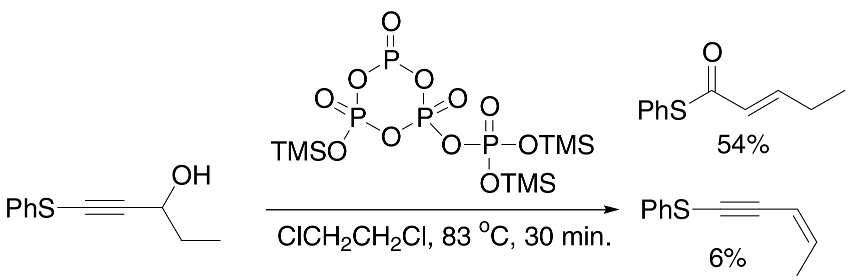
Meyer–Schuster rearrangement

The isomerization of secondary and tertiary α-acetylenic alcohols to α,β-unsaturated carbonyl compounds *via* 1,3-shift. When the acetylenic group is terminal, the products are aldehydes, whereas the internal acetylenes give ketones. *Cf.* Rupe rearrangement.

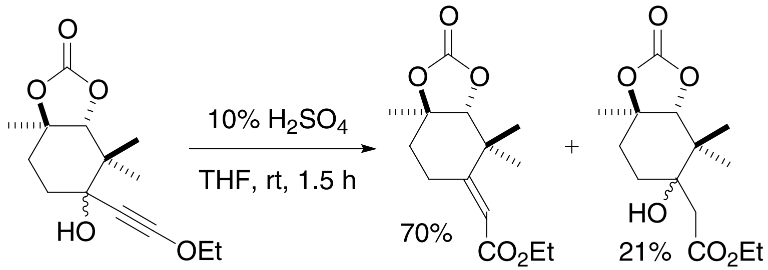




Example 1[8]



Example 2[10]



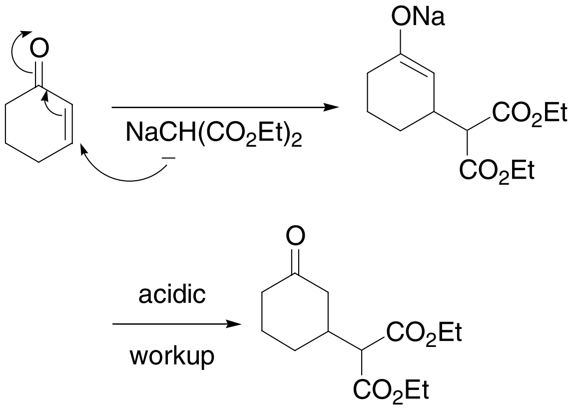
References

1. Meyer, K. H.; Schuster, K. *Ber. Dtsch. Chem. Ges.* **1922**, *55*, 819.
2. Swaminathan, S.; Narayanan, K. V. *Chem. Rev*. **1971**, *71*, 429. (Review).
3. Edens, M.; Boerner, D.; Chase, C. R.; Nass, D.; Schiavelli, M. D. *J. Org. Chem*. **1977**, *42*, 3403.
4. Cachia, P.; Darby, N.; Mak, T. C. W.; Money, T.; Trotter, J. *Can. J. Chem*. **1980**, *58*, 1172.
5. Andres, J.; Cardenas, R.; Silla, E.; Tapia, O. *J. Am. Chem. Soc*. **1988**, *110*, 666.
6. Tapia, O.; Lluch, J. M.; Cardenas, R.; Andres, J. *J. Am. Chem. Soc*. **1989**, *111*, 829.
7. Omar, E. A.; Tu, C.; Wigal, C. T.; Braun, L. L. *J. Heterocycl. Chem*. **1992**, *29*, 947.
8. Yoshimatsu, M.; Naito, M.; Kawahigashi, M.; Shimizu, H.; Kataoka, T. *J. Org. Chem*. **1995**, *60*, 4798.
9. Lorber, C. Y.; Osborn, J. A. *Tetrahedron Lett*. **1996**, *37*, 853.
10. Crich, D.; Natarajan, S.; Crich, J. Z. *Tetrahedron* **1997**, *53*, 7139.
11. Chihab-Eddine, A.; Daich, A.; Jilale, A.; Decroix, B. *J. Heterocycl. Chem*. **2000**, *37*, 1543.

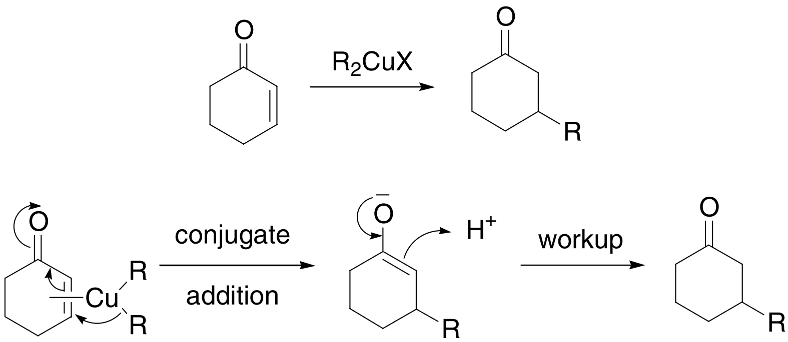
Michael addition

Conjugate addition of a carbon-nucleophile to an α,β-unsaturated system.

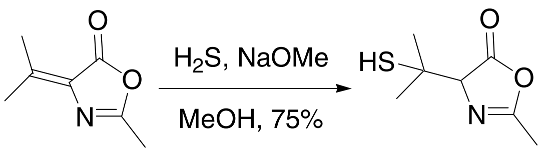
Example 1



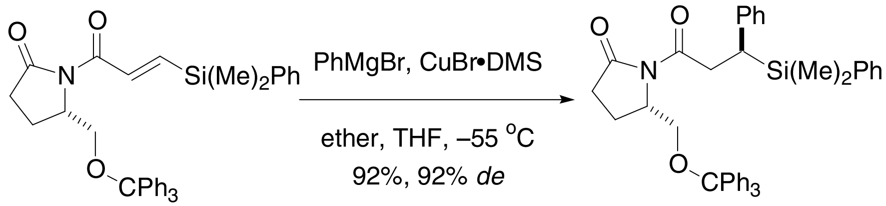
Example 2



Example 3[4]



Example 4[3]



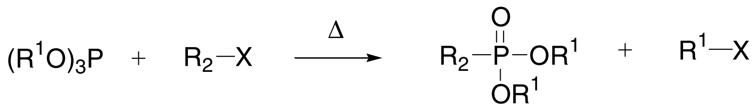
References

1. Michael, A. *J. Prakt. Chem.* **1887**, *35*, 349. Arthur Michael (1853–1942) was born in Buffalo, New York. He studied under Robert Bunsen, August Hofmann, Adolphe Wurtz, and Dimitri Mendeleev, but never bothered to take a degree. Back to the United States, Michael became a Professor of Chemistry at Tufts University, where he married one of his most brilliant students, Helen Abbott, one of the few women organic chemists in this period. Since he failed miserably as an administrator, Michael and his wife set up their own private laboratory at Newton Center, Massachusetts, where the Michael addition was discovered.
2. Fleming, I.; Kindon, N. D. *J. Chem. Soc., Chem. Commun.* **1987**, 1177.
3. Hunt, D. A. *Org. Prep. Proced. Int*. **1989**, *21*, 705.
4. D'Angelo, J.; Desmaële, D.; Dumas, F.; Guingant, A. *Tetrahedron: Asymmetry* **1992**, *3*, 459.
5. Lipshutz, B. H.; Sengupta, S. *Org. React.* **1992**, *41*, 135–631. (Review).
6. Hoz, S. *Acc. Chem. Res*. **1993**, *26*, 69. (Review).
7. Ihara, M.; Fukumoto, K. *Angew. Chem., Int. Ed. Engl.* **1993**, *32*, 1010. (Review).
8. Itoh, T.; Shirakami, S. *Heterocycles* **2001**, *55*, 37.
9. Cai, C.; Soloshonok, V. A.; Hruby, V. J. *J. Org. Chem.* **2001**, *66*, 1339.
10. Sundararajan, G.; Prabagaran, N. *Org. Lett*. **2001**, *3*, 389.
11. Eilitz, U.; Leβmann, F.; Seidelmann, O.; Wendisch, V. *Tetrahedron: Asymmetry* **2003**, *14*, 189.

Michaelis–Arbuzov phosphonate synthesis

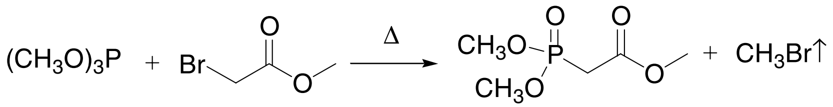
Phosphonate synthesis from the reaction of alkyl halides with phosphites.

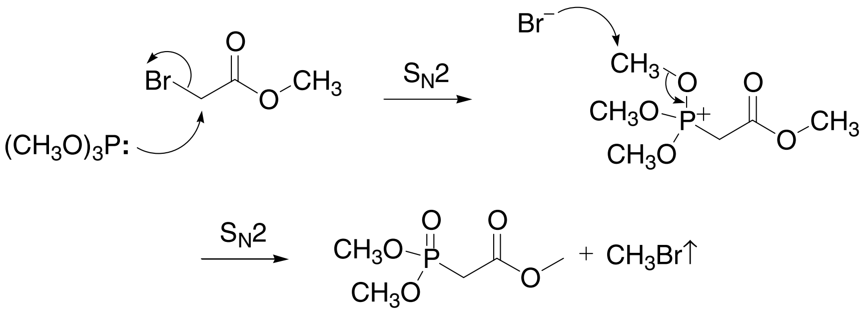
General scheme:



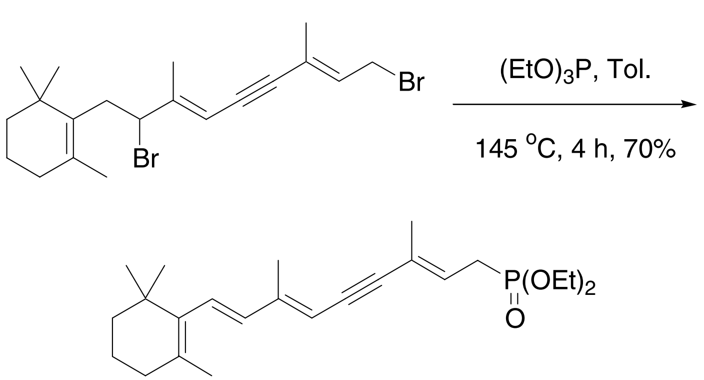
R^1 = alkyl, *etc*.; R_2 = alkyl, acyl, *etc*.; X = Cl, Br, I

For instance:

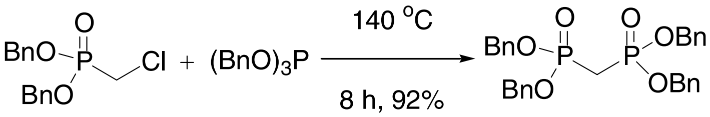




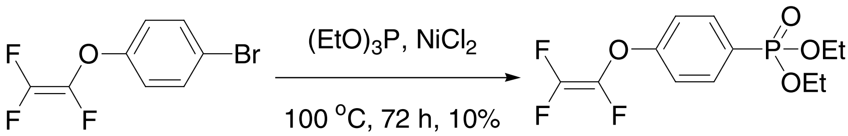
Example 1[3]



Example 2[13]



Example 3[14]

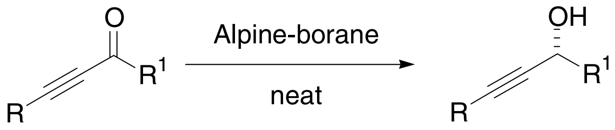


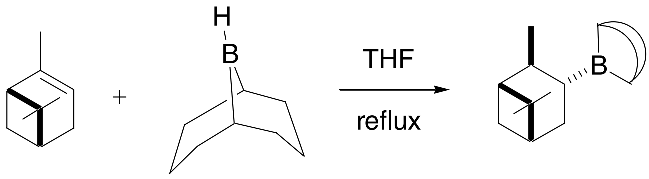
References

1. Michaelis, A.; Kaehne, R. *Ber.* **31,** 1048 (1898).
2. Arbuzov, A. E. *J. Russ. Phys. Chem. Soc.* **1906**, *38*, 687.
3. Surmatis, J. D.; Thommen, R. *J. Org. Chem.* **1969**, *34*, 559.
4. Gillespie, P.; Ramirez, F.; Ugi, I.; Marquarding, D. *Angew. Chem., Int. Ed. Engl.* **1973**, *12*, 91. (Review).
5. Saady, M.; Lebeau, L.; Mioskowski, C. *Tetrahedron Lett.* **1995**, *36*, 5183.
6. Kato, T.; Tejima, M.; Ebiike, H.; Achiwa, K. *Chem. Pharm. Bull.* **1996**, *44*, 1132.
7. Waschbűsch, R.; Carran, J.; Marinetti, A.; Savignac, P. *Synthesis* **1997**, 727.
8. Griffith, J. A.; McCauley, D. J.; Barrans, R. E., Jr.; Herlinger, A. W. *Synth. Commun.* **1998**, *28*, 4317.
9. Kiddle, J. J.; Gurley, A. F. *Phosphorus, Sulfur Silicon Relat. Elem.* **2000**, *160*, 195.
10. Bhattacharya, A. K.; Stolz, F.; Schmidt, R. R. *Tetrahedron Lett.* **2001**, *42*, 5393.
11. Nifantiev, E. E.; Khrebtova, S. B.; Kulikova, Y. V.; Predvoditelv, D. A.; Kukhareva, T. S.; Petrovskii, P. V.; Rose, M.; Meier, C. *Phosphorus, Sulfur Silicon Relat. Elem.* **2002**, *177*, 251.
12. Battaggia, S.; Vyle, J. S. *Tetrahedron Lett.* **2003**, *44*, 861.
13. Erker, T.; Handler, N. *Synthesis* **2004**, 668.
14. Souzy, R.; Ameduri, B.; Boutevin, B.; Virieux, D. *J. Fluorine Chem.* **2004**, *125*, 1317.
15. Kadyrov, A. A.; Silaev, D. V.; Makarov, K. N.; Gervits, L. L.; Röschenthaler, G.-V. *J. Fluorine Chem.* **2004**, *125*, 1407.

Midland reduction

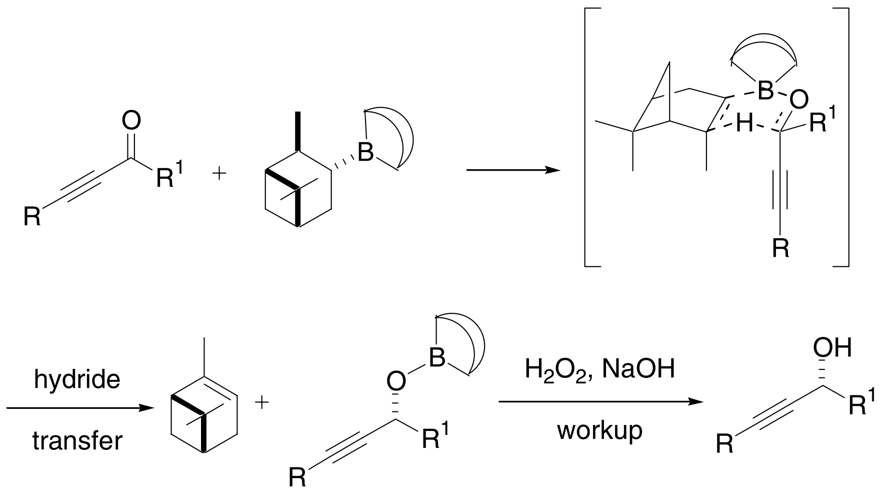
Asymmetric reduction of ketones using Alpine-borane®.
Alpine-borane® = *B*-isopinocampheyl-9-borabicyclo[3.3.1]nonane.



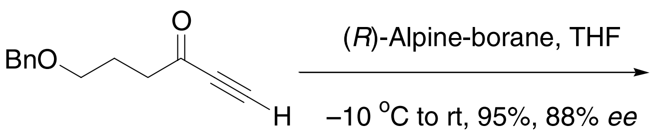


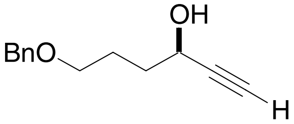
(1*R*)-(+)-α-pinene 9-BBN (*R*)-Alpine-borane

9-BBN = 9-borabicyclo[3.3.1]nonane

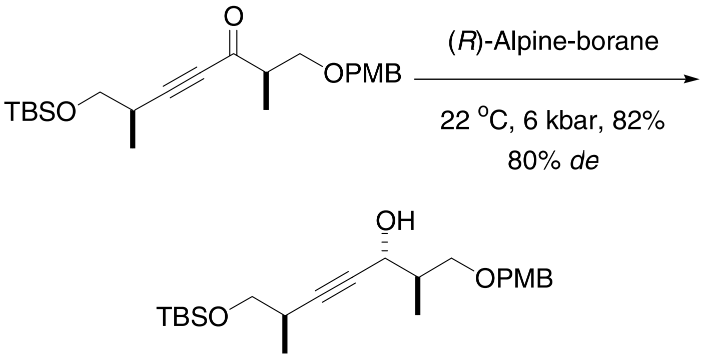


Example 1[6]





Example 2[7]

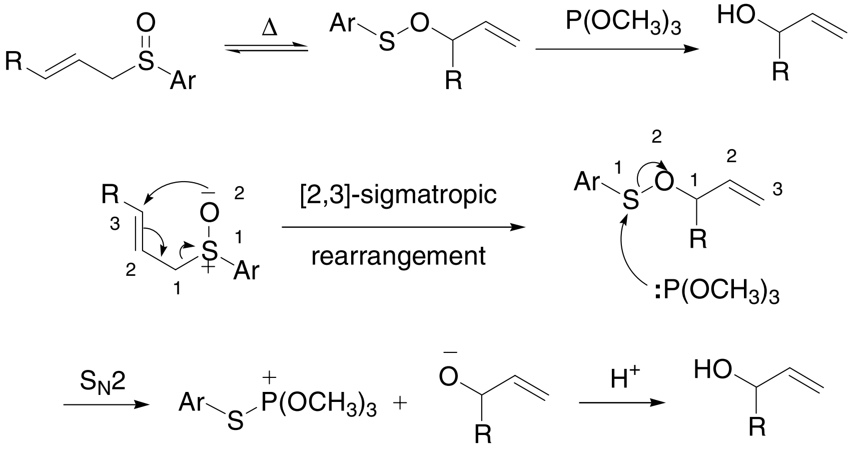


References

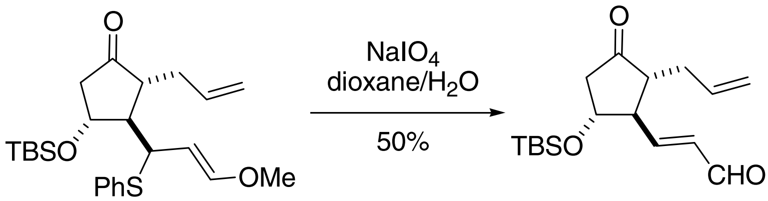
1. Midland, M. M.; Greer, S.; Tramontano, A.; Zderic, S. A. *J. Am. Chem. Soc.* **1979**, *101*, 2352. M. Mark Midland was a professor at the University of California, Riverside.
2. Midland, M. M.; McDowell, D. C.; Hatch, R. L.; Tramontano, A. *J. Am. Chem. Soc.* **1980**, *102*, 867.
3. Brown, H. C.; Pai, G. G.; Jadhav, P. K. *J. Am. Chem. Soc.* **1984**, *106*, 1531.
4. Brown, H. C.; Pai, G. G. *J. Org. Chem.* **1982**, *47*, 1606.
5. Singh, V. K. *Synthesis* **1992**, 605. (Review).
6. Williams, D. R.; Fromhold, M. G.; Earley, J. D. *Org. Lett.* **2001**, *3*, 2721.
7. Mulzer, J.; Berger, M. *J. Org. Chem.* **2004**, *69*, 891.

Mislow–Evans rearrangement

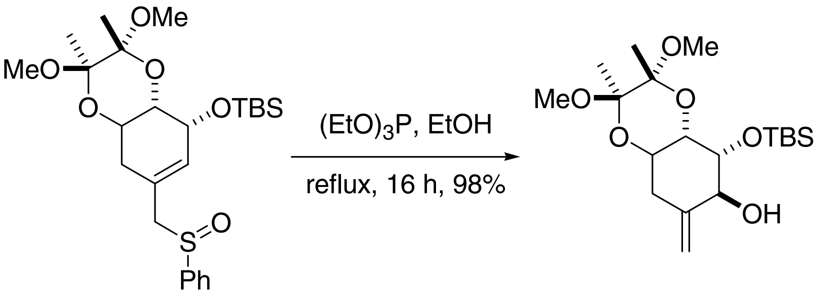
[2,3]-Sigmatropic rearrangement of allylic sulfoxide to allylic alcohol.



Example 1[6]



Example 2[11]



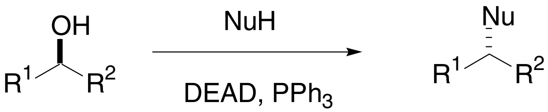
References

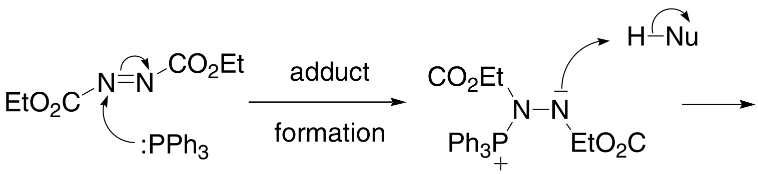
1. Tang, R.; Mislow, K. *J. Am. Chem. Soc.* **1970**, *92*, 2100.
2. Evans, D. A.; Andrews, G. C.; Sims, C. L. *J. Am. Chem. Soc.* **1971**, *93*, 4956.
3. Evans, D. A.; Andrews, G. C. *J. Am. Chem. Soc.* **1972**, *94*, 3672.

4. Evans, D. A.; Andrews, G. C. *Acc. Chem. Res.* **1974**, *7*, 147. (Review).
5. Masaki, Y.; Sakuma, K.; Kaji, K. *Chem. Pharm. Bull.* **1985**, *33*, 2531.
6. Sato, T.; Shima, H.; Otera, J. *J. Org. Chem.* **1995**, *60*, 3936.
7. Jones-Hertzog, D. K.; Jorgensen, W. L. *J. Am. Chem. Soc.* **1995**, *117*, 9077.
8. Jones-Hertzog, D. K.; Jorgensen, W. L. *J. Org. Chem.* **1995**, *60*, 6682.
9. Mapp, A. K.; Heathcock, C. H. *J. Org. Chem.* **1999**, *64*, 23.
10. Zhou, Z. S.; Flohr, A.; Hilvert, D. *J. Org. Chem.* **1999**, *64*, 8334.
11. Shinada, T.; Fuji, T.; Ohtani, Y.; Yoshida, Y.; Ohfune, Y. *Synlett* **2002**, 1341.
12. Aubele, D. L.; Wan, S.; Floreancig, P. E. *Angew. Chem. Int. Ed.* **2005**, *44*, 3485.

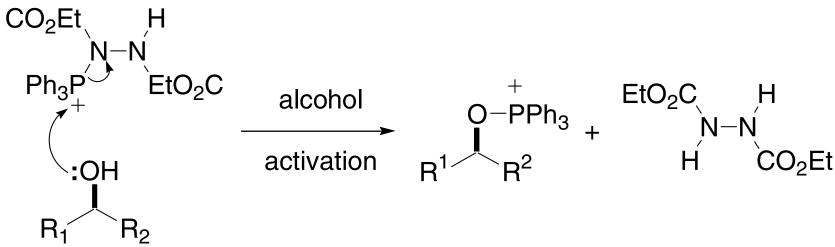
Mitsunobu reaction

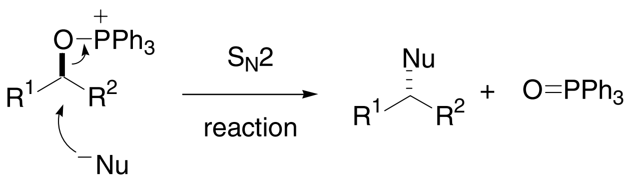
S_N2 inversion of an alcohol by a nucleophile using diethyl azodicarboxylate (DEAD) and triphenylphosphine.



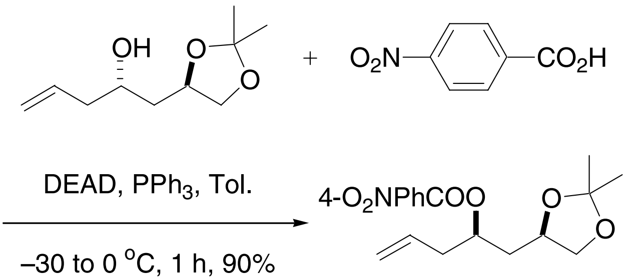


Diethyl azodicarboxylate (DEAD)

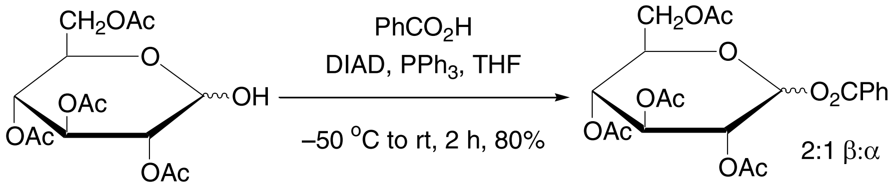




Example 1[4]



Example 2[3]

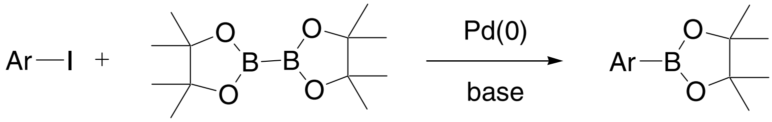


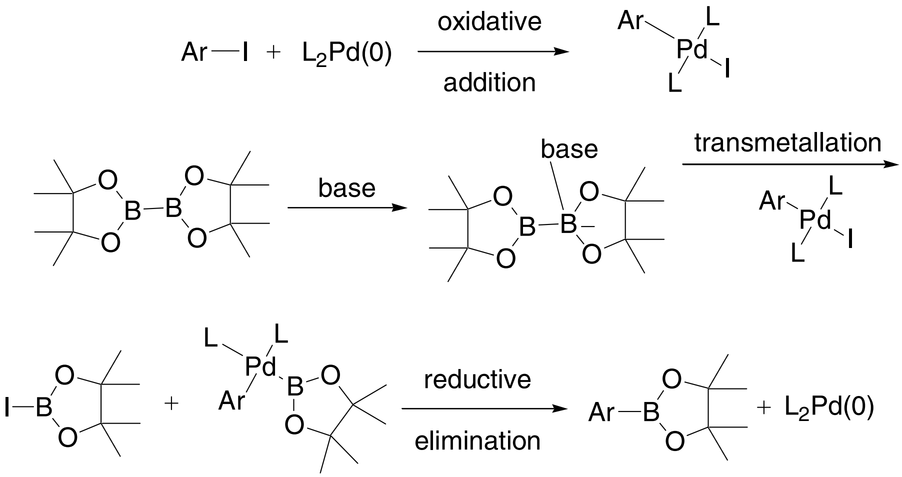
References

1. Mitsunobu, O.; Yamada, M. *Bull. Chem. Soc. Jpn.* **1967**, *40*, 2380.
2. Mitsunobu, O. *Synthesis* **1981**, 1. (Review).
3. Smith, A. B., III; Hale, K. J.; Rivero, R. A. *Tetrahedron Lett.* **1986**, *27*, 5813.
4. Kocieński, P. J.; Yeates, C.; Street, D. A.; Campbell, S. F. *J. Chem. Soc., Perkin Trans. 1*, **1987**, 2183.
5. Hughes, D. L. *Org. React.* **1992**, *42*, 335–656. (Review).
6. Hughes, D. L. *Org. Prep. Proc. Int.* **1996**, *28*, 127. (Review).
7. Barrett, A. G. M.; Roberts, R. S.; Schroeder, J. *Org. Lett.* **2000**, *2*, 2999.
8. Racero, J. C.; Macias-Sanchez, A. J.; Herandez-Galen, R.; Hitchcock, P. B.; Hanson, J./ R.; Collado, I. G. *J. Org. Chem.* **2000**, *65*, 7786.
9. Langlois, N.; Calvez, O. *Tetrahedron Lett.* **2000**, *41*, 8285.
10. Charette, A. B.; Janes, M. K.; Boezio, A. A. *J. Org. Chem.* **2001**, *66*, 2178.
11. Ahn, C.; Correia, R.; DeShong, P. *J. Org. Chem.* **2002**, *67*, 1751.
12. Dandapani, S.; Curran, D. P. *Tetrahedron* **2002**, *58*, 3855.
13. Bitter, I.; Csokai, V. *Tetrahedron Lett.* **2003**, *44*, 2261.

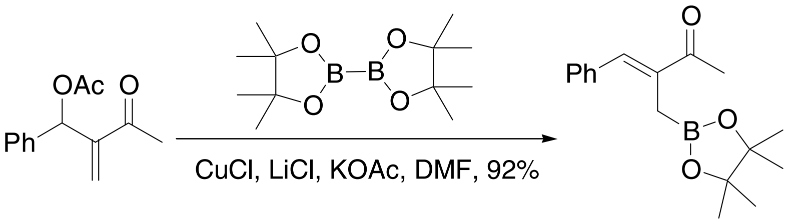
Miyaura borylation

Palladium-catalyzed reaction of aryl halides with diboron reagent to produce aryl-boronates. Also known as Hosomi–Miyaura borylation.

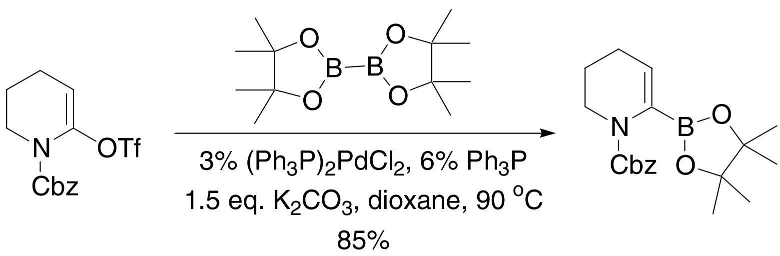




Example 1[11]



Example 2[12]

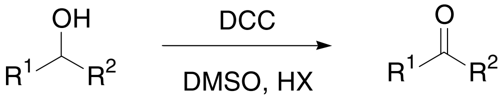


References

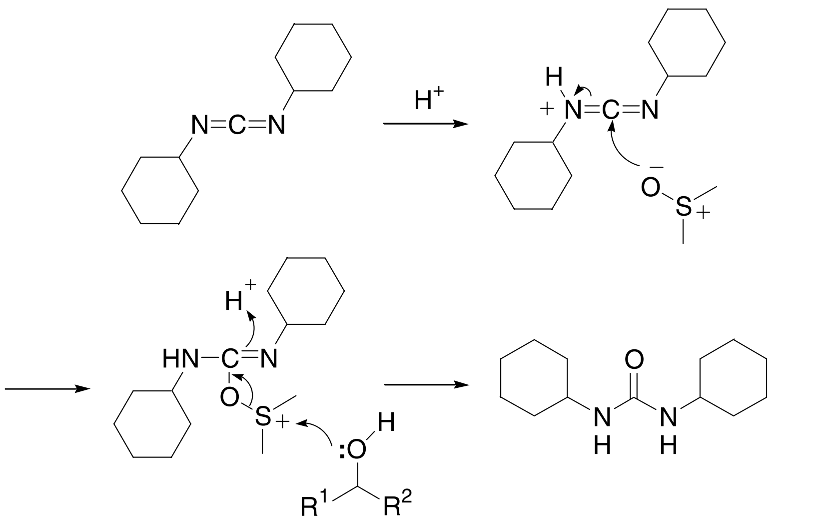
1. Ishiyama, T.; Murata, M.; Miyaura, N. *J. Org. Chem.* **1995**, *60*, 7508.
2. Miyaura, N.; Suzuki, A. *Chem. Rev.* **1995**, *95*, 2457–2483. (Review).
3. Suzuki, A. *J. Organomet. Chem.* **1995**, *576*, 147. (Review).
4. Carbonnelle, A.-C.; Zhu, J. *Org. Lett.* **2000**, *2*, 3477.
5. Willis, D. M.; Strongin, R. M. *Tetrahedron Lett.* **2000**, *41*, 8683.
6. Takahashi, K.; Takagi, J.; Ishiyama, T.; Miyaura, N. *Chem. Lett.* **2000**, 126.
7. Todd, M. H.; Abell, C. *J. Comb. Chem.* **2001**, *3*, 319.
8. Giroux, A. *Tetrahedron Lett.* **2003**, *44*, 233.
9. Arterburn, J. B.; Bryant, B. K.; Chen, D. *Chem. Commun.* **2003**, 1890.
10. Kabalka, G. W.; Yao, M.-L. *Tetrahedron Lett.* **2003**, *44*, 7885.
11. Ramachandran, P. V.; Pratihar, D.; Biswas, D.; Srivastava, A.; Reddy, M. V. R. *Org. Lett.* **2004**, *6*, 481.
12. Occhiato, E. G.; Lo Galbo, F.; Guarna, A. *J. Org. Chem.* **2005**, *70*, 7324.

Moffatt oxidation

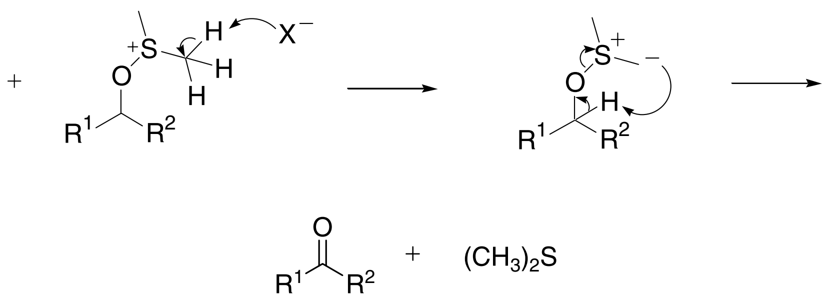
Oxidation of alcohols using DCC and DMSO, also known as "Pfitzner–Moffatt oxidation".



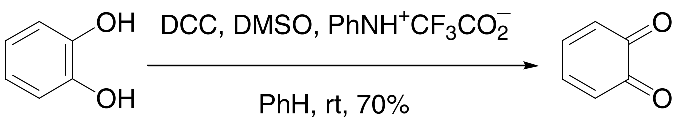
DCC, 1,3-dicyclohexylcarbodiimide



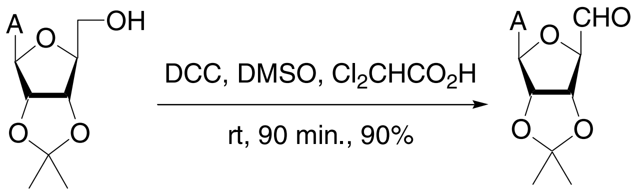
1,3-dicyclohexylurea



Example 1[3]



Example 2[10]



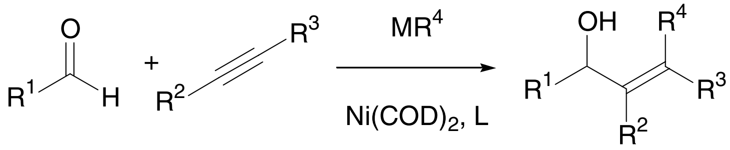
A = adenosine

References

1. Pfitzner, K. E.; Moffatt, J. G. *J. Am. Chem. Soc.* **1963**, *85*, 3027.
2. Harmon, R. E.; Zenarosa, C. V.; Gupta, S. K. *J. Org. Chem.* **1970**, *35*, 1936.
3. Schobert, R. *Synthesis* **1987**, 741.
4. Liu, H. J.; Nyangulu, J. M. *Tetrahedron Lett.* **1988**, *29*, 3167.
5. Tidwell, T. T. *Org. React.* **1990**, *39*, 297−572. (Review).
6. Gordon, J. F.; Hanson, J. R.; Jarvis, A. G.; Ratcliffe, A. H. *J. Chem. Soc., Perkin Trans. 1*, **1992**, 3019.
7. Krysan, D. J.; Haight, A. R.; Lallaman, J. E. *Org. Prep. Proced. Int.* **1993**, *25*, 437.
8. Wnuk, S. F.; Ro, B.-O.; Valdez, C. A.; Lewandowska, E.; Valdez, N. X.; Sacasa, P. R.; Yin, D.; Zhang, J.; Borchardt, R. T.; De Clercq, E. *J. Med. Chem.* **2002**, *45*, 2651.
9. Adak, A. K. *Synlett* **2004**, 1651.
10. Wang, M.; Zhang, J.; Andrei, D.; Kuczera, K.; Borchardt, R. T.; Wnuk, S. F. *J. Med. Chem.* **2005**, *48*, 3649.

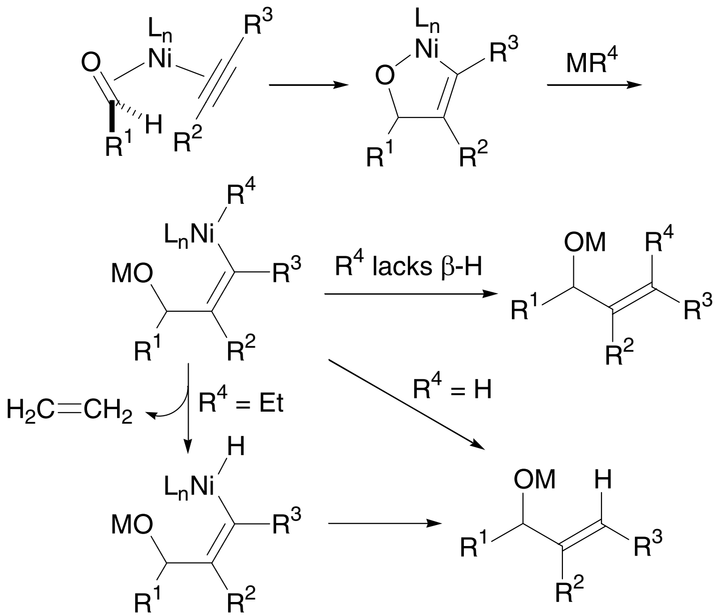
Montgomery coupling

Oxidative nickel-catalyzed coupling of aldehydes and alkynes to generate allylic alcohols. Intermolecular and intramolecular examples are both effective, and the transmetalating agent (MR^4) may be an organosilane, organoborane, organozinc, or alkenylzirconium.[1–5]

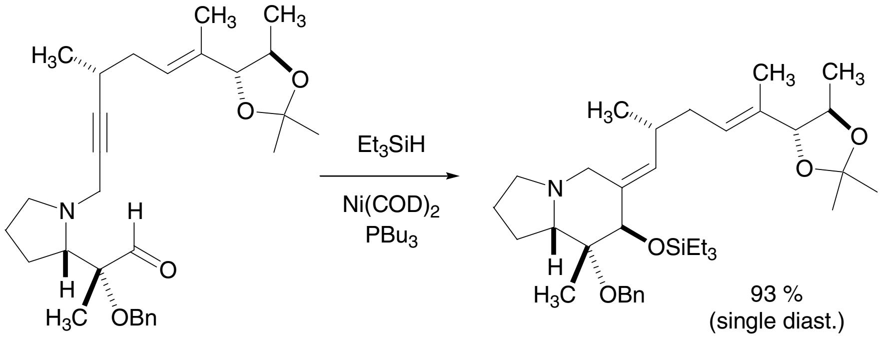


R^1, R^3 = alkyl or aryl
R^2, R^4 = alkyl, aryl, or H

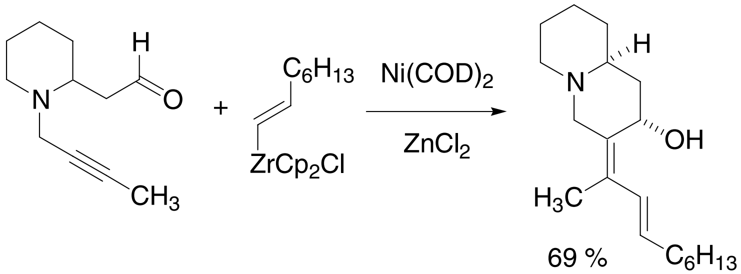
The mechanism was proposed to involve the formation of a nickel metallacycle by the oxidative cyclization of Ni(0) with the aldehyde and alkyne, followed by conversion of the metallacycle to product by a transmetalation/reductive elimination sequence. If R^4 possesses a β-hydrogen, then β-hydride elimination after the transmetalation step generates the product with R^4 = H in some instances. The mechanism was shown to be ligand dependent, and the mechanism depicted below is undoubtedly oversimplified.[4]



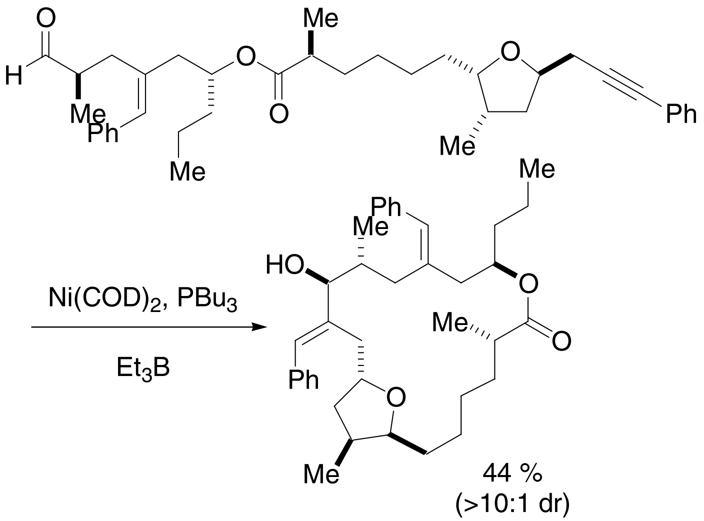
Example 1[6]



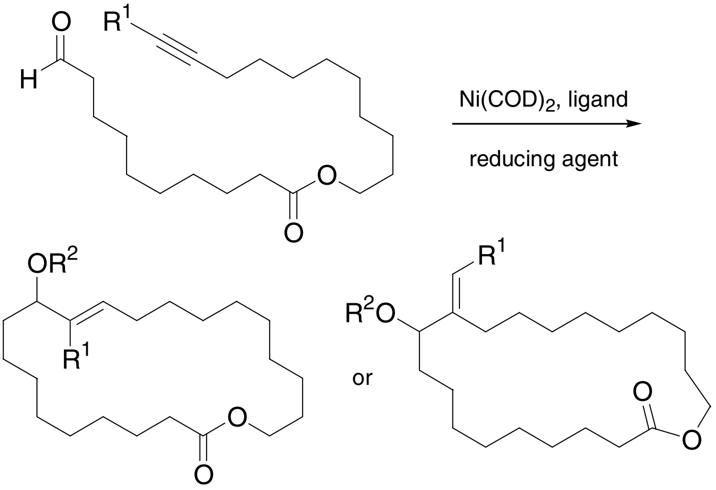
Example 2[7]

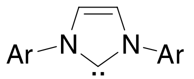


Example 3[8]



Example 4[9]



ligand	reducing agent	yield (ratio)
PMe_3	Et_3B	89 % (4.5:1)
 Ar = 2,6 di-isopropylphenyl	Et_3SiH	93 % (1:5)

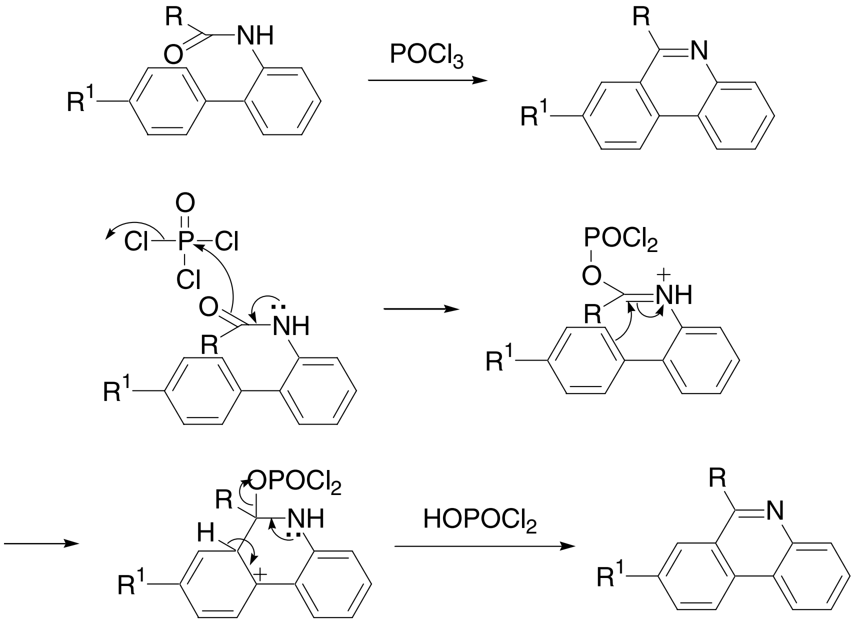
A number of related processes involving alternate π-systems including enones, dienes, and allenes have been reported.[10]

References

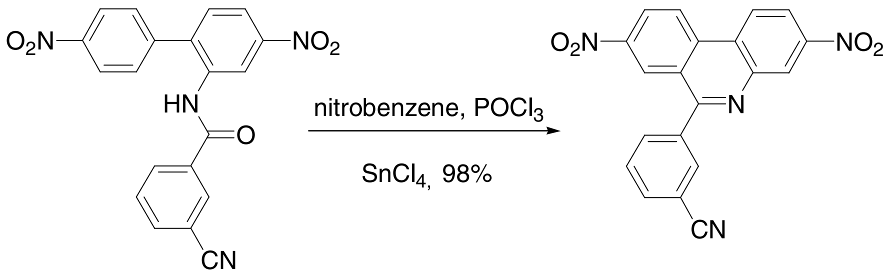
1. Oblinger, E.; Montgomery, J. *J. Am. Chem. Soc.* **1997**, *119*, 9065.
2. Tang, X. Q.; Montgomery, J. *J. Am. Chem. Soc.* **1999**, *121*, 6098.
3. Huang, W.-S.; Chan, J.; Jamison, T. F. *Org. Lett.* **2000**, *2*, 4221.
4. Mahandru, G. M.; Liu, G.; Montgomery, J. *J. Am. Chem. Soc.* **2004**, *126*, 3698.
5. Miller, K. M.; Huang, W.-S.; Jamison, T. F. *J. Am. Chem. Soc.* **2003**, *125*, 3442.
6. Tang, X. Q.; Montgomery, J. *J. Am. Chem. Soc.* **2000**, *122*, 6950.
7. Ni, Y.; Amarasinghe, K. K. D.; Montgomery, J. *Org. Lett.* **2002**, *4*, 1743.
8. Colby, E. A.; O'Brien, K. C.; Jamison, T. F. *J. Am. Chem. Soc.* **2004**, *126*, 998.
9. Knapp-Reed, B.; Mahandru, G. M.; Montgomery, J. *J. Am. Chem. Soc.* **2005**, *127*, 13156.
10. Montgomery, J. *Angew. Chem. Int. Ed.* **2004**, *43*, 3890. (Review).

Morgan–Walls reaction

Phenanthridine cyclization by dehydrative ring closure of acyl-*o*-aminobiphenyls with phosphorus oxychloride in boiling nitrobenzene.

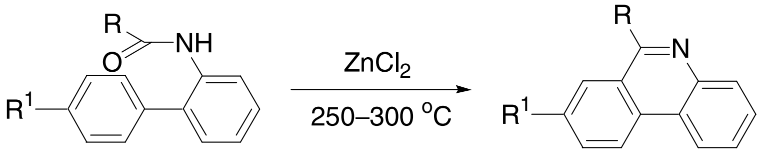


Example 1[10]

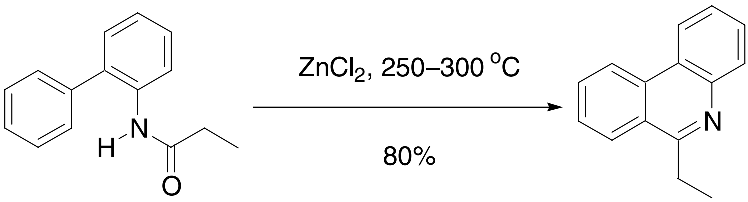


Pictet–Hubert reaction

Phenanthridine cyclization by dehydrative ring closure of acyl-*o*-aminobiphenyls on heating with zinc chloride at 250–300 °C.



Example 2[7]

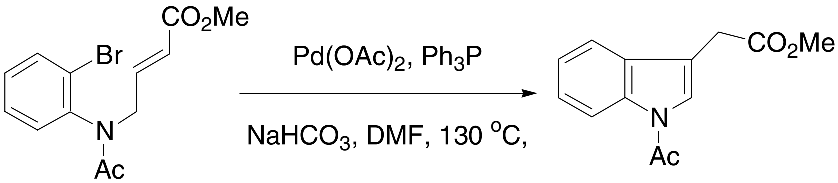


References

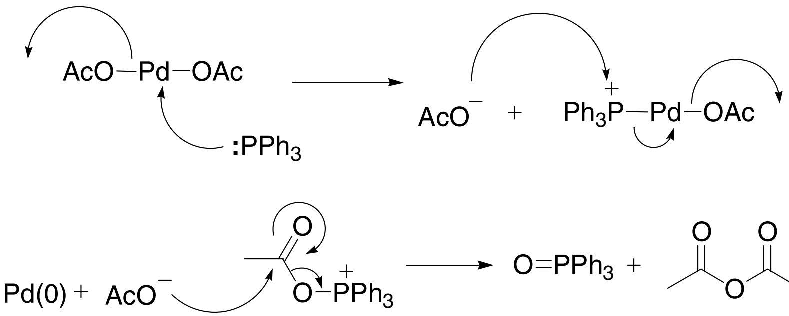
1. Pictet, A.; Hubert, A. *Ber. Dtsch. Chem. Ges.* **1896**, *29*, 1182.
2. Morgan, C. T.; Walls, L. P. *J. Chem. Soc.* **1931**, 2447.
3. Morgan, C. T.; Walls, L. P. *J. Chem. Soc.* **1932**, 2225.
4. Gilman, H.; Eisch, J. *J. Am. Chem. Soc.* **1957**, *79*, 4423.
5. Hollingsworth, B. L.; Petrow, V. *J. Chem. Soc.* **1961**, 3664.
6. Nagarajan, K.; Shah, R. K. *Indian J. Chem.* **1972**, *10*, 450.
7. Fodor, G.; Nagubandi, S. *Tetrahedron* **1980**, 1279.
8. Sivasubramanian, S.; Muthusubramanian, S.; Ramasamy, S.; Arumugam, N. *Indian J. Chem., Sect. B* **1981**, *20B*, 552.
9. Atwell, G. J.; Baguley, B. C.; Denny, W. A. *J. Med. Chem.* **1988**, *31*, 774.
10. Peytou, V.; Condom, R.; Patino, N.; Guedj, R.; Aubertin, A.-M.; Gelus, N.; Bailly, C.; Terreux, R.; Cabrol-Bass, D. *J. Med. Chem.* **1999**, *42*, 4042.
11. Holsworth, D. D. *Pictet–Hubert Reaction* In *Name Reactions in Heterocycl. Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 465–468. (Review).

Mori–Ban indole synthesis

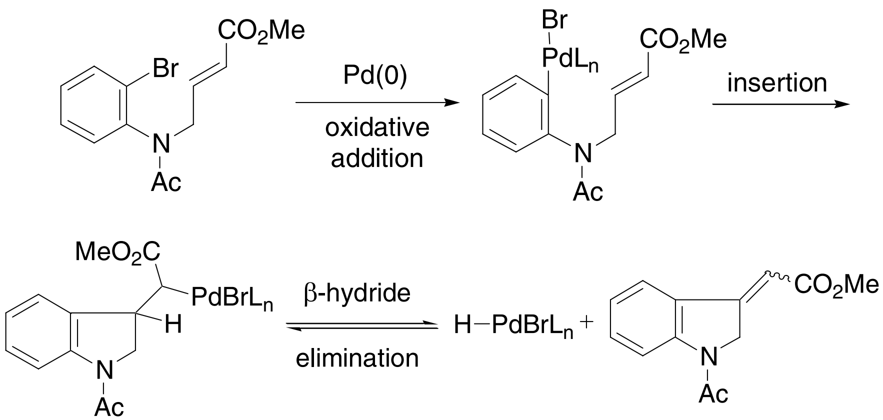
Intramolecular Heck reaction of *o*-halo-aniline with pendant olefin to prepare indole.

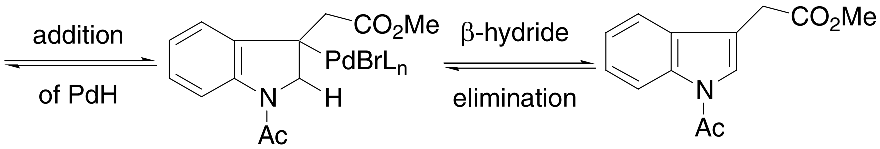


Reduction of $Pd(OAc)_2$ to Pd(0) using Ph_3P:



Mori–Ban indole synthesis:

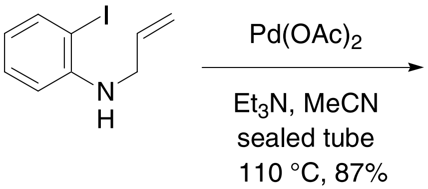




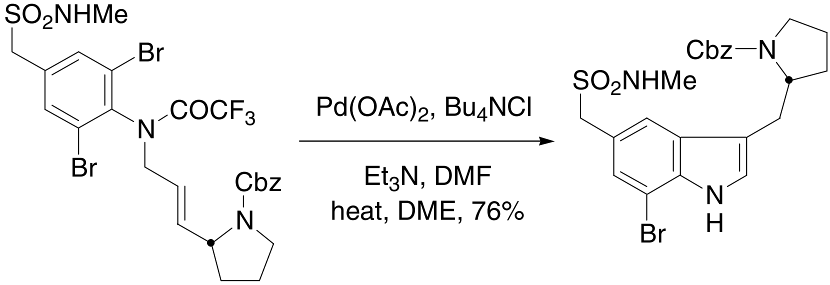
Regeneration of Pd(0):

$$\mathrm{H{-}PdBrL_n + NaHCO_3 \longrightarrow Pd(0) + NaBr + H_2O + CO_2\uparrow}$$

Example 1[1]



Example 2[12]

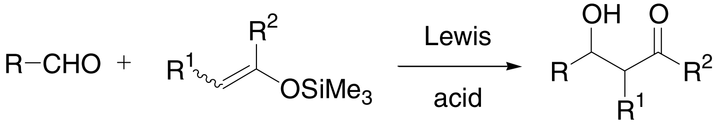


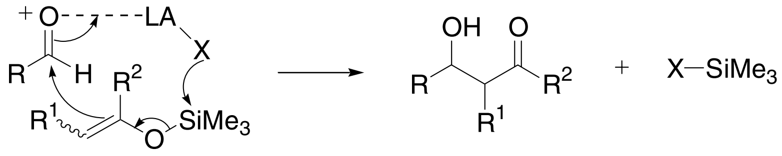
References

1. Mori–Ban indole synthesis, (a) Mori, M.; Chiba, K.; Ban, Y. *Tetrahedron Lett.* **1977**, *12*, 1037; (b) Ban, Y.; Wakamatsu, T.; Mori, M. *Heterocycles* **1977**, *6,* 1711.
2. Reduction of Pd(OAc)$_2$ to Pd(0), (a) Amatore, C.; Carre, E.; Jutand, A.; M'Barki, M. A.; Meyer, G. *Organometallics* **1995**, *14*, 5605; (b) Amatore, C.; Carre, E.; M'Barki, M. A. *Organometallics* **1995**, *14*, 1818; (c) Amatore, C.; Jutand, A.; M'Barki, M. A. *Organometallics* **1992**, *11*, 3009; (d) Amatore, C.; Azzabi, M.; Jutand, A. *J. Am. Chem. Soc.* **1991**, *113,* 8375.
3. Macor, J. E.; Ogilvie, R. J.; Wythes, M. J. *Tetrahedron Lett.* **1996**, *37*, 4289.
4. Li, J. J. *J. Org. Chem.* **1999**, *64,* 8425.
5. Gelpke, A. E. S.; Veerman, J. J. N.; Goedheijt, M. S.; Kamer, P. C. J.; Van Leuwen, P. W. N. M.; Hiemstra, H. *Tetrahedron* **1999**, *55,* 6657.
6. Sparks, S. M.; Shea, K. J. *Tetrahedron Lett.* **2000**, *41*, 6721.
7. Bosch, J.; Roca, T.; Armengol, M.; Fernandez-Forner, D. *Tetrahedron* **2001**, *57,* 1041.

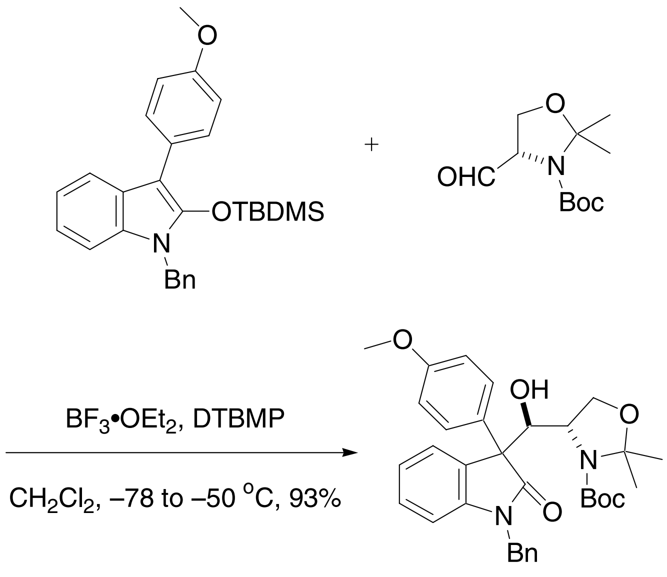
Mukaiyama aldol reaction

Lewis acid-catalyzed aldol condensation of aldehyde and silyl enol ether.

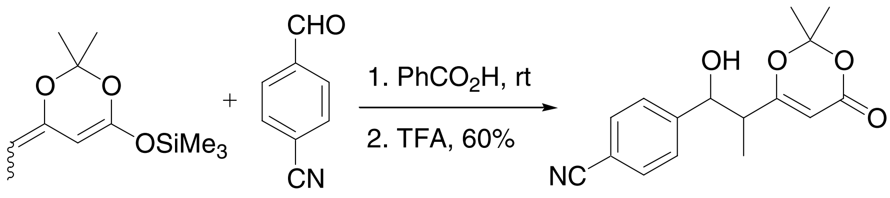




Example 1[14]



Example 2[15]

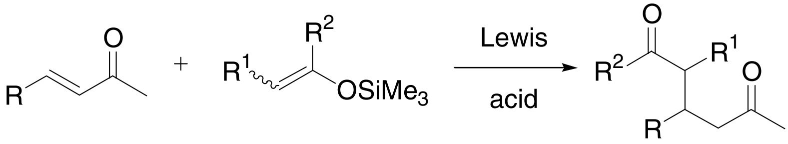


References

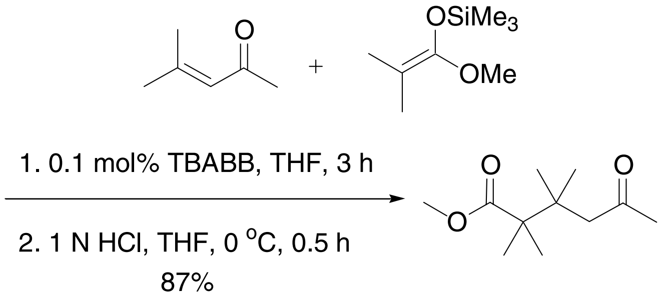
1. Mukaiyama, T.; Narasaka, K.; Banno, K. *Chem. Lett.* **1973**, 1011.
2. Mukaiyama, T.; Narasaka, K.; Banno, K. *J. Am. Chem. Soc.* **1974**, *96*, 7503.
3. Langer, P.; Koehler, V. *Org. Lett.* **2000**, *2*, 1597.
4. Matsukawa, S.; Okano, N.; Imamoto, T. *Tetrahedron Lett.* **2000**, *41*, 103.
5. Delas, C.; Blacque, O.; Moise, C. *Tetrahedron Lett.* **2000**, *41*, 8269.
6. Ishihara, K.; Kondo, S.; Yamamoto, H. *J. Org. Chem.* **2000**, *65*, 9125.
7. Kumareswaran, R.; Reddy, B. G.; Vankar, Y. D. *Tetrahedron Lett.* **2001**, *42*, 7493.
8. Armstrong, A.; Critchley, T. J.; Gourdel-Martin, M.-E.; Kelsey, R. D.; Mortlock, A. A. *J. Chem. Soc., Perkin Trans. 1* **2002**, 1344.
9. Clézio, I. L.; Escudier, J.-M.; Vigroux, A. *Org. Lett.* **2003**, *5*, 161.
10. Muñoz-Muñiz, O.; Quintanar-Audelo, M.; Juaristi, E. *J. Org. Chem.* **2003**, *68*, 1622.
11. Ishihara, K.; Yamamoto, H. *Boron and Silicon Lewis Acids for Mukaiyama Aldol Reactions*. In *Modern Aldol Reactions* Mahrwald, R. (ed.), **2004**, 25–68. (Review).
12. Mukaiyama, T. *Angew. Chem., Int. Ed.* **2004**, *43*, 5590–5614. (Review).
13. Li, H.-J.; Tian, H.-Y.; Wu, Y.-C.; Chen, Y.-J.; Liu, L.; Wang, D.; Li, C.-J. *Adv. Synth. Cat.* **2005**, *347*, 1247.
14. Adhikari, S.; Caille, S.; Hanbauer, M.; Ngo, V. X.; Overman, L. E. *Org. Lett.* **2005**, *7*, 2795.
15. Acocella, M. R.; Massa, A.; Palombi, L.; Villano, R.; Scettri, A. *Tetrahedron Lett.* **2005**, *46*, 6141.

Mukaiyama Michael addition

Lewis acid-catalyzed Michael addition of silyl enol ether to α,β-unsaturated system.

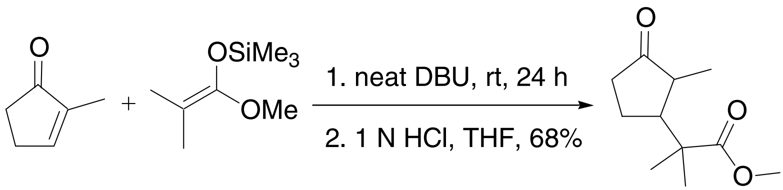


Example 1[4]



TBABB = tetra-*n*-butylammonium bibenzoate

Example 2[7]



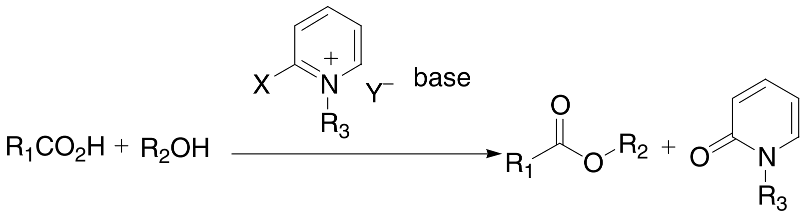
References

1. Mukaiyama, T.; Narasaka, K.; Banno, K. *Chem. Lett.* **1973**, 1011.
2. Mukaiyama, T.; Narasaka, K.; Banno, K. *J. Am. Chem. Soc*. **1974**, *96*, 7503.
3. Mukaiyama, T. *Angew. Chem., Int. Ed.* **2004**, *43*, 5590–5614. (Review).
4. Gnaneshwar, R.; Wadgaonkar, P. P.; Sivaram, S. *Tetrahedron Lett.* **2003**, *44*, 6047.
5. Wang, X.; Adachi, S.; Iwai, H.; Takatsuki, H.; Fujita, K.; Kubo, M.; Oku, A.; Harada, T. *J. Org. Chem*. **2003**, *68*, 10046.
6. Jaber, N.; Assie, M.; Fiaud, J.-C.; Collin, J. *Tetrahedron* **2004**, *60*, 3075.
7. Shen, Z.-L.; Ji, S.-J.; Loh, T.-P. *Tetrahedron Lett.* **2005**, *46*, 507.
8. Wang, W.; Li, H.; Wang, J. *Org. Lett.* **2005**, *7*, 1637.

Mukaiyama reagent

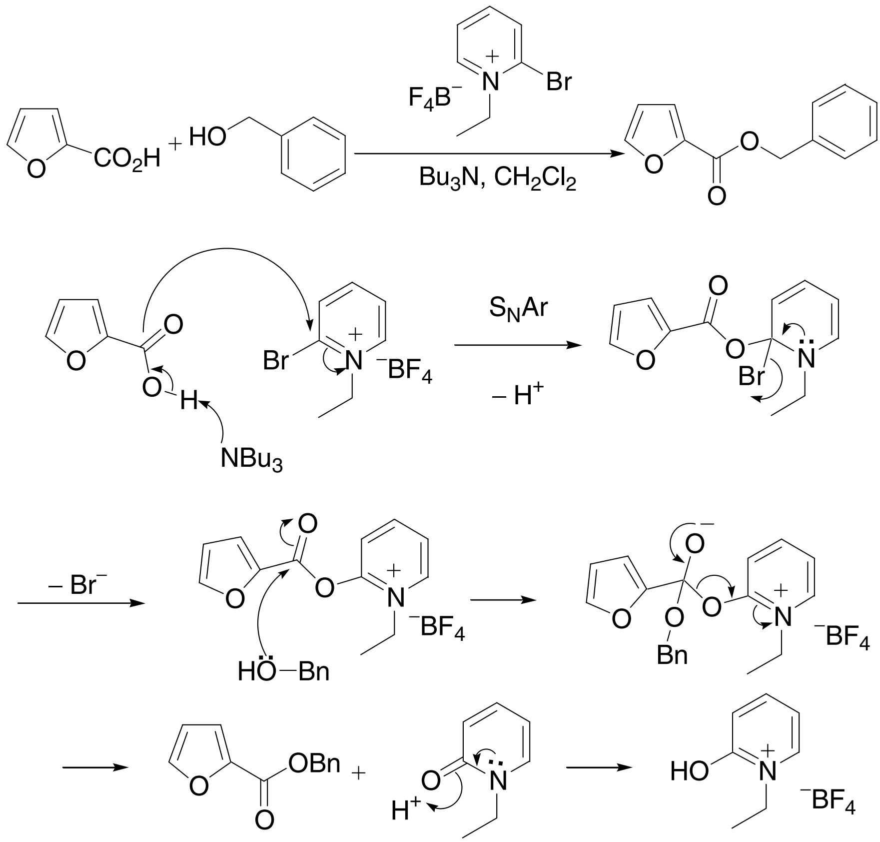
Mukaiyama reagent such as 2-chloro-1-methyl-pyridinium iodide for esterification or amide formation.

General scheme:



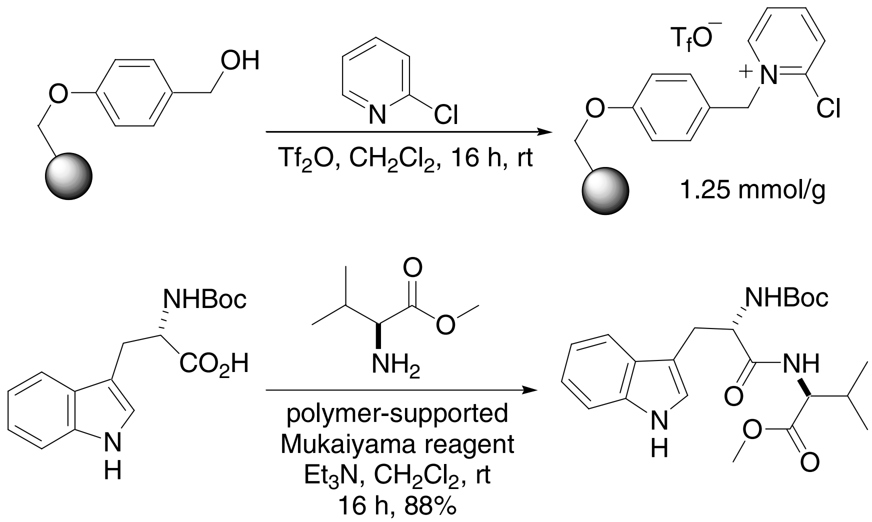
X = F, Cl, Br

Example 1[3]



Amide formation using the Mukaiyama reagent follows a similar mechanistic pathway.[4]

Example 2, polymer-supported Mukaiyama reagent[8]

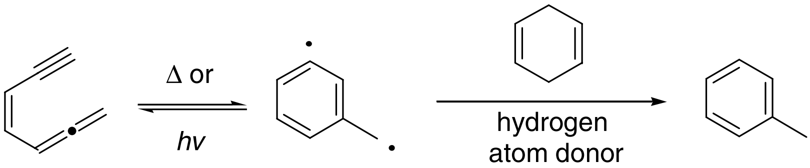


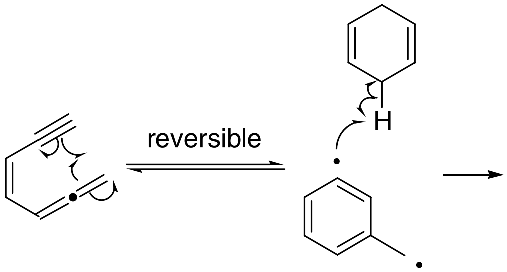
References

1. Mukaiyama, T.; Usui, M.; Shimada, E.; Saigo, K. *Chem. Lett.* **1975**, 1045.
2. Hojo, K.; Kobayashi, S.; Soai, K.; Ikeda, S.; Mukaiyama, T. *Chem. Lett.* **1977**, 635.
3. Mukaiyama, T. *Angew. Chem., Int. Ed.* **1979**, *18*, 707.
4. For amide formation, see: Huang, H.; Iwasawa, N.; Mukaiyama, T. *Chem. Lett.* **1984**, 1465.
5. Nicolaou, K. C.; Bunnage, M. E.; Koide, K. *J. Am. Chem. Soc.* **1994**, *116*, 8402.
6. Yong, Y. F.; Kowalski, J. A.; Lipton, M. A. *J. Org. Chem.* **1997**, *62*, 1540.
7. Folmer, J. J.; Acero, C.; Thai, D. L.; Rapoport, H. *J. Org. Chem.* **1998**, *63*, 8170.
8. Crosignani, S.; Gonzalez, J.; Swinnen, D. *Org. Lett.* **2004**, *6*, 4579.
9. Mashraqui, S. H.; Vashi, D.; Mistry, H. D. *Synth. Commun.* **2004**, *334*, 3129.
10. Donati, D.; Morelli, C.; Taddei, M. *Tetrahedron Lett.* **2005**, *46*, 2817.

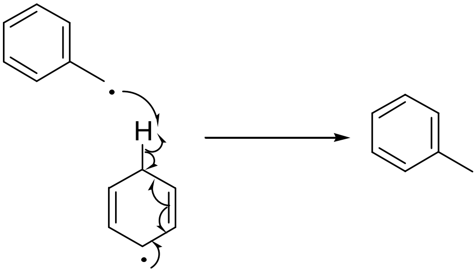
Myers–Saito cyclization

Cf. Bergman cyclization and Schmittel cyclization.

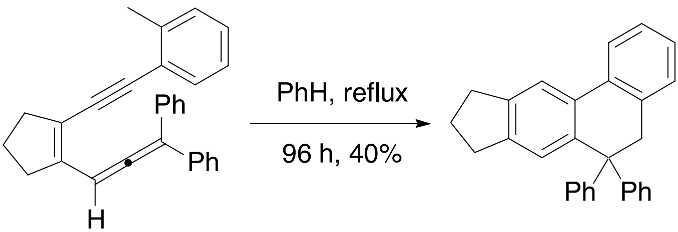




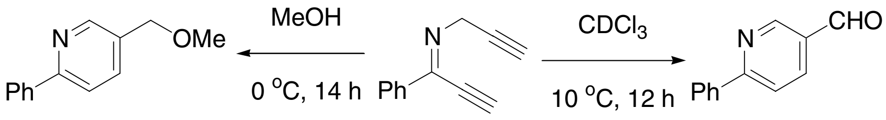
allenyl enyne　　　　　　　　diradical



Example 1[6]



Example 2, aza-Myers–Saito reaction[16]

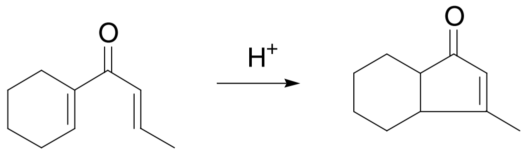


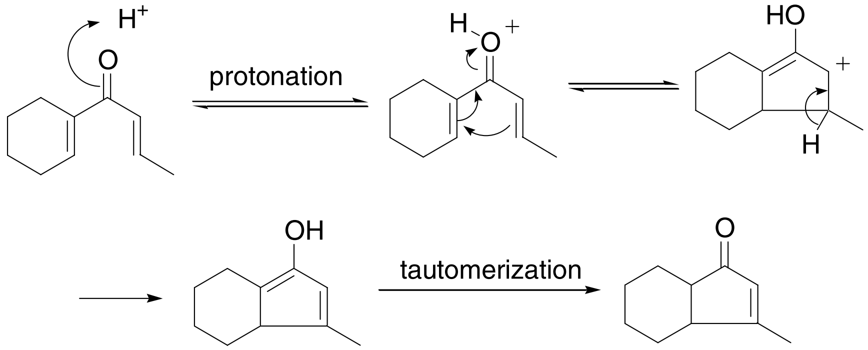
References

1. Myers, A. G.; Proteau, P. J.; Handel, T. M. *J. Am. Chem. Soc.* **1988**, *110,* 7212.
2. Saito, K.; Watanabe, T.; Takahashi, K. *Chem. Lett.* **1989**, 2099.
3. Saito, I.; Nagata, R.; Yamanaka, H.; Murahashi, E. *Tetrahedron Lett.* **1990**, *31* 2907.
4. Myers, A. G.; Dragovich, P. S.; Kuo, E. Y. *J. Am. Chem. Soc.* **1992**, *114,* 9369.
5. Schmittel, M.; Strittmatter, M.; Kiau, S. *Tetrahedron Lett*. **1995**, *36*, 4975.
6. Schmittel, M.; Steffen, J.-P.; Auer, D.; Maywald, M. *Tetrahedron Lett*. **1997**, *38*, 6177.
7. Engels, B.; Lennartz, C.; Hanrath, M.; Schmittel, M.; Strittmatter, M. *Angew. Chem., Int. Ed*. **1998**, *37*, 1960.
8. Ferri, F.; Bruckner, R.; Herges, R. *New J. Chem*. **1998**, *22*, 531.
9. Cramer, C. J.; Squires, R. R. *Org. Lett*. **1999**, *1*, 215.
10. Bruckner, R; Suffert, J. *Synlett* **1999**, 657–679. (Review).
11. Kim, C.-S.; Diez, C.; Russell, K. C. *Chem. Eur. J*. **2000**, *6*, 1555.
12. Cramer, C. J.; Kormos, B. L.; Seierstad, M.; Sherer, E. C.; Winget, P. *Org. Lett*. **2001**, *3*, 1881.
13. Stahl, F.; Moran, D.; Schleyer, P. von R.; Prall, M.; Schreiner, P. R. *J. Org. Chem.* **2002**, *67*, 1453.
14. Musch, P. W; Remenyi, C.; Helten, H.; Engels, B. *J. Am. Chem. Soc.* **2002**, *124*, 1823.
15. Bui, B. H.; Schreiner, P. R. *Org. Lett*. **2003**, *5*, 4871.
16. Feng, L.; Kumar, D.; Birney, D. M.; Kerwin, S. M. *Org. Lett*. **2004**, *6*, 2059.
17. Schmittel, M.; Mahajan, A. A.; Bucher, G. *J. Am. Chem. Soc.* **2005**, *127*, 5324.

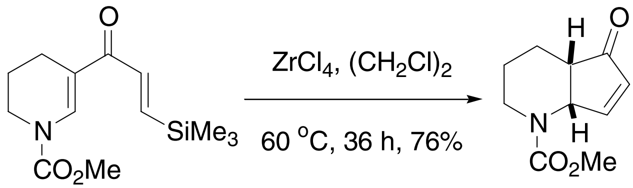
Nazarov cyclization

Acid-catalyzed electrocyclic formation of cyclopentenone from di-vinyl ketone.

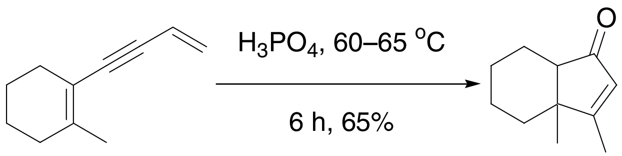




Example 1[2]



Example 2, cyclization of *in situ* generated di-vinyl ketone[12]



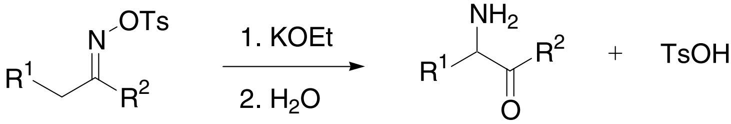
References

1. Nazarov, I. N.; Torgov, I. B.; Terekhova, L. N. *Bull. Acad. Sci. (USSR)* **1942**, 200. I. N. Nazarov (1900−1957) discovered this reaction in 1942 in Russia.
2. Denmark, S. E.; Habermas, K. L.; Hite, G. A. *Helv. Chim. Acta* **1988**, *71*, 2821.
3. Habermas, K. L.; Denmark, S. E.; Jones, T. K. *Org. React.* **1994**, *45,* 1−158. (Review).

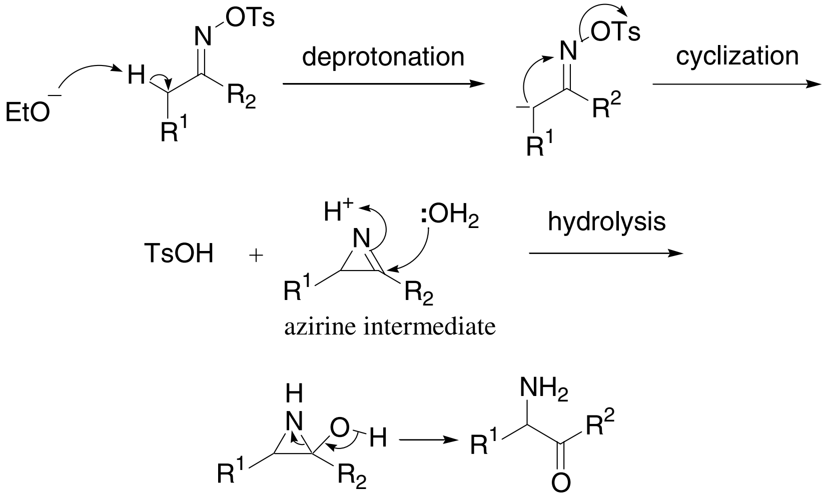
4. Kuroda, C.; Koshio, H.; Koito, A.; Sumiya, H.; Murase, A.; Hitono, Y. *Tetrahedron* **2000**, *56,* 6441.
5. Giese, S.; Kastrup, L.; Stiens, D.; West, F. G. *Angew. Chem., Int. Ed*. **2000**, *39*, 1970.
6. Kim, S.-H.; Cha, J. K. *Synthesis* **2000**, 2113.
7. Giese, S.; West, F. G. *Tetrahedron* **2000**, *56*, 10221.
8. Fernández M., A.; Martin de la Nava, E. M.; González, R. R. *Tetrahedron* **2001**, *57*, 1049.
9. Harmata, M.; Lee, D. R. *J. Am. Chem. Soc*. **2002**, *124*, 14328.
10. Leclerc, E.; Tius, M. A. *Org. Lett.* **2003**, *5*, 1171.

Neber rearrangement

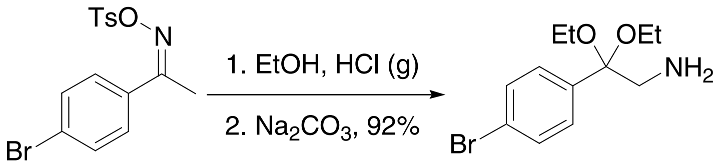
α-Aminoketone from tosyl ketoxime and base.



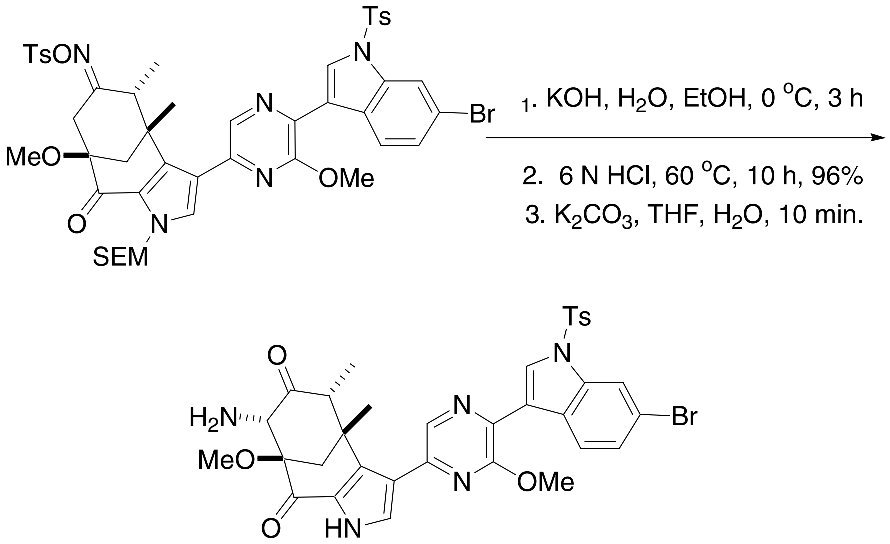
ketoxime α-aminoketone



Example 1[5]



Example 2[15]

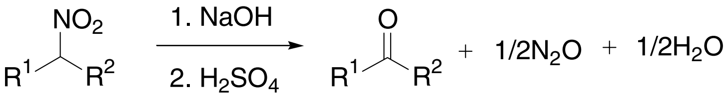


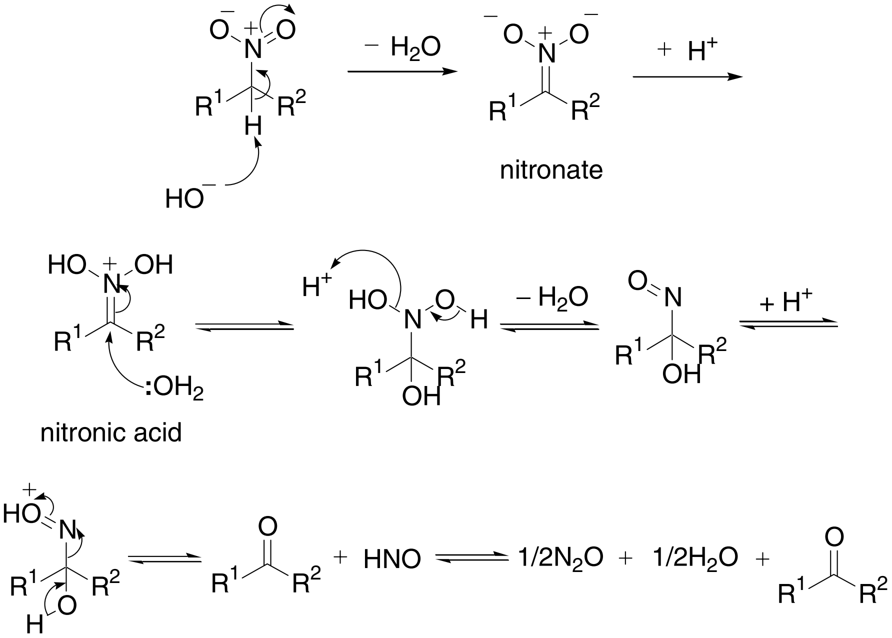
References

1. Neber, P. W.; v. Friedolsheim, A. *Justus Liebigs Ann. Chem.* **1926**, *449*, 109.
2. O'Brien, C. *Chem. Rev.* **1964**, *64*, 81. (Review).
3. Kakehi, A.; Ito, S.; Manabe, T.; Maeda, T.; Imai, K. *J. Org. Chem.* **1977**, *42*, 2514.
4. Friis, P.; Larsen, P. O.; Olsen, C. E. *J. Chem. Soc., Perkin Trans. 1* **1977**, 661.
5. LaMattina, J. L.; Suleske, R. T. *Synthesis* **1980**, 329.
6. Corkins, H. G.; Storace, L.; Osgood, E. *J. Org. Chem.* **1980**, *45*, 3156.
7. Hyatt, J. A. *J. Org. Chem.* **1981**, *46*, 3953.
8. Parcell, R. F.; Sanchez, J. P. *J. Org. Chem.* **1981**, *46*, 5229.
9. Verstappen, M. M. H.; Ariaans, G. J. A.; Zwanenburg, B. *J. Am. Chem. Soc.* **1996**, *118*, 8491.
10. Oldfield, M. F.; Botting, N. P. *J. Labelled Compounds Radio.* **1998**, *41*, 29.
11. Mphahlele, M. J. *Phosphorus, Sulfur Silicon Relat. Elem.* **1999**, *144–146*, 351.
12. Banert, K.; Hagedorn, M.; Liedtke, C.; Melzer, A.; Schoffler, C. *Eur. J. Org. Chem.* **2000**, 257.
13. Palacios, F.; Ochoa de Retana, A. M.; Gil, J. I. *Tetrahedron Lett.* **2002**, *41*, 5363.
14. Ooi, T.; Takahashi, M.; Doda, K.; Maruoka, K. *J. Am. Chem. Soc.* **2002**, *124*, 7640.
15. Garg, N. K.; Caspi, D. D.; Stoltz, B. M. *J. Am. Chem. Soc.* **2005**, *127*, 5970.

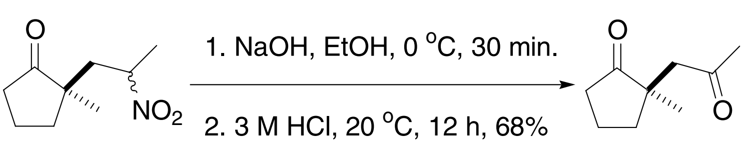
Nef reaction

Conversion of a primary or secondary nitroalkane into the corresponding carbonyl compound.

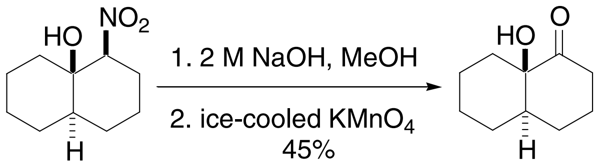




Example 1[7]



Example 2[11]



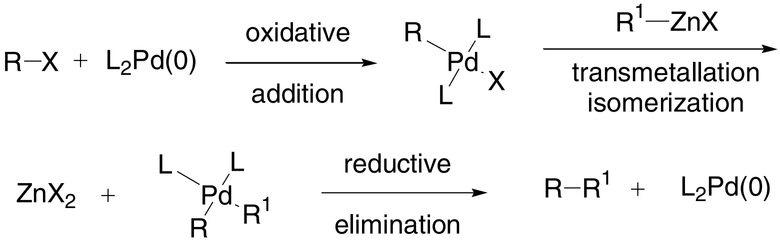
References

1. Nef, J. U. *Justus Liebigs Ann. Chem.* **1894**, *280*, 263. John Ulrich Nef (1862–1915) was born in Switzerland and emmigrated to the US at the age of four with his parents. He went to Munich, Germany to study with Adolf von Baeyer, earning a Ph.D. in 1886. Back to the States, he served as a professor at Purdue University, Clark University, and the University of Chicago. The Nef reaction was discovered at Clark University in Worcester, Massachusetts. Nef was temperamental and impulsive, suffering from a couple of mental breakdowns. He was also highly individualistic, and had never published with a coworker save for three early articles.
2. Pinnick, H. W. *Org. React.* **1990**, *38*, 655–792. (Review).
3. Hwu, J. R.; Gilbert, B. A. *J. Am. Chem. Soc.* **1991**, *113*, 5917.
4. Ceccherelli, P.; Curini, M.; Marcotullio, M. C.; Epifano, F.; Rosati, O. *Synth. Commun.* **1998**, *28*, 3057.
5. Adam, W.; Makosza, M.; Saha-Moeller, C. R.; Zhao, C.-G. *Synlett* **1998**, 1335.
6. Shahi, S. P.; Vankar, Y. D. *Synth. Commun.* **1999**, *29*, 4321.
7. Thominiaux, C.; Rousse, S.; Desmaele, D.; d'Angelo, J.; Riche, C. *Tetrahedron: Asymmetry* **1999**, *10,* 2015.
8. Capecchi, T.; de Koning, C. B.; Michael, J. P. *J. Chem. Soc., Perkin 1* **2000**, 2681.
9. Ballini, R.; Bosica, G.; Fiorini, D.; Petrini, M. *Tetrahedron Lett.* **2002**, *43,* 5233.
10. Petrus, L.; Petrusova, M.; Pham-Huu, D.-P.; Lattova, E.; Pribulova, B.; Turjan, J. *Monatsh. Chem.* **2002**, *133,* 383.
11. Chung, W. K.; Chiu, P. *Synlett* **2005**, 55.

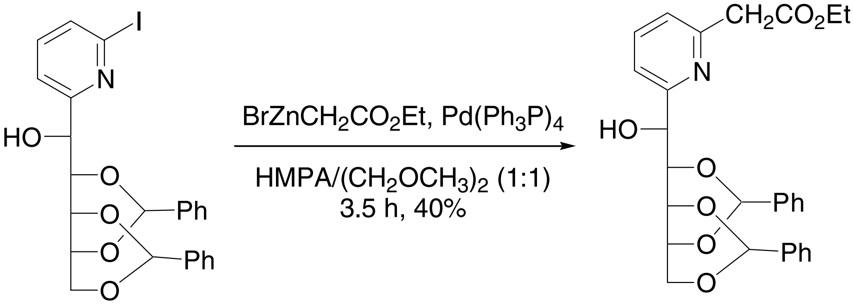
Negishi cross-coupling reaction

Palladium-catalyzed cross-coupling reaction of organozinc reagents with organic halides, triflates, *etc*. It is compatible with many functional groups including ketones, esters, amines, and nitriles. For the catalytic cycle, see the Kumada coupling on page 345.

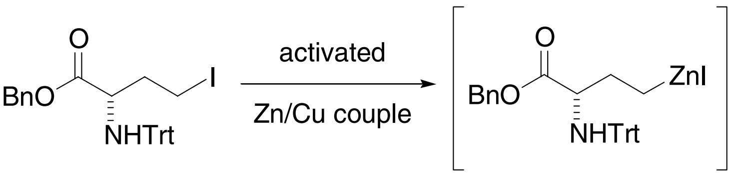
$$R{-}X \;+\; R^1{-}ZnX \xrightarrow{Pd(0)} R{-}R^1 \;+\; ZnX_2$$

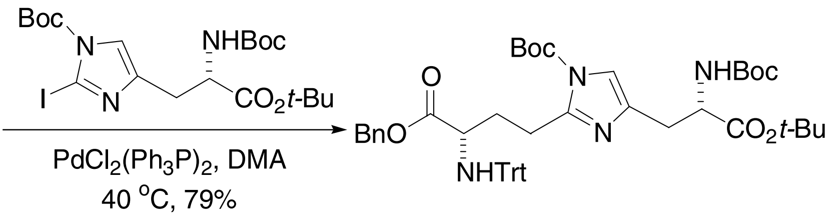


Example 1[5]



Example 2[6]



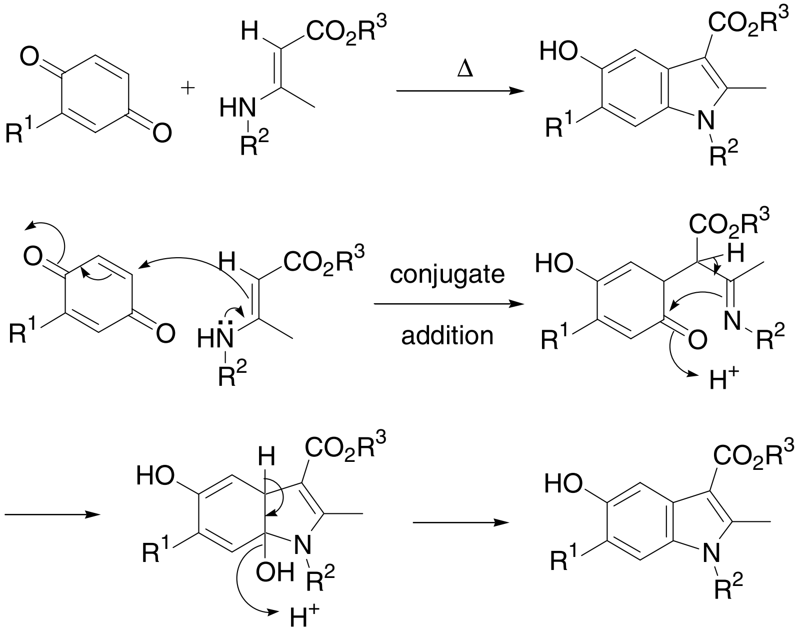


References

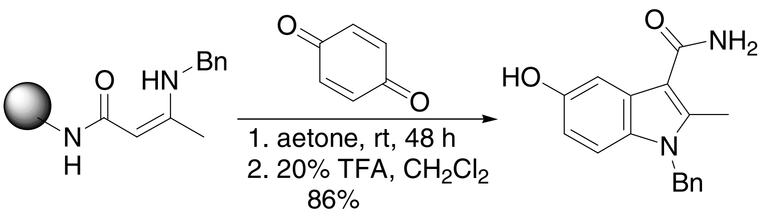
1. Negishi, E.-I.; Baba, S. *J. Chem. Soc., Chem. Commun.* **1976**, 596.
2. Negishi, E.-I. *et al. J. Org. Chem.* **1977**, *42,* 1821.
3. Negishi, E.-I. *Acc. Chem. Res.* **1982**, *15,* 340. (Review).
4. Erdik, E. *Tetrahedron* **1992**, *48,* 9577. (Review).
5. De Vos, E.; Esmans, E. L.; Alderweireldt, F. C.; Balzarini, J.; De Clercq, E. *J. Heterocycl. Chem.* **1993**, *30*, 1245
6. Evans, D. A.; Bach, T. *Angew. Chem., Int. Ed. Engl,* **1993**, *32,* 1326.
7. Negishi, E.-I.; Liu, F. In *Metal-Catalyzed Cross-Coupling Reactions;* **1998**, Diederich, F.; Stang, P. J. eds.; Wiley–VCH: Weinheim, Germany, pp 1–47. (Review).
8. Yus, M.; Gomis, J. *Tetrahedron Lett.* **2001**, *42,* 5721.
9. Lutzen, A.; Hapke, M. *Eur. J. Org. Chem.* **2002**, 2292.
10. Fang, Y.-Q.; Polson, M. I. J.; Hanan, G. S. *Inorg. Chem.* **2003**, *42,* 5.
11. Arvanitis, A. G.; Arnold, C. R.; Fitzgerald, L. W.; Frietze, W. E.; Olson, R. E.; Gilligan, P. J.; Robertson, D. W. *Bioorg. Med. Chem. Lett.* **2003**, *13*, 289.
12. Ma, S.; Ren, H.; Wei, Q. *J. Am. Chem. Soc.* **2003**, *125*, 4817.

Nenitzescu indole synthesis

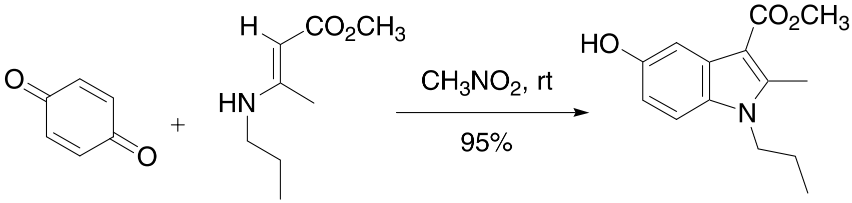
5-Hydroxylindole from condensation of *p*-benzoquinone and β-aminocrotonate.



Example 1[7]



Example 2[8]

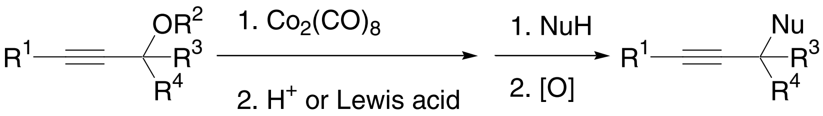


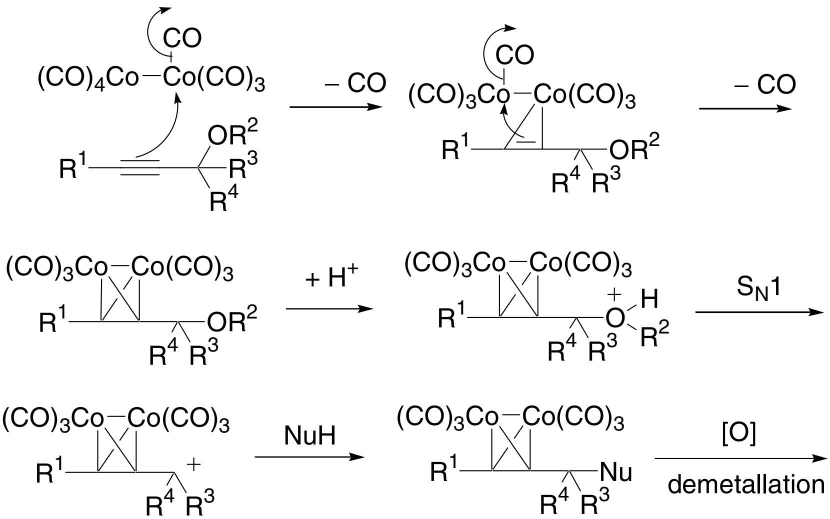
References

1. Nenitzescu, C. D. *Bull. Soc. Chim. Romania* **1929**, *11*, 37.
2. Allen, Jr. G. R. *Org. React.* **1973**, *20*, 337. (Review).
3. Patrick, J. B.; Saunders, E. K. *Tetrahedron Lett.* . **1979**, 4009.
4. Bernier, J. L.; Henichart, J. P. *J. Org. Chem.* **1981**, *46*, 4197.
5. Kinugawa, M.; Arai, H.; Nishikawa, H.; Sakaguchi, A.; Ogasa, T.; Tomioka, S.; Kasai, M. *J. Chem. Soc., Perkin Trans. 1* **1995**, 2677.
6. Mukhanova, T. I.; Panisheva, E. K.; Lyubchanskaya, V. M.; Alekseeva, L. M.; Sheinker, Y. N.; Granik, V. G. *Tetrahedron* **1997**, *53*, 177.
7. Ketcha, D. M.; Wilson, L. J.; Portlock, D. E. *Tetrahedron Lett*. **2000**, *41*, 6253.
8. Brase, S.; Gil, C.; Knepper, K. *Bioorg. Med. Chem. Lett*. **2002**, *10*, 2415.
9. Lyubchanskaya, V. M.; Savina, S. A.; Alekseeva, L. M.; Shashkov, A. S.; Granik, V. G. *Mendeleev Commun*. **2004**, 73.
10. Schenck, L. W.; Sippel, A.; Kuna, K.; Frank, W.; Albert, A.; Kucklaender, U. *Tetrahedron* **2005**, *61*, 9129.

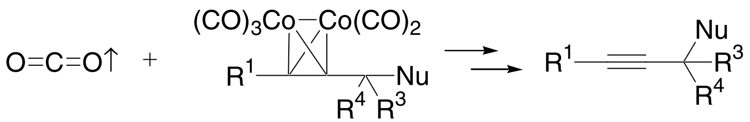
Nicholas reaction

Hexacarbonyldicobalt-stabilized propargyl cation is captured by a nucleophile. Subsequent oxidative demetallation then gives propargylated product.

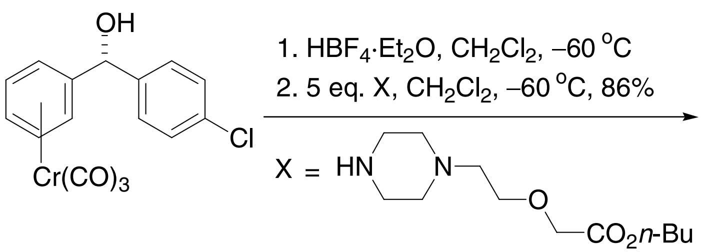


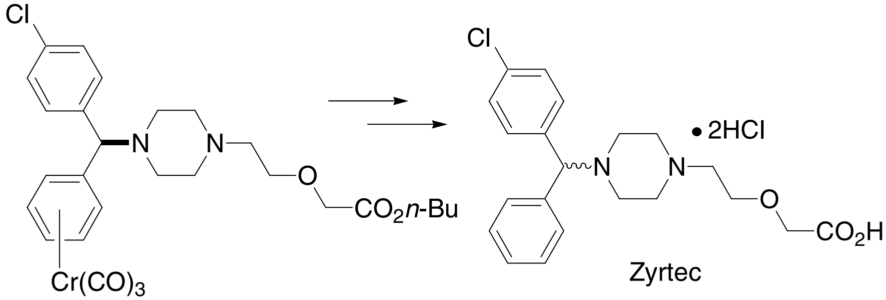


propargyl cation intermediate (stabilized by the hexacarbonyldicobalt complex).

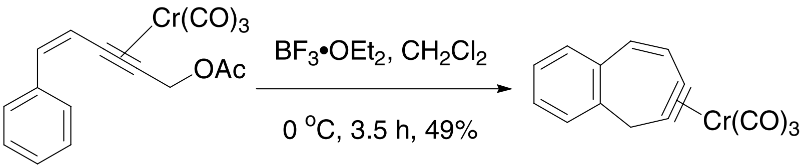


Example 1, chromium variant of the Nicholas reaction[5]





Example 2, intramolecular Nicholas reaction using chromium[11]

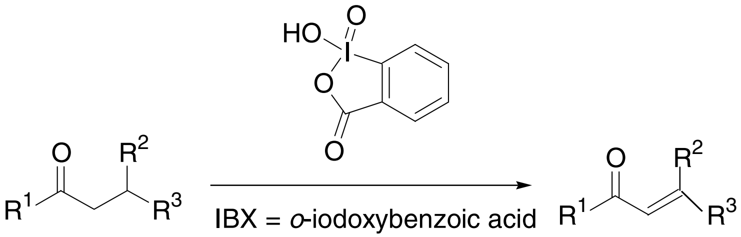


References

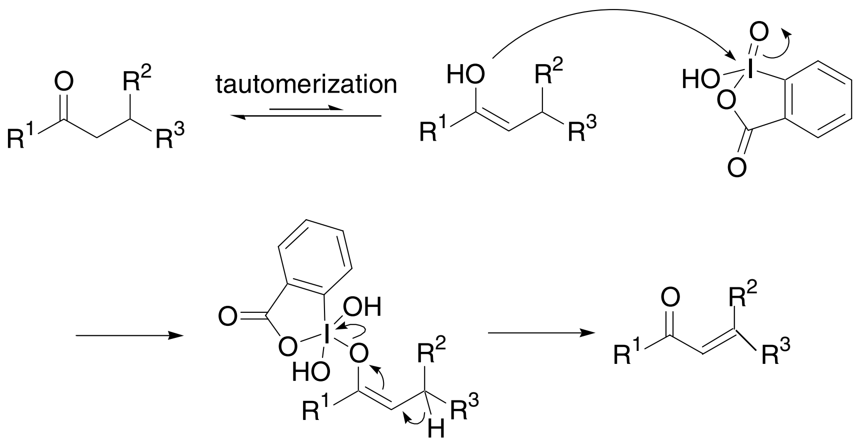
1. Nicholas, K. M. *J. Organomet. Chem.* **1972**, *C21,* 44.
2. Lockwood, R. F.; Nicholas, K. M. *Tetrahedron Lett.* **1977**, 4163.
3. Nicholas, K. M. *Acc. Chem. Res.* **1987**, *20,* 207. (Review).
4. Roth, K. D. *Synlett* **1992**, 435.
5. Corey, E. J.; Helal, C. J. *Tetrahedron Lett.* **1996**, *37*, 4837.
6. Diaz, D.; Martin, V. S. *Tetrahedron Lett*. **2000**, *41*, 743.
7. Guo, R.; Green, J. R. *Synlett* **2000**, 746.
8. Green, J. R. *Curr. Org. Chem*. **2001**, *5*, 809–826. (Review).
9. Teobald, B. J. *Tetrahedron* **2002**, *58*, 4133–4170. (Review).
10. Takase, M.; Morikawa, T.; Abe, H.; Inouye, M. *Org. Lett.* **2003**, *5*, 625.
11. Ding, Y.; Green, J. R. *Synlett* **2005**, 271.
12. Crisostomo, F. R. P.; Carrillo, R.; Martin, T.; Martin, V. S. *Tetrahedron Lett.* **2005**, *46*, 2829.

Nicolaou dehydrogenation

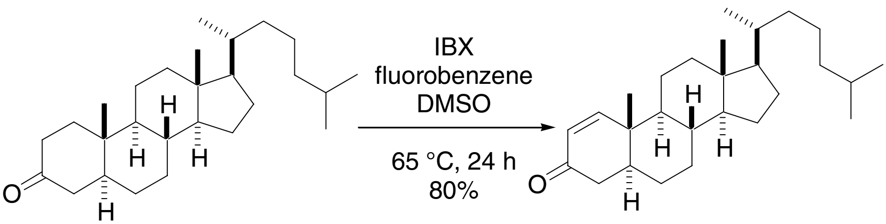
α,β-Unsaturation of aldehydes and ketones mediated by stoichiometric amounts of IBX (*o*-iodoxybenzoic acid), alternative to Saegusa oxidation (page 515).[1]



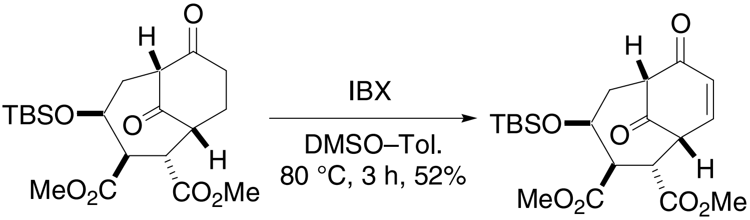
A SET mechanism has also been proposed.[2] Additionally, silyl enol ethers are also viable substrates.[3]



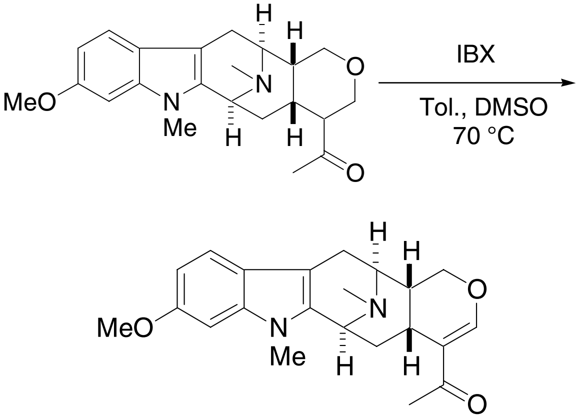
Example 1[1]



Example 2[4]



e. g.3[10]

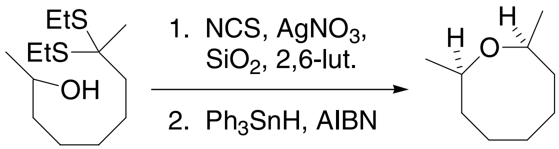


References

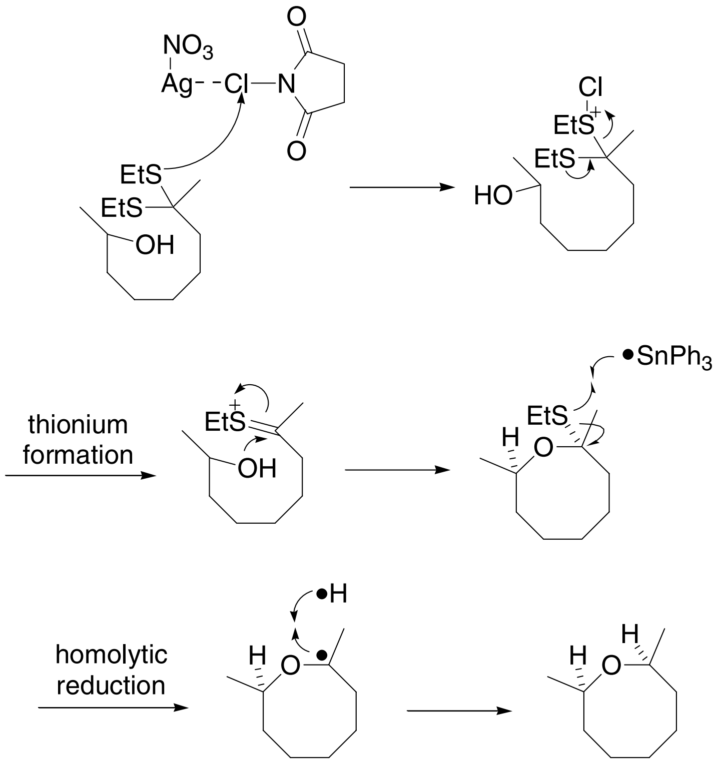
1. Nicolaou, K. C.; Zhong, Y.-L.; Baran, P. S. *J. Am. Chem. Soc.* **2000**, *122*, 7596.
2. Nicolaou, K. C.; Montagnon, T.; Baran, P. S. *Angew. Chem., Int. Ed.* **2002**, *41*, 993.
3. Nicolaou, K. C.; Gray, D. L. F.; Montagnon, T.; Harrison, S. T. *Angew. Chem., Int. Ed.* **2002**, *41*, 996.
4. Ohmori, N. *J. Chem. Soc., Perkin Trans. 1* **2002**, 755.
5. Shimokawa, J.; Shirai, K.; Tanatani, A.; Hashimoto, Y.; Nagasawa, K. *Angew. Chem., Int. Ed.* **2004**, *43*, 1559.
6. Zhang, D.-H.; Cai, F.; Zhou, X.-D.; Zhou, W.-S. *Org. Lett.* **2003**, *5*, 3257.
7. Hayashi, Y.; Yamaguchi, J.; Shoji, M. *Tetrahedron* **2002**, *58*, 9839.
8. Miyazawa, N.; Ogasawara, K. *Synlett* **2002**, 1065.
9. Smith, N. D.; Hayashida. J.; Rawal, V. H. *Org. Lett.* **2005**, *7*, 4309.
10. Liu, X.; Deschamp, J. R.; Cook, J. M. *Org. Lett.* **2002**, *4*, 3339.
11. Nagata, H.; Miyazawa, N.; Ogasawara, K. *Org. Lett.* **2001**, *3*, 1737.
12. Herzon, S. B.; Myers, A. G. *J. Am. Chem. Soc.* **2005**, *127*, 5342.

Nicolaou hydroxy-dithioketal cyclization

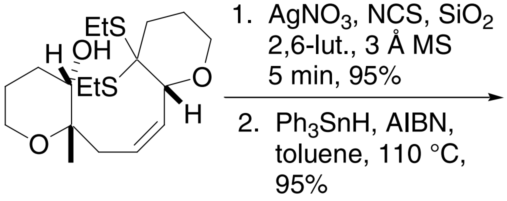
Two step synthesis of medium-ring ethers through the intermediacy of thionium ions followed by sulfide reduction.



The mechanism is analogous to the hydroxy-ketone cyclization except that the mixed ketal is isolable. It can be reductively cleaved using Ph_3SnH/AIBN:

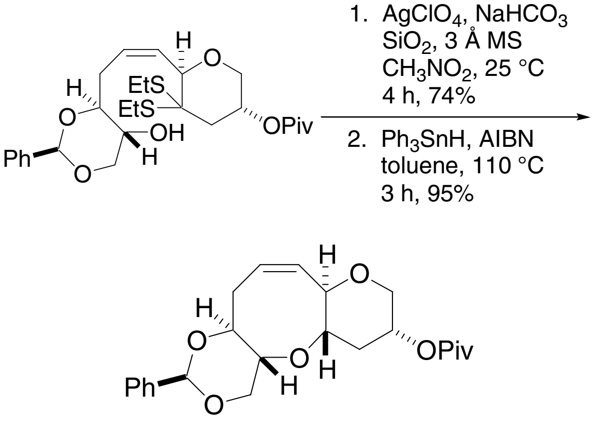


e. g. 1[1]



Example 2, carbocyclization is also possible[3]:

Example 3, the cyclizations tolerate ordinary acetals[5]:

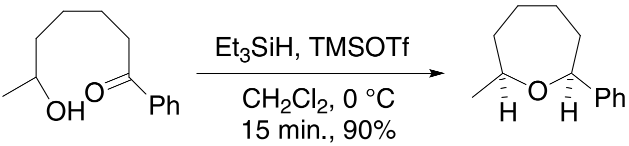


References

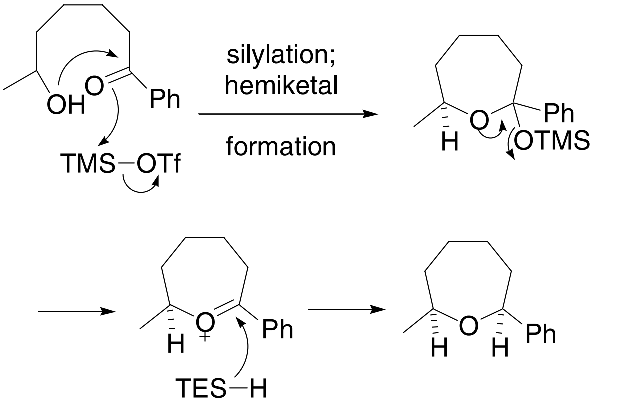
1. Nicolaou, K. C.; Duggan, M. E.; Hwang, C.-K. *J. Am. Chem. Soc.* **1986**, *108*, 2468.
2. Inoue, M.; Sasaki, M.; Tachibana, K. *J. Org. Chem.* **1999**, *64*, 9416.
3. Shin, K.; Moriya, M.; Ogasawara, K. *Tetrahedron Lett.* **1998**, *39*, 3765.
4. Trost, B. M.; Nübling, C. *Carbohydrate Res.* **1990**, *202*, 1.
5. Nicolaou, K. C.; Bunnage, M. E.; McGarry, D. G.; Shi, S.; Somers, P. K.; Wallace, P. A.; Chu, X.-J.; Agrios, K. A.; Gunzner, J. L.; Yang, Z. *Chem. Eur. J.* **1999**, *5*, 599.
6. Nicolaou, K. C.; Gunzner, J. L.; Shi, G.-Q.; Agrios, K. A.; Gärtner, P.; Yang, Z. *Chem. Eur. J.* **1999**, *5*, 646.

Nicolaou hydroxy-ketone reductive cyclic ether formation

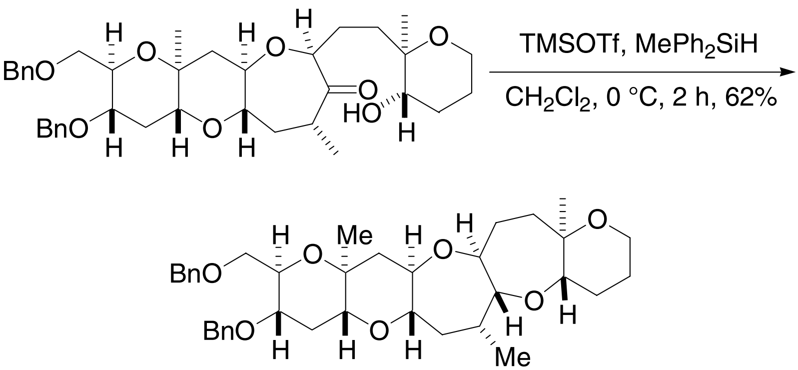
Acid-catalyzed conversion of a ketone with a pendant hydroxyl group into a cyclic ether with net reduction of the carbonyl.



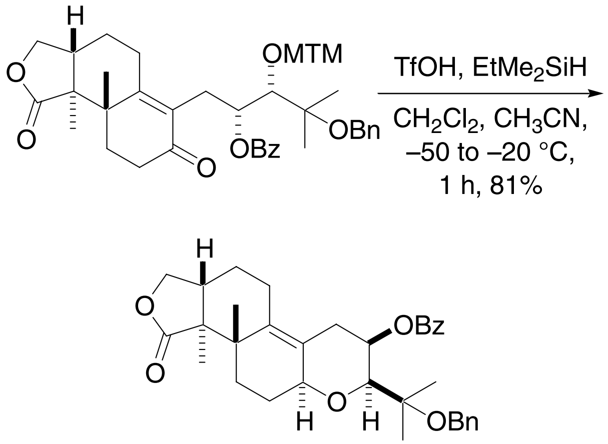
The mechanism involves hemiketal formation followed by reduction of the oxocarbonium group:



Example 1[1]



e. g. 2[2]



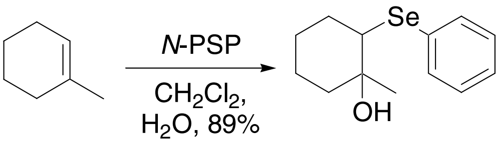
References

1. Nicolaou, K. C.; Hwang, C.-K.; Nugiel, D. A. *J. Am. Chem. Soc.* **1989**, *111*, 4136.
2. Smith, A. B.; Cui, H. *Helv. Chim. Acta* **2003**, *86*, 3908.
3. Watanabe, K.; Suzuki, M.; Murata, M.; Oishi, T. *Tetrahedron Lett.* **2005**, *46*, 3991.
4. Fujiwara, K.; Goto, A.; Sato, D.; Ohtaniuchi, Y.; Tanaka, H.; Murai, A.; Kawai, H.; Suzuki, T. *Tetrahedron Lett.* **2004**, *45*, 7011.
5. González, I. C.; Forsyth, C. J. *J. Am. Chem. Soc.* **2000**, *122*, 9099.
6. Alvarez, E.; Pérez, R.; Rico, M.; Rodríguez, R. M.; Martín, J. D. *J. Org. Chem.* **1996**, *61*, 3003.

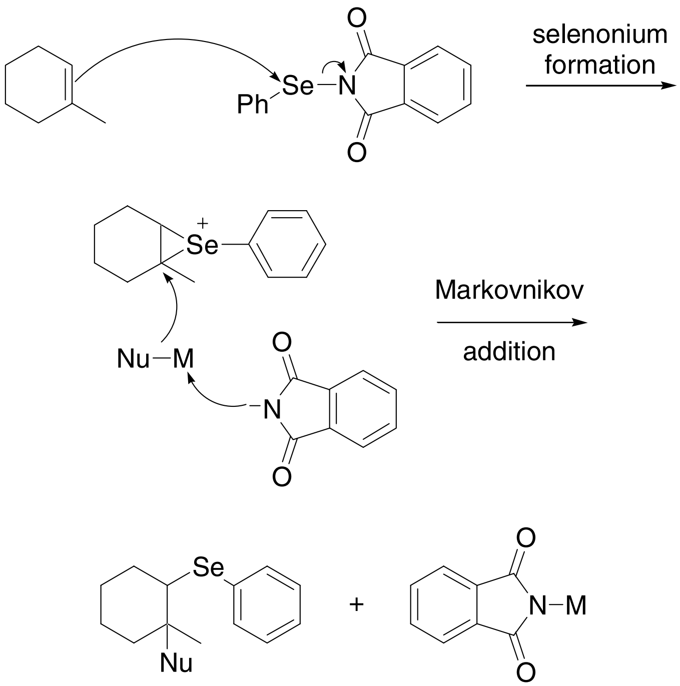
Nicolaou oxyselenation

Activation of alkenes towards nucleophilic attack by a variety of nucleophiles employing *N*-phenylselenophthalimide or *N*-phenylselenosuccinimide as an electrophilic source of the phenylseleno group.

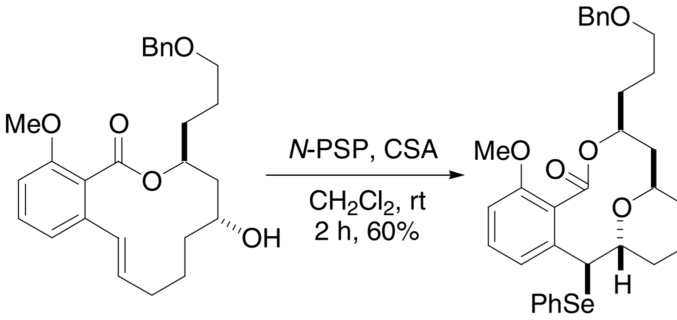
N-PSP = *N*-phenylselenophthalimide   *N*-PSS = *N*-phenylselenosuccinimide



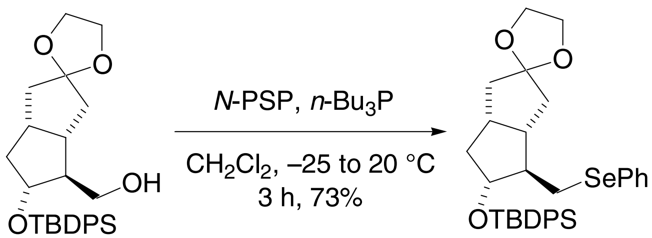
The reagent may require acid activation depending on the type of transformation being attempted. The mechanism parallels that of halohydrin formation using an electrophilic source of halide in an aqueous medium:



Example 1[3]



Example 2, in addition to oxyselenide formation, carbo- and heteroseleno cyclization, *N*-PSP can be used to generate selenides from alcohols and selenol esters from carboxylic acids, respectively, in the presence of a stoichiometric amount of n-Bu_3P.[6]

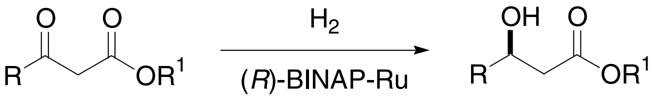


References

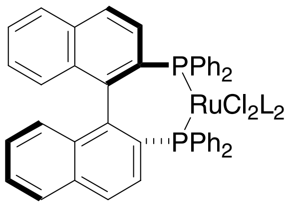
1. Nicolaou, K. C.; Claremon, D. A.; Barnette, W. E.; Seitz, S. P. *J. Am. Chem. Soc.* **1979**, *101*, 3704.
2. Chrétien, F.; Chapleur, Y. *J. Org. Chem.* **1988**, *53*, 3615.
3. Kühnert, S. M.; Maier, M. E. *Org. Lett.* **2002**, *4*, 643.
4. Zakarian, A.; Batch, A.; Holton, R. A. *J. Am. Chem. Soc.* **2003**, *125*, 7822.
5. Depew, K. M.; Marsden, S. P.; Zatorska, D.; Zatorski, A.; Bornmann, W. G.; Danishefsky, S. J. *J. Am. Chem. Soc.* **1999**, *121*, 11953.
6. Grieco, P. A.; Jaw, J. Y.; Claremon, D. A.; Nicolaou, K. C. *J. Org. Chem.* **1981**, *46*, 1215.
7. Nicolaou, K. C.; Petasis, N. A.; Claremon, D. A. *Tetrahedron* **1985**, *41*, 4835.

Noyori asymmetric hydrogenation

Asymmetric reduction of carbonyl *via* hydrogenation catalyzed by ruthenium(II) BINAP complex.

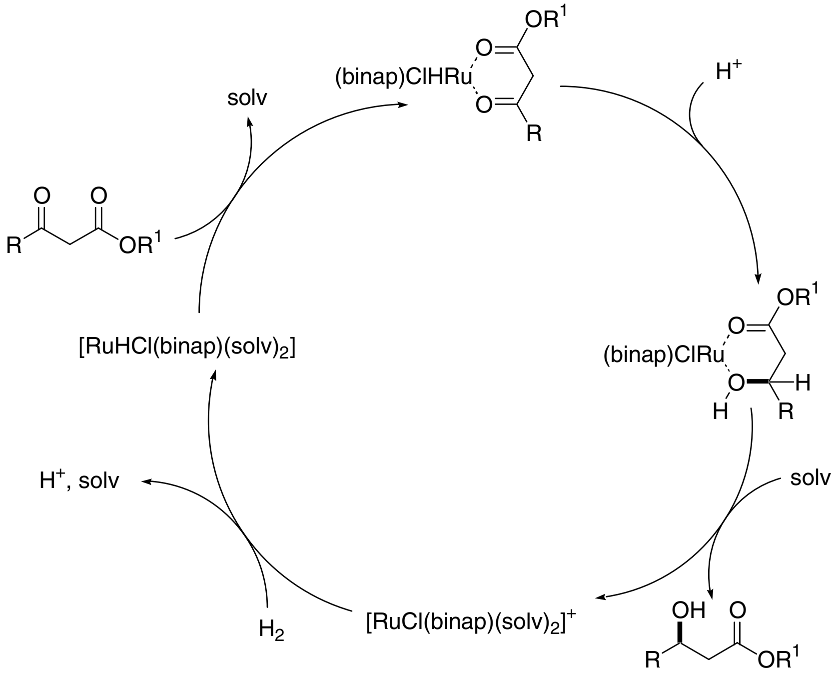


(*R*)-BINAP-Ru =

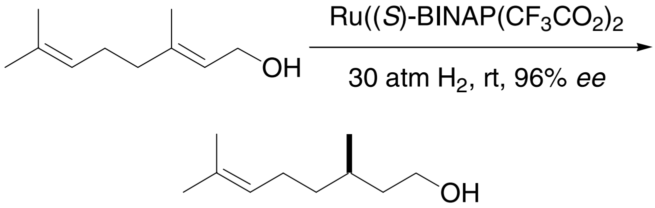


$$[RuCl_2(binap)(solv)_2] \xrightarrow[-\,HCl]{H_2} [RuHCl(binap)(solv)_2]$$

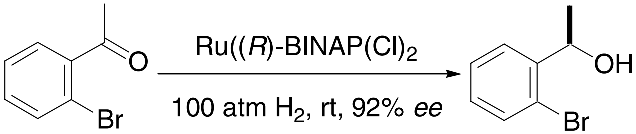
The catalytic cycle:



Example 1[2]



Example 2[3]

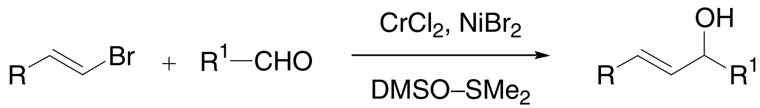


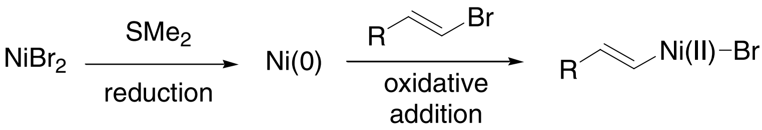
References

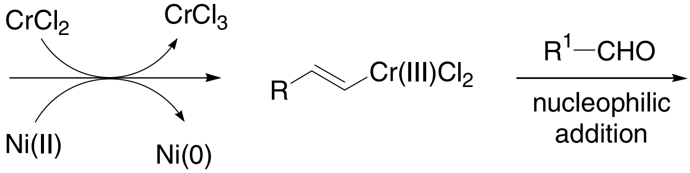
1. Noyori, R.; Ohta, M.; Hsiao, Y.; Kitamura, Ma.; Ohta, T.; Takaya, H. *J. Am. Chem. Soc.* **1986**, *108*, 7117. Ryoji Noyori (Japan, 1938–) and Herbert William S. Knowles (USA, 1917–) shared half of the Nobel Prize in Chemistry in 2001 for their work on chirally catalyzed hydrogenation reactions. K. Barry Sharpless (USA, 1941–) shared the other half for his work on chirally catalyzed oxidation reactions.
2. Takaya, H.; Ohta, T.; Sayo, N.; Kumobayashi, H.; Akutagawa, S.; Inoue, S.; Kasahara, I.; Noyori, R.; nnn *J. Am. Chem. Soc.* **1987**, *109*, 1596.
3. Kitamura, M.; Ohkuma, T.; Inoue, S.; Sayo, N.; Kumobayashi, Hi.Akutagawa, S.; Ohta, T.; Takaya, H.; Noyori, R. *et al. J. Am. Chem. Soc.* **1988**, *110*, 629.
4. Noyori, R.; Ohkuma, T.; Kitamura, H.; Takaya, H.; Sayo, H.; Kumobayashi, S.; Akutagawa, S. *J. Am. Chem. Soc.* **1987**, *109*, 5856.
5. Case-Green, S. C.; Davies, S. G.; Hedgecock, C. J. R. *Synlett* **1991**, 781.
6. King, S. A.; Thompson, A. S.; King, A. O.; Verhoeven, T. R. *J. Org. Chem.* **1992**, *57*, 6689.
7. Noyori, R. In *Asymmetric Catalysis in Organic Synthesis;* Ojima, I., ed.; Wiley: New York, **1994**, chapter 2. (Review).
8. Chung, J. Y. L.; Zhao, D.; Hughes, D. L.; Mcnamara, J. M.; Grabowski, E. J. J.; Reider, P. J. *Tetrahedron Lett.* **1995**, *36*, 7379.
9. Bayston, D. J.; Travers, C. B.; Polywka, M. E. C. *Tetrahedron: Asymmetry* **1998**, *9*, 2015.
10. Noyori, R.; Ohkuma, T. *Angew. Chem. Int. Ed.* **2001**, *40*, 40.
11. Noyori, R. *Angew. Chem., Int. Ed.* **2002**, *41*, 2008. (Review, Nobel Prize Address).
12. Berkessel, A.; Schubert, T. J. S.; Mueller, T. N. *J. Am. Chem. Soc.* **2002**, *124*, 8693.
13. Fujii, K.; Maki, K.; Kanai, M.; Shibasaki, M. *Org. Lett.* **2003**, *5*, 733.

Nozaki–Hiyama–Kishi reaction

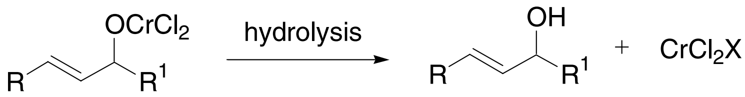
Cr−Ni bimetallic catalyst-promoted redox addition of vinyl halides to aldehydes.



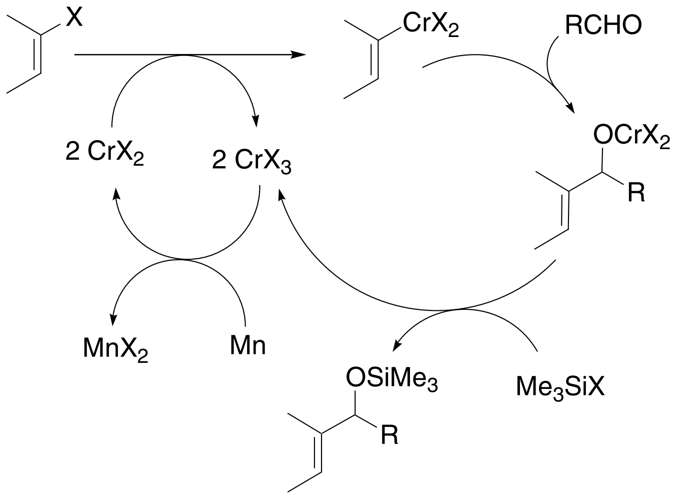




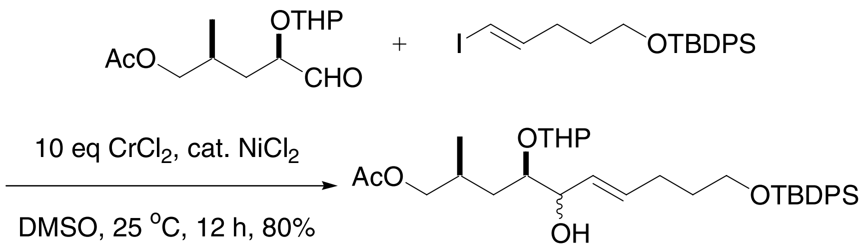
Transmetalation and then reduction by Me_2S



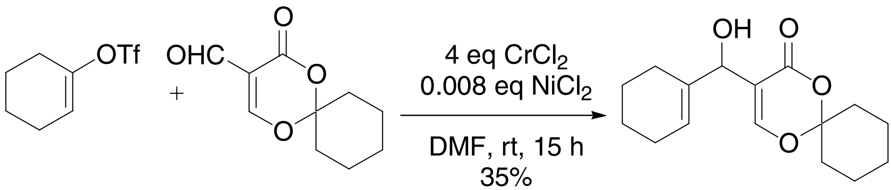
The catalytic cycle:[7]



Example 1[8]



Example 2[12]

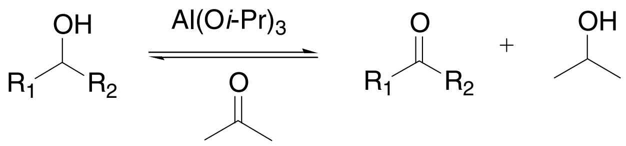


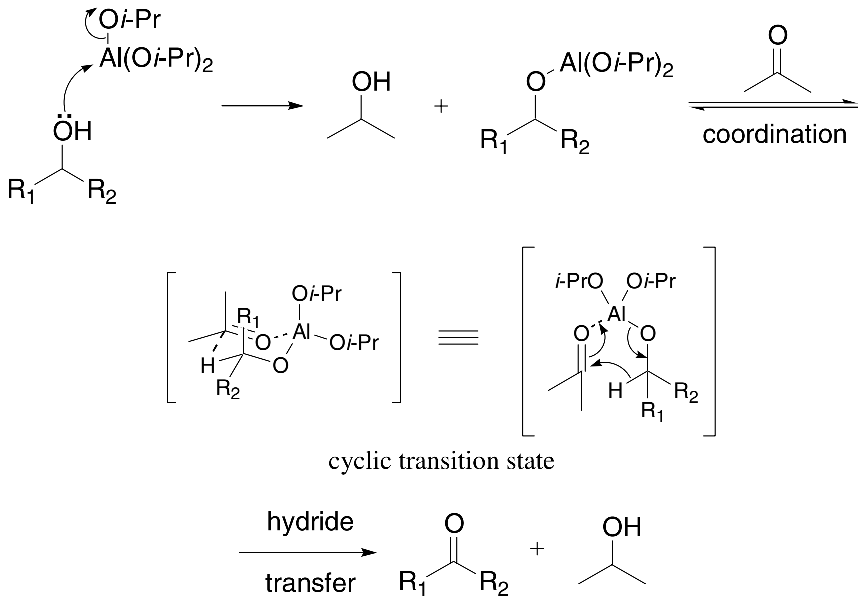
References

1. Okude, C. T.; Hirano, S.; Hiyama, T.; Nozaki, H. *J. Am. Chem. Soc.* **1977**, *99*, 3179. Hitosi Nozaki and T. Hiyama are professors at the Japanese Academy.
2. Takai, K.; Kimura, K.; Kuroda, T.; Hiyama, T.; Nozaki, H. *Tetrahedron Lett.* **1983**, *24*, 5281. Kazuhiko Takai was Prof. Nozaki's student during the discovery of the reaction and is a professor at Okayama University.
3. Jin, H.; Uenishi, J.; Christ, W. J.; Kishi, Y. *J. Am. Chem. Soc.* **1986**, *108*, 5644. Yoshita Kishi at Harvard independently discovered the catalytic effect of nickel during his total synthesis of polytoxin.
4. Takai, K.; Tagahira, M.; Kuroda, T.; Oshima, K.; Utimoto, K.; Nozaki, H. *J. Am. Chem. Soc.* **1986**, *108*, 6048.
5. Wessjohann, L. A.; Scheid, G. *Synthesis* **1991**, 1. (Review).
6. Kress, M. H.; Ruel, R.; Miller, L. W. H.; Kishi, Y. *Tetrahedron Lett.* **1993**, *34*, 5999.
7. The catalytic cycle: Fürstner, A.; Shi, N. *J. Am. Chem. Soc.* **1996**, *118*, 12349.
8. Chakraborty, T. K.; Suresh, V. R. *Chem. Lett.* **1997**, 565.
9. Boeckman, R. K., Jr.; Hudack, R. A., Jr. *J. Org. Chem.* **1998**, *63*, 3524.
10. Fürstner, A. *Chem. Rev.* **1999**, *99*, 991–1046. (Review).
11. Kuroboshi, M.; Tanaka, M.; Kishimoto, S. Goto, K.; Mochizuki, M.; Tanaka, H. *Tetrahedron Lett.* **2000**, *41*, 81.
12. Blaauw, R. H.; Benningshof, J. C. J.; van Ginkel, A. E.; van Maarseveen, J. H.; Hiemstra, H. *J. Chem. Soc., Perkin Trans. 1* **2001**, 2250.
13. Berkessel, A.; Menche, D.; Sklorz, C. A.; Schroder, M.; Paterson, I. *Angew. Chem. Int. Ed.* **2003**, *42*, 1032.
14. Takai, K. *Org. React.* **2004**, *64*, 253–612. (Review).

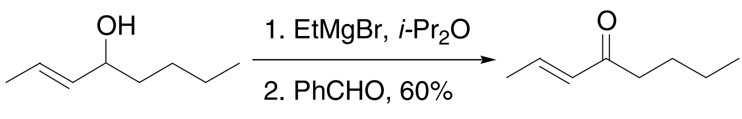
Oppenauer oxidation

Alkoxide-catalyzed oxidation of secondary alcohols.

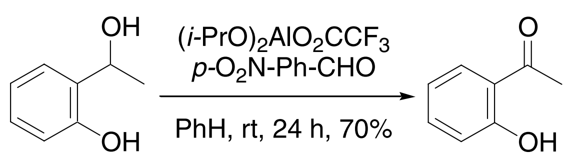




Example 1, magnesium Oppenauer oxidation[3]



Example 2[12]

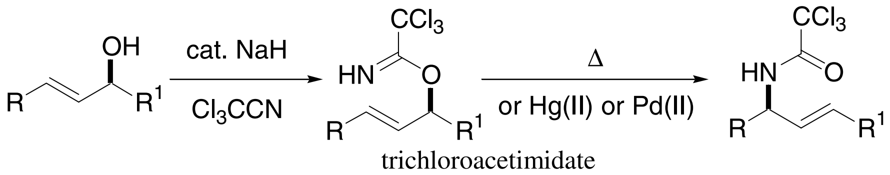


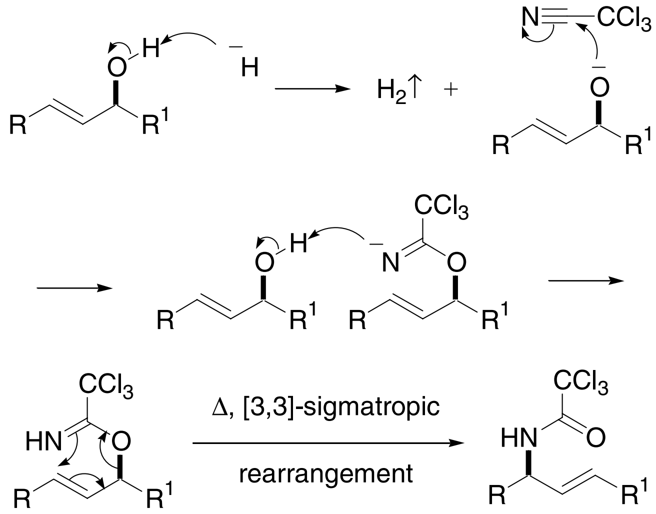
References

1. Oppenauer, R. V. *Rec. Trav. Chim.* **1937**, *56*, 137. Rupert V. Oppenauer (1910–), born in Burgstall, Italy, studied at ETH in Zurich under Ruzicka and Reichstei, both Nobel laureates. After a string of academic appointments around Europe and a stint at Hoffman–La Roche, Oppenauer worked for the Ministry of Public Health in Buenos Aires, Argentina.
2. Djerassi, C. *Org. React.* **1951**, *6*, 207. (Review).
3. Byrne, B.; Karras, M. *Tetrahedron Lett.* **1987**, *28*, 769.
4. de Graauw, C. F.; Peters, J. A.; van Bekkum, H.; Huskens, J. *Synthesis* **1994**, 1007.
5. Almeida, M. L. S.; Kocovsky, P.; Bäckvall, J.-E. *J. Org. Chem.* **1996**, *61*, 6587.
6. Akamanchi, K. G.; Chaudhari, B. A. *Tetrahedron Lett.* **1997**, *38*, 6925.
7. Raja, T.; Jyothi, T. M.; Sreekumar, K.; Talawar, M. B.; Santhanalakshmi, J.; Rao, B. S. *Bull. Chem. Soc. Jpn.* **1999**, *72*, 2117.
8. Nait Ajjou, A. *Tetrahedron Lett.* **2001**, *42*, 13.
9. Schrekker, H. S.; de Bolster, M. W. G.; Orru, R. V. A.; Wessjohann, L. A. *J. Org. Chem.* **2002**, *67*, 1975.
10. Ooi, T.; Otsuka, H.; Miura, T.; Ichikawa, H.; Maruoka, K. *Org. Lett.* **2002**, *4*, 2669.
11. Suzuki, T.; Morita, K.; Tsuchida, M.; Hiroi, K. *J. Org. Chem.* **2003**, *68*, 1601.
12. Auge, J.; Lubin-Germain, N.; Seghrouchni, L. *Tetrahedron Lett.* **2003**, *44*, 819.
13. Hon, Y.-S.; Chang, C.-P.; Wong, Y.-C. Byrne, B.; Karras, M. *Tetrahedron Lett.* **2004**, *45*, 3313.

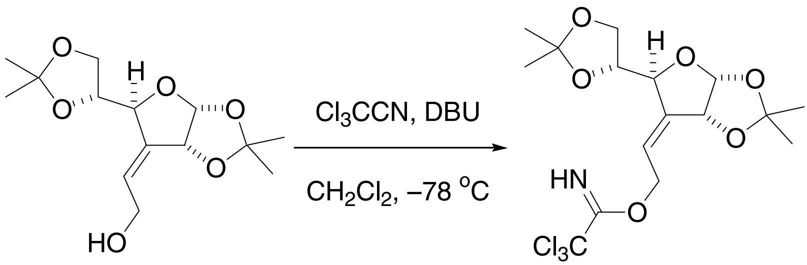
Overman rearrangement

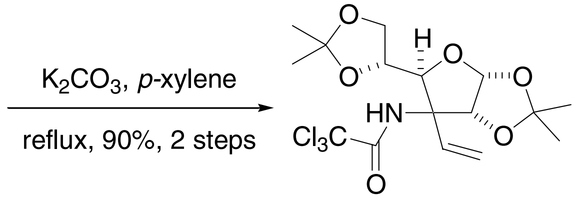
Stereoselective transformation of allylic alcohol to allylic trichloroacetamide *via* trichloroacetimidate intermediate.



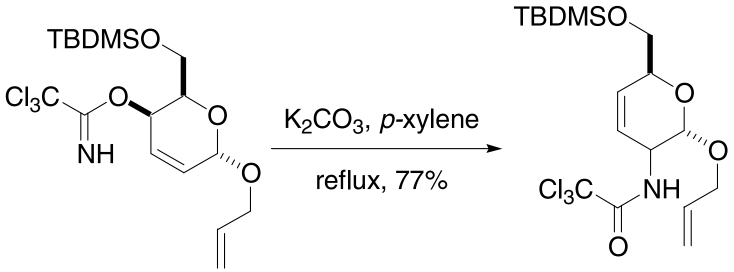


Example 1[13]





Example 2[14]

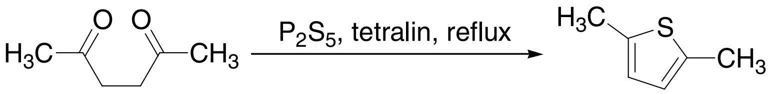


References

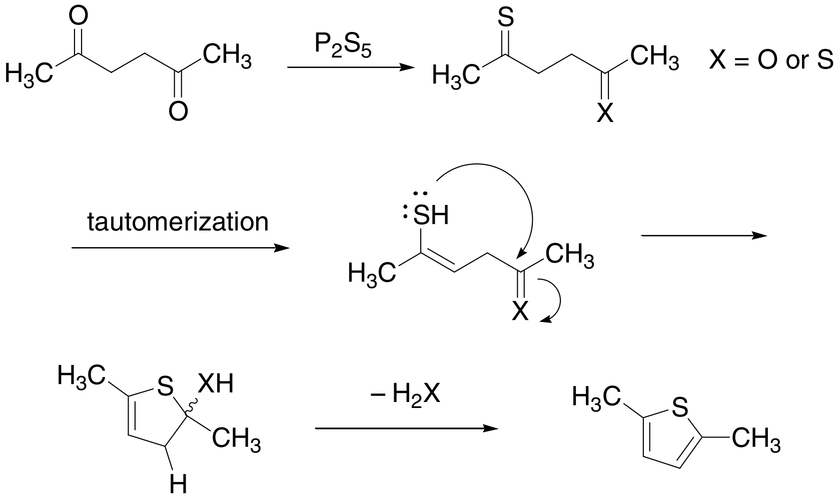
1. Overman, L. E. *Acc. Chem. Res.* **1971**, *4*, 49. (Review).
2. Overman, L. E. *J. Am. Chem. Soc.* **1974**, *96*, 597.
3. Overman, L. E. *J. Am. Chem. Soc.* **1976**, *98*, 2901.
4. Isobe, M.; Fukuda, Y.; Nishikawa, T.; Chabert, P.; Kawai, T.; Goto, T. *Tetrahedron Lett.* **1990**, *31*, 3327.
5. Eguchi, T.; Koudate, T.; Kakinuma, K. *Tetrahedron* **1993**, *49*, 4527.
6. Toshio, N.; Masanori, A.; Norio, O.; Minoru, I. *J. Org. Chem.* **1998**, *63*, 188.
7. Cho, C.-G.; Lim, Y.-K.; Lee, K.-S.; Jung, I.-H.; Yoon, M.-Y. *Synth. Commun.* **2000**, *30*, 1643.
8. Martin, C.; Prunck, W.; Bortolussi, M.; Bloch, R. *Tetrahedron: Asymmetry* **2000**, *11*, 1585.
9. Demay, S.; Kotschy, A.; Knochel, P. *Synthesis* **2001**, 863.
10. Oishi, T.; Ando, K.; Inomiya, K.; Sato, H.; Iida, M.; Chida, N. *Org. Lett.* **2002**, *4*, 151.
11. Reilly, M.; Anthony, D. R.; Gallagher, C. *Tetrahedron Lett.* **2003**, *44*, 2927.
12. O'Brien, P.; Pilgram, C. D. *Org. Biomol. Chem.* **2003**, *1*, 523.
13. Tsujimoto, T.; Nishikawa, T.; Urabe, D.; Isobe, M. *Synlett* **2004**, 433.
14. Montero, A.; Mann, E.; Herradon, B. *Tetrahedron Lett.* **2005**, *46*, 401.
15. Ramachandran, P. V.; Burghardt, T. E.; Reddy, M. V. R. *Tetrahedron Lett.* **2005**, *46*, 2121.

Paal thiophene synthesis

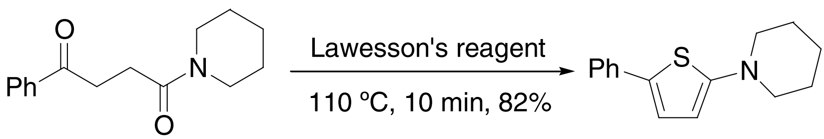
Thiophene synthesis from addition of a sulfur atom to 1,4-dicarbonyl compounds and subsequent dehydration.



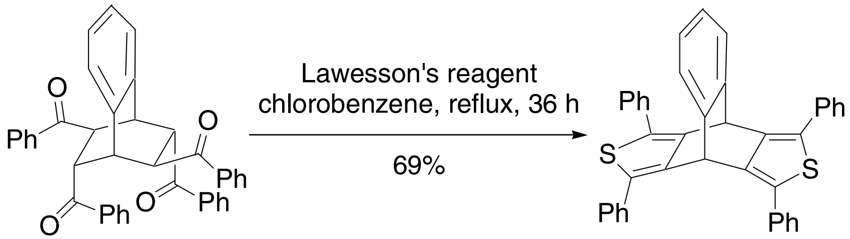
The reaction now is frequently carried out using the Lawesson's reagent. For the mechanism of carbonyl to thiocarbonyl transformation, see Lawesson's reagent on page 348.



Example 1[4]



Example 2[8]

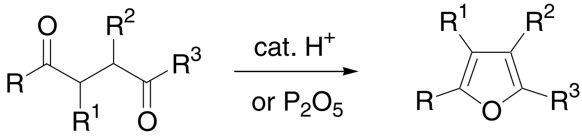


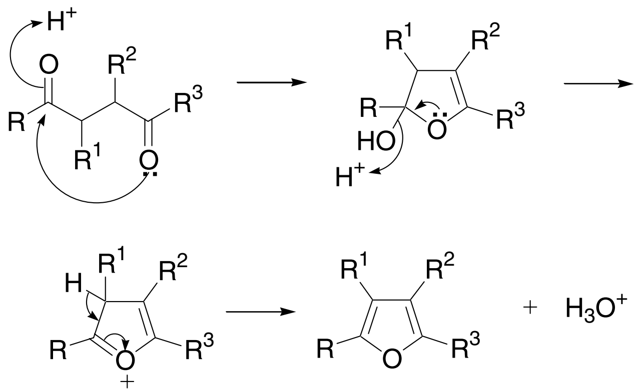
References

1. Paal, C. *Chem. Ber.* **1885**, *18*, 251.
2. Paal, C. *Chem. Ber.* **1885**, *18*, 367.
3. Campaigne, E.; Foye, W. O. *J. Org. Chem.* **1952**, *17*, 1405.
4. Thomsen, I.; Pedersen, U.; Rasmussen, P. B.; Yde, B.; Andersen, T. P.; Lawesson, S.-O. *Chem. Lett.* **1983**, 809.
5. Freeman, F.; Kim, D. S. H. L. *J. Org. Chem.* **1992**, *57*, 1722.
6. Johnson, M. R.; Miller, D. C.; Bush, K.; Becker, J. J.; Ibers, J. A. *J. Org. Chem.* **1992**, *57*, 4414.
7. Freeman, F.; Lee, M. Y.; Lu, H.; Rodriguez, E.; Wang, X. *J. Org. Chem.* **1994**, *59*, 3695.
8. Parakka, J. P.; Sadannandan, E. V.; Cava, M. P. *J. Org. Chem.* **1994**, *59*, 4208.
9. Hemperius, M. A.; Lengeveld, B. M. W.; van Haave, J. A. E. H.; Janssen, R. A. J. Sheiko, S. S.; Spatz, J. P.; Möller, M.; Meijer, E. W. *J. Am. Chem. Soc.* **1998**, *120*, 2798.
10. Kikuchi, K.; Hibi, S.; Yoshimura, H.; Tokuhara, N.; Tai, K.; Hida, T.; Yamauchi, T.; Nagai, M. *J. Med. Chem.* **2000**, *43*, 409.
11. Sonpatki, V. M.; Herbert, M. R.; Sandvoss, L. M.; Seed, A. J. *J. Org. Chem.* **2001**, *66*, 7283.
12. Kiryanov, A. A.; Sampson, P.; Seed, A. J. *J. Org. Chem.* **2001**, *66*, 7925.
13. Mullins, R. J.; Williams, D. R. *Paal Thiophene Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J. Eds., Wiley & Sons: Hoboken, NJ, **2005**, 207–217. (Review).

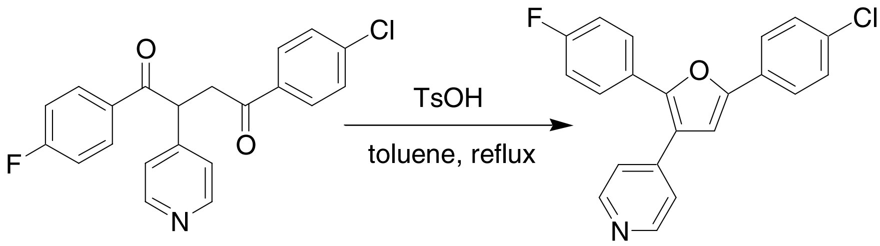
Paal–Knorr furan synthesis

Acid-catalyzed cyclization of 1,4-ketones to form furans.

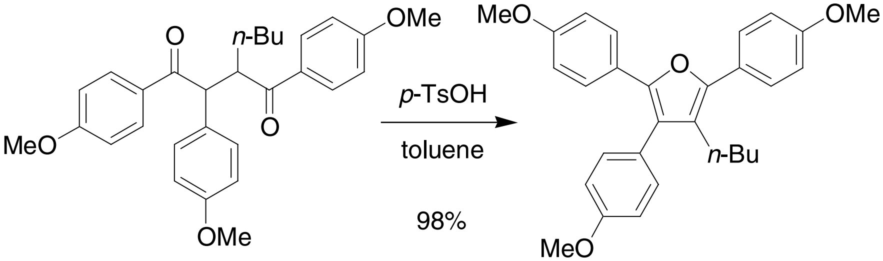




Example 1[10]



Example 2[14]

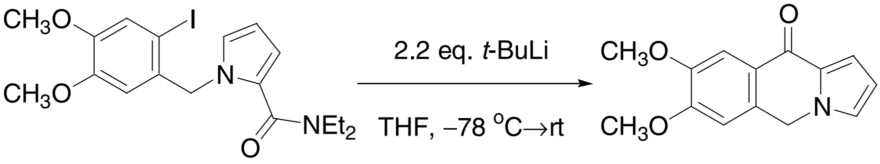


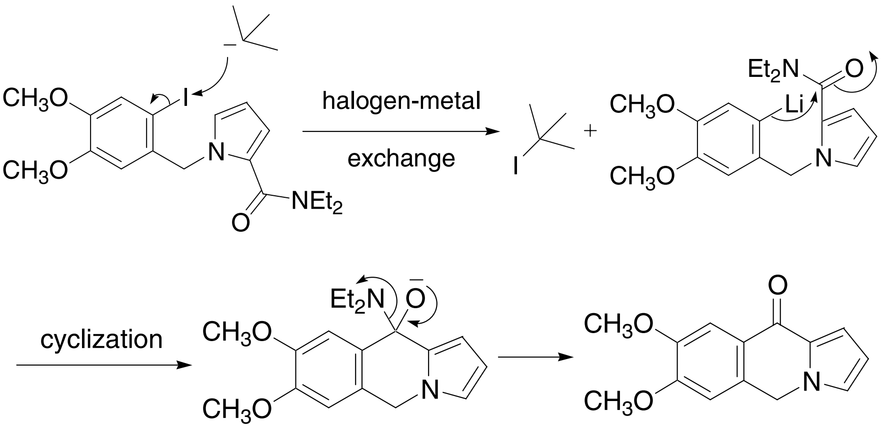
References

1. Paal, C. *Ber. Dtsch. Chem. Ges.* **1884**, *17*, 2756.
2. Knorr, L. *Ber. Dtsch. Chem. Ges.* **1885**, *18*, 299
3. Paal, C. *Ber. Dtsch. Chem. Ges.* **1885**, *18*, 367.
4. Haley, J. F., Jr.; Keehn, P. M. *Tetrahedron Lett.* **1973**, 4017.
5. Dean, F. M. *Recent Advances in Furan Chemistry. Part I.* In *Advances in Heterocyclic Chemistry*; Katritzky, A. R., Ed.; Academic Press: New York, **1982**; Vol. 30, 167–238. (Review).
6. Amarnath, V.; Amarnath, K. *J. Org. Chem.* **1995**, *60*, 301.
7. Truel, I.; Mohamed-Hachi, A.; About-Jaudet, E.; Collignon, N. *Synth. Commun.* **1997**, *27*, 1165.
8. Friedrichsen, W. Furans and Their Benzo Derivatives: Synthesis. In *Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R., Rees, C. W., Scriven, E. F. V., Eds.; Pergamon: New York, **1996**; Vol. 2, 351–393. (Review).
9. Gilchrist, T. L. *Heterocyclic Chemistry*, 3rd ed.; Longman: Singapore, **1997**; 211. (Review).
10. de Laszlo, S. E.; Visco, D.; Agarwal, L.; *et al. Bioorg. Med. Chem. Lett.* **1998**, *8*, 2689.
11. Gupta, R. R.; Kumar, M.; Gupta, V. *Heterocyclic Chemistry*, Springer: New York, **1999**; Vol. 2, 83–84. (Review).
12. Stauffer, F.; Neier, R. *Org. Lett.* **2000**, *2*, 3535.
13. Joule, J. A.; Mills, K. *Heterocyclic Chemistry*, 4th ed.; Blackwell Science: Cambridge, **2000**; 308-309. (Review).
14. Mortensen, D. S.; Rodriguez, A. L.; Carlson, K. E.; Sun, J.; Katzenellenbogen, B. S.; Katzenellenbogen, J. A. *J. Med. Chem.* **2001**, *44*, 3838.
15. König, B. Product Class 9: Furans. In *Science of Synthesis: Houben-Weyl Methods of Molecular Transformations*; Maas, G., Ed.; Georg Thieme Verlag: New York, **2001**; Cat. 2, Vol. 9, 183–278. (Review).
16. Shea, K. M. *Paal–Knorr Furan Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 168–181. (Review).

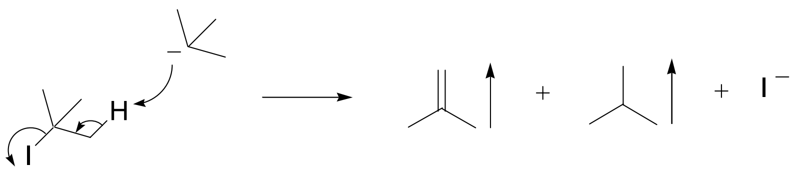
Parham cyclization

Annulation of aryl halides with *ortho* side chains bearing a pendant electrophilic moiety *via* treatment with an organolithium reagent, involving halogen-metal exchange and subsequent nucleophilic cyclization to form 4- to 7-membered rings.

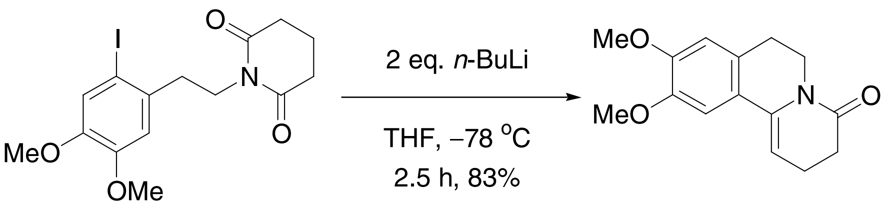




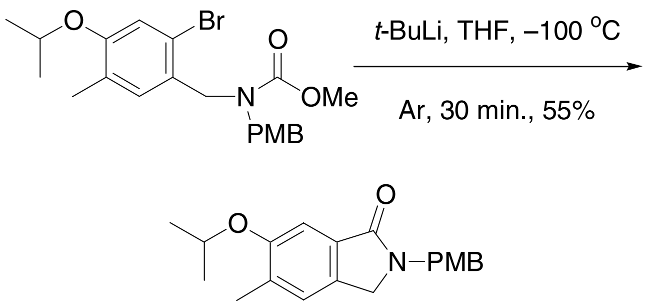
The fate of the second equivalent of *t*-BuLi:



Example 1[9]



Example 2[16]

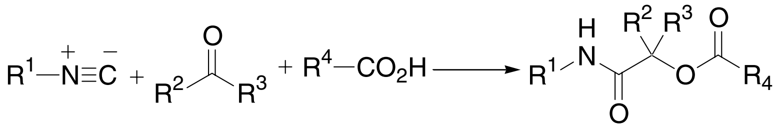


References

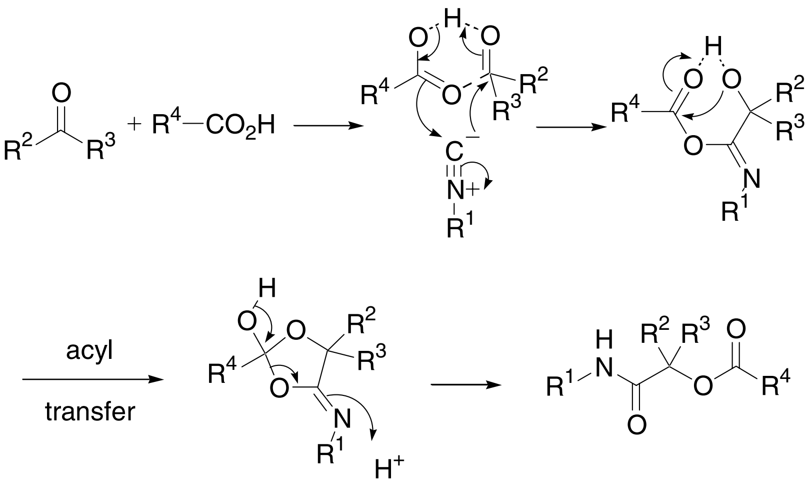
1. Parham, W. E.; Jones, L. D.; Sayed, Y. *J. Org. Chem.* **1975**, *40*, 2394. William E. Parham was a professor at Duke University.
2. Parham, W. E.; Jones, L. D.; Sayed, Y. *J. Org. Chem.* **1976**, *41*, 1184.
3. Bradsher, C. K.; Hunt, D. A. *Org. Prep. Proced. Int.* **1978**, *10*, 267.
4. Bradsher, C. K.; Hunt, D. A. *J. Org. Chem.* **1981**, *46*, 4608.
5. Parham, W. E.; Bradsher, C. K. *Acc. Chem. Res.* **1982**, *15*, 300. (Review).
6. Quallich, G. J.; Fox, D. E.; Friedmann, R. C.; Murtiashaw, C. W. *J. Org. Chem.* **1992**, *57*, 761.
7. Couture, A.; Deniau, E.; Grandclaudon, P. *J. Chem. Soc., Chem. Commun.* **1994**, 1329.
8. Gray, M.; Tinkl, M.; Snieckus, V. In *Comprehensive Organometallic Chemistry II*; Abel, E. W., Stone, F. G. A., Wilkinson, G., Eds.; Pergamon: Exeter, **1995**; Vol. 11; p 66. (Review).
9. Collado, M. I.; Manteca, I.; Sotomayor, N.; Villa, M.-J.; Lete, E. *J. Org. Chem.* **1997**, *62*, 2080.
10. Ardeo, A.; Lete, E.; Sotomayor, N. *Tetrahedron Lett.* **2000**, *41*, 5211.
11. Osante, I.; Collado, M. I.; Lete, E.; Sotomayor, N. *Eur. J. Org. Chem.* **2001**, 1267.
12. Ardeo, A.; Collado, M. I.; Osante, I.; Ruiz, J.; Sotomayor, N.; Lete, E. In *Targets in Heterocyclic Systems Vol. 5*; Atanassi, O., Spinelli, D., Eds.; Italian Society of Chemistry: Rome, **2001**; p 393. (Review).
13. Mealy, M. M.; Bailey, W. F. *J. Organomet. Chem.* **2002**, *646*, 59. (Review).
14. Sotomayor, N.; Lete, E. *Current Org. Chem.* **2003**, *7*, 275. (Review).
15. González-Temprano, I.; Osante, I.; Lete, E.; Sotomayor, N. *J. Org. Chem.* **2004**, *69*, 3875.
16. Moreau, A.; Couture, A.; Deniau, E.; Grandclaudon, P.; Lebrun, S. *Org. Biomol. Chem.* **2005**, *3*, 2305.

Passerini reaction

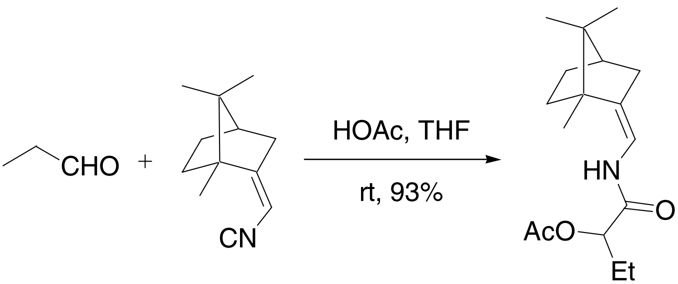
Three-component condensation (3CC) of carboxylic acids, *C*-isocyanides, and carbonyl compounds to afford α-acyloxycarboxamides. *Cf.* Ugi reaction.



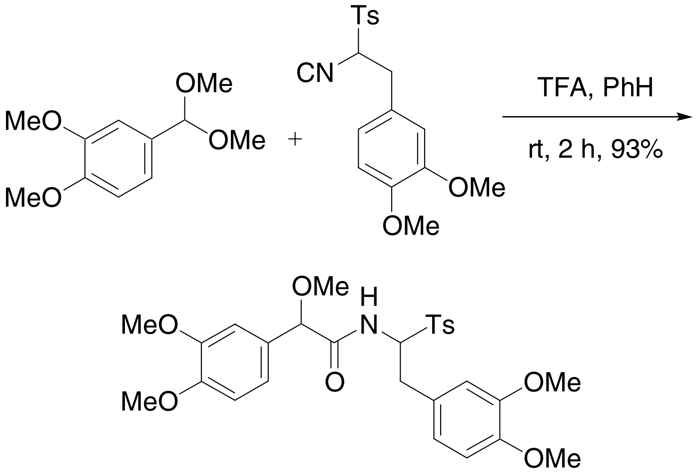
isocyanide



Example 1[5]



Example 2[3]

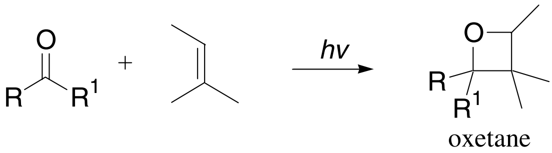


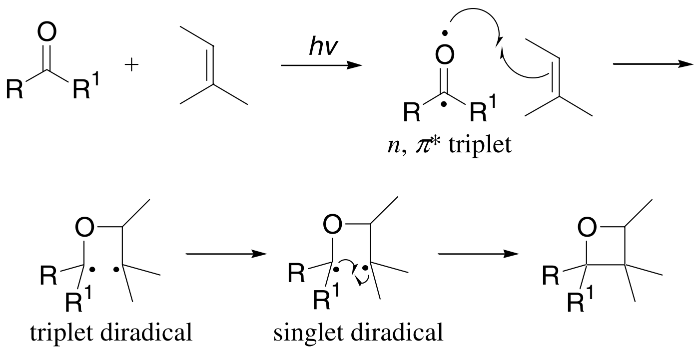
References

1. Passerini, M. *Gazz. Chim. Ital.* **1921**, *51*, 126, 181. Mario Passerini (1891−) was born in Scandicci, Italy. He obtained his Ph.D. in chemistry and pharmacy at the University of Florence, where he was a professor for most of his career.
2. Ferosie, I. *Aldrichimica Acta* **1971**, *4*, 21. (Review).
3. Barrett, A. G. M.; Barton, D. H. R.; Falck, J. R.; Papaioannou, D.; Widdowson, D. A. *J. Chem. Soc., Perkin Trans. 1* **1979**, 652.
4. Ugi, I.; Lohberger, S.; Karl, R. In *Comprehensive Organic Synthesis*; Trost, B. M.; Fleming, I., Eds.; Pergamon: Oxford, **1991**, *Vol. 2*, p.1083. (Review).
5. Bock, H.; Ugi, I. *J. Prakt. Chem.* **1997**, *339*, 385.
6. Ziegler, T.; Kaisers, H.-J.; Schlomer, R.; Koch, C. *Tetrahedron* **1999**, *55*, 8397.
7. Banfi, L.; Guanti, G.; Riva, R. *Chem. Commun*. **2000**, 985.
8. Semple, J. E.; Owens, T. D.; Nguyen, K.; Levy, O. E. *Org. Lett*. **2000**, *2*, 2769.
9. Owens, T. D.; Semple, J. E. *Org. Lett*. **2001**, *3*, 3301.
10. Xia, Q.; Ganem, B. *Org. Lett.* **2002**, *4*, 1631.
11. Basso, A.; Banfi, L.; Riva, R.; Piaggio, P.; Guanti, G. *Tetrahedron Lett*. **2003**, *44*, 2367.
12. Banfi, L.; Riva, R. *Org. React.* **2005**, *65*, 1−140. (Review).

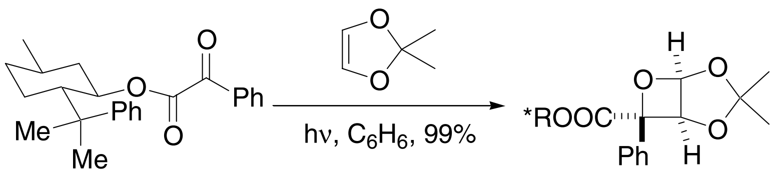
Paternó–Büchi reaction

Photoinduced electrocyclization of a carbonyl with an alkene to form polysubstituted oxetane ring systems

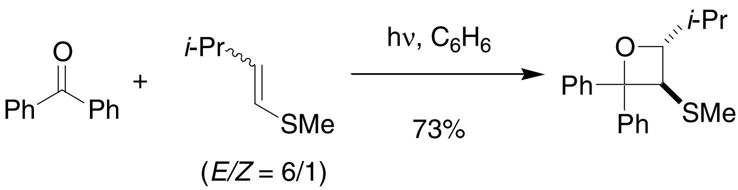




Example 1[4]



Example 2[6]

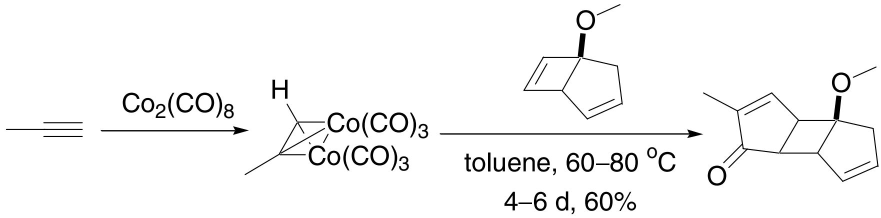


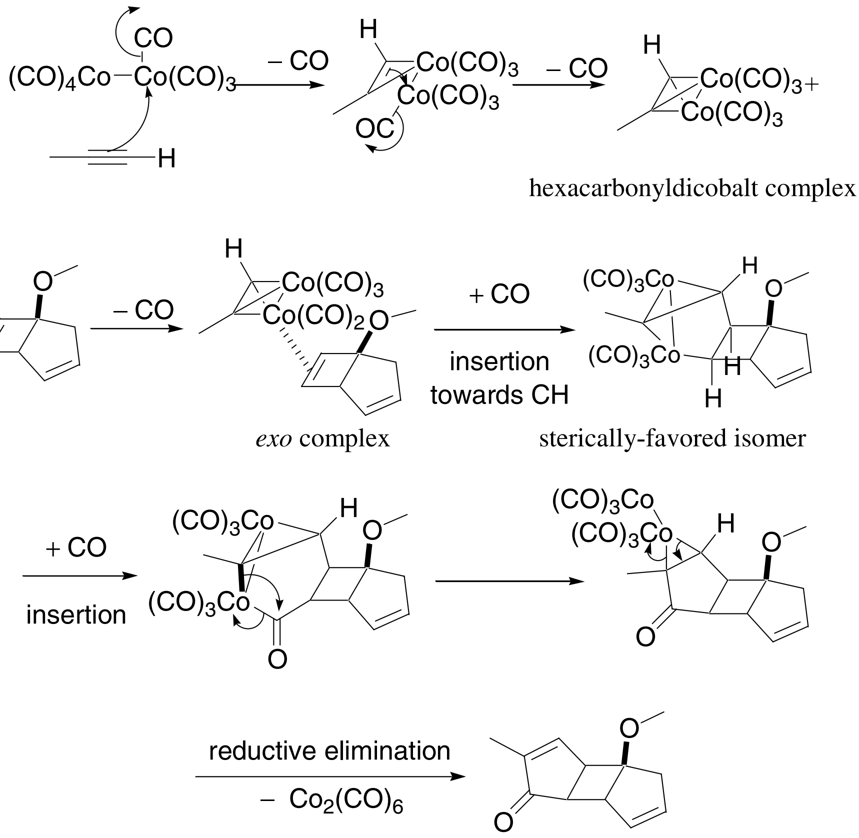
References

1.釘Paternó, E.; Chieffi, G. *Gazz. Chim. Ital.* **1909**, *39*, 341. Emaubuele Paternó (1847–1935) was born in Palermo, Sicily, Italy.
2. Büchi, G.; Inman, C. G.; Lipinsky, E. S. *J. Am. Chem. Soc*. **1954**, *76*, 4327. George H. Büchi (1921–1998) was born in Baden, Switzerland. He was a professor at MIT when he elucidated the structure of oxetanes, the products from the light-catalyzed addition of carbonyl compounds to olefins, which had been observed by E. Paterno in 1909. Büchi died of heart failure while hiking with his wife in his native Switzerland.
3. Jones, G. In *Organic Photochemistry*; Padwa, A., Ed.; Dekker: New York, **1981**, pp 1. (Review).
4. Koch, H.; Runsink, J.; Scharf, H.-D. *Tetrahedron Lett.* **1983**, *24*, 3217.
5. Carless, H. A. J. In *Synthetic Organic Photochemistry*; Horspool, W. M., Ed.; Plenum Press: New York, **1984**, pp 425. (Review).
6. Morris, T. H.; Smith, E. H.; Walsh, R. *J. Chem. Soc., Chem. Commun.* **1987**, 964.
7. Porco, J. A., Jr.; Schreiber, S. L. In *Comprehensive Organic Synthesis* Trost, B. M.; Fleming, I., Eds.; Pergamon: Oxford, **1991**, *Vol. 5*, 151–192. (Review).
8. Griesbeck, A. G.; Mauder, H.; Stadtmüller, S. *Acc. Chem. Res.* **1994**, *27*, 70. (Review).
9. Fleming, S. A.; Gao, J. J. *Tetrahedron Lett*. **1997**, *38*, 5407.
10. Hubig, S. M.; Sun, D.; Kochi, J. K. *J. Chem. Soc., Perkin Trans. 2* **1999**, 781.
11. D'Auria, M.; Racioppi, R.; Romaniello, G. *Eur. J. Org. Chem*. **2000**, 3265.
12. Bach, T.; Brummerhop, H.; Harms, K. *Chem. Eur. J*. **2000**, *6*, 3838.
13. Bach, T. *Synlett* **2000**, 1699.
14. Abe, M.; Tachibana, K.; Fujimoto, K.; Nojima, M. *Synthesis* **2001**, 1243.
15. D'Auria, M.; Emanuele, L.; Poggi, G.; Racioppi, R.; Romaniello, G. *Tetrahedron* **2002**, *58*, 5045.
16. Griesbeck, A. G. *Synlett* **2003**, 451.
17. Liu, C. M. *Paternó–Büchi Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 44–49. (Review).

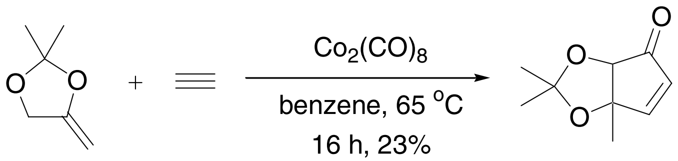
Pauson−Khand cyclopentenone synthesis

Formal [2 + 2 +1] cycloaddition of an alkene, alkyne, and carbon monoxide mediated by octacarbonyl dicobalt.

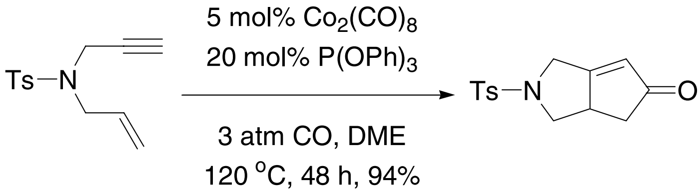




Example 1[6]



Example 2, a catalytic version[9]

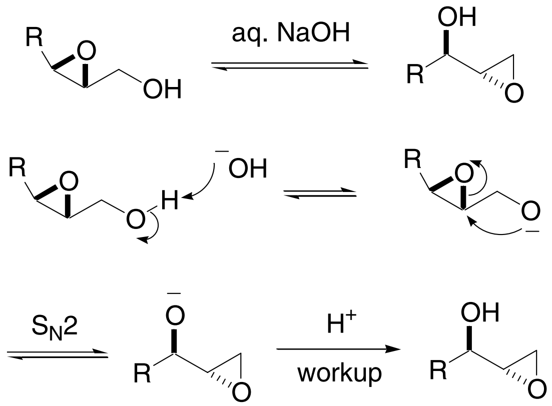


References

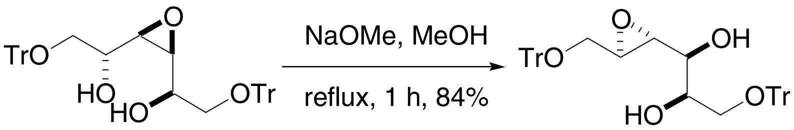
1. Khand, I. U.; Knox, G. R.; Pauson, P. L.; Watts, W. E. *J. Chem. Soc., Chem. Commun.* **1971**, 36. Ihsan U. Khand and Peter L. Pauson were at the University of Strathclyde, Glasgow in Scotland.
2. Khand, I. U.; Knox, G. R.; Pauson, P. L.; Watts, W. E.; Foreman, M. I. *J. Chem. Soc., Perkin Trans. 1* **1973**, 977.
3. Bladon, P.; Khand, I. U.; Pauson, P. L. *J. Chem. Res. (M)*, **1977**, 153.
4. Pauson, P. L. *Tetrahedron* **1985**, *41*, 5855. (Review).
5. Schore, N. E. *Chem. Rev.* **1988**, *88*, 1081. (Review).
6. Billington, D. C.; Kerr, W. J.; Pauson, P. L.; Farnocchi, C. F. *J. Organometal. Chem.* **1988**, *356*, 213.
7. Schore, N. E. In *Comprehensive Organic Synthesis*; Paquette, L. A.; Fleming, I.; Trost, B. M., Eds.; Pergamon: Oxford, **1991**, *Vol. 5*, p.1037. (Review).
8. Schore, N. E. *Org. React.* **1991**, *Vol. 40*, pp 1–90. (Review).
9. Jeong, N.; Hwang, S. H.; Lee, Y.; Chung, J. *J. Am. Chem. Soc.* **1994**, *116*, 3159.
10. Brummond, K. M.; Kent, J. L. *Tetrahedron* **2000**, *56*, 3263. (Review).
11. Son, S. U.; Lee, S. I.; Chung, Y. K. *Angew. Chem., Int. Ed.* **2000**, *39*, 4158.
12. Kraft, M. E.; Fu, Z.; Boñaga, L. V. R. *Tetrahedron Lett.* **2001**, *42*, 1427.
13. Muto, R.; Ogasawara, K. *Tetrahedron Lett.* **2001**, *42*, 4143.
14. Areces, P.; Durán, M. Á.; Plumet, J.; Hursthouse, M. B.; Light, M. E. *J. Org. Chem.* **2002**, *67*, 3506.
15. Mukai, C.; Nomura, I.; Kitagaki, S. *J. Org. Chem.* **2003**, *68*, 1376.
16. Tsujimoto, T.; Nishikawa, T.; Urabe, D.; Isobe, M. *Synlett* **2005**, 433.

Payne rearrangement

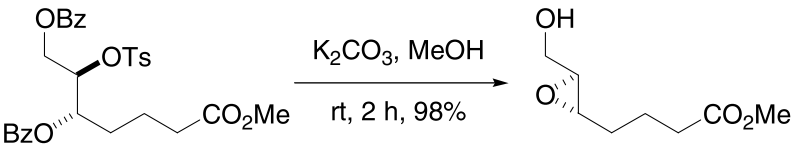
Base-promoted isomerization of 2,3-epoxy alcohols. Also known as epoxide migration.



Example 1[2]



Example 2[3]



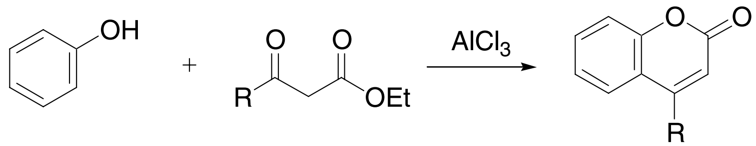
References

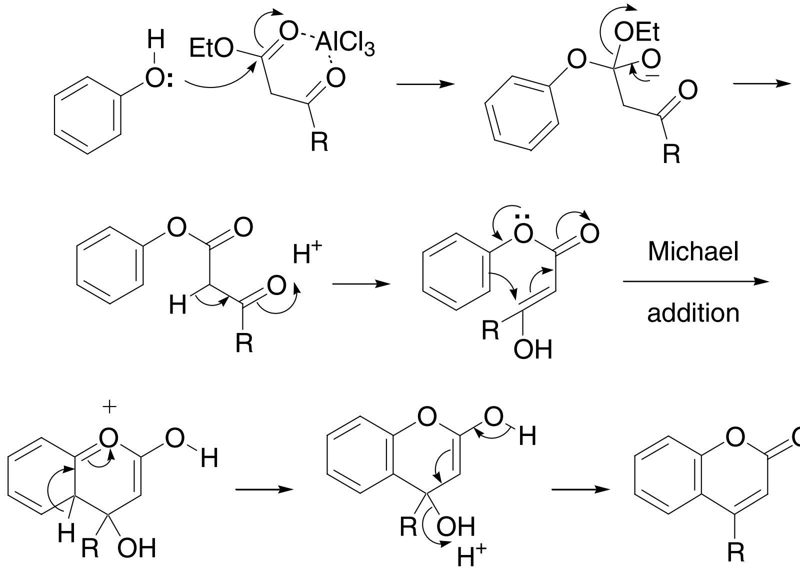
1. Payne, G. B. *J. Org. Chem.* **1962**, *27*, 3819. George B. Payne was a chemist at Shell Development Co. in Emeryville, CA.
2. Buchanan, J. G.; Edgar, A. R. *Carbohydr. Res.* **1970**, *10*, 295.
3. Corey, E. J.; Clark, D. A.; Goto, G.; Marfat, A.; Mioskowski, C.; Samuelsson, B.; Hammerstrom, S. *J. Am. Chem. Soc.* **1980**, *102*, 1436, 3663.
4. Page, P. C. B.; Rayner, C. M.; Sutherland, I. O. *J. Chem. Soc., Perkin Trans. 1*, **1990**, 1375.
5. Konosu, T.; Miyaoka, T.; Tajima, Y.; Oida, S. *Chem. Pharm. Bull.* **1992**, *40*, 562.
6. Dols, P. P. M. A.; Arnouts, E. G.; Rohaan, J.; Klunder, A. J. H.; Zwanenburg, B. *Tetrahedron* **1994**, *50*, 3473.

7. Ibuka, T. *Chem. Soc. Rev*. **1998**, *27*, 145. (Review).
8. Bickley, J. F.; Gillmore, A. T.; Roberts, S. M.; Skidmore, J.; Steiner, A. *J. Chem. Soc., Perkin Trans. 1* **2001**, 1109.
9. Tamamura, H.; Hori, T.; Otaka, A.; Fujii, N. *J. Chem. Soc., Perkin Trans. 1* **2002**, 577.
10. Hanson, R. M. *Org. React.* **2002**, *60*, 1−156. (Review).
11. Tamamura, H.; Kato, T.; Otaka, A.; Fujii, N. *Org. Biomol. Chem*. **2003**, *1*, 2468.
12. Yamazaki, T.; Ichige, T.; Kitazume, T. *Org. Lett.* **2004**, *6*, 4073.
13. Bilke, J. L.; Dzuganova, M.; Froehlich, R.; Wuerthwein, E.-U. *Org. Lett.* **2005**, *7*, 3267.

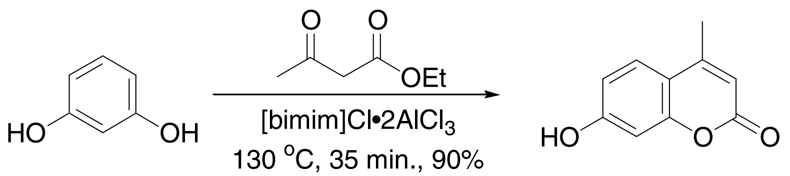
Pechmann coumarin synthesis

Lewis acid-mediated condensation of phenol with β-ketoester to produce coumarin.



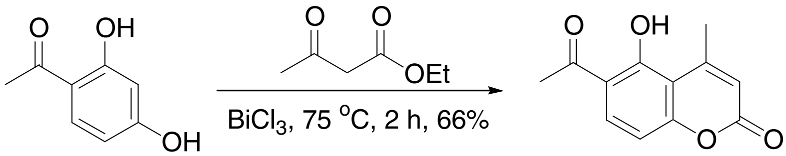


Example 1[11]



[bimim]Cl•2AlCl$_3$ = 1-Butyl-3-methylimidazolium chloroaluminuminate (a Lewis acid ionic liquid)

Example 2[14]

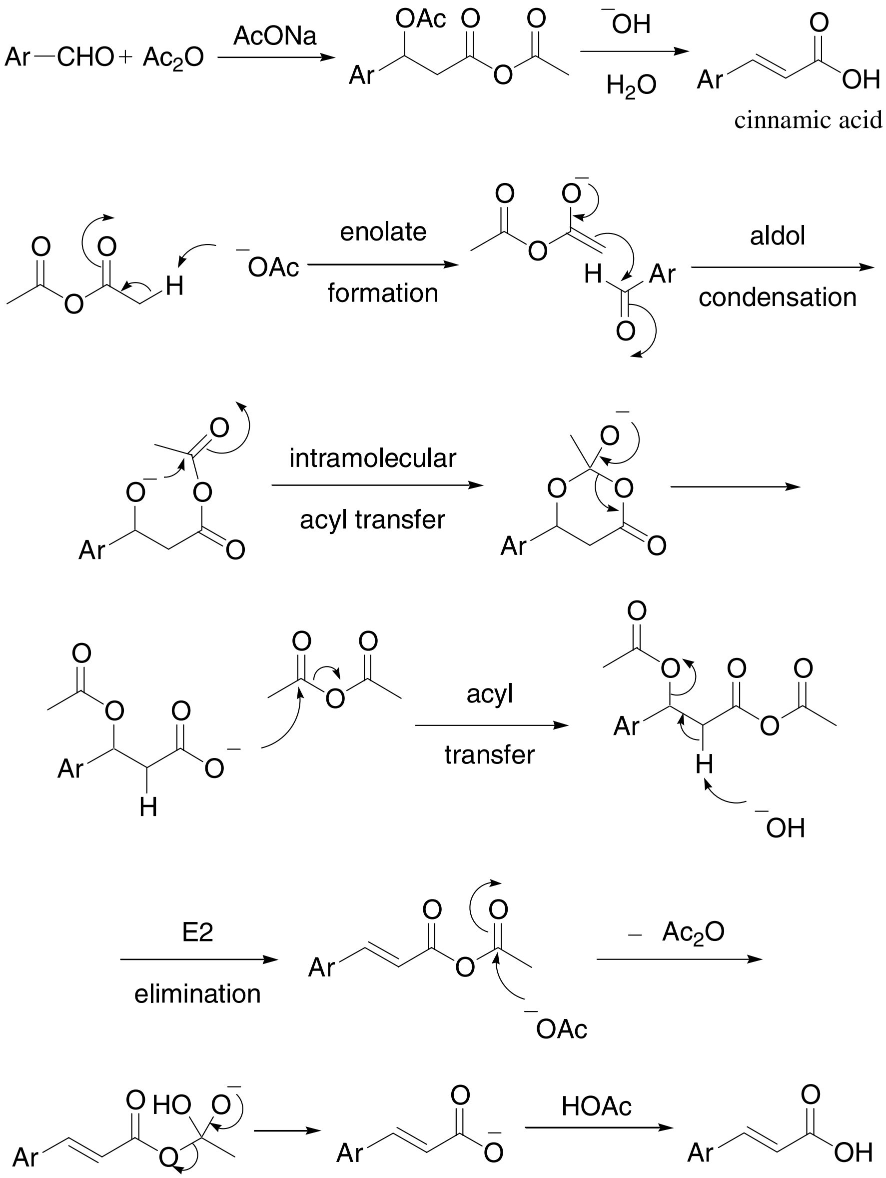


References

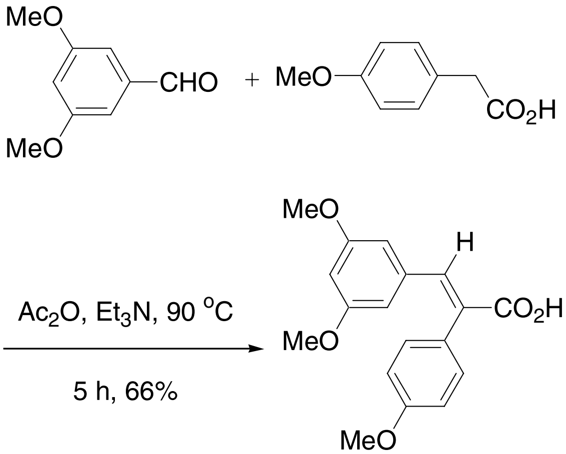
1. v. Pechmann, H.; Duisberg, C. *Ber. Dtsch. Chem. Ges.* **1883**, *16*, 2119. Hans von Pechmann (1850–1902) was born in Nürnberg, Germany. After his doctorate, he worked with Frankland and von Baeyer. Pechmann taught at Munich and Tübingen. He committed suicide by taking cyanide.
2. Hirata, T.; Suga, T. *Bull. Chem. Soc. Jpn*. **1974**, *47*, 244.
3. Chaudhari, D. D. *Chem. Ind*. **1983**, 568.
4. Holden, M. S.; Crouch, R. D. *J. Chem. Educ*. **1998**, *75*, 1631.
5. Corrie, J. E. T. *J. Chem. Soc., Perkin Trans. 1* **1990**, 2151.
6. Hua, D. H.; Saha, S.; Roche, D.; Maeng, J. C.; Iguchi, S.; Baldwin, C. *J. Org. Chem.* **1992**, *57*, 399.
7. Biswas, G. K.; Basu, K.; Barua, A. K.; Bhattacharyya, P. *Indian J. Chem., Sect. B* **1992**, *31B*, 628.
8. Li, T.-S.; Zhang, Z.-H.; Yang, F.; Fu, C.-G. *J. Chem. Res., (S)* **1998**, 38.
9. Sugino, T.; Tanaka, K. *Chem. Lett*. **2001**, 110.
10. Potdar, M. K.; Mohile, S. S.; Salunkhe, M. M. *Tetrahedron Lett*. **2001**, *42*, 9285.
11. Khandekar, A. C.; Khandilkar, B. M. *Synlett*. **2002**, 152.
12. Shockravi, A.; Heravi, M. M.; Valizadeh, H. *Phosphorus, Sulfur Silicon Relat. Elem.* **2003**, *178*, 143.
13. Smitha, G.; Sanjeeva Reddy, C. *Synth. Commun*. **2004**, *34*, 3997.
14. De, S. K.; Gibbs, R. A. *Synthesis* **2005**, 1231.

Perkin reaction

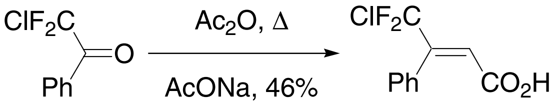
Cinnamic acid synthesis from aryl aldehyde and acetic anhydride.



Example 1[9]



Example 2[10]

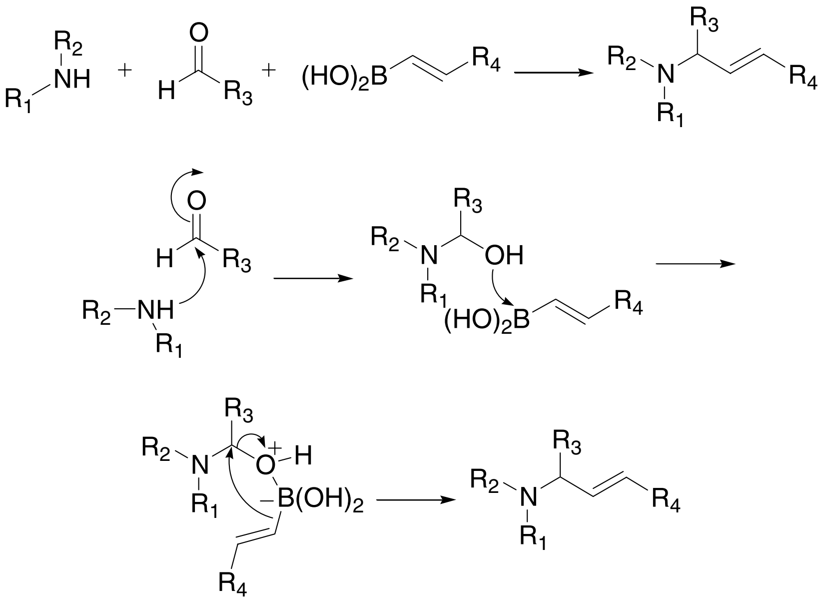


References

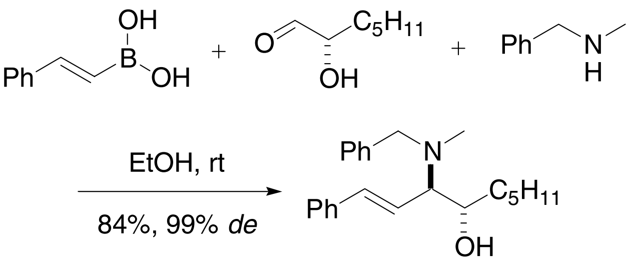
1. Perkin, W. H. *J. Chem. Soc.* **1868**, *21,* 53. William Henry Perkin (1838–1907), born in London, England, studied under Hofmann at the Royal College of Chemistry. In an attempt to synthesize quinine in his home laboratory in 1856, Perkin synthesized mauve, the purple dye. He then started a factory to manufacture mauve and later other dyes including alizarin. Perkin was the first person to show that organic chemistry was not just mere intellectual curiosity but could be profitable, which catapulted the discipline into a higher level. In addition, Perkin was also an exceptionally talented pianist.
2. Pohjala, E. *Heterocycles* **1975**, *3,* 615.
3. Poonia, N. S.; Sen, S.; Porwal, P. K.; Jayakumar, A. *Bull. Chem. Soc. Jpn.* **1980**, *53,* 3338.
4. Gaset, A.; Gorrichon, J. P. *Synth. Commun.* **1982**, *12,* 71.
5. Kinastowski, S.; Nowacki, A. *Tetrahedron Lett.* **1982**, *23,* 3723.
6. Koepp, E.; Voegtle, F. *Synthesis* **1987**, 177.
7. Brady, W. T.; Gu, Y.-Q. *J. Heterocycl. Chem.* **1988**, *25,* 969.
8. Pálinkó, I.; Kukovecz, A.; Török, B.; Körtvélyesi, T. *Monatsh. Chem.* **2001**, *131,* 1097.
9. Solladié, G.; Pasturel-Jacopé, Y.; Maignan, J. *Tetrahedron* **2003**, *59,* 3315.
10. Sevenard, D. V. *Tetrahedron Lett.* **2003**, *44,* 7119.

Petasis reaction

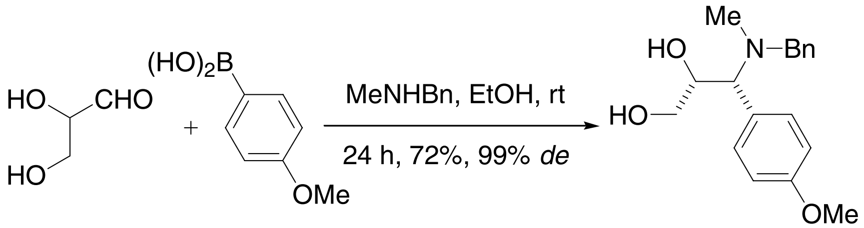
Allylic amine from the three-component reaction of a vinyl boronic acid, a carbonyl and an amine. Also known as boronic acid-Mannich or Petasis boronic acid-Mannich reaction. *Cf.* Mannich reaction.



Example 1[5]



Example 2[7]

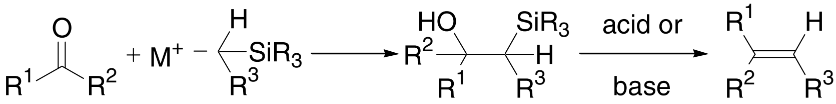


References

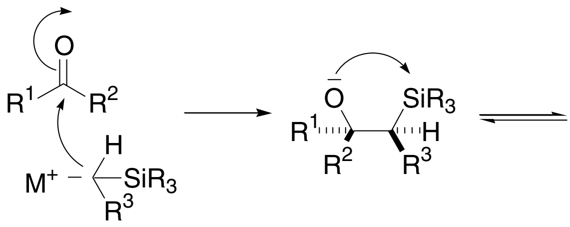
1. Petasis, N. A.; Akritopoulou, I. *Tetrahedron Lett*. **1993**, *34*, 583.
2. Petasis, N. A.; Zavialov, I. A. *J. Am. Chem. Soc*. **1997**, *119*, 445.
3. Petasis, N. A.; Goodman, A.; Zavialov, I. A. *Tetrahedron* **1997**, *53*, 16463.
4. Petasis, N. A.; Zavialov, I. A. *J. Am. Chem. Soc*. **1998**, *120*, 11798.
5. Koolmeister, T.; Södergren, M.; Scobie, M. *Tetrahedron Lett*. **2002**, *43*, 5969.
6. Orru, R. V. A.; deGreef, M. *Synthesis* **2003**, 1471. (Review).
7. Sugiyama, S.; Arai, S.; Ishii, K. *Tetrahedron: Asymmetry* **2004**, *15*, 3149.
8. Chang, Y. M.; Lee, S. H.; Nam, M. H.; Cho, M. Y.; Park, Y. S.; Yoon, C. M. *Tetrahedron* **2005**, *46*, 3053.
9. Follmann, M.; Graul, F.; Schaefer, T.; Kopec, S.; Hamley, P. *Synlett* **2005**, 1009.

Peterson olefination

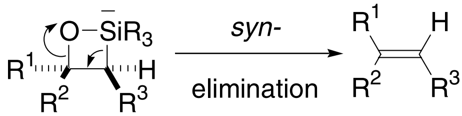
Alkenes from α-silyl carbanion and carbonyl compounds. Also known as sila-Wittig reaction.



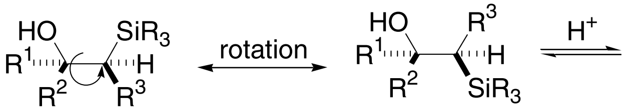
Basic conditions:



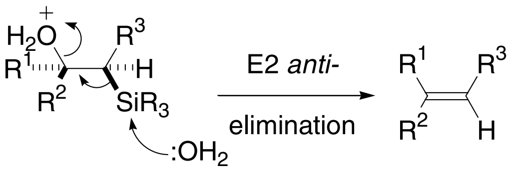
β-silylalkoxide intermediate



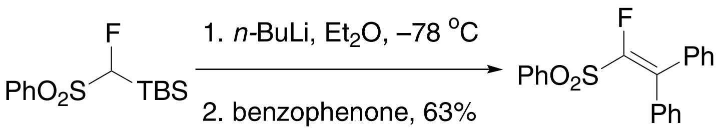
Acidic conditions:



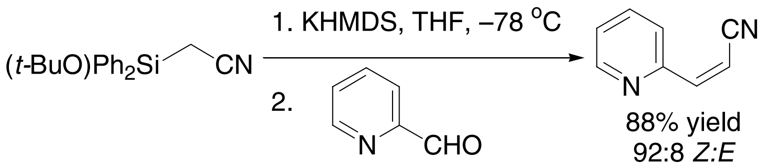
β-hydroxysilane



Example 1[10]



Example 2[12]

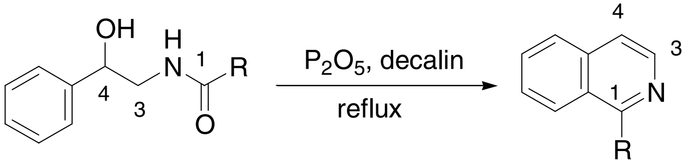


References

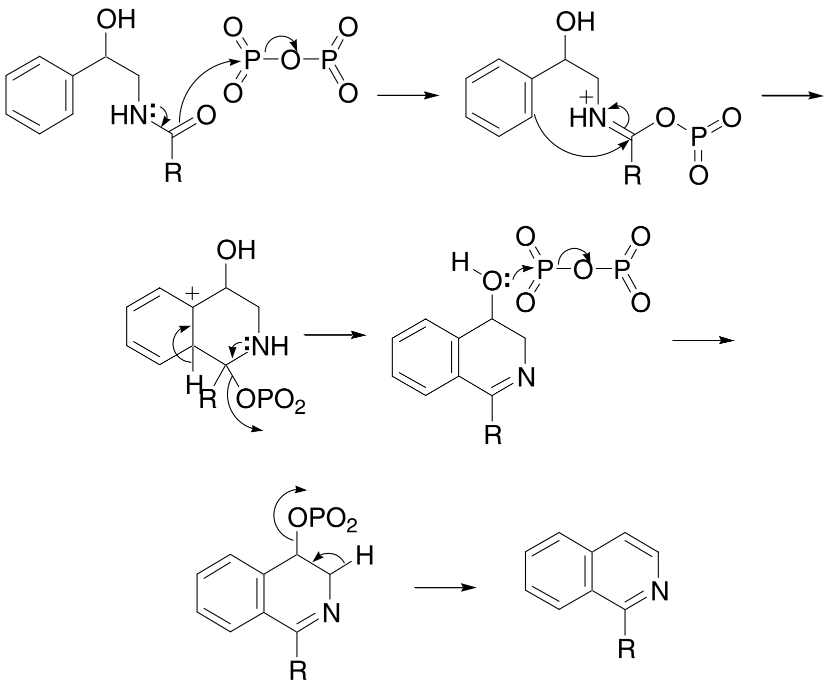
1. Peterson, D. J. *J. Org. Chem.* **1968**, *33*, 780.
2. Ager, D. J. *Synthesis* **1984**, 384–398. (Review).
3. Ager, D. J. *Org. React.* **1990**, *38*, 1–223. (Review).
4. Barrett, A. G. M.; Hill, J. M.; Wallace, E. M.; Flygare, J. A. *Synlett* **1991**, 764–770. (Review).
5. Galano, J.-M.; Audran, G.; Monti, H. *Tetrahedron Lett.* **2001**, *42,* 6125.
6. van Staden, L. F.; Gravestock, D.; Ager, D. J. *Chem. Soc. Rev.* **2002**, *31*, 195–200. (Review).
7. Ager, D. J. *Science of Synthesis* **2002**, *4*, 789–809. (Review).
8. Adam, W.; Ortega-Schulte, C. M. *Synlett* **2003**, 414.
9. Murai, T.; Fujishima, A.; Iwamoto, C.; Kato, S. *J. Org. Chem.* **2003**, *68*, 7979.
10. Asakura, N.; Usuki, Y.; Iio, H. *J. Fluorine Chem.* **2003**, *124*, 81.
11. Suzuki, H.; Ohta, S.; Kuroda, C. *Synth. Commun.* **2004**, *34*, 1383.
12. Kojima, S.; Fukuzaki, T.; Yamakawa, A.; Murai, Y. *Org. Lett.* **2004**, *6,* 3917.
13. Kano, N.; Kawashima, T. *The Peterson and Related Reactions* in *Modern Carbonyl Olefination* Takeda, T. (ed.), Wiley-VCH: Weinheim, Germany, **2004**, 18–103. (Review).
14. Aubele, D. L.; Wan, S.; Floreancig, P. E. *Angew. Chem., Int. Ed.* **2005**, *44*, 3485.

Pictet–Gams isoquinoline synthesis

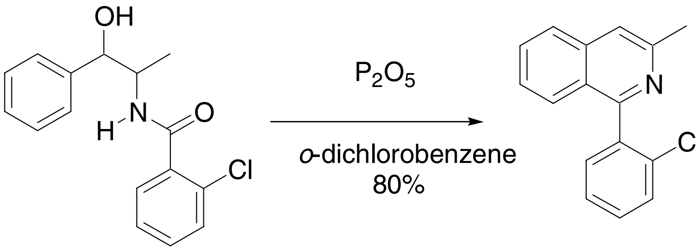
The isoquinoline framework is derived from the corresponding acyl derivatives of β-hydroxy-β-phenylethylamines. Upon exposure to a dehydrating agent such as phosphorus pentaoxide, or phosphorus oxychloride, under reflux conditions and in an inert solvent such as decalin, isoquinoline frameworks are formed.



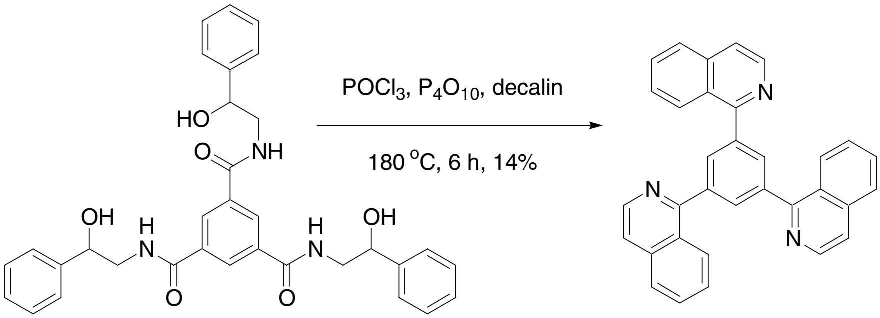
P_2O_5 actually exists as P_4O_{10}, an adamantane-like structure.



Example 1[10]



Example 2[7]

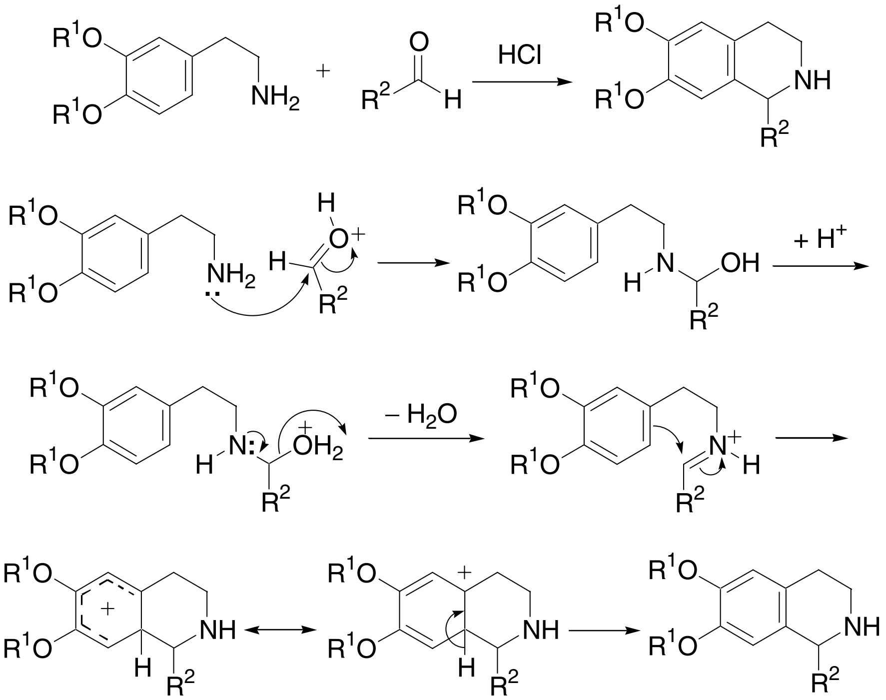


Reference

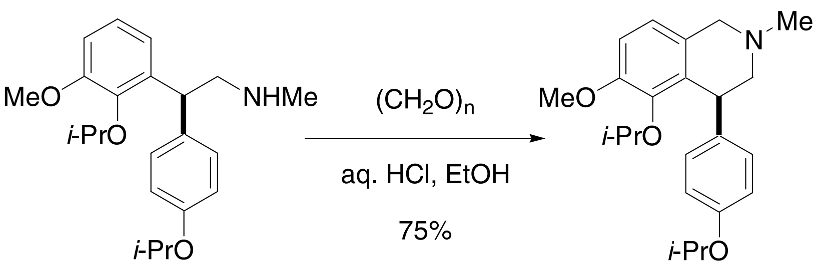
1. Pictet, A.; Gams, A. *Ber. Dtsch. Chem. Ges.* **1909**, *42*, 1973, 2943. Amé Pictet (1857–1937), born in Geneva, Switzerland, carried out a tremendous amount of work on alkaloids.
2. Kulkarni, S. N.; Nargund, K. S. *Indian J. Chem., B* **1967**, *5*, 294.
3. Ardabilchi, N.; Fitton, A. O.; Frost, J. R.; Oppong-Boachie, F. *Tetrahedron Lett.* **1977**, *18,* 4107.
4. Ardabilchi, N.; Fitton, A. O.; Frost, J. R.; Oppong-Boachie, F. K.; Hadi, A. H. A.; Sharif, A. M. *J. Chem. Soc., Perkin Trans. 1* **1979**, 539.
5. Ardabilchi, N.; Fitton, A. O. *J. Chem. Soc. (S)* **1979**, 310.
6. Cerri, A.; Mauri, P.; Mauro, M.; Melloni, P. *J. Heterocycl. Chem.* **1993**, *30*, 1581.
7. Dyker, G.; Gabler, M.; Nouroozian, M.; Schulz, P. *Tetrahedron Lett.* **1994**, *35,* 9697.
8. Poszávácz, L.; Simig, G. *J. Heterocycl. Chem.* **2000**, *37*, 343.
9. Poszávácz, L.; Simig, G. *Tetrahedron* **2001**, *57*, 8573.
10. Manning, H. C.; Goebel, T.; Marx, J. N.; Bornhop, D. J. *Org. Lett.* **2002**, *4*, 1075.
11. Holsworth, D. D. *Pictet–Gams Isoquinoline Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 457–465. (Review).

Pictet–Spengler tetrahydroisoquinoline synthesis

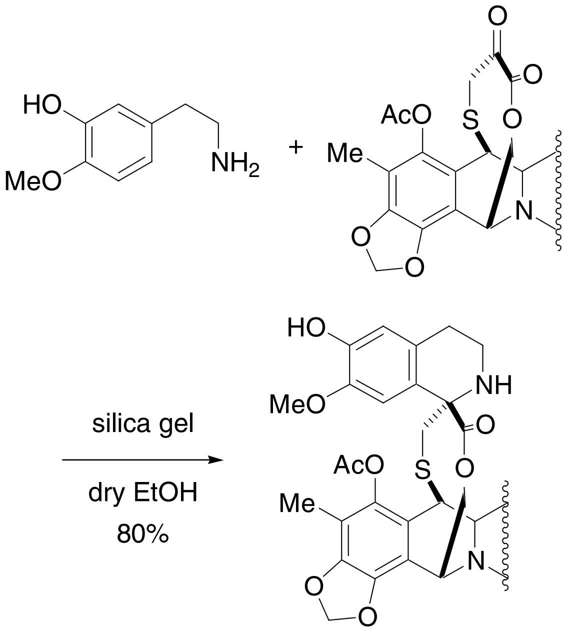
Tetrahydroisoquinolines from condensation of β-arylethylamines and carbonyl compounds followed by cyclization.



Example 1[12]



Example 2[9]

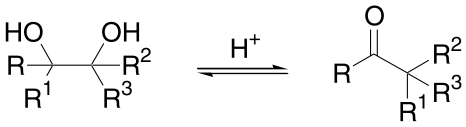


References

1. Pictet, A.; Spengler, T. *Ber. Dtsch. Chem. Ges.* **1911**, *44*, 2030.
2. Hudlicky, T.; Kutchan, T. M.; Shen, G.; Sutliff, V. E.; Coscia, C. J. *J. Org. Chem.* **1981**, *46*, 1738.
3. Miller, R. B.; Tsang, T. *Tetrahedron Lett.* **1988**, *29*, 6715.
4. Rozwadowska, M. D. *Heterocycles* **1994**, *39*, 903.
5. Cox, E. D.; Cook, J. M. *Chem. Rev.* **1995**, *95*, 1797. (Review).
6. Corey, E. J.; Gin, D. Y.; Kania, R. S. *J. Am. Chem. Soc.* **1996**, *118*, 9202.
7. Yokoyama, A.; Ohwada, T.; Shudo, K. *J. Org. Chem.* **1999**, *64*, 611.
8. Kang, I.-J.; Wang, H.-M.; Su, C.-H.; Chen, L.-C. *Heterocycles* **2002**, *57*, 1.
9. Zhou, B.; Guo, J.; Danishefsky, S. J. *Org. Lett.* **2002**, *4*, 43.
10. Yu, J.; Wearing, X. Z.; Cook, J. M. *Tetrahedron Lett.* **2003**, *44*, 543.
11. Tsuji, R.; Nakagawa, M.; Nishida, A. *Tetrahedron: Asymmetry* **2003**, *14*, 177.
12. Couture, A.; Deniau, E.; Grandclaudon, P.; Lebrun, S. *Tetrahedron: Asymmetry* **2003**, *14*, 1309.
13. Tinsley, J. M. *Pictet–Spengler Isoquinoline Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 469–479. (Review).

Pinacol rearrangement

Acid-catalyzed rearrangement of vicinyl diols (pinacols) to carbonyl compounds.

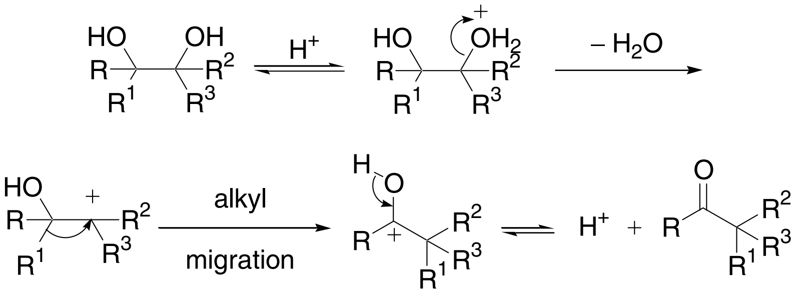


The most electron-rich alkyl group (more substituted carbon) migrates first. The general migration order:

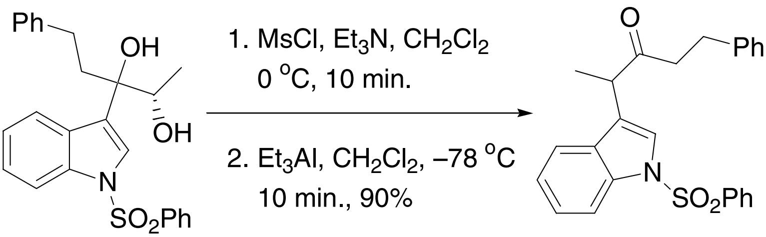
tertiary alkyl > cyclohexyl > secondary alkyl > benzyl > phenyl > primary alkyl > methyl >> H.

For substituted aryls:

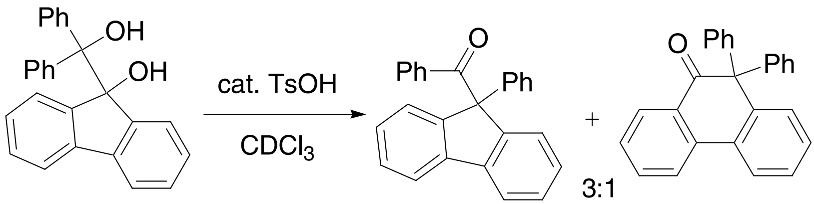
p-MeO-Ar > *p*-Me-Ar > *p*-Cl-Ar > *p*-Br-Ar > *p*-MeOAr > *p*-O_2N-Ar



Example 1[12]



Example 2[14]

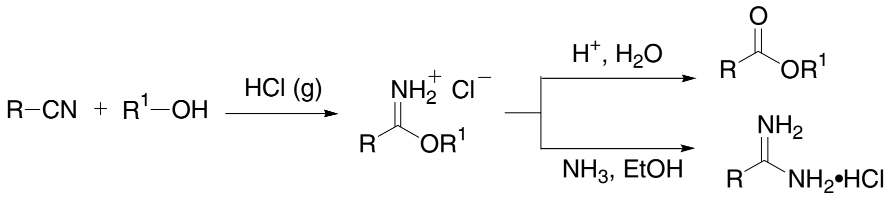


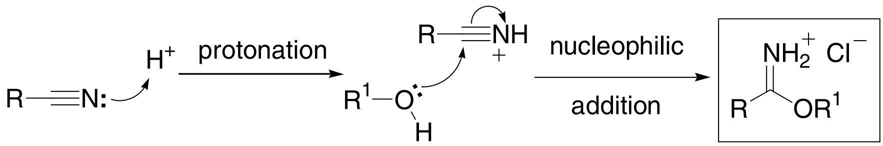
References

1. Fittig, R. *Justus Liebigs Ann. Chem.* **1860**, *114*, 54.
2. Toda, F.; Shigemasa, T. *J. Chem. Soc., Perkin Trans. 1* **1989**, 209.
3. Nakamura, K.; Osamura, Y. *J. Am. Chem. Soc*. **1993**, *115*, 9112.
4. Paquette, L. A.; Lord, M. D.; Negri, J. T. *Tetrahedron Lett*. **1993**, *34*, 5693.
5. Jabur, F. A.; Penchev, V. J.; Bezoukhanova, C. P. *J. Chem. Soc., Chem. Commun.* **1994**, 1591.
6. Patra, D.; Ghosh, S. *J. Org. Chem*. **1995**, *60*, 2526.
7. Magnus, P.; Diorazio, L.; Donohoe, T. J.; Giles, M.; Pye, P.; Tarrant, J.; Thom, S. *Tetrahedron* **1996**, *52*, 14147.
8. Bach, T.; Eilers, F. *J. Org. Chem*. **1999**, *64*, 8041.
9. Razavi, H.; Polt, R. *J. Org. Chem*. **2000**, *65*, 5693.
10. Chen, X.; Esser, L.; Harran, P. G. *Angew. Chem., Int. Ed*. **2000**, *39*, 937.
11. Rashidi-Ranjbar, P.; Kianmehr, E. *Molecules* **2001**, *6*, 442.
12. Shinohara, T.; Suzuki, K. *Tetrahedron Lett*. **2002**, *43*, 6937.
13. Overman, L. E.; Pennington, L. D. *J. Org. Chem*. **2003**, *68*, 7143−7157. (Review).
14. Mladenova, G.; Singh, G.; Acton, A.; Chen, L.; Rinco, O.; Johnston, L. J.; Lee-Ruff, E. *J. Org. Chem*. **2004**, *69*, 2017.
15. Birsa, M. L.; Jones, P. G.; Hopf, H. *Eur. J. Org. Chem*. **2005**, 3263.

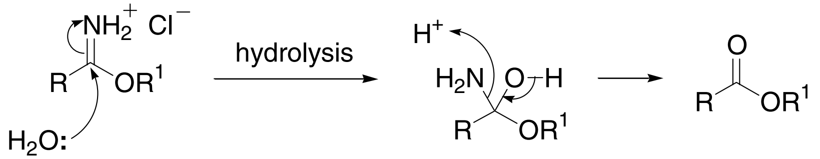
Pinner reaction

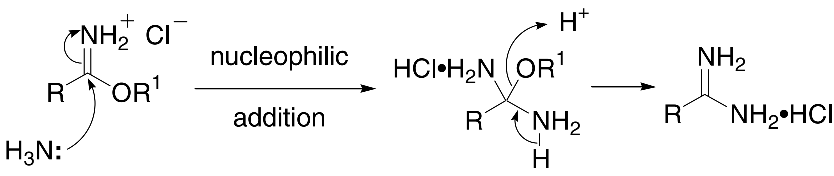
Transformation of a nitrile into an imino ether, which can be converted to either an ester or an amidine.



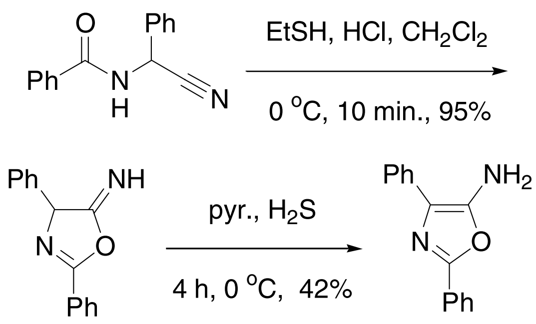


common intermediate

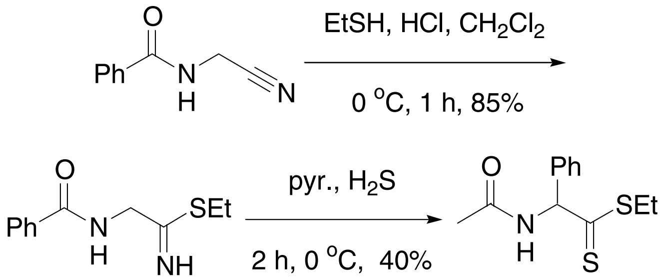




Example 1[3]



Example 2[3]

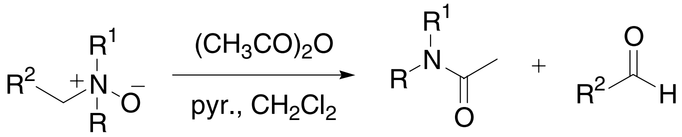


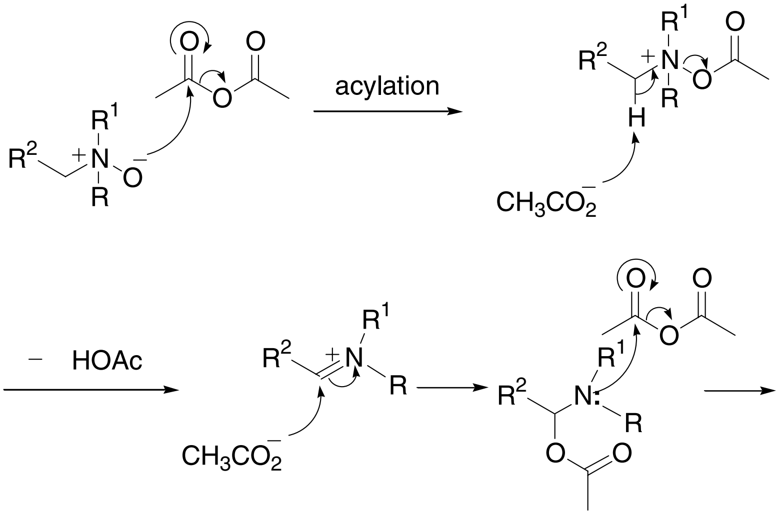
References

1. Pinner, A.; Klein, F. *Ber. Dtsch. Chem. Ges.* **1877**, *10*, 1889.
2. Pinner, A.; Klein, F. *Ber. Dtsch. Chem. Ges.* **1878**, *11*, 1825.
3. Poupaert, J.; Bruylants, A.; Crooy, P. *Synthesis* **1972**, 622.
4. Wagner, G.; Horn, H. *Pharmazie* **1975**, *30*, 353.
5. Lee, Y. B.; Goo, Y. M.; Lee, Y. Y.; Lee, J. K. *Tetrahedron Lett*. **1990**, *31*, 1169.
6. Cheng, C. C. *Org. Prep. Proced. Int*. **1990**, *22*, 643.
7. Neugebauer, W.; Pinet, E.; Kim, M.; Carey, P. R. *Can. J. Chem*. **1996**, *74*, 341.
8. Siskos, A. P.; Hill, A. M. *Tetrahedron Lett*. **2003**, *44*, 789.
9. Fringuelli, F.; Piermatti, O.; Pizzo, F. *Synthesis* **2003**, 2331.
10. Cushion, M. T.; Walzer, P. D.; Collins, M. S.; Rebholz, S.; Vanden Eynde, J. J.; Mayence, A.; Huang, T. L. *Antimicrob. Agents Chemoth*. **2004**, *48*, 4209.

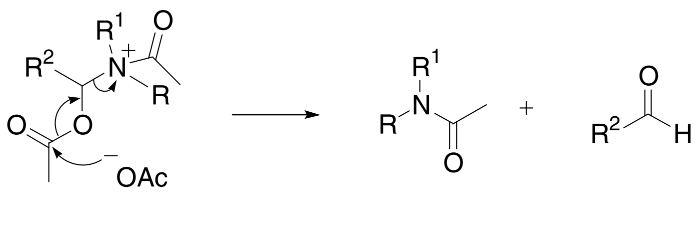
Polonovski reaction

Treatment of a tertiary *N*-oxide with an activating agent such as acetic anhydride, resulting in rearrangement where an *N,N*-disubstituted acetamide and an aldehyde are generated.

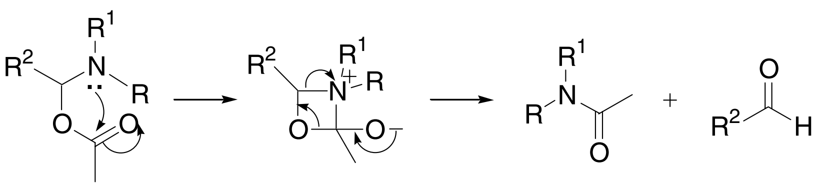




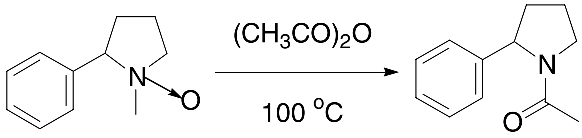
iminium ion



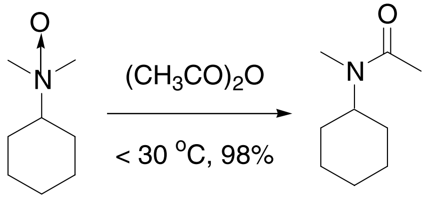
The intramolecular pathway is also possible:



Example 1[1]



Example 2[2]

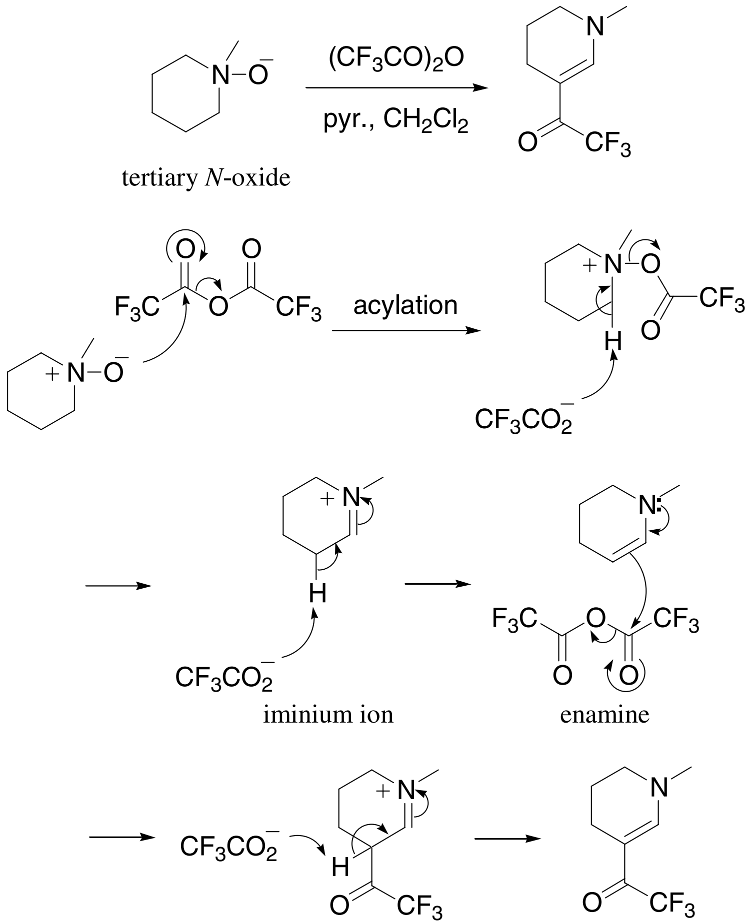


References

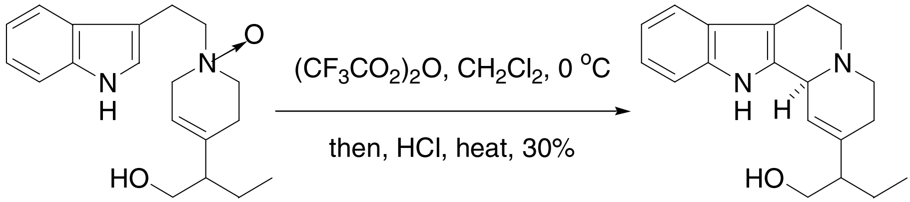
1. Polonovski, M.; Polonovski, M. *Bull. Soc. Chim. Fr.* **1927**, *41*, 1190.
2. Michelot, R. *Bull. Soc. Chim. Fr.* **1969**, 4377.
3. Volz, H.; Ruchti, L. *Ann*. **1972**, *763*, 184.
4. Hayashi, Y.; Nagano, Y.; Hongyo, S.; Teramura, K. *Tetrahedron Lett*. **1974**, *15,* 1299.
5. M'Pati, J.; Mangeney, P.; Langlois, Y. *Tetrahedron Lett*. **1981**, *22*, 4405.
6. Lounasmaa, M.; Koskinen, A. *Tetrahedron Lett*. **1982**, *23*, 349.
7. Lounasmaa, M.; Karvinen, E.; Koskinen, A.; Jokela, R. *Tetrahedron* **1987**, *43*, 2135.
8. Tamminen, T.; Jokela, R.; Tirkkonen, B.; Lounasmaa, M. *Tetrahedron* **1989**, *45*, 2683.
9. Grierson, D. *Org. React.* **1990**, *39*, 85. (Review).
10. Lounasmaa, M.; Jokela, R.; Halonen, M.; Miettinen, J. *Heterocycles* **1993**, *36*, 2523.
11. Morita, H.; Kobayashi, J. *J. Org. Chem*. **2002**, *67*, 5378.
12. McCamley, K.; Ripper, J. A.; Singer, R. D.; Scammells, P. J. *J. Org. Chem*. **2003**, *68*, 9847.
13. Nakahara, S.; Kubo, A. *Heterocycles* **2004**, *63*, 1849.

Polonovski–Potier reaction

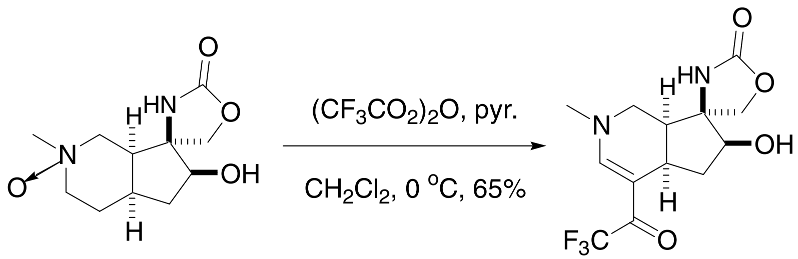
A modification of the Polonovski reaction where trifluoroacetic anhydride is used in place of acetic anhydride. Because the reaction conditions for the Polonovski–Potier reaction are mild, it has largely replaced the Polonovski reaction.



Example 1[2]



Example 2[5]

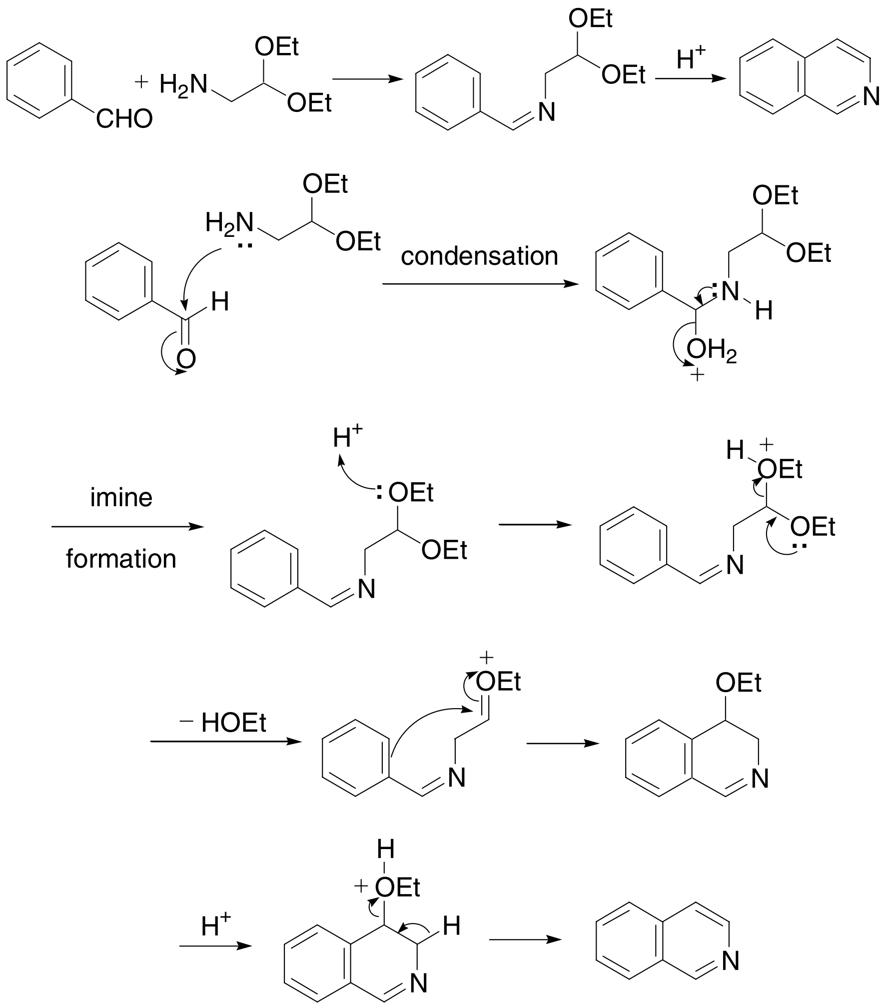


References

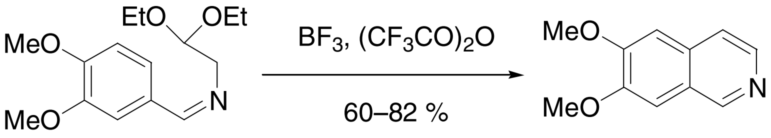
1. Ahond, A.; Cavé, A.; Kan-Fan, C.; Husson, H.-P.; cle Rostolan, J.; Potier, P. *J. Am. Chem. Soc*. **1968**, *90,* 5622.
2. Husson, H.-P.; Chevolot, L.; Langlois, Y.; Thal, C.; Potier, P. *J. Chem. Soc., Chem. Commun*. **1972**, 930.
3. Grierson, D. *Org. React.* **1990**, *39*, 85. (Review).
4. Lewin, G.; Poisson, J.; Schaeffer, C.; Volland, J. P. *Tetrahedron* **1990**, *46*, 7775.
5. Kende, A. S.; Liu, K.; Jos Brands, K. M. *J. Am. Chem. Soc*. **1995**, *117*, 10597.
6. Sundberg, R. J.; Gadamasetti, K. G.; Hunt, P. J. *Tetrahedron* **1992**, *48*, 277.
7. Lewin, G.; Schaeffer, C.; Morgant, G.; Nguyen-Huy, D. *J. Org. Chem*. **1996**, *61*, 9614.
8. Renko, D.; Mary, A.; Guillou, C.; Potier, P.; Thal, C. *Tetrahedron Lett*. **1998**, *39*, 4251.
9. Suau, R.; Nájera, F.; Rico, R. *Tetrahedron* **2000**, *56*, 9713.
10. Thomas, O. P.; Zaparucha, A.; Husson, H.-P. *Tetrahedron Lett*. **2001**, *42*, 3291.

Pomeranz–Fritsch reaction

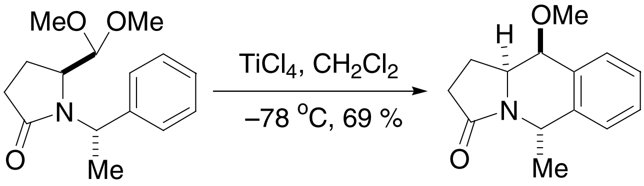
Isoquinoline synthesis *via* acid-mediated cyclization of the appropriate aminoacetal intermediate.



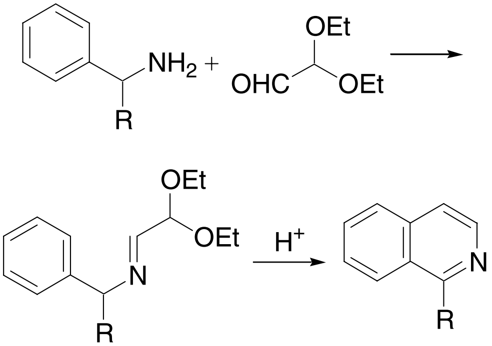
Example 1[5]



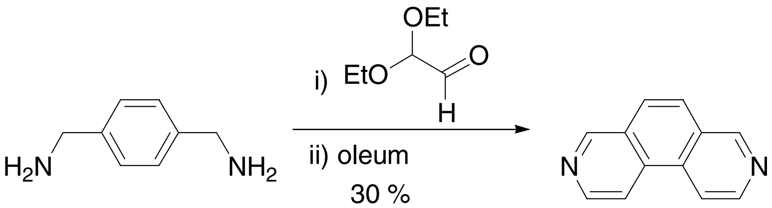
Example 2[12]



Schlittler–Müller modification



Example 3[7]

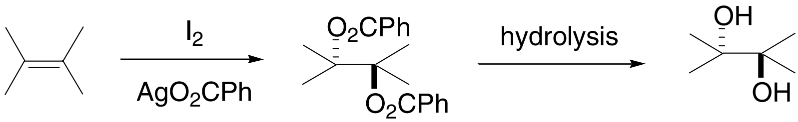


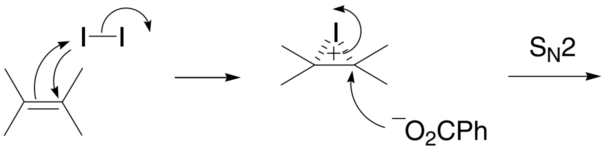
References

1. Pomeranz, C. *Monatsh.* **1893**, *14*, 116. Cesar Pomeranz (1860−1926) received his Ph.D. degree at Vienna, where he was employed as an associate professor of chemistry.
2. Fritsch, P. *Ber. Dtsch. Chem. Ges.* **1893**, *26*, 419. Paul Fritsch (1859−1913) was born in Oels, Silesia. He studied at Munich where he received his doctorate in 1884. Fritsch eventually became a professor at Marburg after several junior positions.
3. Schlittler, E.; Müller, J. *Helv. Chim. Acta* **1948**, *31*, 914, 1119.
4. Gensler, W. J. *Org. React.* **1951**, *6*, 191. (Review).
5. Bevis, M. J.; Forbes, E. J.; Naik, N. N.; Uff, B. C. *Tetrahedron* **1971**, *27*, 1253.
6. Birch, A. J.; Jackson, A. H.; Shannon, P. V. R. *J. Chem. Soc., Perkin Trans. 1* **1974**, 2185, 2190.
7. Gill, E. W.; Bracher, A. W. *J. Heterocycl. Chem.* **1983**, *20*, 1107.
8. Ishii, H.; Ishida, T. *Chem. Pharm. Bull.* **1984**, *32*, 3248.
9. Bobbitt, J. M.; Bourque, A. J. *Heterocycles* **1987**, *25*, 601. (Review).
10. Katritzky, A. R.; Yang, Z.; Cundy, D. J. *Heteroat. Chem.* **1994**, *5*, 103.
11. Schlosser, M.; Simig, G.; Geneste, H. *Tetrahedron* **1998**, *54*, 9023.
12. Poli, G.; Baffoni, S. C.; Giambastiani, G.; Reginato, G. *Tetrahedron* **1998**, *54*, 10403.
13. Gluszyńska, A.; Rozwadowska, M. D. *Tetrahedron: Asymmetry* **2000**, *11*, 2359.
14. Capilla, A. S.; Romero, M.; Pujol, M. D.; Caignard, D. H.; Renard, P. *Tetrahedron* **2001**, *57*, 8297.
15. Hudson, A. *Pomeranz–Fritsch Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 480−486. (Review).

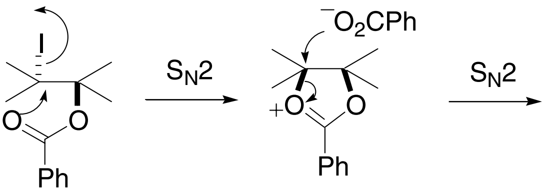
Prévost *trans*-dihydroxylation

Cf. Woodward *cis*-dihydroxylation.

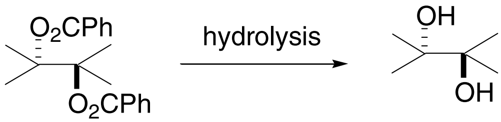




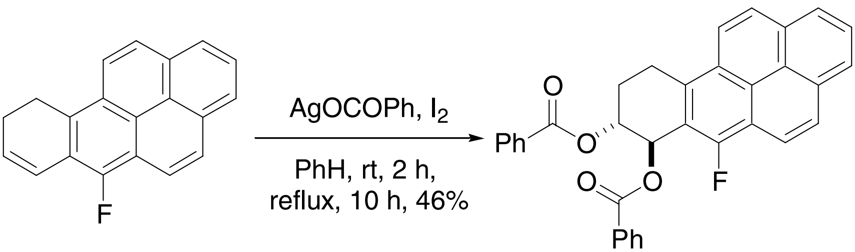
cyclic iodonium ion intermediate



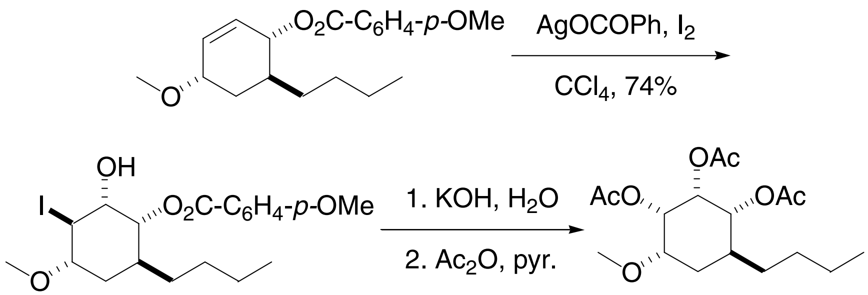
neighboring group assistance



Example 1[8]

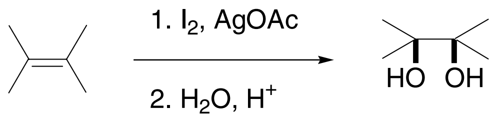


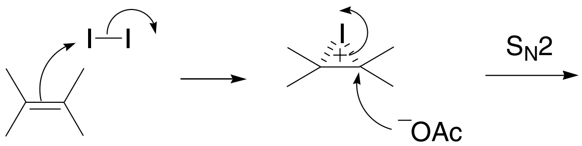
Example 2[12]



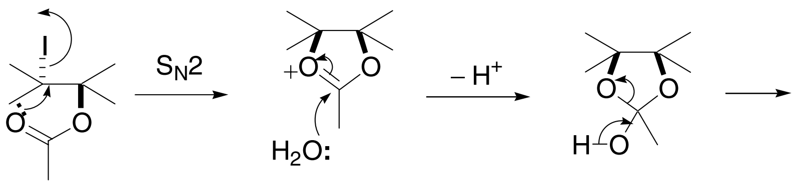
Woodward *cis*-dihydroxylation[13]

Cf. Prévost *trans*-dihydroxylation.

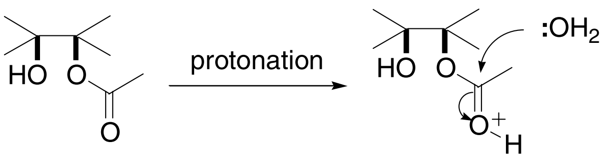


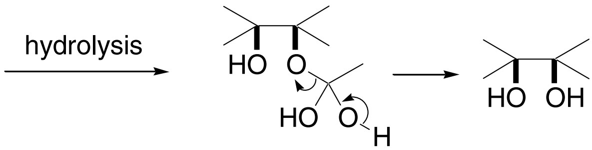


cyclic iodonium ion intermediate



neighboring group assistance



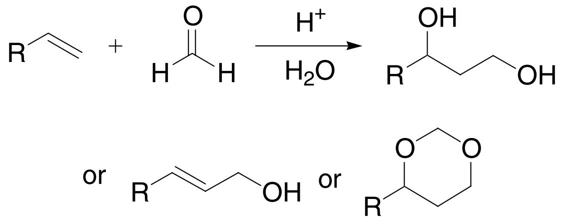


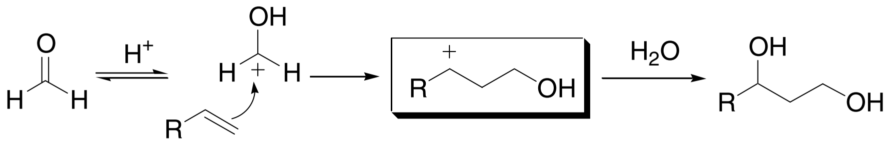
References

1. Prévost, C. *Compt. Rend.* **1933**, *196* 1129.
2. Campbell, M. M.; Sainsbury, M.; Yavarzadeh, R. *Tetrahedron* **1984**, *40*, 5063.
3. Campi, E. M.; Deacon, G. B.; Edwards, G. L.; Fitzroy, M. D.; Giunta, N.; Jackson, W. R.; Trainor, R. *J. Chem. Soc., Chem. Commun*. **1989**, 407.
4. Prasad, K. J. R.; Subramaniam, M. *Indian J. Chem., Sect. B* **1994**, *33B*, 696.
5. Ciganek, E.; Calabrese, J. C. *J. Org. Chem.* **1995**, *60*, 4439.
6. Deota, P. T.; Singh, V. *J. Chem. Res. (S)*, **1996**, 258.
7. Brimble, M. A.; Nairn, M. R. *J. Org. Chem.* **1996**, *61*, 4801.
8. Zajc, B. *J. Org. Chem.* **1999**, *64*, 1902.
9. Hamm, S.; Hennig, L.; Findeisen, M.; Muller, D.; Welzel, P. *Tetrahedron* **2000**, *56*, 1345.
10. Ray, J. K.; Gupta, S.; Kar, G. K.; Roy, B. C.; Lin, J.-M.; Amin, S. *J. Org. Chem.* **2000**, *65*, 8134.
11. Sabat, M.; Johnson, C. R. *Tetrahedron Lett*. **2001**, *42*, 1209.
12. Hodgson, R.; Nelson, A. *Org. Biomol. Chem*. **2004**, *2*, 373.
13. Woodward, R. B.; Brutcher, F. V. *J. Am. Chem. Soc.* **1958**, *80*, 209. Robert Burns Woodward (USA, 1917–1979) won the Nobel Prize in Chemistry in 1953 for his synthesis of natural products.

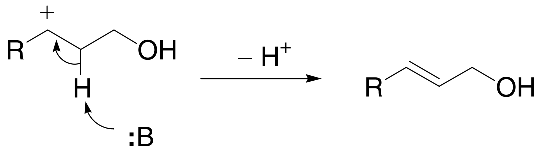
Prins reaction

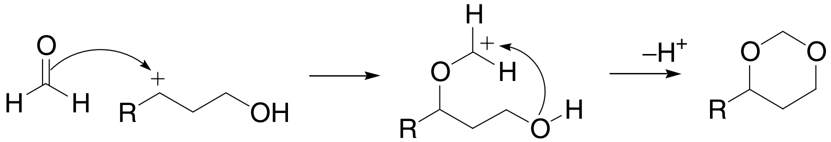
Addition of alkene to formaldehyde.



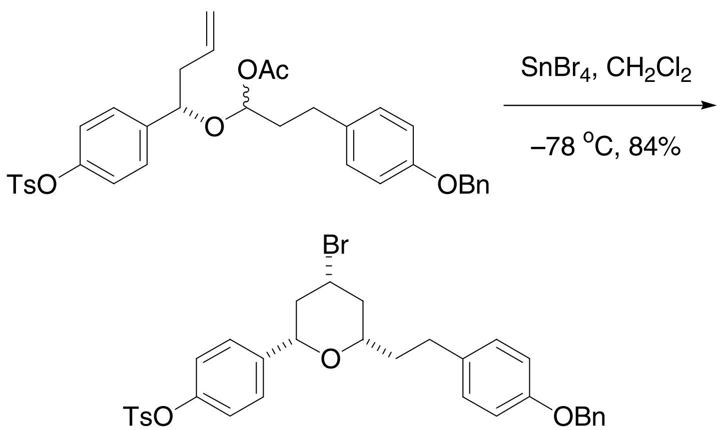


the common intermediate

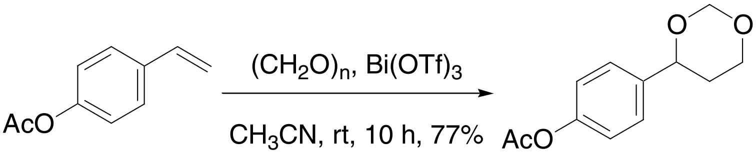




Example 1[8]



Example 2[10]

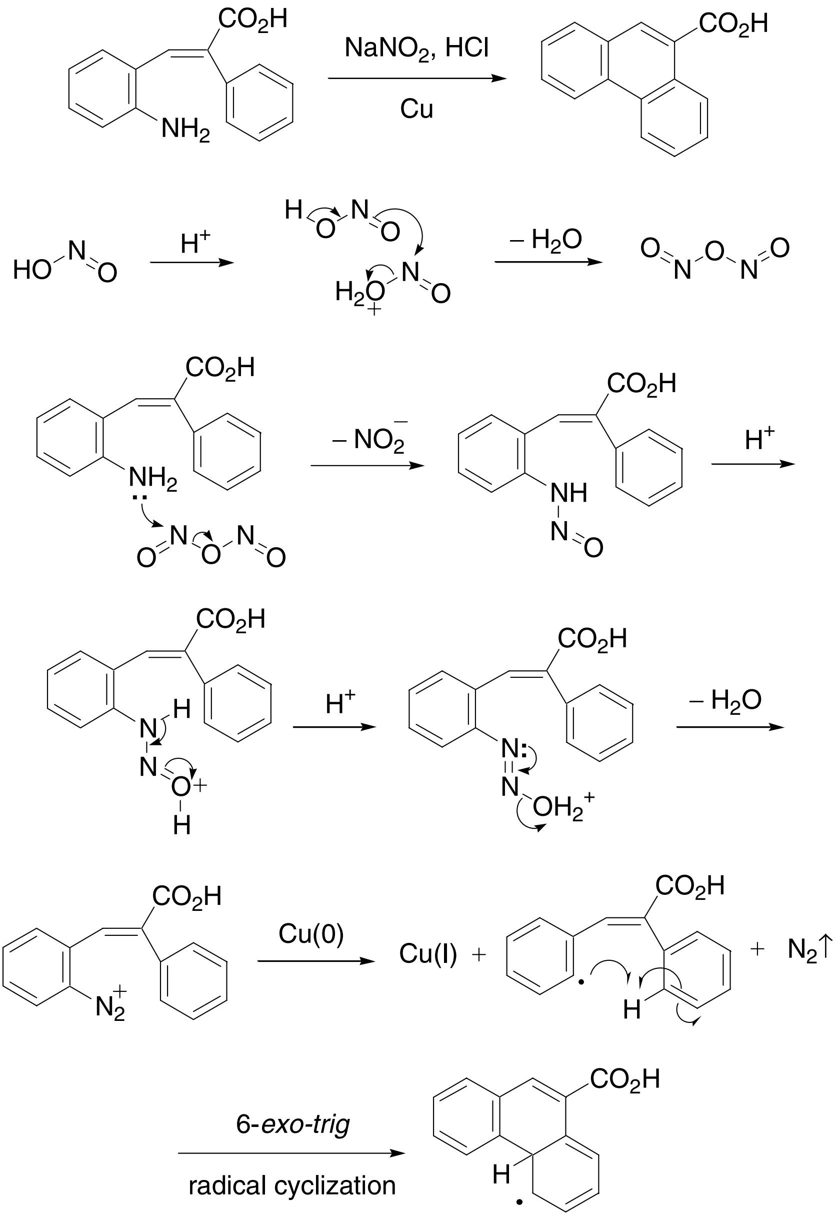


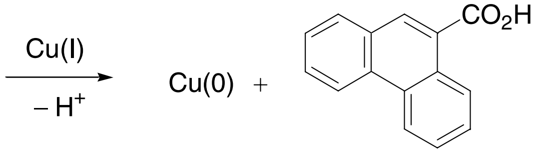
References

1. Prins, H. J. *Chem. Weekblad* **1919**, *16*, 64, 1072. Hendrik J. Prins (1889–1958), born in Zaandam, The Netherlands, was not even an organic chemist *per se*. After obtaining a doctorate in chemical engineering, Prins worked for an essential oil company and then a company dealing with the rendering of condemned meats and carcasses. But he had a small laboratory near his house where he carried out his experiments in his spare time, which obviously was not a big distraction—for he rose to be the president-director of the firm he worked for.
2. Adam, D. R.; Bhatnagar, S. P. *Synthesis* **1977**, 661–672. (Review).
3. El Gharbi, R.; Delmas, M. *Synthesis* **1981**, 361.
4. Hanaki, N.; Link, J. T.; MacMillan, D. W. C.; Overman, L. E.; Trankle, W. G.; Wurster, J. A. *Org. Lett.* **2000**, *2*, 223.
5. Yadav, J. S.; Reddy, B. V. S.; Kumar, G. M.; Murthy, C. V. S. R. *Tetrahedron Lett.* **2001**, *42*, 89.
6. Cho, Y. S.; Kim, H. Y.; Cha, J. H.; Pae, A. N.; Koh, H. Y.; Choi, J. H.; Chang, M. H. *Org. Lett.* **2002**, *4*, 2025.
7. Davis, C. E.; Coates, R. M. *Angew. Chem., Int. Ed.* **2002**, *41*, 491.
8. Marumoto, S.; Jaber, J. J.; Vitale, J. P.; Rychnovsky, S.D. *Org. Lett.* **2002**, *4*, 3919.
9. Braddock, D. C.; Badine, D. M.; Gottschalk, T.; Matsuno, A.; Rodrihuez-Lens, M. *Synlett* **2003**, 345.
10. Sreedhar, B.; Swapna, V.; Sridhar, Ch.; Saileela, D.; Sunitha, A. *Synth. Commun.* **2005**, *35*, 1177.
11. Aubele, D. L.; Wan, S.; Floreancig, P. E. *Angew. Chem., Int. Ed.* **2005**, *44*, 3485.

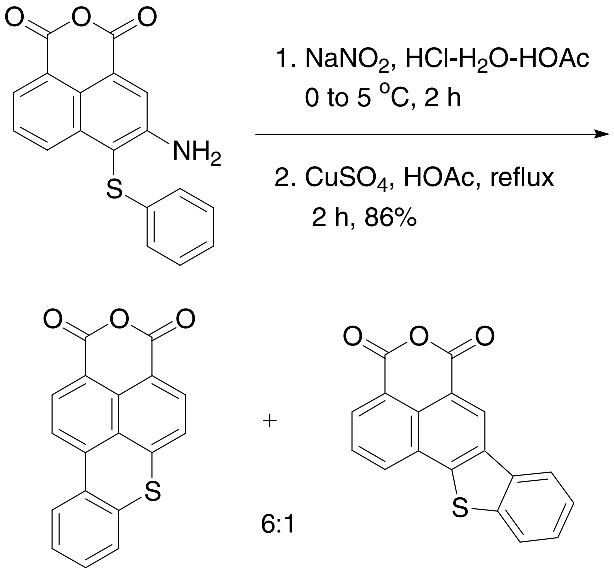
Pschorr cyclization

The intramolecular version of the Gomberg–Bachmann reaction.

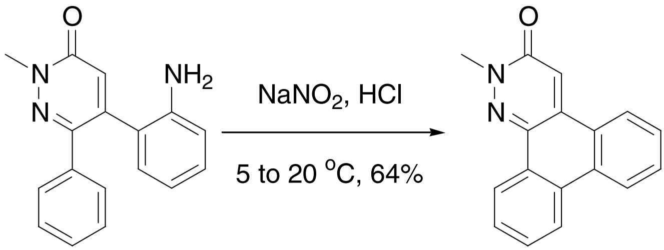




Example 1[10]



Example 2[11]

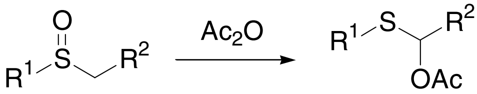


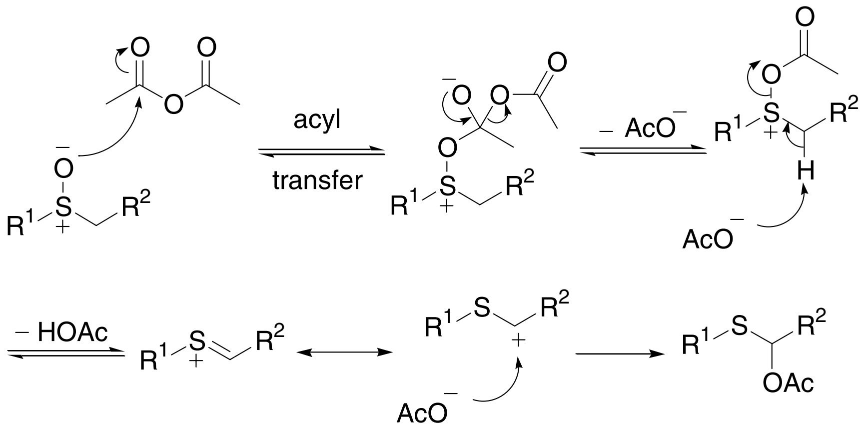
References

1. Pschorr, R. *Ber. Dtsch. Chem. Ges.* **1896**, *29*, 496. Robert Pschorr (1868−1930), born in Munich, Germany, studied under von Baeyer, Bamberger, Knorr, and Fischer. He became an assistant professor in 1899 at Berlin where he discovered the phenanthrene synthesis. During WWI, Pschorr served as a major in the German Army.
2. Kametani, T.; Fukumoto, K. *J. Heterocycl. Chem.* **1971**, *8*, 341.
3. Kupchan, S. M.; Kameswaran, V.; Findlay, J. W. A. *J. Org. Chem.* **1973**, *38*, 405.
4. Daidone, G.; Plesia, S.; Fabra, J. *J. Heterocycl. Chem.* **1980**, *17*, 1409.
5. Buck, K. T.; Edgren, D. L.; Blake, G. W.; Menachery, M. D. *Heterocycles* **1993**, *36*, 2489.
6. Wassmundt, F. W.; Kiesman, W. F. *J. Org. Chem.* **1995**, *60*, 196.
7. Qian, X.; Cui, J.; Zhang, R. *Chem. Commun*. **2001**, 2656.
8. Hassan, J.; Sévignon, M.; Gozzi, C.; Schulz, E.; Lemaire, M. *Chem. Rev*. **2002**, *102*, 1359−1469. (Review).
9. Karady, S.; Cummins, J. M.; Dannenberg, J. J.; del Rio, E.; Dormer, P. G.; Marcune, B. F.; Reamer, R. A.; Sordo, T. L. *Org. Lett.* **2003**, *5*, 1175.
10. Xu, Y.; Qian, X.; Yao, W.; Mao, P.; Cui, J. *Bioorg. Med. Chem.* **2003**, *11*, 5427.
11. Tapolcsányi, P.; Maes, B. U. W.; Monsieurs, K.; *et al*. *Tetrahedron* **2003**, *59*, 5919.
12. Mátyus, P.; Maes, B. U. W.; Riedl, Z.; Hajós, G.; Lemière, G. L. F.; Tapolcśanyi, P.; Monsieurs, K.; Éliás, O.; Dommisse, R. A.; Krajsovszky, G. *Synlett* **2004**, 1123-1139. (Review).

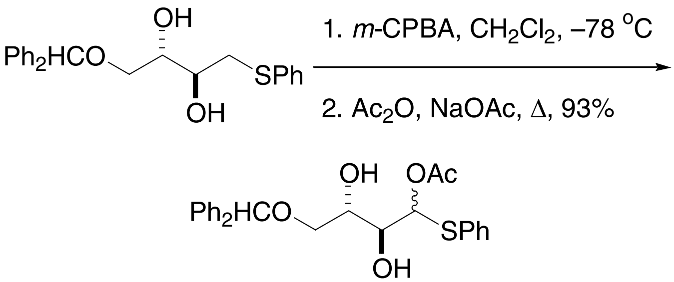
Pummerer rearrangement

The transformation of sulfoxides into α-acyloxythioethers using acetic anhydride.

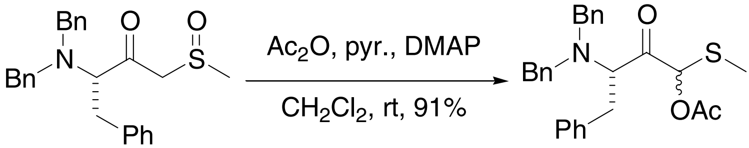




Example 1[2]



Example 2[13]

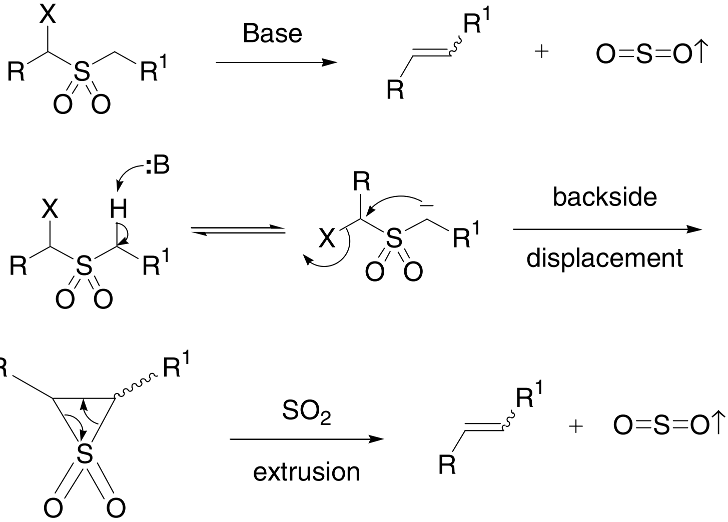


References

1. Pummerer, R. *Ber. Dtsch. Chem. Ges.* **1910**, *43*, 1401. Rudolf Pummerer, born in Austria in 1882, studied under von Baeyer, Willstätter, and Wieland. He worked for BASF for a few years and in 1921 he was appointed head of the organic division of the Munich Laboratory, fulfilling his long-desired ambition.
2. Masamune, S.; Sharpless, K. B. *et al. J. Org. Chem.* **1982**, *47*, 1373.
3. De Lucchi, O.; Miotti, U.; Modena, G. *Org. React.* **1991**, *40*, 157–406. (Review).
4. Padwa, A.; Gunn, D. E., Jr.; Osterhout, M. H. *Synthesis* **1997**, 1353–1378. (Review).
5. Kita, Y. *Phosphorus, Sulfur Silicon Relat. Elem.* **1997**, *120 & 121*, 145–164. (Review).
6. Padwa, A.; Waterson, A. G. *Curr. Org. Chem.* **2000**, *4*, 175–203. (Review).
7. Marchand, P.; Gulea, M.; Masson, S.; Averbuch-Pouchot, M.-T. *Synthesis* **2001**, 1623.
8. Padwa, A.; Bur, S. K.; Danca, D. M.; Ginn, J. D.; Lynch, S. M. *Synlett* **2002**, 851–862. (Review).
9. Padwa, A.; Danca, M. D.; Hardcastle, K. I.; McClure, M. S. *J. Org. Chem.* **2003**, *68*, 929.
10. Matsuda, H.; Fujita, J.; Morii, Y.; Hashimoto, M.; Okuno, T.; Hashimoto, K. *Tetrahedron Lett.* **2003**, *44*, 4089.
11. Fujita, J.; Matsuda, H.; Yamamoto, K.; Morii, Y.; Hashimoto, M.; Okuno, T.; Hashimoto, K. *Tetrahedron* **2004**, *60*, 6829.
12. Ruano, J. L.; Alemán, J.; Aranda, M. T.; Arévalo, M. J.; Padwa, A. *Org. Lett.* **2005**, *7*, 19.
13. Suzuki, T.; Honda, Y.; Izawa, K.; Williams, R. M. *J. Org. Chem.* **2005**, *70*, 7317.

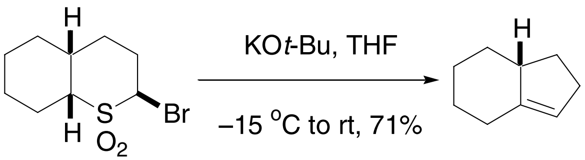
Ramberg–Bäcklund reaction

Olefin synthesis *via* α-halosulfone extrusion.

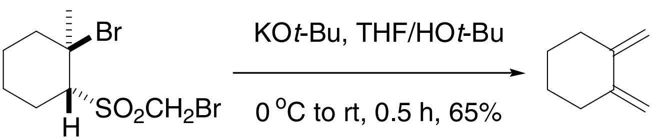


episulfone intermediate

Example 1[4]



Example 2[5]

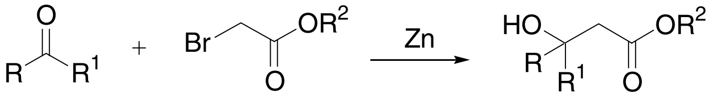


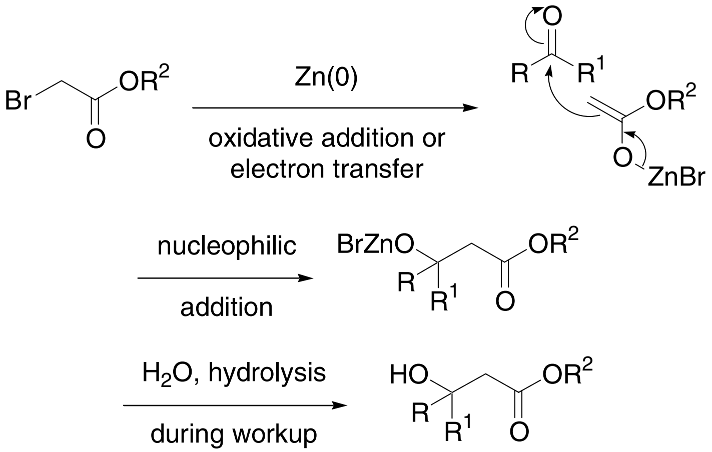
References

1. Ramberg, L.; Bäcklund, B. *Arkiv. Kemi, Mineral Geol.* **1940**, *13A*, 50.
2. Paquette, L. A. *Acc. Chem. Res.* **1968**, *1*, 209−216. (Review).
3. Paquette, L. A. *Org. React.* **1977**, *25*, 1−71. (Review).
4. Becker, K. B.; Labhart, M. P. *Helv. Chim. Acta* **1983**, *66*, 1090.
5. Block, E.; Aslam, M.; Eswarakishnan, V. *et al. J. Am. Chem. Soc.* **1986**, *108,* 4568.
6. Braverman, S.; Zafrani, Y. *Tetrahedron* **1998**, *54*, 1901.
7. Taylor, R. J. K. *Chem. Commun.* **1999**, 217−227. (Review).
8. MaGee, D. I.; Beck, E. J. *Can. J. Chem.* **2000**, *78*, 1060.
9. McAllister, G. D.; Taylor, R. J. K. *Tetrahedron Lett*. **2001**, *42*, 1197.
10. Murphy, P. V.; McDonnell, C.; Hämig, L.; Paterson, D. E.; Taylor, R. J. K. *Tetrahedron: Asymmetry* **2003**, *14*, 79.
11. Wei, C.; Mo, K.-F.; Chan, T.-L. *J. Org. Chem*. **2003**, *68*, 2948.
12. Taylor, R. J. K.; Casy, G. *Org. React.* **2003**, *62*, 357–475. (Review).

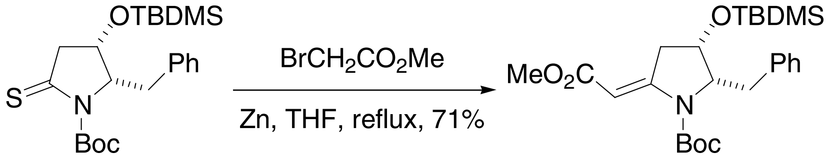
Reformatsky reaction

Nucleophilic addition of organozinc reagents generated from α-haloesters to carbonyls.

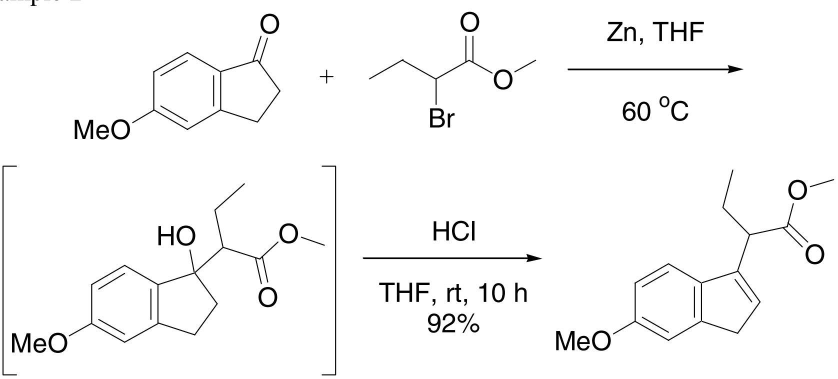




Example 1[5]



Example 2[11]

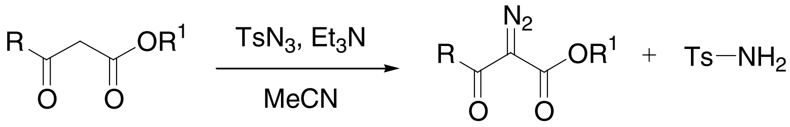


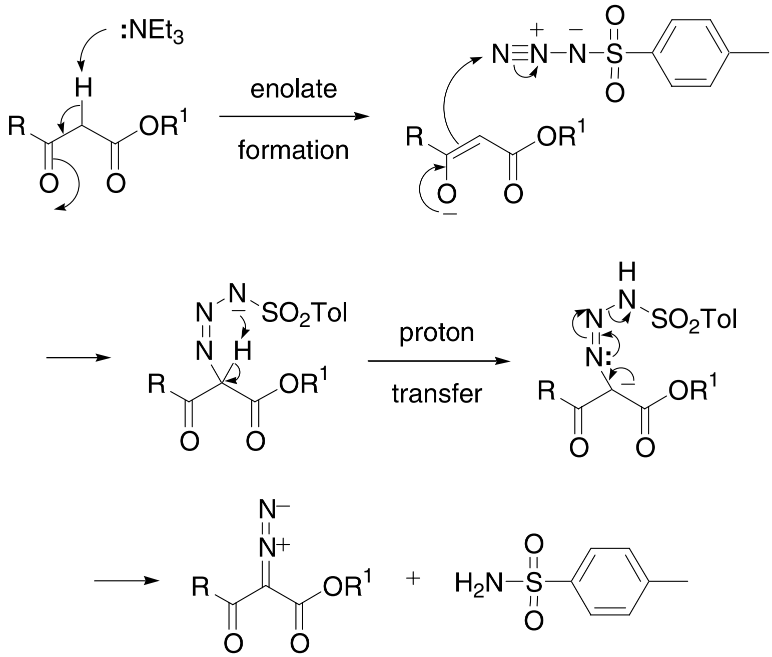
References

1. Reformatsky, S. *Ber. Dtsch. Chem. Ges.* **1887**, *20,* 1210. Sergei Reformatsky (1860–1934) was born in Russia. He studied at the University of Kazan in Russia, the cradle of Russian chemistry professors, where he found competent guidance of a distinguished chemist, Alexander M. Zaĭtsev. Reformatsky then studied at Göttingen, Heidelberg, and Leipzig in Germany. After returning to Russia Reformatsky became the Chair of Organic Chemistry at the University of Kiev.
2. Gaudemar, M. *Organometal. Chem. Rev., A* **1972**, *8*, 183. (Review).
3. Rathke, M. W. *Org. React.* **1975**, *22*, 423–460. (Review).
4. Fürstner, A. *Synthesis* **1989**, 571–590. (Review).
5. Lee, H. K.; Kim, J.; Pak, C. S. *Tetrahedron Lett.* **1999**, *40*, 2173.
6. Fürstner, A. In *Organozinc Reagents* Knochel, P.; Jones, P. eds.; Oxford University Press: New York, **1999**, pp 287–305. (Review).
7. Hirashita, T.; Kinoshita, K.; Yamamura, H.; Kawai, M.; Araki, S. *J. Chem. Soc., Perkin Trans. 1* **2000**, 825.
8. Kurosawa, T.; Fujiwara, M.; Nakano, H.; Sato, M.; Yoshimura, T.; Murai, T. *Steroids* **2001**, *66,* 499.
9. Ocampo, R.; Dolbier, W. R., Jr.; Abboud, K. A.; Zuluga, F. *J. Org. Chem.* **2002**, *67*, 72.
10. Obringer, M.; Colobert, F.; Neugnot, B.; Solladié, G. *Org. Lett.* **2003**, *5*, 629.
11. Zhang, M.; Zhu, L. *Tetrahedron: Asymmetry* **2003**, *14*, 3447.
12. Ocampo, R.; Dolbier, W. R., Jr. *Tetrahedron* **2004**, *60*, 9325–9374. (Review).
13. Scherkenbeck, T.; Siegel, K. *Org. Proc. Res. Dev.* **2005**, *9*, 216.
14. Orsini, F.; Sello, G.; Manzo, A. M.; Lucci, E. M. *Tetrahedron: Asymmetry* **2005**, *16*, 1913.
15. Cozzi, P. G.; Rivalta, E. *Angew. Chem., Int. Ed.* **2005**, *44*, 3600.

Regitz diazo synthesis

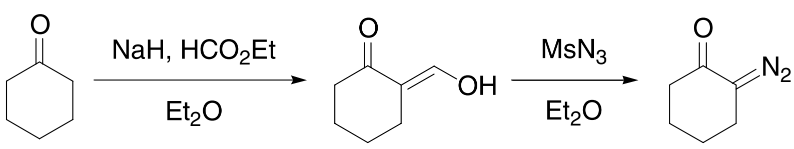
Synthesis of 2-diazo-1,3-dicarbonyl or 2-diazo-3-ketoesters using sulfonyl azide.

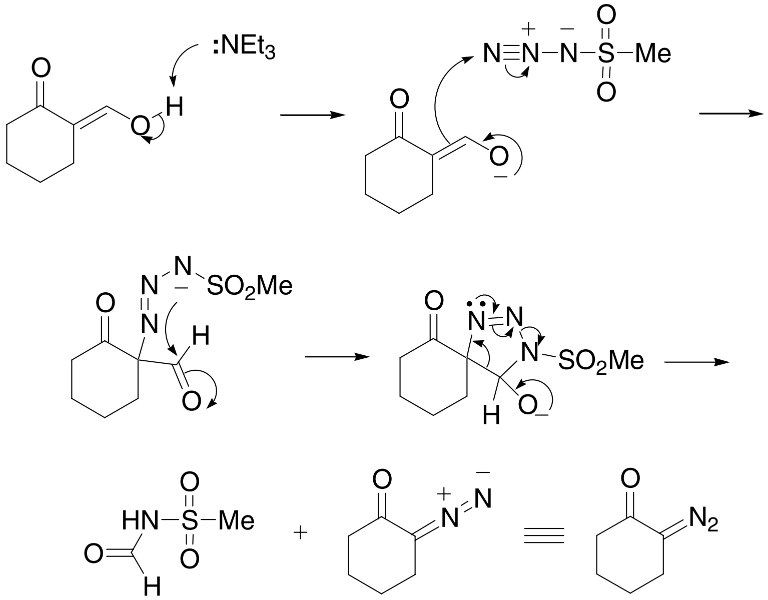




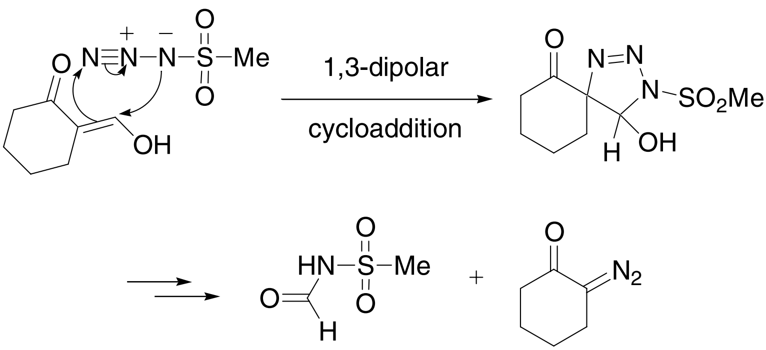
tosyl amide is the by-product

When only one carbonyl is present, ethylformate can be used as an activating auxiliary:[6–9]

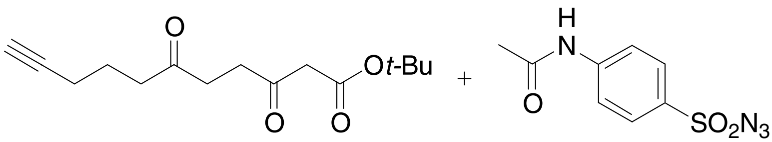


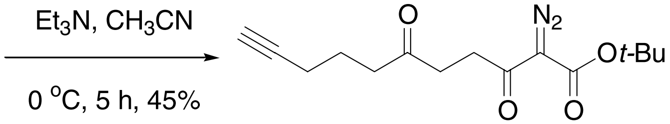


Alternatively, the triazole intermediate may be assembled *via* a 1,3-dipolar cycloaddition of the enol and mesyl azide:

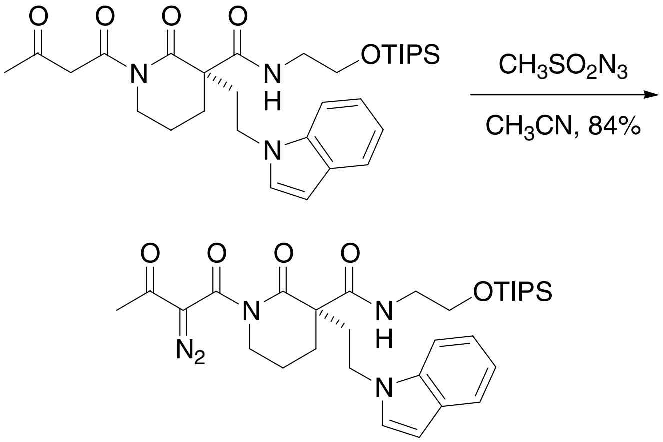


Example 1[10]





Example 2[6]

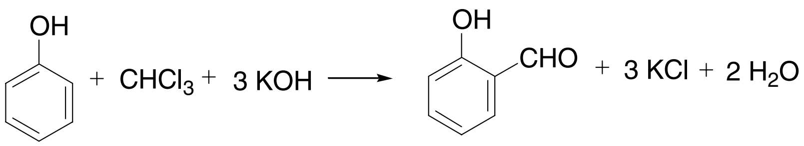


References

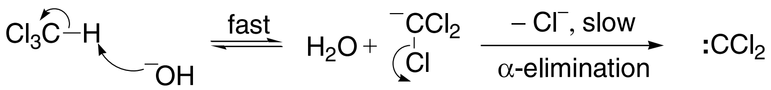
1. Regitz, M. *Angew. Chem., Int. Ed. Engl.* **1967**, *6*, 733.
2. Regitz, M.; Anschütz, W.; Bartz, W.; Liedhegener, A. *Tetrahedron Lett.* **1968**, 3171.
3. Regitz, M. *Synthesis* **1972**, 351–373. (Review).
4. Taber, D. F.; Ruckle, R. E., Jr.; Hennessy, M. J. *J. Org. Chem.* **1986**, *51*, 4077.
5. Taber, D. F.; Schuchardt, J. L. *Tetrahedron* **1987**, *43*, 5677.
6. Pudleiner, H.; Laatsch, H. *Justus Liebigs Ann. Chem.* **1990**, 423.
7. Evans, D. A.; Britton, T. C.; Ellman, J. A.; Dorow, R. L. *J. Am. Chem. Soc.* **1990**, *112*, 4011.
8. Ihara, M.; Suzuki, T.; Katogi, M.; Taniguchi, N.; Fukumoto, K. *J. Chem. Soc., Chem. Commun.* **1991**, 646.
9. Charette, A. B.; Wurz, R. P.; Ollevier, T. *J. Org. Chem.* **2000**, *65*, 9252.
10. Hodgson, D. M.; Labande, A. H.; Pierard, F. Y. T. M.; Expésito Castro, M. A. *J. Org. Chem.* **2003**, *68*, 6153.
11. Sarpong, R.; Su, J. T.; Stoltz, B. M. *J. Am. Chem. Soc.* **2003**, *125*, 13624.
12. Mejía-Oneto, J. M.; Padwa, A. *Org. Lett.* **2004**, *6*, 3241.
13. Muroni, D.; Saba, A.; Culeddu, N. *Tetrahedron: Asymmetry* **2004**, *15*, 2609.
14. Rowlands, G. J.; Barnes, W. K. *Tetrahedron Lett.* **2004**, *45*, 5347.
15. Davies, J. R.; Kane, P. D.; Moody, C. J. *Tetrahedron* **2004**, *60*, 3967.
16. Oguri, H.; Schreiber, S. L. *Org. Lett.* **2005**, *7*, 47.

Reimer–Tiemann reaction

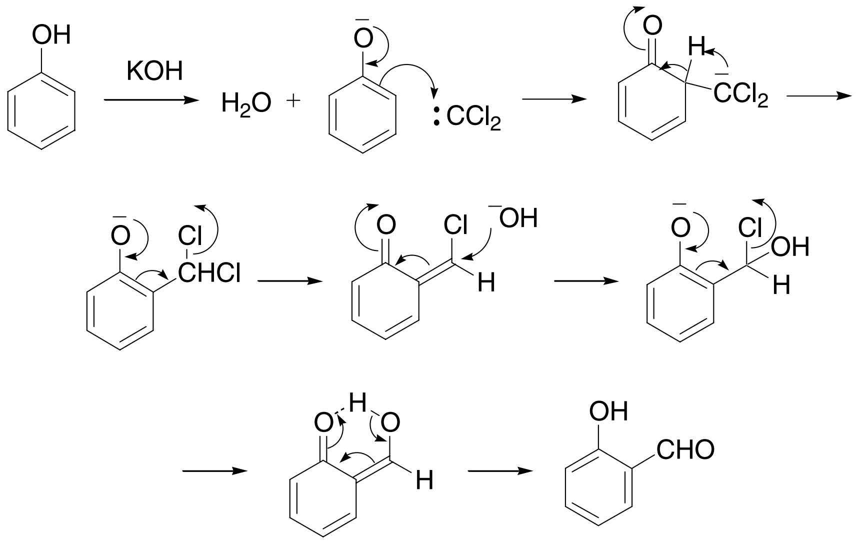
Synthesis of *o*-formylphenol from phenols and chloroform in alkaline medium.



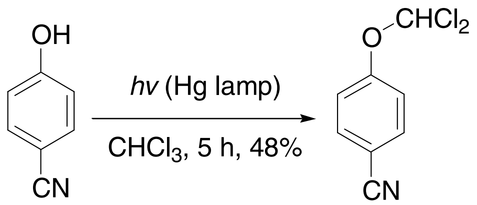
a. Carbene generation:



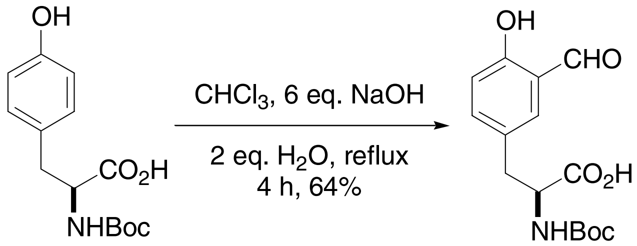
b. Addition of dichlorocarbene and hydrolysis:



Example 1, photo Reimer–Tiemann reaction without base[8]



Example 2[9]

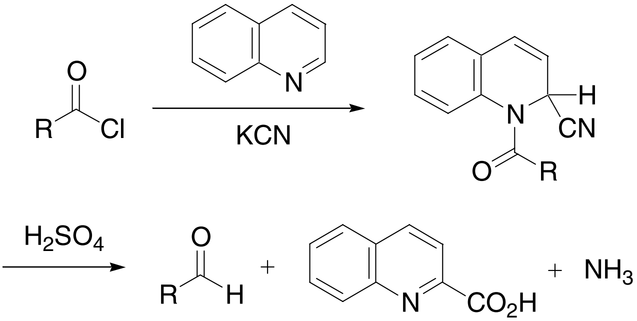


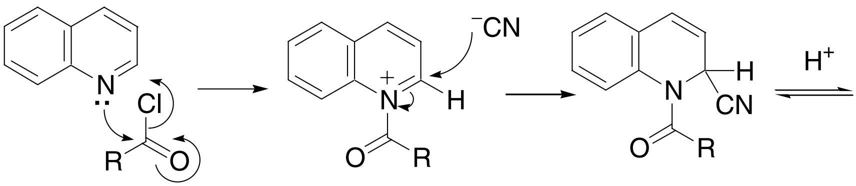
References

1. Reimer, K.; Tiemann, F. *Ber. Dtsch. Chem. Ges.* **1876**, *9*, 824. Karl L. Reimer (1845−1883) was born in Leipzig, Germany. He interrupted his study to serve in the Bohemian War in 1866. After the war, Reimer returned to his study and obtained his Ph.D. in 1871. He held several jobs but at the end had to resign because of poor health. The discovery of the Reimer–Tiemann reaction was the beginning of his short-lived career in organic chemistry. Johann K. F. Tiemann (1848−1899) was born in Rübeland, Germany. He was a student and a big fan of W. Hofmann, from whom Tiemann received his Ph.D. in 1871. Tiemann then became a Professor of Chemistry at Berlin.
2. Wynberg, H.; Meijer, E. W. *Org. React.* **1982**, *28*, 1–36. (Review).
3. Smith, K. M.; Bobe, F. W.; Minnetian, O. M.; Hope, H.; Yanuck, M. D. *J. Org. Chem.* **1985**, *50*, 790.
4. Bird, C. W.; Brown, A. L.; Chan, C. C. *Tetrahedron* **1985**, *41*, 4685.
5. Neumann, R.; Sasson, Y. *Synthesis* **1986**, 569.
6. Cochran, J. C.; Melville, M. G. *Synth. Commun.* **1990**, *20*, 609.
7. Langlois, B. R. *Tetrahedron Lett.* **1991**, *32*, 3691.
8. Jiménez, M. C.; Miranda, M. A.; Tormos, R. *Tetrahedron* **1995**, *51*, 5825.
9. Jung, M. E.; Lazarova, T. I. *J. Org. Chem.* **1997**, *62*, 1553.

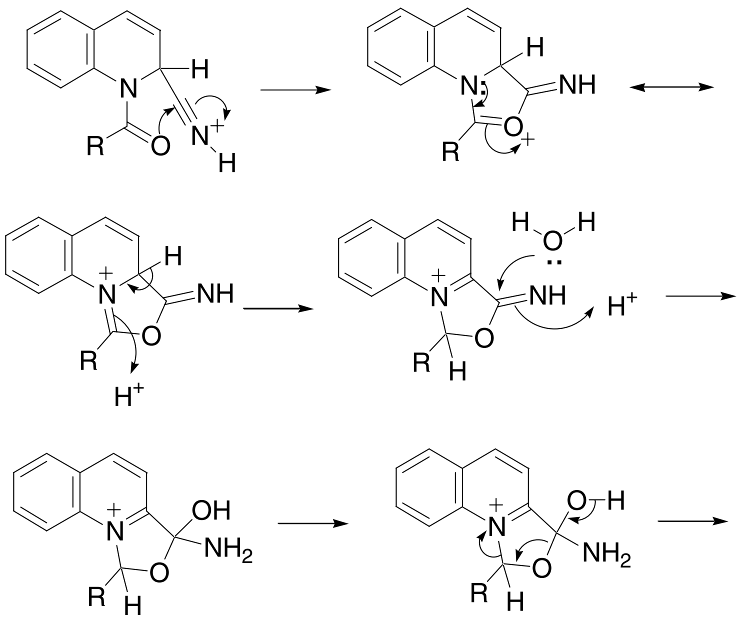
Reissert aldehyde synthesis

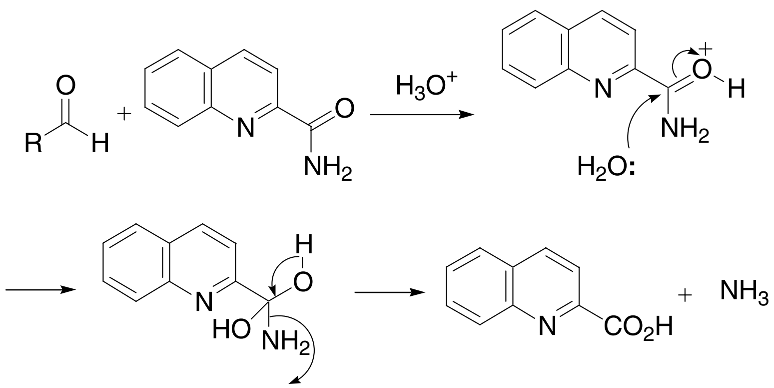
Aldehyde synthesis from the corresponding acid chloride, quinoline, and KCN.



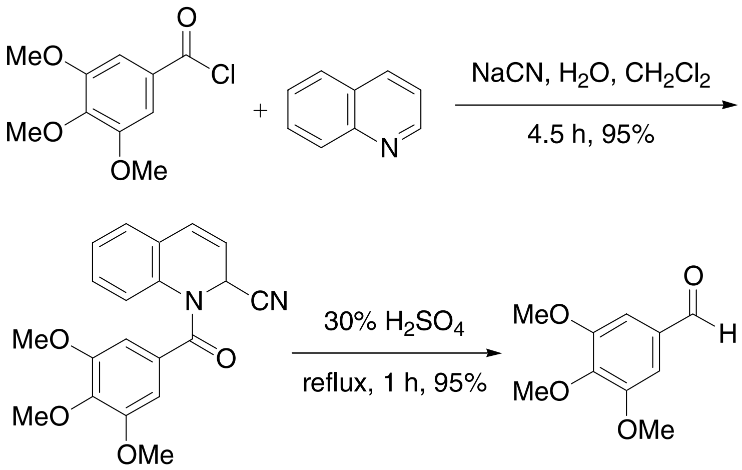


Reissert compound

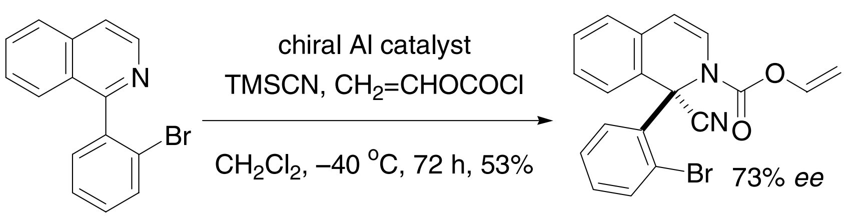




Example 1[4]



Example 2[10]

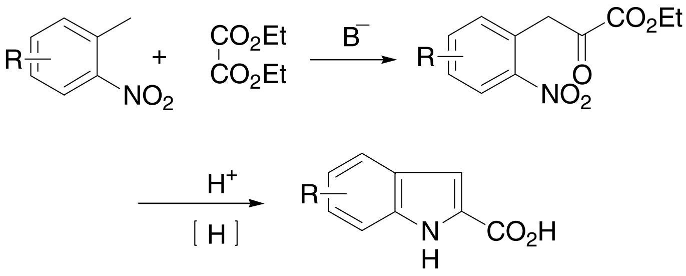


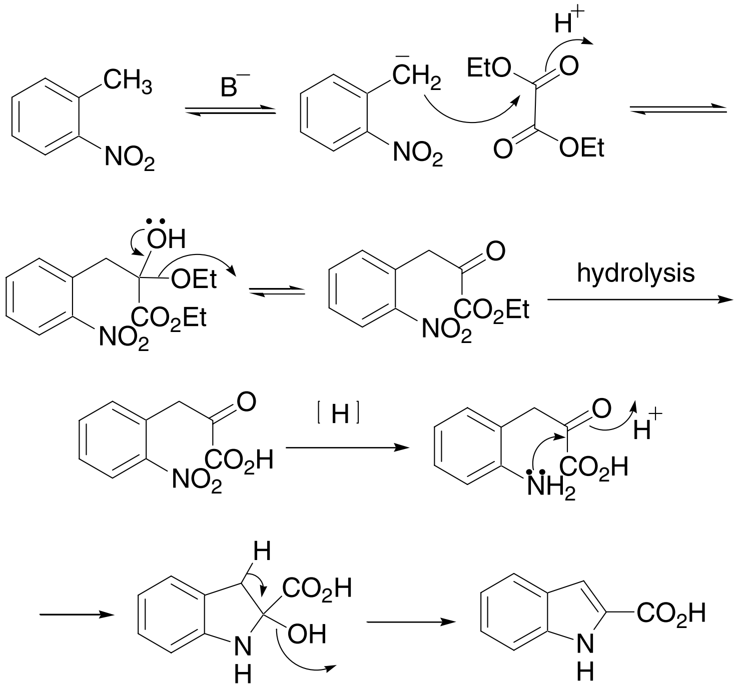
References

1. Reissert, A. *Ber. Dtsch. Chem. Ges.* **1905**, *38*, 1603, 3415. Carl Arnold Reissert was born in 1860 in Powayen, Germany. He received his Ph.D. in 1884 at Berlin, where he became an assistant professor. He collaborated with Tiemann. Reissert later joined the faculty at Marburg in 1902.
2. McEwen, W. E.; Hazlett, R. N. *J. Am. Chem. Soc*. **1949**, *71*, 1949.
3. Popp, F. D. *Adv. Heterocyclic Chem.* **1979**, *24*, 187. (Review).
4. Schwartz, A. *J. Org. Chem.* **1982**, *47*, 2213.
5. Fife, W. K.; Scriven, E. F. V. *Heterocycles* **1984**, *22*, 2375.
6. Popp, F. D.; Uff, B. C. *Heterocycles* **1985**, *23*, 731.
7. Lorsbach, B. A.; Bagdanoff, J. T.; Miller, R. B.; Kurth, M. J. *J. Org. Chem.* **1998**, *63*, 2244.
8. Perrin, S.; Monnier, K.; Laude, B.; Kubicki, M.; Blacque, O. *Eur. J. Org. Chem.* **1999**, 297.
9. Takamura, M.; Funabashi, K.; Kanai, M.; Shibasaki, M. *J. Am. Chem. Soc*. **2001**, *123*, 6801.
10. Shibasaki, M.; Kanai, M.; Funabashi, K. *Chem. Commun*. **2002**, 1989.
11. Sieck, O.; Schaller, S.; Grimme, S.; Liebscher, J. *Synlett* **2003**, 337.

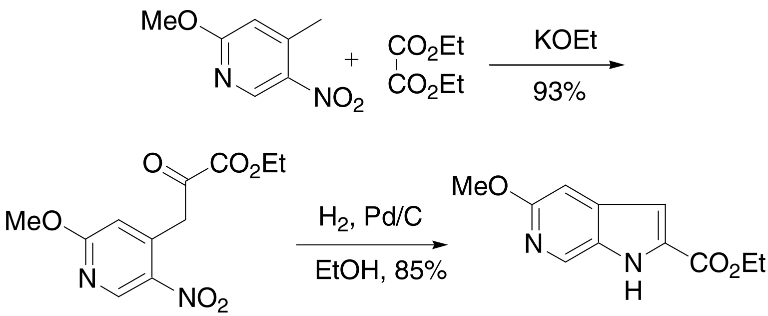
Reissert indole synthesis

The Reissert indole synthesis involves base-catalyzed condensation of an *o*-nitrotoluene derivative with an ethyl oxalate, which is followed by reductive cyclization to an indole-2-carboxylic acid derivative.

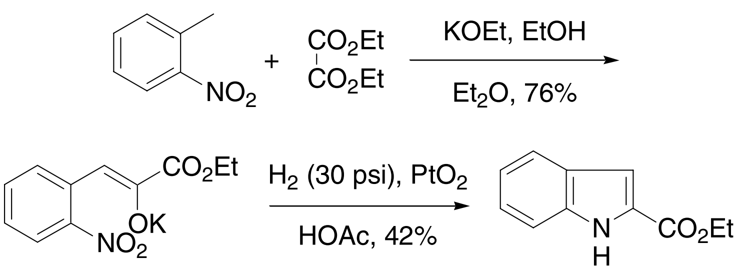




Example 1[3]



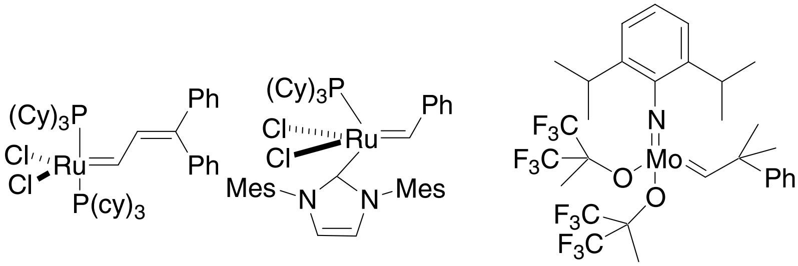
Example 2[5]



References

1. Reissert, A. *Ber.* **1897**, *30*, 1030.
2. Julian, P. C.; Meyer, E. W.; Printy, S. C. *Heterocyclic Compounds*; : New York, **1962**; p 18. (Review).
3. Frydman, B.; Despuy, M. E.; Rapoport, H. *J. Am. Chem. Soc.* **1965**, *87*, 3530.
4. Brown, R. K. In *Indoles, Part 1*; Houlihan, W. J. Ed.; Wiley & Sons: New York, **1972**; pp 397–413. (Review).
5. Noland, W. E.; Baude, F. J. *Org. Synth.*; Ed, Baumgarten, H. E.; Wiley & Sons: New York, **1973**; p. 567.
6. Leadbetter, G.; Fost, D. L.; Ekwuribe, N. N.; Remers, W. A. *J. Org. Chem.* **1974**, *39*, 3580.
7. Butin, A. V.; Stroganova, T. A.; Lodina, I. V.; Krapivin, G. D. *Tetrahedron Lett.* **2001**, *42*, 2031.
8. Suzuki, H.; Gyoutoku, H.; Yokoo, H.; Shinba, M.; Sato, Y.; Yamada, H.; Murakami, Y. *Synlett* **2000**, 1196.
9. Li, J.; Cook, J. M. *Reissert Indole Synthesis* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 154–158. (Review).

Ring-closing metathesis (RCM)

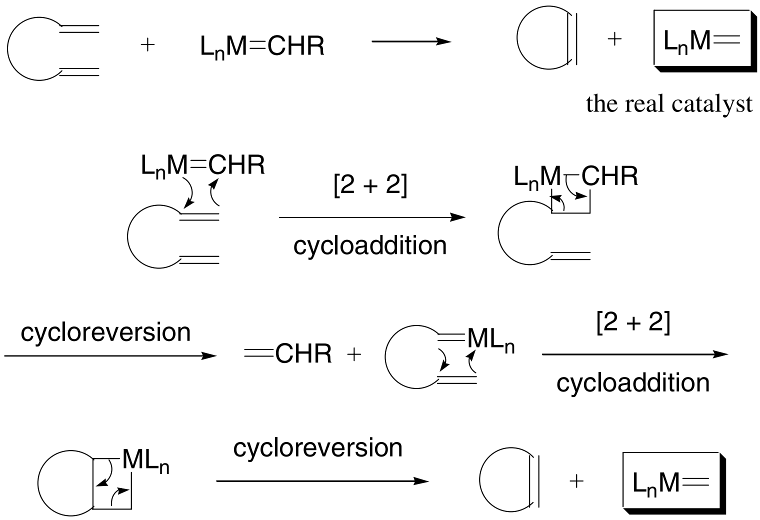


Grubbs' reagents Schrock's reagent

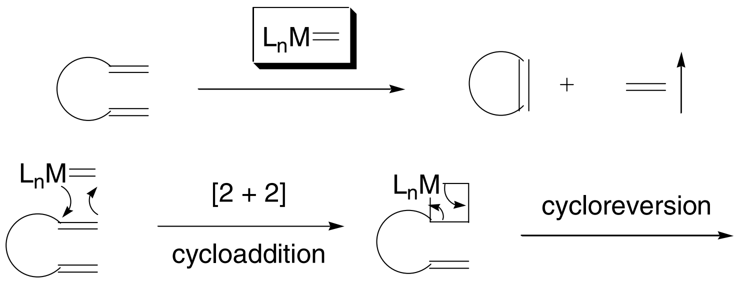
Mes = mesityl

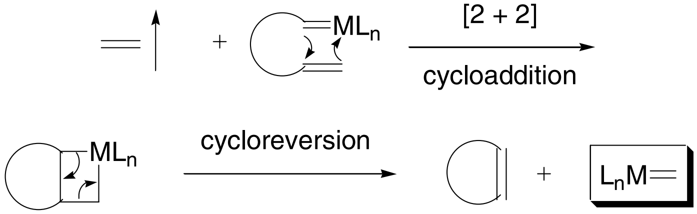
All three catalysts are illustrated as "L_nM=CHR" in the mechanism below.

Generation of the catalyst from the precatalysts:

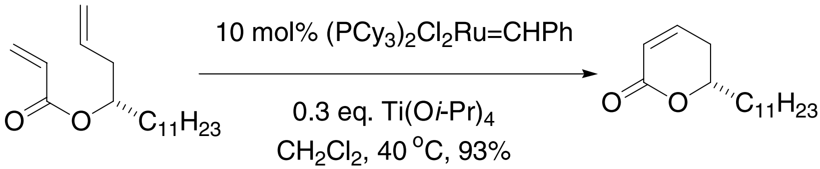


Catalytic cycle:

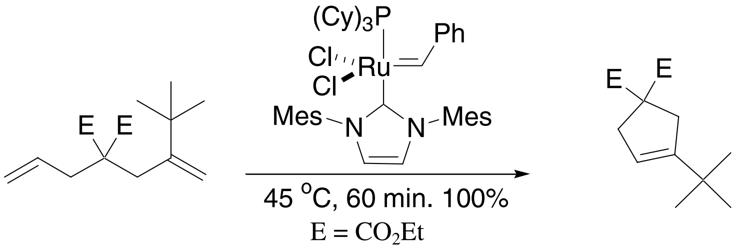




Example 1[4]



Example 2[9]



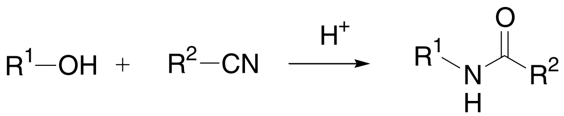
References

1. Schrock R. R.; Murdzek, J. S.; Bazan, G. C.; Robbins, J.; DiMare, M.; O'Regan, M. *J. Am. Chem. Soc.* **1990**, *112*, 3875. Richard Schrock is a professor at MIT. He shared the 2005 Nobel Prize in Chemistry with Robert Grubbs of Caltech and Yves Chauvin of Institut Français du Petrole in France for their contributions to metathesis.
2. Grubbs, R. H.; Miller, S. J.; Fu, G. C. *Acc. Chem. Res.* **1995**, *28,* 446–452. (Review).
3. Armstrong, S. K. *J. Chem. Soc., Perkin Trans. 1* **1998**, 371.
4. Scholl, M.; Tunka, T. M.; Morgan, J. P.; Grubbs, R. H. *Tetrahedron Lett*. **1999**, *40,* 2247.
5. Morgan, J. P.; Grubbs, R. H. *Org. Lett*. **2000**, *2*, 3153.
6. Renaud, J.; Graf, C.-D.; Oberer, L. *Angew. Chem., Int. Ed*. **2000**, *39*, 3101.
7. Lane, C.; Snieckus, V. *Synlett* **2000**, 1294.
8. Fellows, I. M.; Kaelin, D. E., Jr.; Martin, S. F. *J. Am. Chem. Soc*. **2000**, *122*, 10781.
9. Timmer, M. S. M.; Ovaa, H.; Filippov, D. V.; van der Marel, G. A.; van Boom, J. H. *Tetrahedron Lett*. **2000**, *41*, 8635.
10. Ghosh, A. K.; Liu, C. *Chem. Commun.* **1999**, 1743.
11. Lee, C. W.; Grubbs, R. H. *J. Org. Chem*. **2001**, *66*, 7155.
12. van Otterlo, W. A. L.; Ngidi, E. L.; Coyanis, E. M.; de Koning, C. B. *Tetrahedron Lett*. **2003**, *44*, 311.

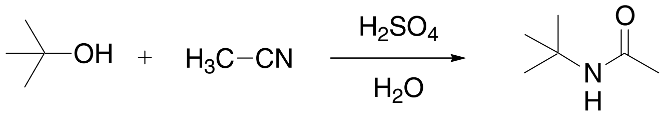
Ritter reaction

Amides from nitriles and alcohols in strong acids.

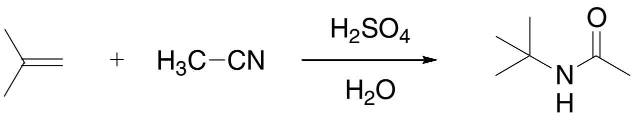
General scheme:

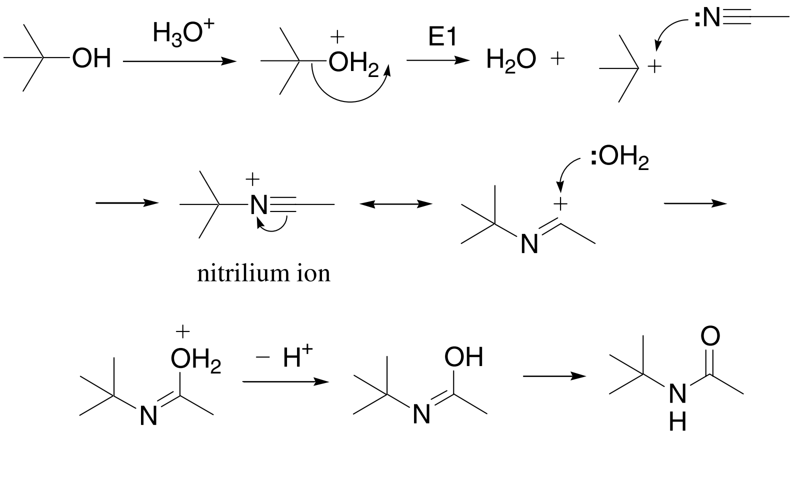


e.g.:

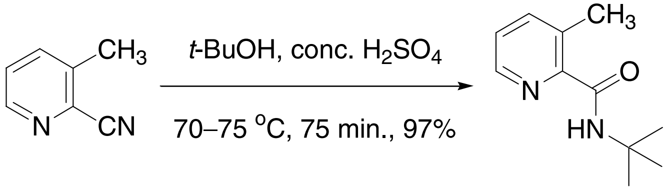


Similarly:

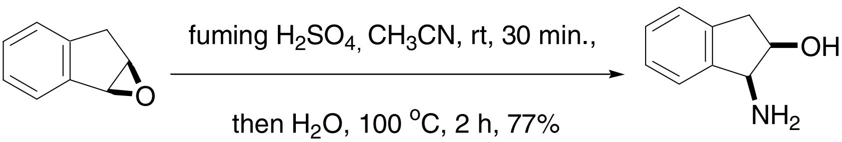




Example 1[4]



Example 2[8]

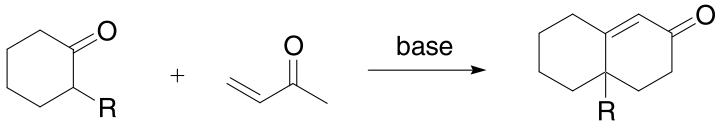


References

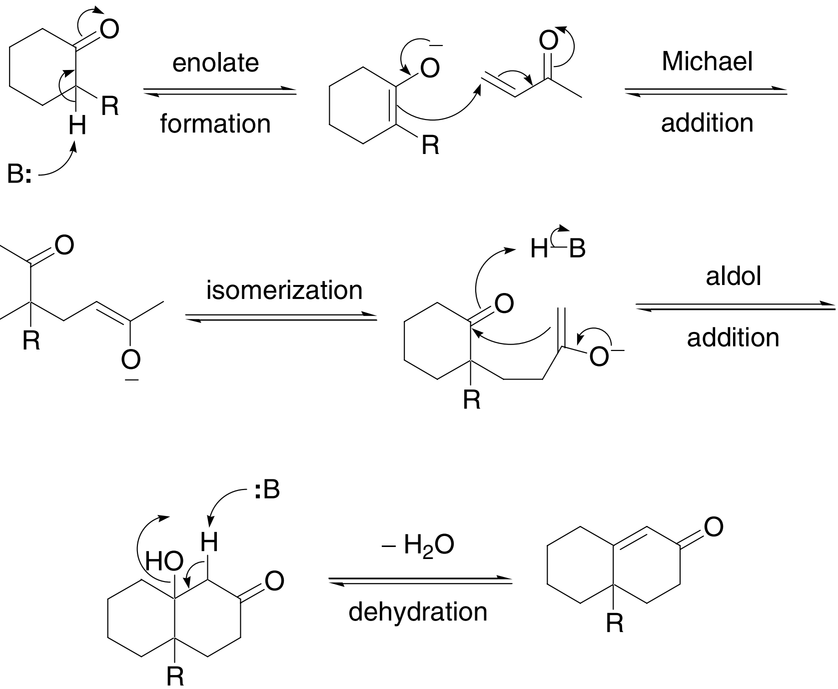
1. Ritter, J. J.; Minieri, P. P. *J. Am. Chem. Soc.* **1948**, *70*, 4045.
2. Ritter, J. J.; Kalish, J. *J. Am. Chem. Soc.* **1948**, *70*, 4048.
3. Krimen, L. I.; Cota, D. J. *Org. React.* **1969**, *17*, 213–329. (Review).
4. Schumacher, D. P.; Murphy, B. L.; Clark, J. E.; Tahbaz, P.; Mann, T. A. *J. Org. Chem.* **1989**, *54,* 2242.
5. Djaidi, D.; Leung, I. S. H.; Bishop, R.; Craig, D. C.; Scudder, M. L. *J. Chem. Soc., Perkin 1* **2000**, 2037.
6. Jirgensons, A.; Kauss, V.; Kalvinsh, I.; Gold, M. R. *Synthesis* **2000**, 1709.
7. Le Goanric, D.; Lallemand, M.-C.; Tillequin, F.; Martens, T. *Tetrahedron Lett.* **2001**, *42*, 5175.
8. Tanaka, K.; Kobayashi, T.; Mori, H.; Katsumura, S. *J. Org. Chem.* **2004**, *69*, 5906.
9. Nair, V.; Rajan, R.; Rath, N. P. *Org. Lett.* **2002**, *4*, 1575.
10. Reddy, K. L. *Tetrahedron Lett.* **2003**, *44*, 1453.
11. Janin, Y. L.; Decaudin, D.; Monneret, C.; Poupon, M.-F. *Tetrahedron* **2004**, *60*, 5481.
12. Concellén, J. M.; Riego, E.; Suárez, J. R.; García-Granda, S.; Díaz, M. R. *Org. Lett.* **2004**, *6*, 4499.
13. Penner, M.; Taylor, D.; Desautels, D.; Marat, K.; Schweizer, F. *Synlett* **2005**, 212.

Robinson annulation

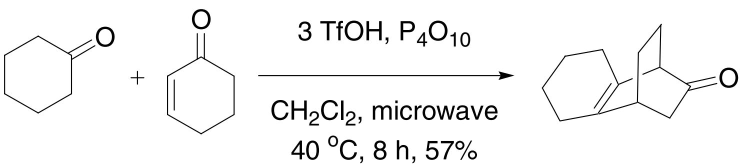
Michael addition of cyclohexanones to methyl vinyl ketone followed by intramolecular aldol condensation to afford six-membered α,β-unsaturated ketones.



methyl vinyl ketone (MVK)



Example[11]

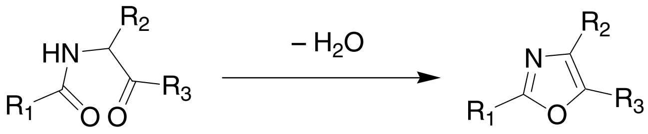


References

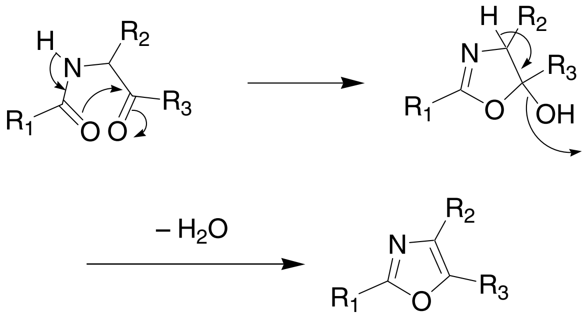
1. Rapson, W. S.; Robinson, R. *J. Chem. Soc.* **1935**, 1285. Robert Robinson used the Robinson annulaton in his total synthesis of cholesterol. Here is a story told by Derek Barton about Robinson and Woodward: "By pure chance, the two great men met early in a Monday morning on an Oxford train station platform in 1951. Robinson politely asked Woodward what kind of research he was doing these days; Woodward replied that he thought that Robinson would be interested in his recent total synthesis of cholesterol. Robinson, incensed and shouting 'Why do you always steal my research topic?', hit Woodward with his umbrella."—An excerpt from Barton, Derek, H. R. *Some Recollections of Gap Jumping,* American Chemical Society, Washington, DC, **1991**.
2. Gawley, R. E. *Synthesis* **1976**, 777–794. (Review).
3. Bui, T.; Barbas, C. F., III *Tetrahedron Lett.* **2000**, *41*, 6951.
4. Jansen, B. J. M.; Hendrikx, C. C. J.; Masalov, N.; Stork, G. A.; Meulemans, T. M.; Macaev, F. Z.; de Groot, A. *Tetrahedron* **2000**, *56*, 2075.
5. Guarna, A.; Lombardi, E.; Machetti, F.; Occhiato, E. G.; Scarpi, D. *J. Org. Chem.* **2000**, *65*, 8093.
6. Tai, C.-L.; Ly, T. W.; Wu, J.-D.; Shia, K.-S,; Liu, H.-J. *Synlett* **2001**, 214.
7. Jung, M. E.; Piizzi, G. *Org. Lett.* **2003**, *5*, 137.
8. Liu, H.-J.; Ly, T. W.; Tai, C.-L.; Wu, J.-D. *et al. Tetrahedron* **2003**, *59*, 1209.
9. Kawanami, H.; Ikushima, Y. *Tetrahedron Lett.* **2004**, *45*, 5147.
10. Singletary, J. A.; Lam, H.; Dudley, G. B. *J. Org. Chem.* **2005**, *70*, 739.
11. Jung, M. E.; Maderna, A. *Tetrahedron Lett.* **2005**, *46*, 5057.

Robinson–Gabriel synthesis

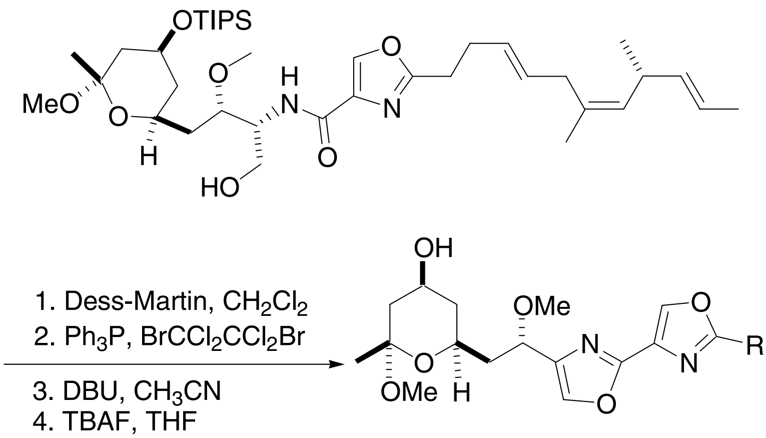
Cyclodehydration of 2-acylamidoketones to give 2,5-di- and 2,4,5-trialkyl, aryl, heteroaryl-, and aralkyloxazoles.



R1, R2, R3 = alkyl, aryl, heteroaryl

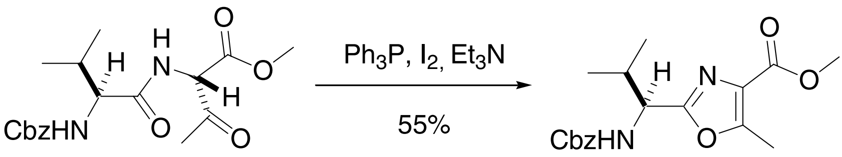


Example 1[9]



(+)-hennoxazole A

Example 2[8]

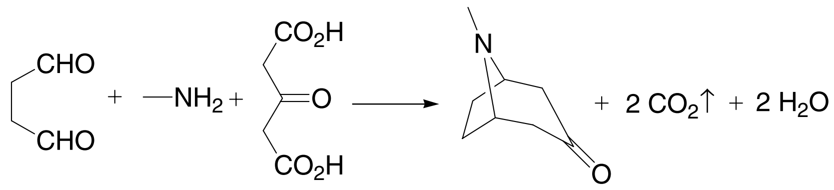


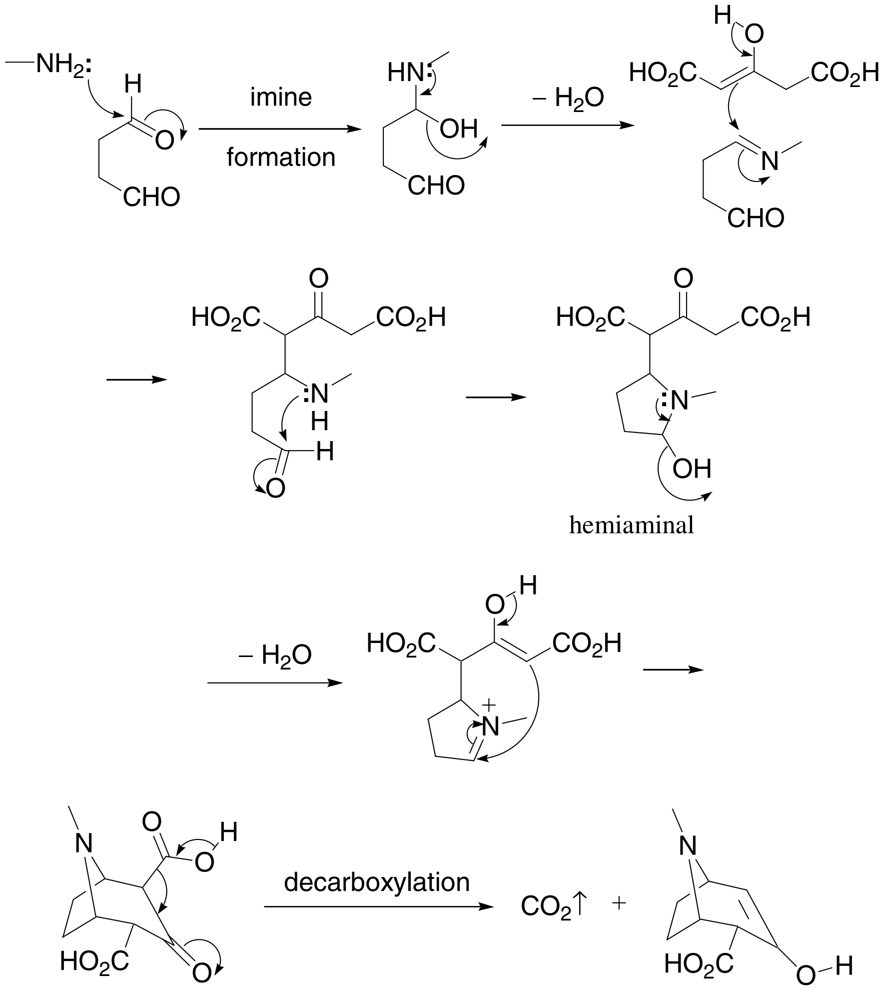
References

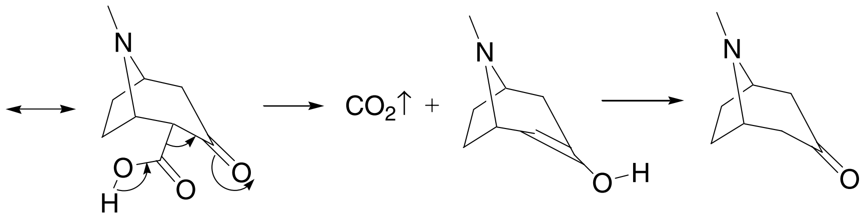
1. Robinson, R. *J. Chem. Soc.* **1909**, *95*, 2167.
2. Gabriel, S. *Chem. Ber.* **1910**, *43*, 134, 1283.
3. Wiley, R. H.; Borum, O. H. *J. Am. Chem. Soc.* **1948**, *70*, 2005.
4. Atkins, G. M., Jr.; Burgess, E. M. *J. Am. Chem. Soc.* **1968**, *90*, 4744.
5. Wasserman, H. H.; Vinick, F. J. *J. Org. Chem.* **1973**, *38*, 2407.
6. Meguro, K.; Tawada, H.; Sugiyama, Y.; Fujita, T.; Kawamatsu, Y. *Chem. Pharm. Bull.* **1986**, *34*, 2840.
7. Turchi, I. J. In *The Chemistry of Heterocyclic Compounds*, *45*; Wiley: New York, **1986**; pp 1−342. (Review).
8. Wipf, P.; Miller, C. P. *J. Org. Chem.* **1993**, *58*, 3604.
9. Wipf, P. Lim, S. *J. Am. Chem. Soc.* **1995**, *117*, 558.
10. Brain, C. T.; Paul, J. M. *Synlett* **1999**, *10*, 1642.
11. Yokokawa, F.; Asano, T.; Shioiri, T. *Org Lett* **2000**, *2*, 4169.
12. Morwick, T.; Hrapchak, M.; DeTuri, M.; Campbell, S. *Org Lett* **2002**, *4*, 2665.
13. Nicolaou, K. C.; Rao, P. B.; Hao, J.; Reddy, M. V.; Rassias, G.; Huang, X.; Chen, D. Y.-K.; Snyder, S. A. *Angew. Chem., Int. Ed.* **2003**, *42*, 1753.
14. Godfrey, A. G.; Brooks, D. A.; Hay, L. A.; Peters, M.; McCarthy, J. R.; Mitchell, D. *J. Org. Chem.* **2003**, *68*, 2623.
15. Brooks, D. A. *Robinson–Gabriel Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 249−253. (Review).

Robinson–Schöpf reaction

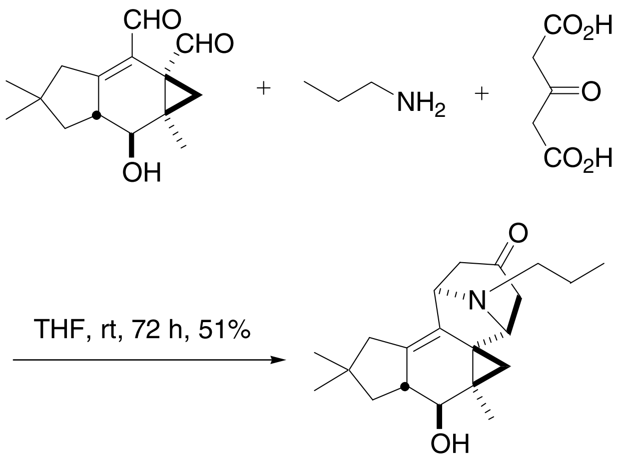
Tropinone synthesis.







Example[7]

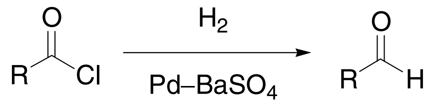


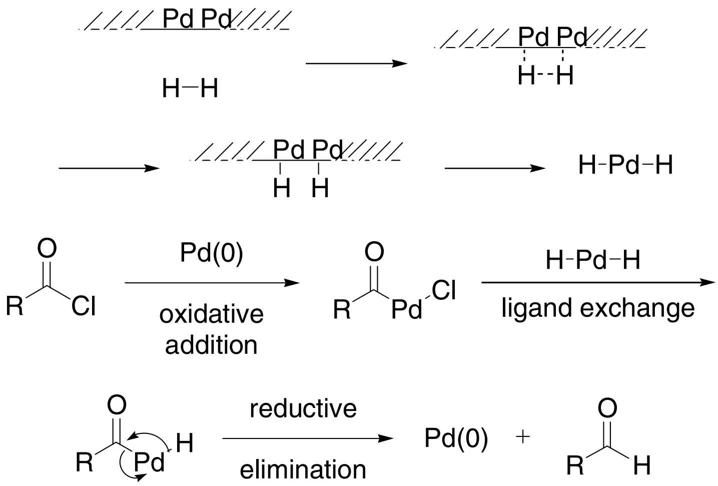
References

1. Robinson, R. *J. Chem. Soc.* **1917**, *111*, 762.
2. Büchi, G.; Fliri, H.; Shapiro, R. *J. Org. Chem.* **1978**, *43*, 4765.
3. Guerrier, L.; Royer, J.; Grierson, D. S.; Husson, H. P. *J. Am. Chem. Soc.* **1983**, *105*, 7754.
4. Royer, J.; Husson, H. P. *Tetrahedron Lett.* **1987**, *28*, 6175.
5. Bermudez, J.; Gregory, J. A.; King, F. D.; Starr, S.; Summersell, R. J. *Bioorg. Med. Chem. Lett.* **1992**, *2*, 519.
6. Langlois, M.; Yang, D.; Soulier, J. L.; Florac, C. *Synth. Commun.* **1992**, *22*, 3115.
7. Jarevång, T.; Anke, H.; Anke, T.; Erkel, G.; Sterner, O. *Acta Chem. Scand.* **1998**, *52*, 1350.
8. Amedjkouh, M.; Westerlund, K. *Tetrahedron Lett.* **2004**, *45*, 5175.

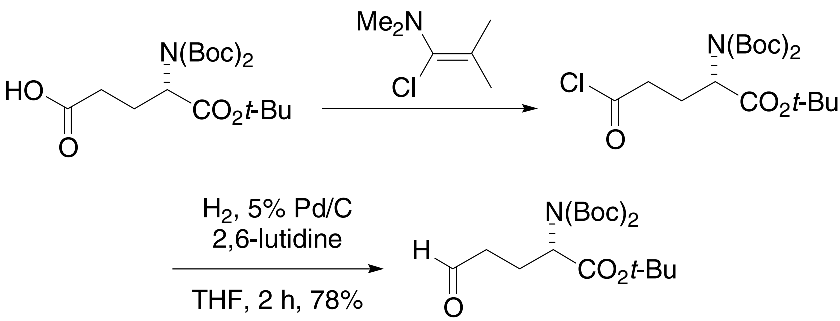
Rosenmund reduction

Hydrogenation reduction of acid chloride to aldehyde using $BaSO_4$-poisoned palladium catalyst. Without poison, the resulting aldehyde may be further reduced to alcohol.

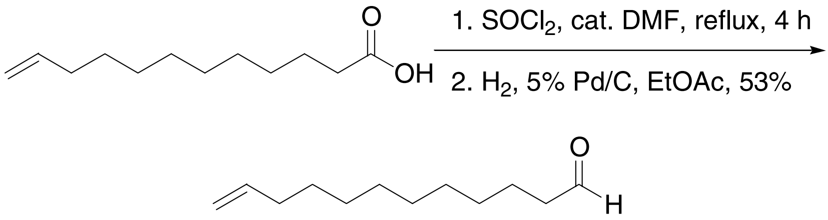




Example 1[6]



Example 2[9]

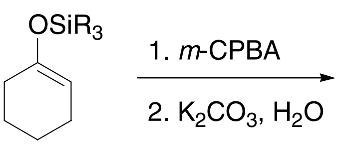


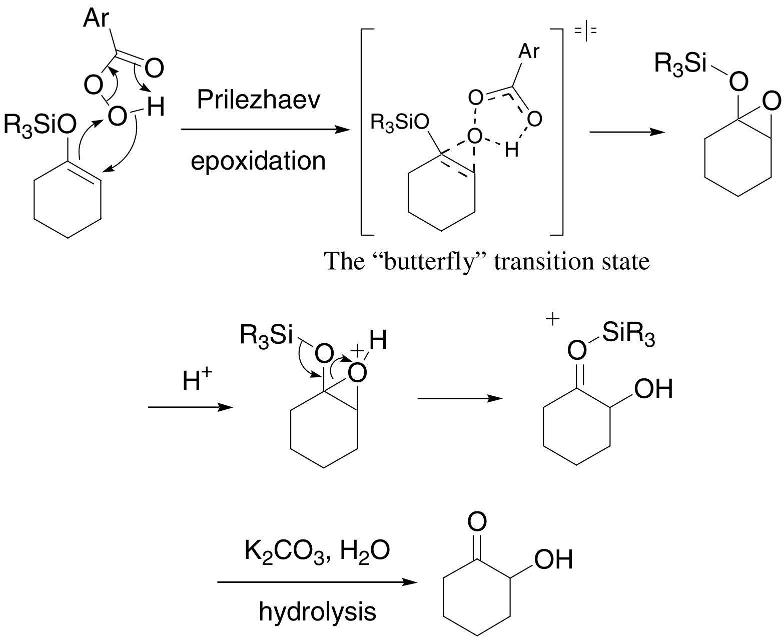
References

1. Rosenmund, K. W. *Ber. Dtsch. Chem. Ges.* **1918**, *51*, 585. Karl Wilhelm Rosenmund was born in Berlin, Germany in 1884. He was a student of Otto Diels and received his Ph.D. in 1906. Rosenmund became professor and director of the Pharmaceutical Institute in Kiel in 1925.
2. Mosettig, E.; Mozingo, R. *Org. React.* **1948**, *4*, 362–377. (Review).
3. Tsuji, J.; Ono, K.; Kajimoto, T. *Tetrahedron Lett.* **1965**, 4565.
4. Burgstahler, A. W.; Weigel, L. O.; Schäfer, C. G. *Synthesis* **1976**, 767.
5. McEwen, A. B.; Guttieri, M. J.; Maier, W. F.; Laine, R. M.; Shvo, Y. *J. Org. Chem.* **1983**, *48*, 4436.
6. Bold, V. G.; Steiner, H.; Moesch, L.; Walliser, B. *Helv. Chim. Acta* **1990**, *73*, 405.
7. Yadav, V. G.; Chandalia, S. B. *Org. Proc. Res. Dev.* **1997**, *1*, 226.
8. Chandnani, K. H.; Chandalia, S. B. *Org. Proc. Res. Dev.* **1999**, *3*, 416.
9. Chimichi, S.; Boccalini, M.; Cosimelli, B. *Tetrahedron* **2002**, *58*, 4851.

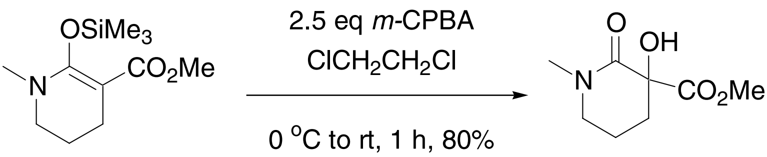
Rubottom oxidation

α-Hydroxylation of enolsilanes.

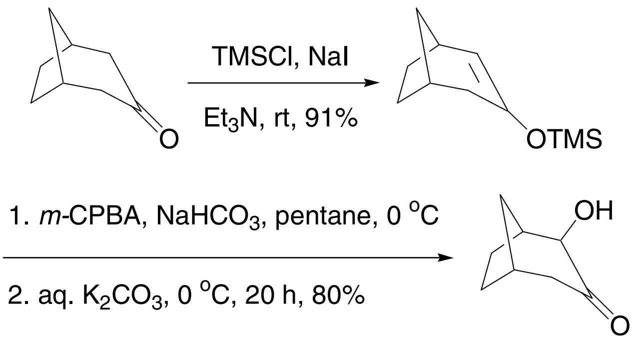




Example 1[5]



Example 2[10]

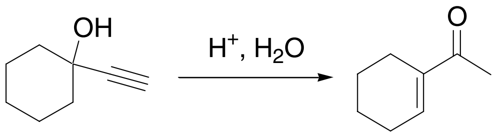


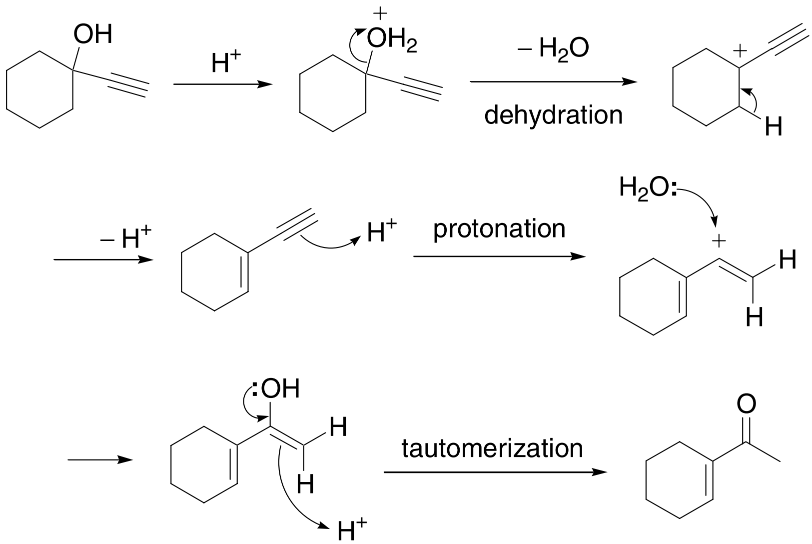
References

1. Rubottom, G. M.; Vazquez, M. A.; Pelegrina, D. R. *Tetrahedron Lett.* **1974**, 4319. George Rubottom discovered the Rubottom oxidation when he was an assistant professor at the University of Puerto Rico. He is now a grant officer at the National Science Foundation.
2. Brook, A. G.; Macrae, D. M. *J. Organomet. Chem.* **1974**, *77,* C19.
3. Hassner, A.; Reuss, R. H.; Pinnick, H. W. *J. Org. Chem.* **1975**, *40*, 3427.
4. Rubottom, G. M.; Gruber, J. M.; Boeckman, R. K., Jr.; Ramaiah, M.; Medwid, J. B. *Tetrahedron Lett.* **1978**, 4603.
5. Andriamialisoa, R. Z.; Langlois, N.; Langlois, Y. *Tetrahedron Lett.* **1985**, *26*, 3563.
6. Paquette, L. A.; Lin, H.-S.; Coghlan, M. J. *Tetrahedron Lett.* **1987**, *28,* 5017.
7. Hirota, H.; Yokoyama, A.; Miyaji, K.; Nakamura, T.; Takahashi, T. *Tetrahedron Lett.* **1987**, *28,* 435.
8. Gleiter, R.; Krämer, R.; Irngartinger, H.; Bissinger, C. *J. Org. Chem.* **1992**, *57*, 252.
9. Johnson, C. R.; Golebiowski, A.; Steensma, D. H. *J. Am. Chem. Soc.* **1992**, *114*, 9414.
10. Jauch, J. *Tetrahedron* **1994**, *50*, 12903.
11. Gleiter, R.; Staib, M.; Ackermann, U. *Liebigs Ann.* **1995**, 1655.
12. Xu, Y.; Johnson, C. R. *Tetrahedron Lett.* **1997**, *38*, 1117.
13. Paquette, L. A.; Hartung, R. E.; Hofferberth, J. E.; Vilotijevic, I.; Yang, J. *J. Org. Chem.* **2004**, *69*, 2454.
14. Christoffers, J.; Baro, A.; Werner, T. *Adv. Synth. Cat.* **2004**, *346*, 143−151. (Review).

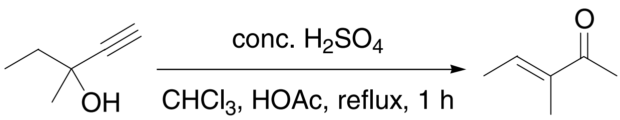
Rupe rearrangement

Acid-catalyzed rearrangement of tertiary α-acetylenic (terminal) alcohols, leading to the formation of α,β-unsaturated ketones rather than the corresponding α,β-unsaturated aldehydes. *Cf.* Meyer–Schuster rearrangement.

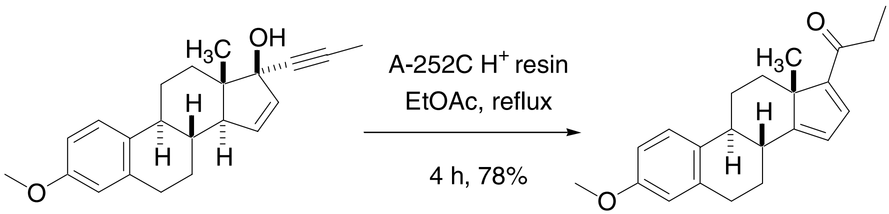




Example 1[6]



Example 2[10]

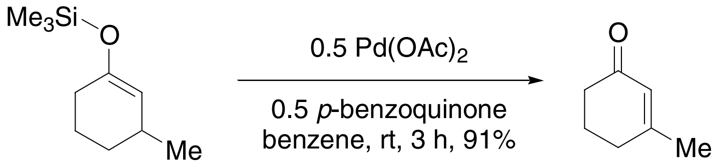


References

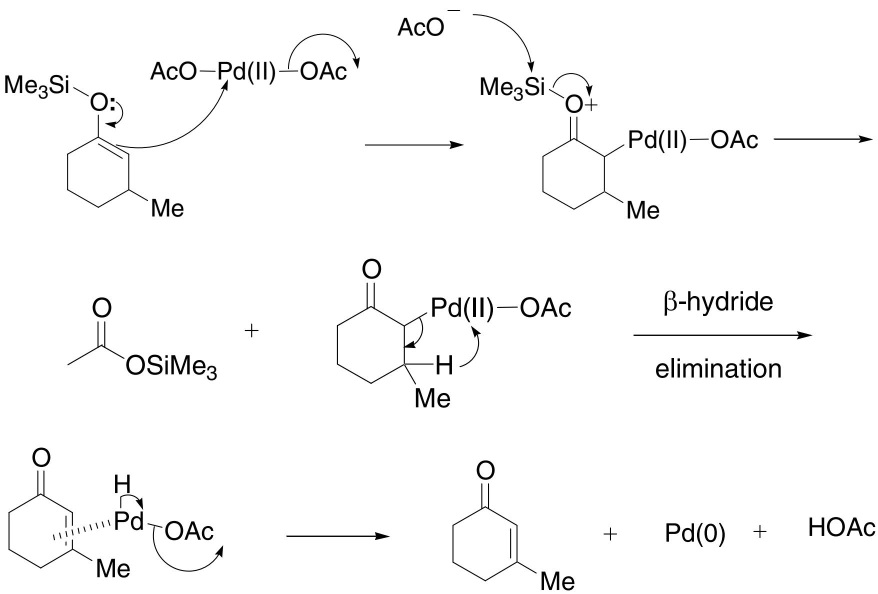
1. Rupe, H.; Kambli, E. *Helv. Chim. Acta* **1926**, *9*, 672.
2. Hennion, G. F.; Davis, R. B.; Maloney, D. E. *J. Am. Chem. Soc*. **1949**, *71*, 2813.
3. Schmidt, C.; Thazhuthaveetil, J. *Tetrahedron Lett*. **1970**, 2653.
4. Swaminathan, S.; Narayanan, K. V. *Chem. Rev*. **1971**, *71*, 429. (Review).
5. Hasbrouck, R. W.; Kiessling, A. D. *J. Org. Chem*. **1973**, *38*, 2103.
6. Apparu, M.; Glenat, R. *Tetrahedron* **1988**, *41,* 2181.
7. Barre, V.; Massias, F.; Uguen, D. *Tetrahedron Lett*. **1989**, *30*, 7389.
8. An, J.; Bagnell, L.; Cablewski, T.; Strauss, C. R.; Trainor, R. W. *J. Org. Chem*. **1997**, *62*, 2505.
9. Strauss, C. R. *Aust. J. Chem*. **1999**, *52*, 83–96. (Review).
10. Weinmann, H.; Harre, M.; Neh, H.; Nickisch, K.; Skötsch, C.; Tilstam, U. *Org. Proc. Res. Dev.* **2002**, *6*, 216.

Saegusa oxidation

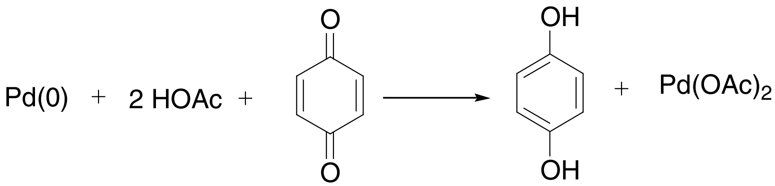
Palladium-catalyzed conversion of enol silanes to enones, also known as the Saegusa enone synthesis.



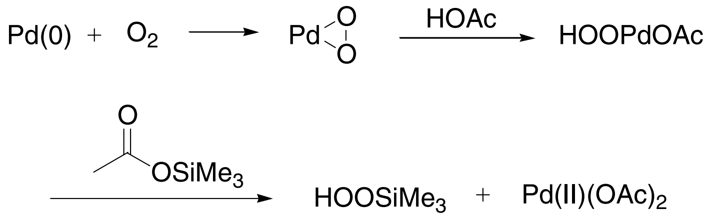
The mechanism is similar to that of the Wacker oxidation (page 610).



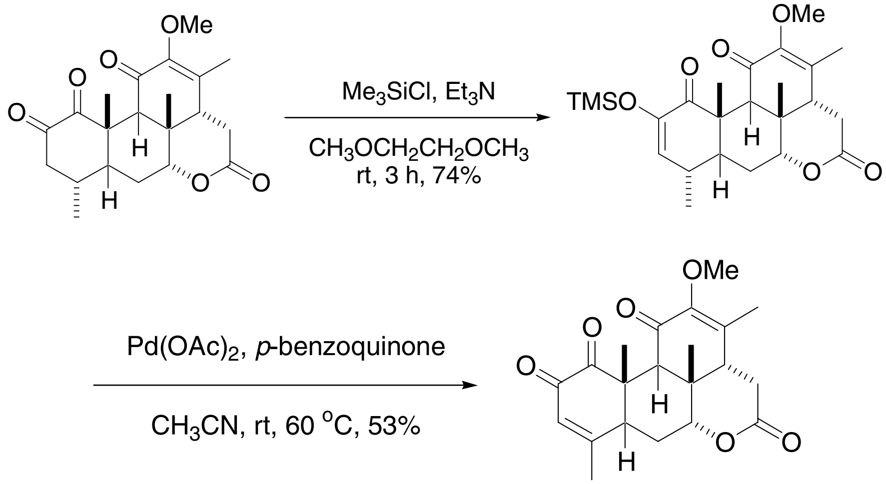
Regenerating the Pd(II) oxidant:



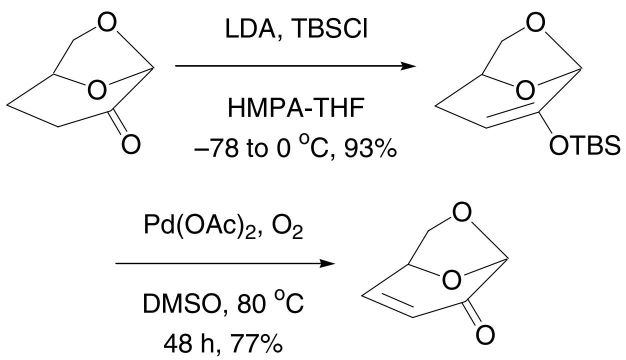
Larock reported regeneration of the Pd(II) oxidant using oxygen:[4]



Example 1[3]



Example 2[8]

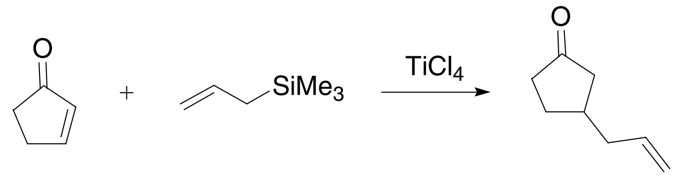


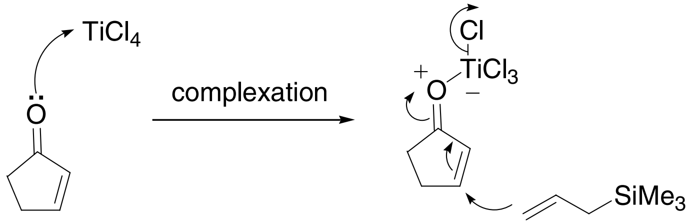
References

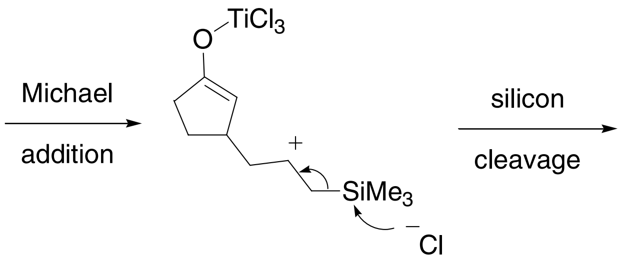
1. Ito, Y.; Hirao, T.; Saegusa, T.; *J. Org. Chem.* **1978**, *43*, 1011.
2. Dickson, J. K., Jr.; Tsang, R.; Llera, J. M.; Fraser-Reid, B. *J. Org. Chem.* **1989**, *54*, 5350.
3. Kim, M.; Applegate, L. A.; Park, O.-S.; Vasudevan, S.; Watt, D. S. *Synth. Commun.* **1990**, *20*, 989.
4. Larock, R. C.; Hightower, T. R.; Kraus, G. A.; Hahn, P.; Zheng, D. *Tetrahedron Lett.* **1995**, 36, 2423.
5. Porth, S.; Bats, J. W.; Trauner, D.; Giester, G.; Mulzer, J. *Angew. Chem., Int. Ed.* **1999**, *38*, 2015. The authors proposed sandwiched Pd(II) as a possible alternative pathway.
6. Williams, D. R.; Turske, R. A. *Org. Lett.* **2000**, *2*, 3217.
7. Nicolaou, K. C.; Zhong, Y.-L.; Baran, P. S. *J. Am. Chem. Soc.* **2000**, *122*, 7596.
8. Kadota, K.; Kurusu, T.; Taniguchi, T.; Ogasawara, K. *Adv. Synth. Catal.* **2001**, *343*, 618.
9. Sha, C.-K.; Huang, S.-J.; Zhan, Z.-P. *J. Org. Chem.* **2002**, *67*, 831.

Sakurai allylation reaction

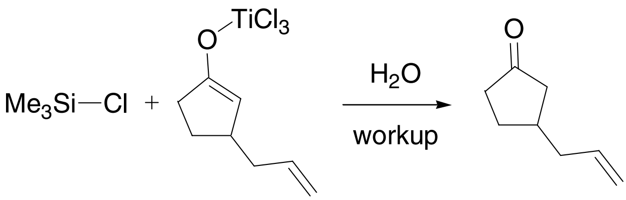
Lewis acid-mediated addition of allylsilanes to carbon nucleophiles. Also known as the Hosomi–Sakurai reaction. The allylsilane will add to the carbonyl compound directly if it is not part of an α,β-unsaturated system (Example 2), giving rise to an alcohol.



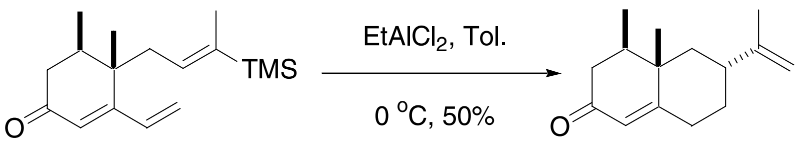




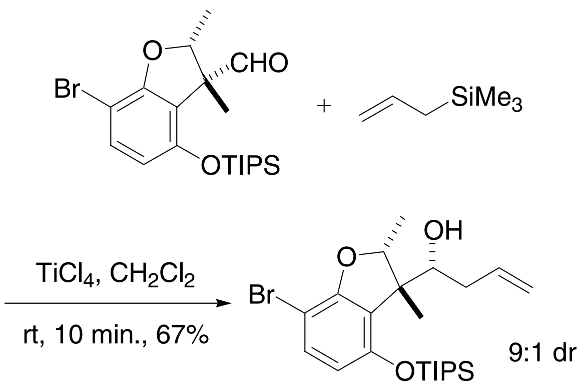
The β-carbocation is stabilized by the silicon atom



Example 1[2]



Example 2[14]



References

1. Hosomi, A.; Sakurai, H. *Tetrahedron Lett.* **1976**, 1295.
2. Majetich, G.; Behnke, M.; Hull, K. *J. Org. Chem.* **1985**, *50*, 3615.
3. Hollis, T. K.; Bosnich, B. *J. Am. Chem. Soc.* **1995**, *117*, 4570.
4. Markó, I. E.; Mekhalfia, A.; Murphy, F.; Bayston, D. J.; Bailey, M.; Janousek, Z.; Dolan, S. *Pure Appl. Chem.* **1997**, *69*, 565.
5. Bonini, B. F.; Comes-Franchini, M.; Fochi, M.; Mazzanti, G.; Ricci, A.; Varchi, G. *Tetrahedron: Asymmetry* **1998**, *9*, 2979.
6. Wang, D.-K.; Zhou, Y.-G.; Tang, Y.; Hou, X.-L.; Dai, L.-X. *J. Org. Chem.* **1999**, *64*, 4233.
7. Sugita, Y.; Kimura, Y.; Yokoe, I. *Tetrahedron Lett.* **1999**, *40*, 5877.
8. Wang, M. W.; Chen, Y. J.; Wang, D. *Synlett* **2000**, 385.
9. Organ, M. G.; Dragan, V.; Miller, M.; Froese, R. D. J.; Goddard, J. D. *J. Org. Chem.* **2000**, *65*, 3666.
10. Tori, M.; Makino, C.; Hisazumi, K.; Sono, M.; Nakashima, K. *Tetrahedron: Asymmetry* **2001**, *12*, 301.
11. Leroy, B.; Markó, I. E. *J. Org. Chem.* **2002**, *67*, 8744.
12. Itsuno, S.; Kumagai, T. *Helv. Chim. Acta* **2002**, *85*, 3185.
13. Nosse, B.; Chhor, R. B.; Jeong, W. B.; Böhm, C.; Reiser, O. *Org. Lett.* **2003**, *5*, 941.
14. Trost, B. M.; Thiel, O. R.; Tsui, H.-C. *J. Am. Chem. Soc.* **2003**, *125*, 13155.
15. Knepper, K.; Ziegert, R. E.; Bräse, S. *Tetrahedron* **2004**, *60*, 8591.
16. Rikimaru, K.; Mori, K.; Kan, T.; Fukuyama, T. *Chem. Commun.* **2005**, 394.

Sandmeyer reaction

Haloarenes from the reaction of a diazonium salt with CuX.

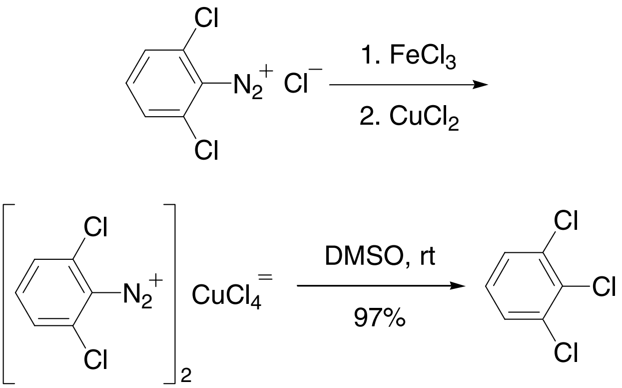
$$\mathrm{ArN_2^{+}\ Y^{-}} \xrightarrow{\mathrm{CuX}} \mathrm{Ar{-}X} \qquad \mathrm{X = Cl, Br, CN}$$

e.g.:

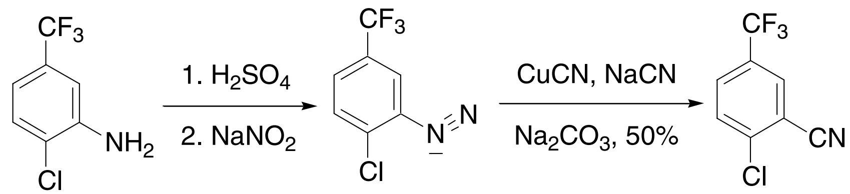
$$\mathrm{ArN_2^{+}\ Cl^{-}} \xrightarrow{\mathrm{CuCl}} \mathrm{Ar{-}Cl}$$

$$\mathrm{ArN_2^{+}\ Cl^{-}} \xrightarrow{\mathrm{CuCl}} \mathrm{N_2}\uparrow + \mathrm{Ar}\bullet + \mathrm{CuCl_2} \longrightarrow \mathrm{Ar{-}Cl} + \mathrm{CuCl}$$

Example 1[5]



Example 2[11]



References

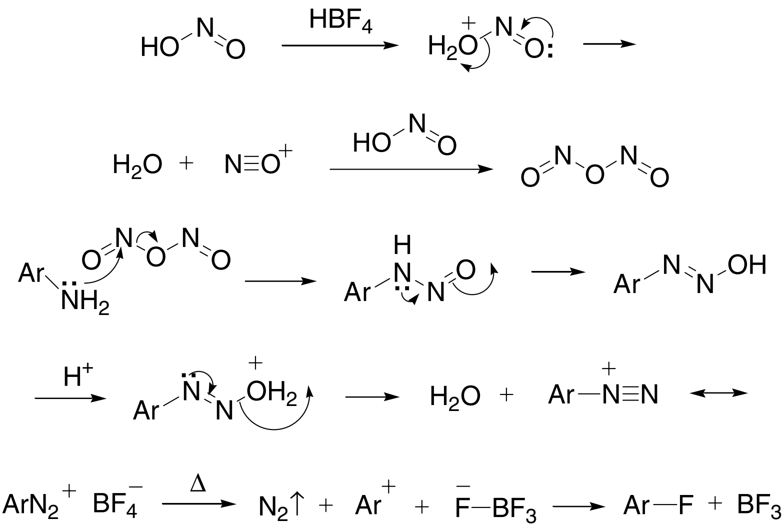
1. Sandmeyer, T. *Ber. Dtsch. Chem. Ges.* **1884**, *17*, 1633. Traugott Sandmeyer (1854–1922) was born in Wettingen, Switzerland. He apprenticed under Victor Meyer and Arthur Hantzsch although he never took a doctorate. He later spent 31 years at the firm J. R. Geigy, which is now part of Novartis.
2. Galli, C. *J. Chem. Soc., Perkin Trans. 2* **1984**, 897.

3. Suzuki, N.; Azuma, T.; Kaneko, Y.; Izawa, Y.; Tomioka, H.; Nomoto, T. *J. Chem. Soc., Perkin Trans. 1* **1987**, 645.
4. Merkushev, E. B. *Synthesis* **1988**, 923–927. (Review).
5. Obushak, M. D.; Lyakhovych, M. B.; Ganushchak, M. I. *Tetrahedron Lett.* **1998**, *39*, 9567.
6. Hanson, P.; Lövenich, P. W.; Rowell, S. C.; Walton, P. H.; Timms, A. W. *J. Chem. Soc., Perkin Trans. 2* **1999**, 49.
7. Chandler, S. A.; Hanson, P.; Taylor, A. B.; Walton, P. H.; Timms, A. W. *J. Chem. Soc., Perkin Trans. 2* **2001**, 214.
8. Hanson, P.; Rowell, S. C.; Taylor, A. B.; Walton, P. H.; Timms, A. W. *J. Chem. Soc., Perkin Trans. 2* **2002**, 1126.
9. Hanson, P.; Jones, J. R.; Taylor, A. B.; Walton, P. H.; Timms, A. W. *J. Chem. Soc., Perkin Trans. 2* **2002**, 1135.
10. Daab, J. C.; Bracher, F. *Monatsh. Chem.* **2003**, *134*, 573.
11. Nielsen, M. A.; Nielsen, M. K.; Pittelkow, T. *Org. Proc. Res. Dev.* **2004**, *8*, 1059.

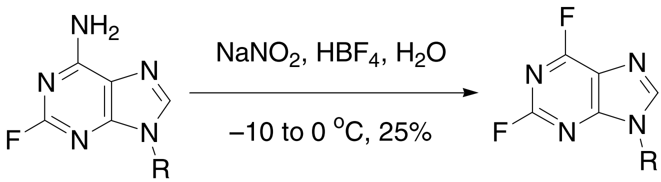
Schiemann reaction

Fluoroarene formation from arylamines. Also known as the Balz–Schiemann reaction.

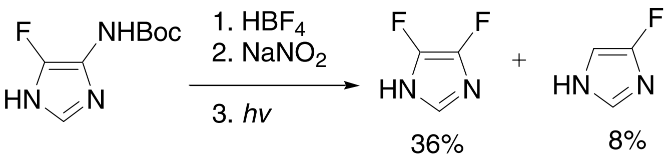
$$Ar{-}NH_2 + HNO_2 + HBF_4 \longrightarrow ArN_2^{+}\ BF_4^{-} \xrightarrow{\Delta} Ar{-}F + N_2\uparrow + BF_3$$



Example 1[4]



Example 2[10]

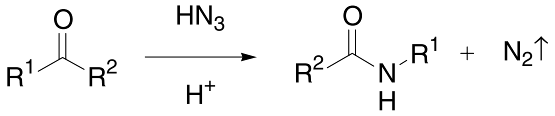


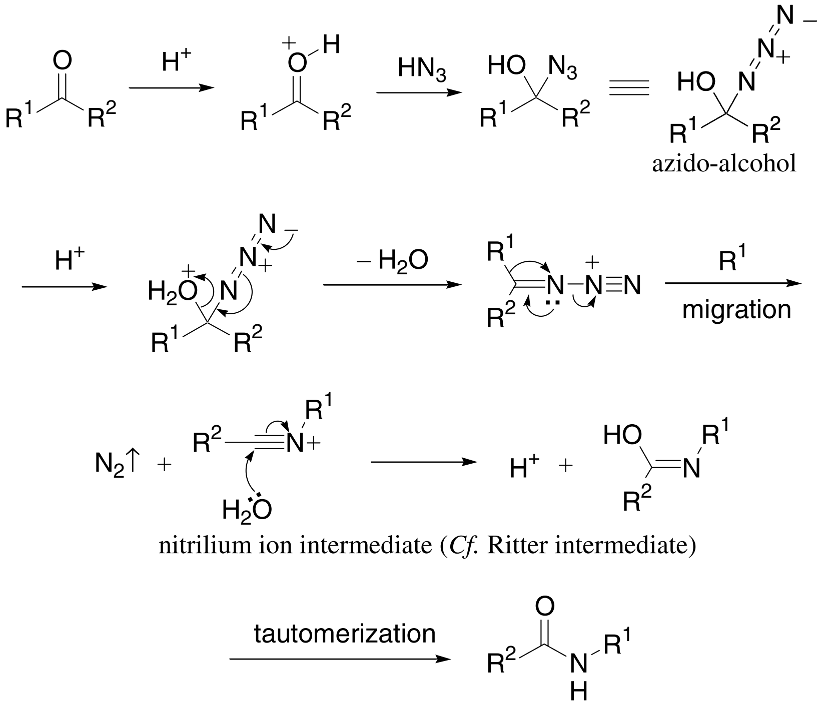
References

1. Balz, G.; Schiemann. G. *Ber. Dtsch. Chem. Ges.* **1927**, *60*, 1186. Günther Schiemann was born in Breslau, Germany in 1899. In 1925, he received his doctorate at Breslau, where he became an assistant professor. In 1950, he became the Chair of Technical Chemistry at Istanbul, where he extensively studied aromatic fluorine compounds.
2. Roe, A. *Org. React.* **1949**, *5*, 193–228. (Review).
3. Sharts, C. M. *J. Chem. Educ.* **1968**, *45*, 185. (Review).
4. Montgomery, J. A.; Hewson, K. *J. Org. Chem.* **1969**, *34*, 1396.
5. Matsumoto, J.-i.; Miyamoto, T.; Minamida, A.; Nishimura, Y.; Egawa, H.; Nishimura, H. *J. Heterocycl. Chem.* **1984**, *21*, 673.
6. Corral, C.; Lasso, A.; Lissavetzky, J.; Alvarez-Insua, A. S.; Valdeolmillos, A. M. *Heterocycles* **1985**, *23*, 1431.
7. Tsuge, A.; Moriguchi, T.; Mataka, S.; Tashiro, M. *J. Chem. Res., (S)* **1995**, 460.
8. Saeki, K.-i.; Tomomitsu, M.; Kawazoe, Y.; Momota, K.; Kimoto, H. *Chem. Pharm. Bull.* **1996**, *44*, 2254.
9. Laali, K. K.; Gettwert, V. J. *J. Fluorine Chem.* **2001**, *107*, 31.
10. Dolensky, B.; Takeuchi, Y.; Cohen, L. A.; Kirk, K. L. *J. Fluorine Chem.* **2001**, *107*, 147.
11. Gronheid, R.; Lodder, G.; Okuyama, T. *J. Org. Chem.* **2002**, *67*, 693.

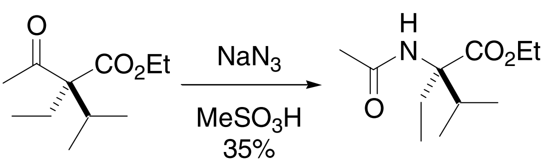
Schmidt reaction

Conversion of ketones to amides using HN_3 (hydrazoic acid).

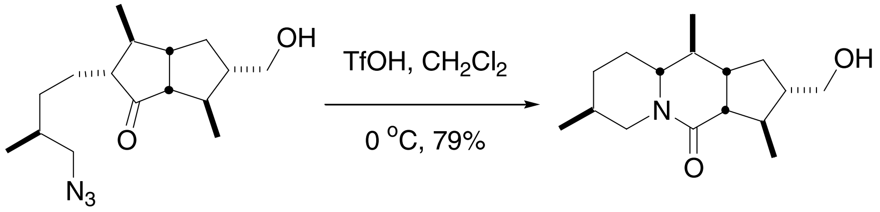




Example 1, a classic example[11]



Example 2, a variant[15]

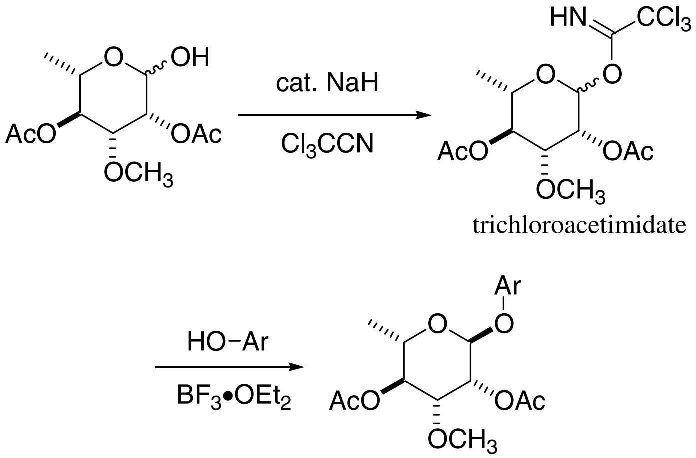


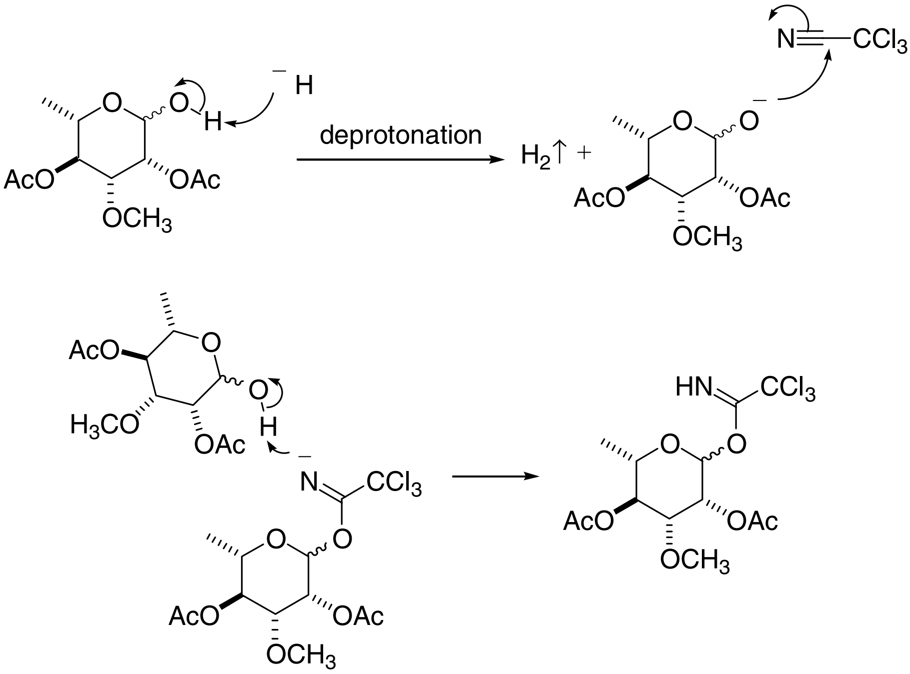
References

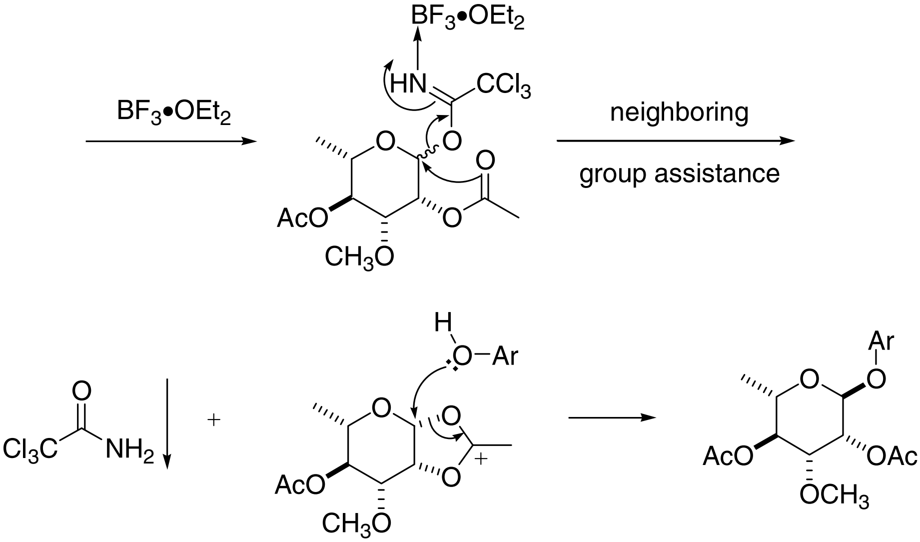
1. Schmidt, K. F. *Z. Angew. Chem.* **1923**, *36*, 511. Karl Friedrich Schmidt (1887–1971) collaborated with Curtius at the University of Heidelberg, where Schmidt became a Professor of Chemistry after 1923.
2. Schmidt, K. F. *Ber. Dtsch. Chem. Ges.* **1924**, *57*, 704.
3. Wolff, H. *Org. React.* **1946**, *3*, 307. (Review).
4. Richard, J. P.; Amyes, T. L.; Lee, Y.-G.; Jagannadham, V. *J. Am. Chem. Soc.* **1994**, *116*, 10833.
5. Kaye, P. T.; Mphahlele, M. J. *Synth. Commun.* **1995**, *25*, 1495.
6. Krow, G. R.; Szczepanski, S W.; Kim, J. Y.; Liu, N.; Sheikh, A.; Xiao, Y.; Yuan, J. *J. Org. Chem.* **1999**, *64*, 1254.
7. Mphahlele, M. J. *Phosphorus, Sulfur Silicon Relat. Elem.* **1999**, *144-146*, 351.
8. Mphahlele, M. J. *J. Chem. Soc., Perkin Trans. 1* **1999**, 3477.
9. Iyengar, R.; Schildknegt, K.; Aubé, J. *Org. Lett.* **2000**, *2*, 1625.
10. Pearson, W. H.; Hutta, D. A.; Fang, W.-k. *J. Org. Chem.* **2000**, *65*, 8326.
11. Tanaka, M.; Oba, M.; Tamai, K.; Suemune, H. *J. Org. Chem.* **2001**, *66*, 2667.
12. Pearson, W. H.; Walavalkar, R. *Tetrahedron* **2001**, *57*, 5081.
13. Golden, J. E.; Aubé, J. *Angew. Chem., Int. Ed.* **2002**, *41*, 4316.
14. Cristau, H.-J.; Marat, X.; Vors, J.-P.; Pirat, J.-L. *Tetrahedron Lett.* **2003**, *44*, 3179.
15. Wrobleski, A.; Sahasrabudhe, K.; Aubé, J. *J. Am. Chem. Soc.* **2004**, *126*, 5475.
16. Gorin, D. J.; Davis, N. R.; Toste, F. D. *J. Am. Chem. Soc.* **2005**, *127*, 11260.

Schmidt's trichloroacetimidate glycosidation reaction

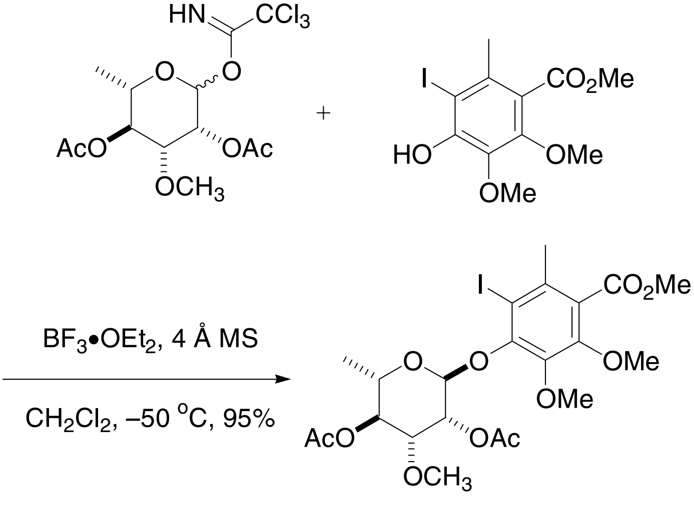
Lewis acid-promoted glycosidation of trichloroacetimidates with alcohols or phenols.



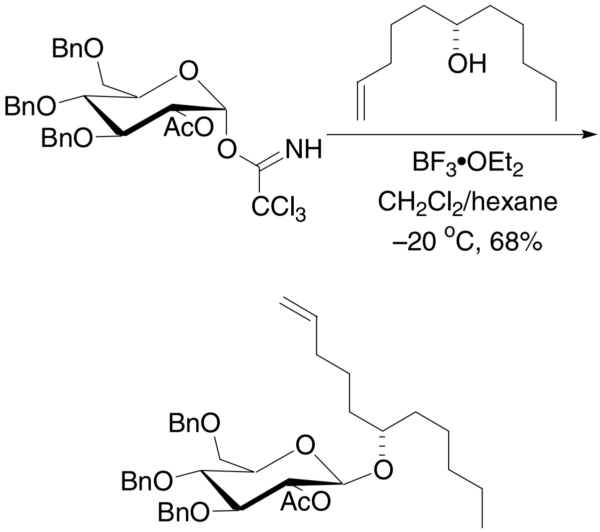



BF3•OEt2
BF3•OEt2
HN
CCl3
O
O
O
O
AcO
CH3O
neighboring
group assistance
O
Cl3C
NH2
+
H
O
Ar
O
O
O
+
AcO
CH3O
Ar
O
O
AcO
OAc
OCH3

Example 1[5]


HN
CCl3
O
O
AcO
OAc
OCH3
+
I
CO2Me
HO
OMe
OMe
BF3•OEt2, 4 Å MS
CH2Cl2, –50 °C, 95%
I
CO2Me
O
O
OMe
OMe
AcO
OAc
OCH3

Example 2[7]

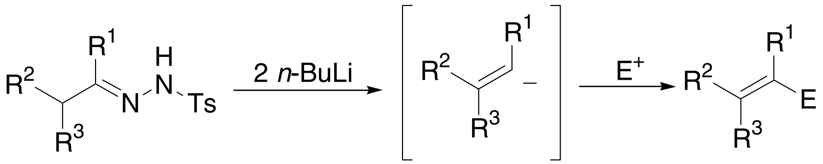


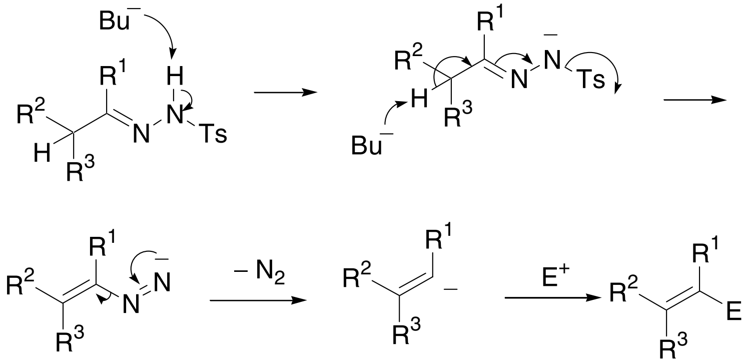
References

1. Grundler, G.; Schmidt, R. R. *Carbohydr. Res.* **1985**, *135*, 203.
2. Schmidt, R. R. *Angew. Chem., Int. Ed. Engl.* **1986**, *25*, 212. (Review).
3. Smith, A. L.; Hwang, C.-K.; Pitsinos, E.; Scarlato, G. R.; Nicolaou, K. C. *J. Am. Chem. Soc*. **1992**, *114*, 3134.
4. Toshima, K.; Tatsuta, K. *Chem. Rev.* **1993**, *93*, 1503–1531. (Review).
5. Nicolaou, K. C. *Angew. Chem., Int. Ed. Engl.* **1993**, *32*, 1377.
6. Weingart, R.; Schmidt, R. R. *Tetrahedron Lett.* **2000**, *41*, 8753.
7. Furstner, A.; Jeanjean, F.; Razon, P. *Angew. Chem., Int. Ed. Engl.* **2002**, *41*, 2097.
8. Yan, L. Z.; Mayer, J. P. *Org. Lett.* **2003**, *5*, 1161.
9. Roy, S.; Sarkar, S. K.; Mukhopadhyay, B.; Roy, N. *Indian J. Chem*., *Sect. B* **2005**, *44B*, 130.
10. Harding, J. R.; King, C. D.; Perrie, J. A.; Sinnott, D.; Stachulski, A. V. *Org. Biomol. Chem*. **2005**, *3*, 1501.

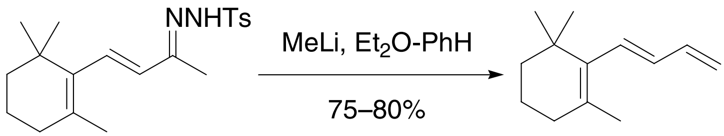
Shapiro reaction

The Shapiro reaction is a variant of the Bamford–Stevens reaction. The former uses bases such as alkyl lithium and Grignard reagents whereas the latter employs bases such as Na, NaOMe, LiH, NaH, $NaNH_2$, *etc*. Consequently, the Shapiro reaction generally affords the less-substituted olefins as the kinetic products, while the Bamford–Stevens reaction delivers the more-substituted olefins as the thermodynamic products.

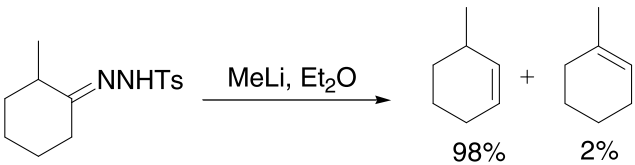




Example 1[3]



Example 2[2]

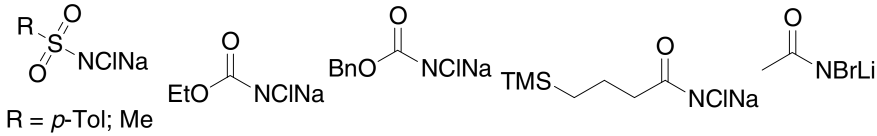


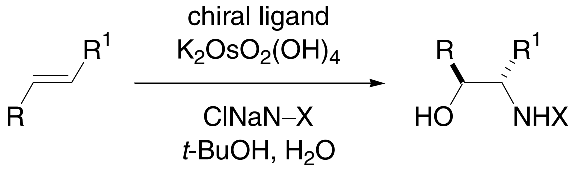
References

1. Shapiro, R. H.; Duncan, J. H.; Clopton, J. C. *J. Am. Chem. Soc*. **1967**, *89*, 471. Robert H. Shapiro was a professor at the University of Colorado.
2. Shapiro, R. H.; Heath, M. J. *J. Am. Chem. Soc*. **1967**, *89*, 5734.
3. Dauben, W. G.; Lorber, M. E.; Vietmeyer, N. D.; Shapiro, R. H.; Duncan, J. H.; Tomer, K. *J. Am. Chem. Soc*. **1968**, *90*, 4762.
4. Casanova, J.; Waegell, B. *Bull. Soc. Chim. Fr.* **1975**, 922.
5. Shapiro, R. H. *Org. React.* **1976**, *23*, 405–507. (Review).
6. Adlington, R. M.; Barrett, A. G. M. *Acc. Chem. Res.* **1983**, *16*, 55. (Review).
7. Chamberlin, A. R.; Bloom, S. H. *Org. React.* **1990**, *39*, 1–83. (Review).
8. Corey, E. J.; Lee, J.; Roberts, B. E. *Tetrahedron Lett*. **1997**, *38,* 8915.
9. Corey, E. J.; Roberts, B. E. *Tetrahedron Lett*. **1997**, *38,* 8919.
10. Kurek-Tyrlik, A.; Marczak, S.; Michalak, K.; Wicha, J. *Synlett* **2000**, 547.
11. Kurek-Tyrlik, A.; Marczak, S.; Michalak, K.; Wicha, J.; Zarecki, A. *J. Org. Chem.* **2001**, *65,* 6994.
12. Tormakangas, O. P.; Toivola, R. J.; Karvinen, E. K.; Koskinen, A. M. P. *Tetrahedron* **2002**, *58,* 2175.
13. Alvarez, R.; Dominguez, M.; Pazos, Y.; Sussman, F.; de Lera, A. R. *Chem. Eur. J.* **2003**, *9,* 5821.
14. Harrowven, D. C.; Pascoe, D. D.; Demurtas, D.; Bourne, H. O. *Angew. Chem., Int. Ed. Engl*. **2005**, *44,* 1221.
15. Girard, N.; Hurvois, J.-P.; Moinet, C.; Toupet, L. *Eur. J. Org. Chem.* **2005**, 2269.

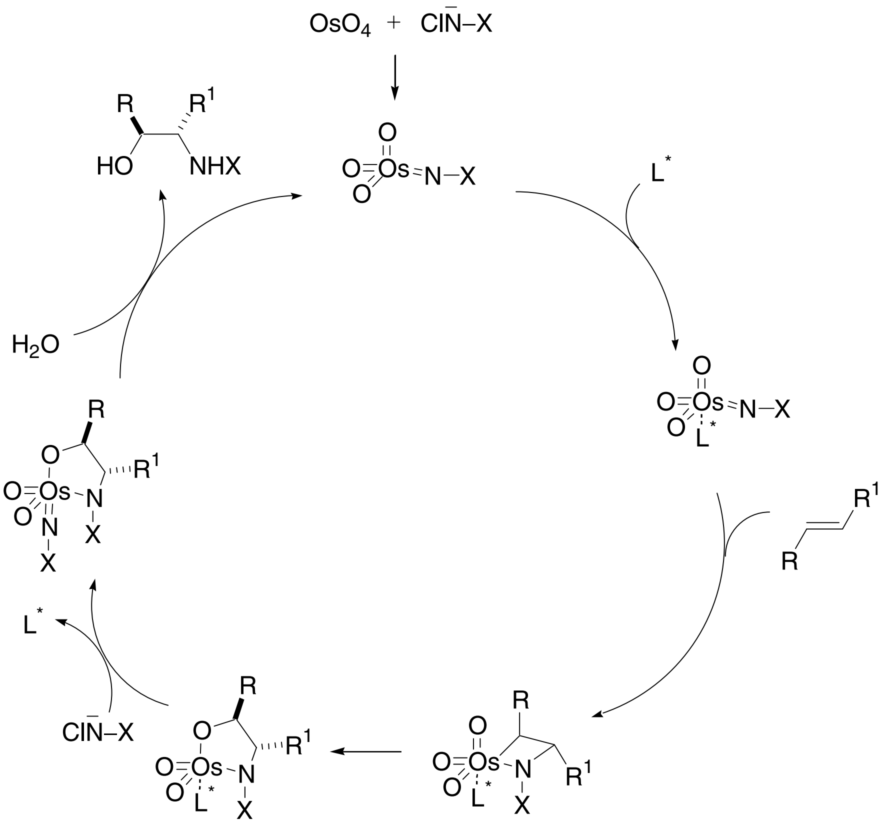
Sharpless asymmetric amino hydroxylation

Osmium-mediated *cis*-addition of nitrogen and oxygen to olefins. Regioselectivity may be controlled by ligand. Nitrogen sources (X–NClNa) include:

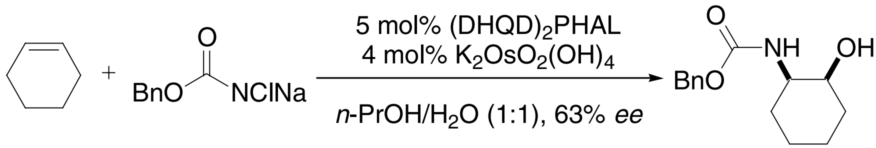




The catalytic cycle:

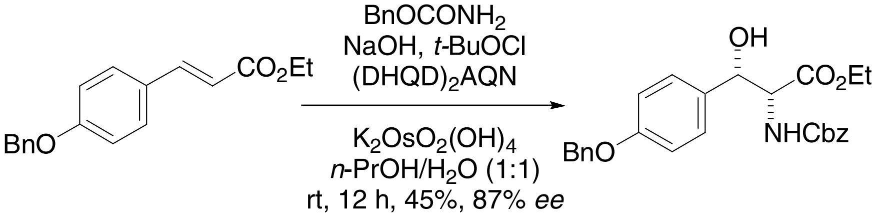


Example 1[4]



$(DHQD)_2$-PHAL = 1,4-bis(9-*O*-dihydroquinidine)phthalazine (page 536).

Example 2[9]

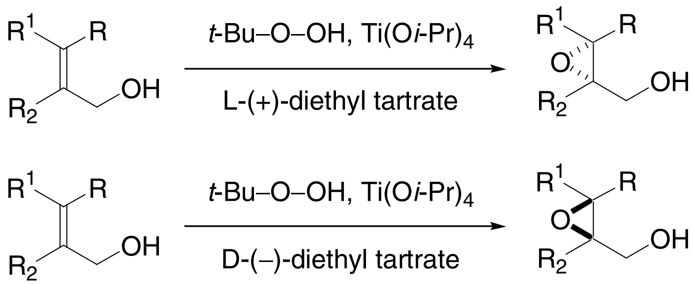


References

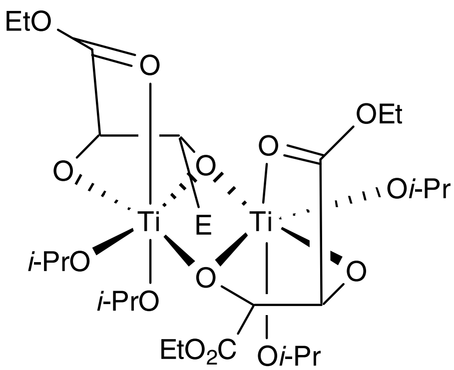
1. Herranz, E.; Sharpless, K. B. *J. Org. Chem.* **1978**, *43*, 2544. K. Barry Sharpless (USA, 1941−) shared the Nobel Prize in Chemistry in 2001 with Herbert William S. Knowles (USA, 1917−) and Ryoji Noyori (Japan, 1938−) for his work on chirally catalyzed oxidation reactions.
2. Mangatal, L.; Adeline, M. T.; Guenard, D.; Gueritte-Voegelein, F.; Potier, P. *Tetrahedron* **1989**, *45*, 4177.
3. Engelhardt, L. M.; Skelton, B. W.; Stick, R. V.; Tilbrook, D. M. G.; White, A. H. *Aust. J. Chem.* **1990**, *43*, 1657.
4. Li, G.; Angert, H. H.; Sharpless, K. B. *Angew. Chem., Int. Ed. Engl.* **1996**, *35*, 2813.
5. Rubin, A. E.; Sharpless, K. B. *Angew. Chem., Int. Ed. Engl.* **1997**, *36*, 2637.
6. Kolb, H. C.; Sharpless, K. B. *Transition Met. Org. Synth.* **1998**, *2*, 243. (Review).
7. Thomas, A.; Sharpless, K. B. *J. Org. Chem.* **1999**, *64*, 8279.
8. Gontcharov, A. V.; Liu, H.; Sharpless, K. B. *Org. Lett.* **1999**, *1*, 783.
9. Nicoloau, K. C.; Li, H.; Boddy, C. N. C.; Ramajulu, J. M.; Yue, T.-Y.; Natarajan, S.; Chu, X.-J.; Bräse, S.; Rübsam, F. *Chem. Eur. J.* **1999**, *5*, 2584.
10. Demko, Z. P.; Bartsch, M.; Sharpless, K. B. *Org. Lett.* **2000**, *2*, 2221.
11. Bolm, C.; Hildebrand, J. P.; Muñiz, K. In *Catalytic Asymmetric Synthesis;* 2nd edn., Ojima, I., ed.; Wiley−VCH: New York, **2000**, 399. (Review).
12. Bodkin, J. A.; McLeod, M. D. *J. Chem. Soc., Perkin 1* **2002**, 2733−2746. (Review).
13. Nilov, D.; Reiser, O. *Recent Advances on The Sharpless Asymmetric Aminohydroxylation.* In *Organic Synthesis Highlights* Schmalz, H.-G.; Wirth, T., eds., Wiley-VCH: Weinheim, Germany **2003**, 118−124. (Review).
14. Lindstroem, U. M.; Ding, R.; Hidestal, O. *Chem. Commun.* **2005**, 1773.

Sharpless asymmetric epoxidation

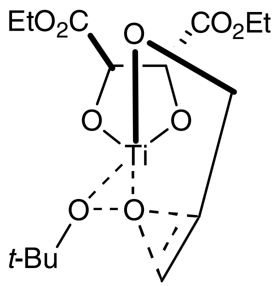
Enantioselective epoxidation of allylic alcohols using *t*-butyl peroxide, titanium tetra-*iso*-propoxide, and optically pure diethyl tartrate.



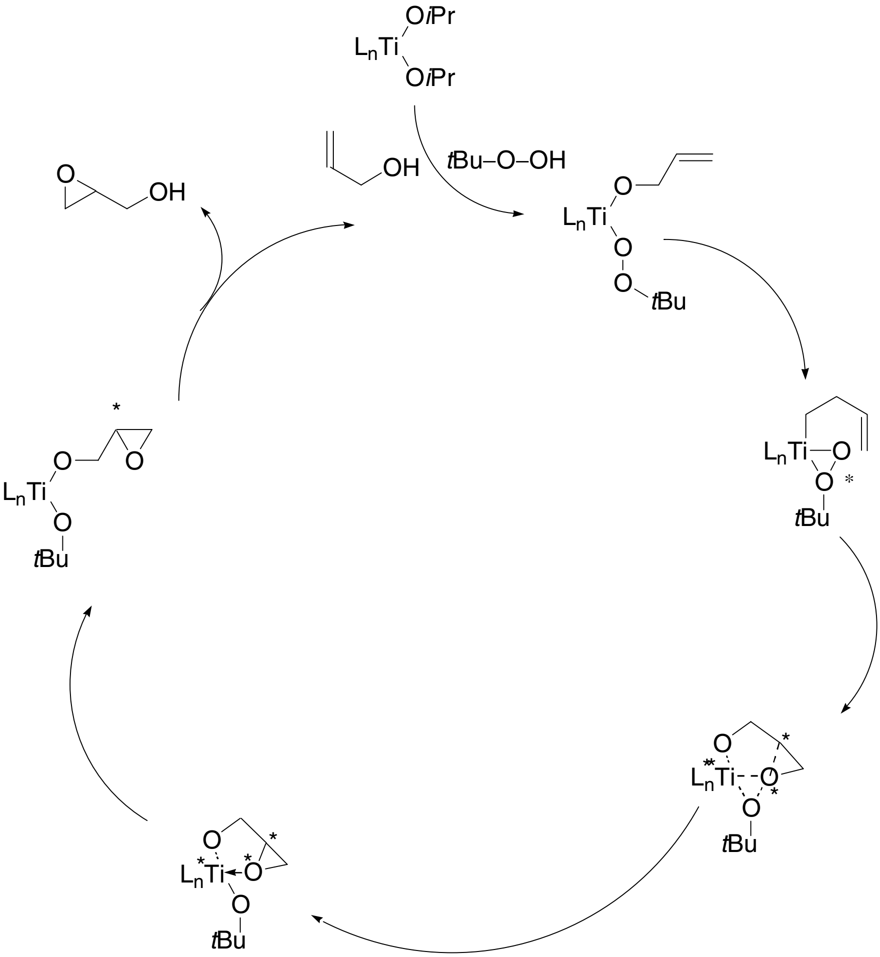
The putative active catalyst, E = CO_2Et:[2]



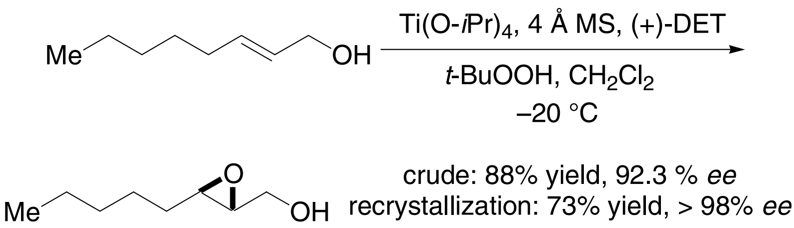
The transition state:



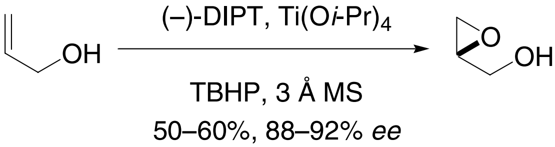
The catalytic cycle:



Example 1[5]



Example 2[5]

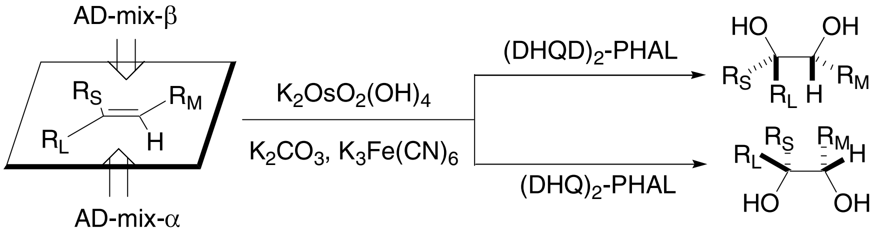


References

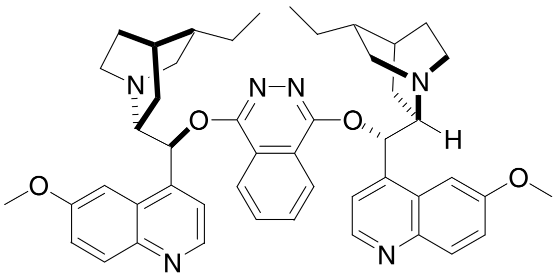
1. Katsuki, T.; Sharpless, K. B. *J. Am. Chem. Soc*. **1980**, *102*, 5974.
2. Williams, I. D.; Pedersen, S. F.; Sharpless, K. B.; Lippard, S. J. *J. Am. Chem. Soc*. **1984**, *106*, 6430.
3. Rossiter, B. E. *Chem. Ind.* **1985**, *22(Catal. Org. React.),* 295. (Review).
4. Pfenninger, A. *Synthesis* **1986**, 89. (Review).
5. Gao, Y.; Hanson, R. M.; Klunder, J. M.; Ko, S. Y.; Masamune, H.; Sharpless, K. B. *J. Am. Chem. Soc*. **1987**, *109*, 5765.
6. Corey, E. J. *J. Org. Chem*. **1990**, *55*, 1693−1694. (Review).
7. Johnson, R. A.; Sharpless, K. B. In *Comprehensive Organic Synthesis*; Trost, B. M., Ed,; Pergamon Press: New York, **1991**; Vol. 7, Chapter 3.2. (Review).
8. Woodard, S. S.; Finn, M. G.; Sharpless, K. B. *J. Am. Chem. Soc*. **1991**, *113*, 106.
9. Johnson, R. A.; Sharpless, K. B. In *Catalytic Asymmetric Synthesis*; Ojima, I., ed,; VCH: New York, **1993**; Chapter 4.1, pp 103−158. (Review).
10. Schinzer, D. *Org. Synth. Highlights II* **1995**, 3. (Review).
11. Katsuki, T.; Martin, V. S. *Org. React.* **1996**, *48*, 1−299. (Review).
12. Johnson, R. A.; Sharpless, K. B. In *Catalytic Asymmetric Synthesis;* 2nd ed., Ojima, I., ed.; Wiley-VCH: New York, **2000**, 231−285. (Review).
13. Black, P. J.; Jenkins, K.; Williams, J. M. J. *Tetrahedron: Asymmetry* **2002**, *13*, 317.
14. Ghosh, A. K.; Lei, H. *Tetrahedron: Asymmetry* **2003**, *14*, 629.
15. Palucki, M. *Sharpless−Katsuki Epoxidation* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 50–62. (Review).

Sharpless asymmetric dihydroxylation

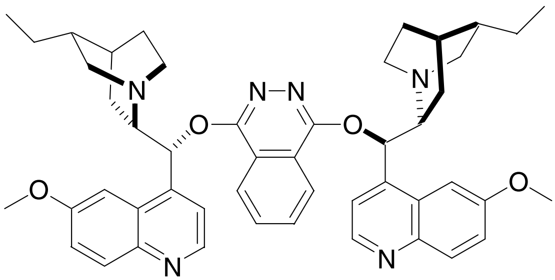
Enantioselective *cis*-dihydroxylation of olefins using osmium catalyst in the presence of cinchona alkaloid ligands.



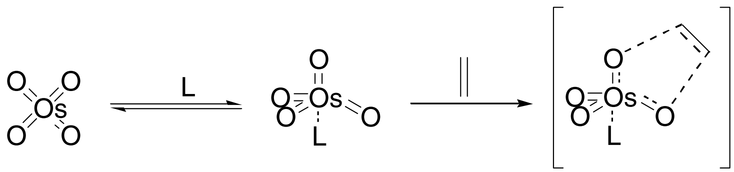
$(DHQD)_2$-PHAL = 1,4-bis(9-*O*-dihydroquinidine)phthalazine:

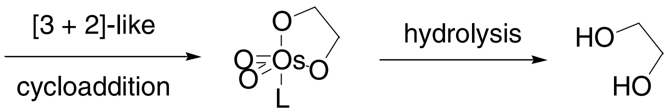


$(DHQ)_2$-PHAL = 1,4-bis(9-*O*-dihydroquinine)phthalazine:



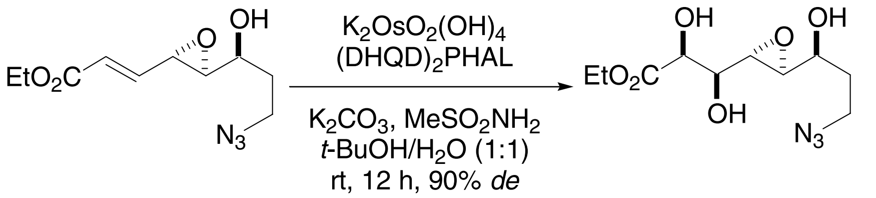
The concerted [3 + 2] cycloaddition mechanism:



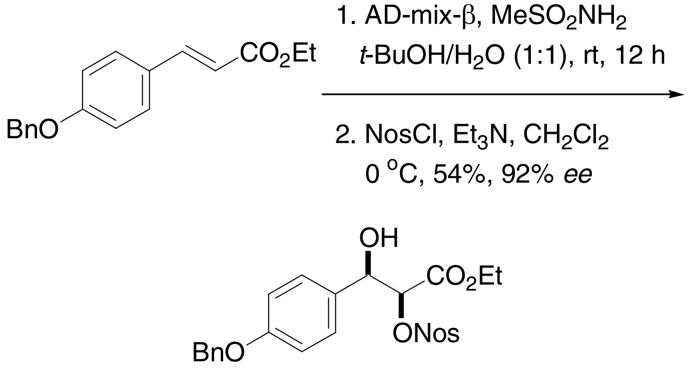


The catalytic cycle is shown on page 539 (the secondary cycle is shut off by maintaining a low concentration of olefin):

Example 1[3]



Example 2[9]

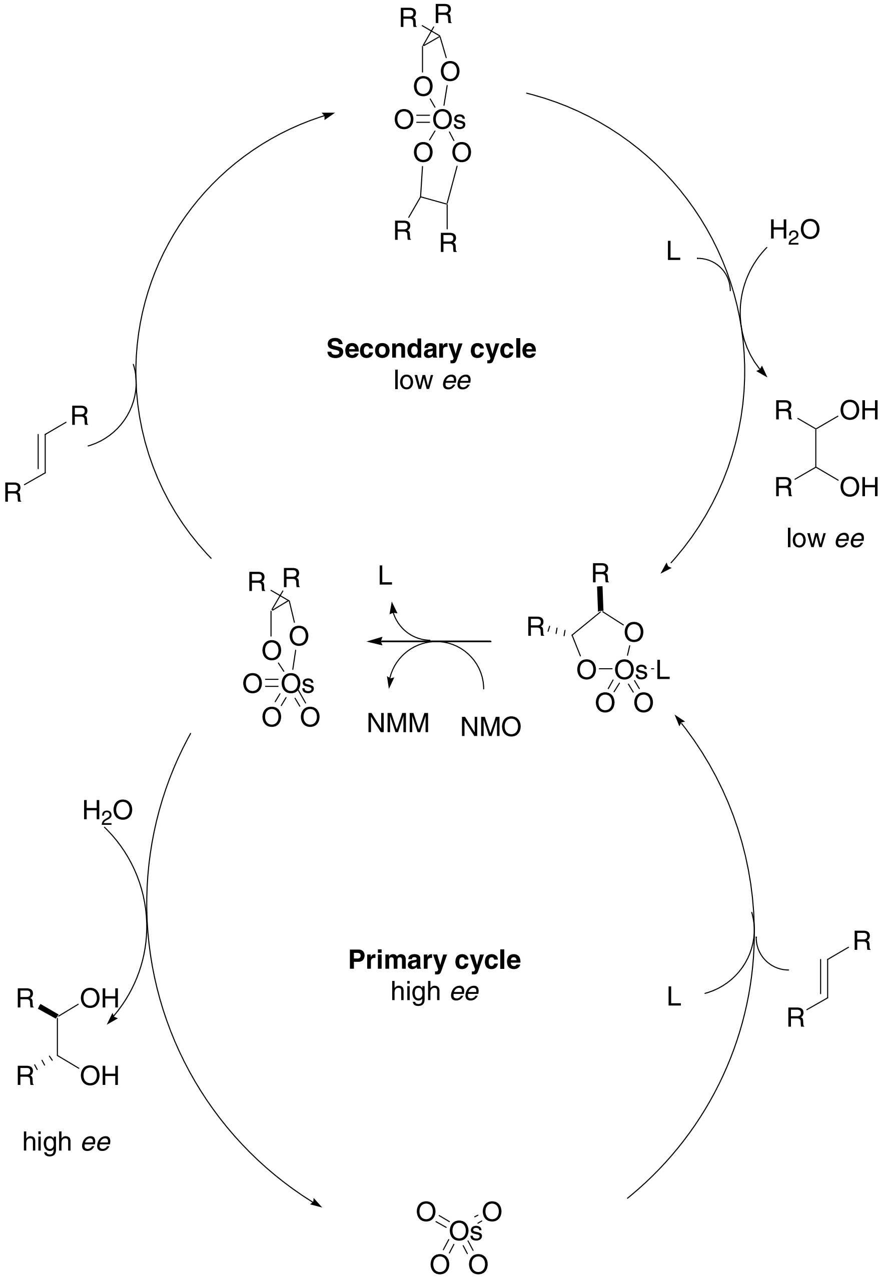


Nos = nosylate = 4-nitrobenzenesulfonyl

References

1. Jacobsen, E. N.; Markó, I.; Mungall, W. S.; Schröder, G.; Sharpless, K. B. *J. Am. Chem. Soc.* **1988**, *110*, 1968.
2. Wai, J. S. M.; Markó, I.; Svenden, J. S.; Finn, M. G.; Jacobsen, E. N.; Sharpless, K. B. *J. Am. Chem. Soc.* **1989**, *111*, 1123.
3. Kim, N.-S.; Choi, J.-R.; Cha, J. K. *J. Org. Chem.* **1993**, *58,* 7096.
4. Kolb, H. C.; VanNiewenhze, M. S.; Sharpless, K. B. *Chem. Rev.* **1994**, *94*, 2483–2547. (Review).
5. Corey, E. J.; Noe, M. C. *J. Am. Chem. Soc.* **1996**, *118*, 319. (Mechanism).
6. DelMonte, A. J.; Haller, J.; Houk, K. N.; Sharpless, K. B.; Singleton, D. A.; Strassner, T.; Thomas, A. A. *J. Am. Chem. Soc.* **1997**, *119*, 9907. (Mechanism).

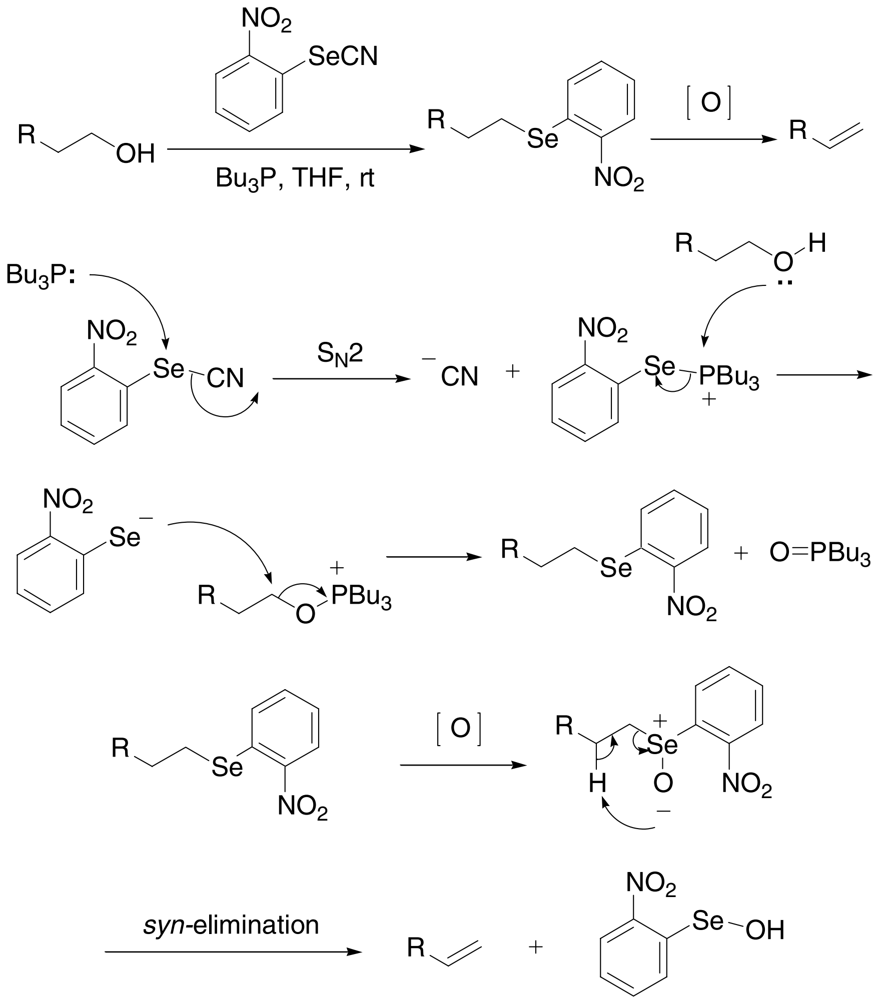
7. Rouhi, A. M. *A Reaction under Scrutiny,* in *Chem. Eng. News* **1997**, *November 3*, 23. (Review, Mechanism).
8. Bolm, C.; Gerlach, A. *Eur. J. Org. Chem.* **1998**, 21.
9. Nicoloau, K. C.; Li, H.; Boddy, C. N. C.; Ramajulu, J. M.; Yue, T.-Y.; Natarajan, S.; Chu, X.-J.; Bräse, S.; Rübsam, F. *Chem. Eur. J.* **1999**, *5*, 2584.
10. Balachari, D.; O'Doherty, G. A. *Org. Lett*. **2000**, *2*, 863.
11. Liang, J.; Moher, E. D.; Moore, R. E.; Hoard, D. W. *J. Org. Chem.* **2000**, *65*, 3143.
12. Mehltretter, G. M.; Dobler, C.; Sundermeier, U.; Beller, M. *Tetrahedron Lett*. **2000**, *41*, 8083.
13. Sharpless, K. B. *Angew. Chem., Int. Ed.* **2002**, *41*, 2024. (Review, Nobel Prize Address).
14. Moitessier, N.; Henry, C.; Len, C.; Postel, D.; Chapleur, Y. *J. Carbohydrate Chem.* **2003**, *22*, 25.
15. Choudary, B. M.; Chowdari, N. S.; Madhi, S.; Kantam, M. L. *J. Org. Chem.* **2003**, *68*, 1736.
16. Junttila, M. H.; Hormi, O. E. O. *J. Org. Chem.* **2004**, *69*, 4816.
17. McNamara, C. A.; King, F.; Bradley, M. *Tetrahedron Lett*. **2004**, *45*, 8527.
18. Zhang, Y.; O'Doherty, G. A. *Tetrahedron* **2005**, *61*, 6337.
19. Hoevelmann, C. H.; Muniz, K. *Chem. Eur. J.* **2005**, *11*, 3951.



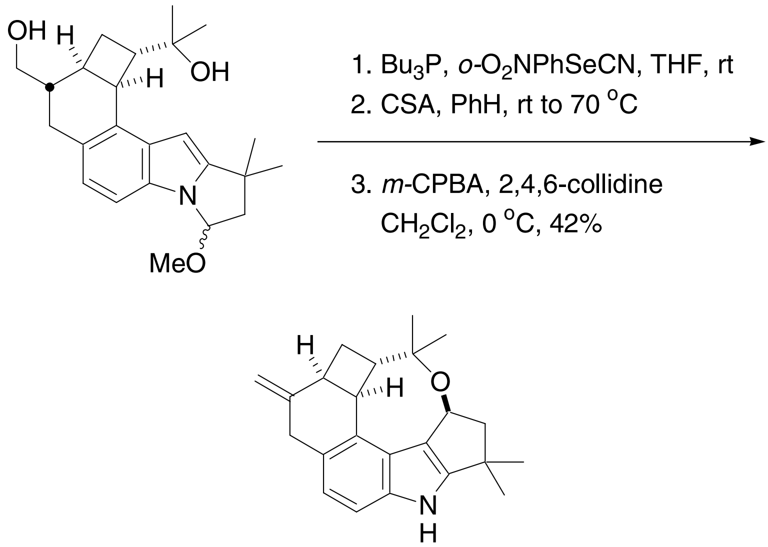
The catalytic cycle of the Sharpless dihydroxylation

Sharpless olefin synthesis

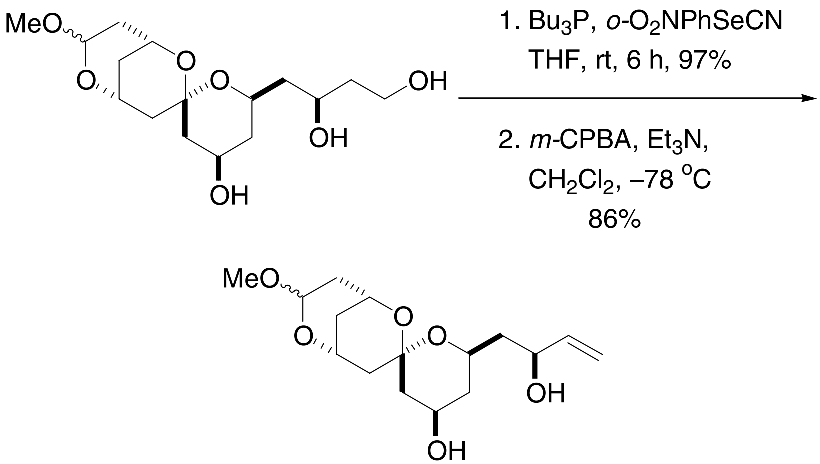
Olefin synthesis from the *syn*-oxidative elimination of *o*-nitrophenyl selenides, which may be prepared using *o*-nitrophenyl selenocyanate and Bu_3P, among other methods.



Example 1[9]



Example 2[13]



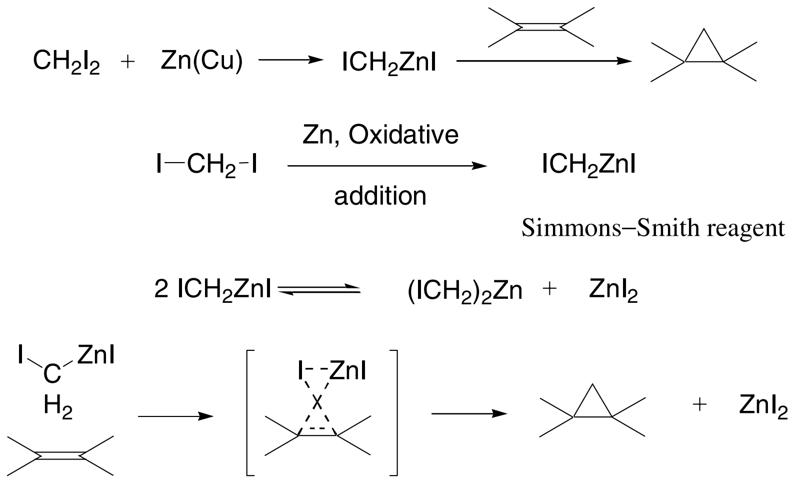
References

1. Sharpless, K. B.; Young, M. Y.; Lauer, R. F. *Tetrahedron Lett.* **1973**, 1979.
2. Grieco, P. A.; Miyashita, M. *J. Org. Chem.* **1974**, *39*, 120.
3. Grieco, P. A.; Miyashita, M. *Tetrahedron Lett.* **1974**, 1869.
4. Sharpless, K. B.; Young, M. Y. *J. Org. Chem.* **1975**, *40*, 947.
5. Grieco, P. A.; Masaki, Y.; Boxler, D. *J. Am. Chem. Soc.* **1977**, *97*, 1597.
6. Grieco, P. A.; Gilman, S.; Nishizawa, M. *J. Org. Chem.* **1976**, *41*, 1485.

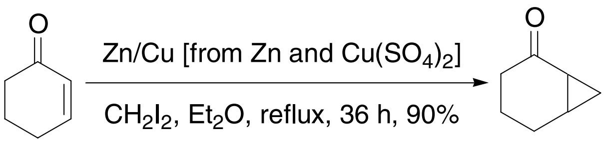
7. Grieco, P. A.; Yokoyama, Y. *J. Am. Chem. Soc.* **1977**, *99*, 5210.
8. Meade, E. A.; Krawczyk, S. H.; Townsend, L. B. *Tetrahedron Lett.* **1988**, *29,* 4073.
9. Smith, A. B., III; Haseltine, J. N.; Visnick, M. *Tetrahedron* **1989**, *45,* 2431.
10. Reich, H. J.; Wollowitz, S. *Org. React.* **1993**, *44,* 1–296. (Review).
11. Krief, A.; Laval, A.-M. *Bull. Soc. Chim. Fr.* **1997**, *134,* 869–874. (Review).
12. Hsu, D.-S.; Liao, C.-C. *Org. Lett.* **2003**, *5,* 4741.
13. Meilert, K.; Pettit, G. R.; Vogel, P. *Helv. Chim. Acta* **2004**, *87,* 1493.
14. Siebum, A. H. G.; Woo, W. S.; Raap, J.; Lugtenburg, J. *Eur. J. Org. Chem.* **2004**, 2905.
15. Blay, G.; Cardona, L.; Collado, A. M.; Garcia, B.; Morcillo, V.; Pedro, J. R. *J. Org. Chem.* **2004**, *69,* 7294. The authors observed the concurrent epoxidation of a trisubsituted olefin, possibly by the *o*-nitrophenylselenic acid *via* an intramolecular process.

Simmons–Smith reaction

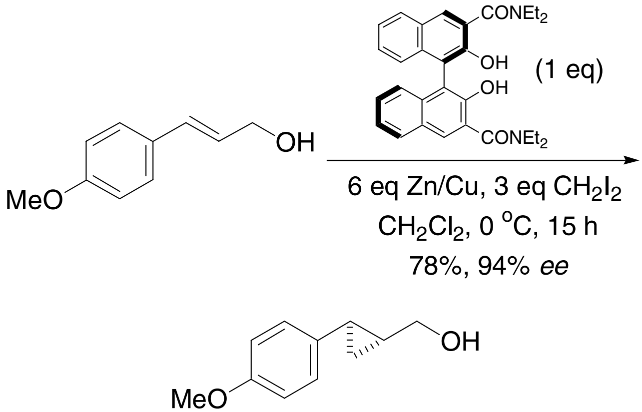
Cyclopropanation of olefins using CH_2I_2 and Zn(Cu).



Example 1[2]



Example 2, asymmetric version[13]

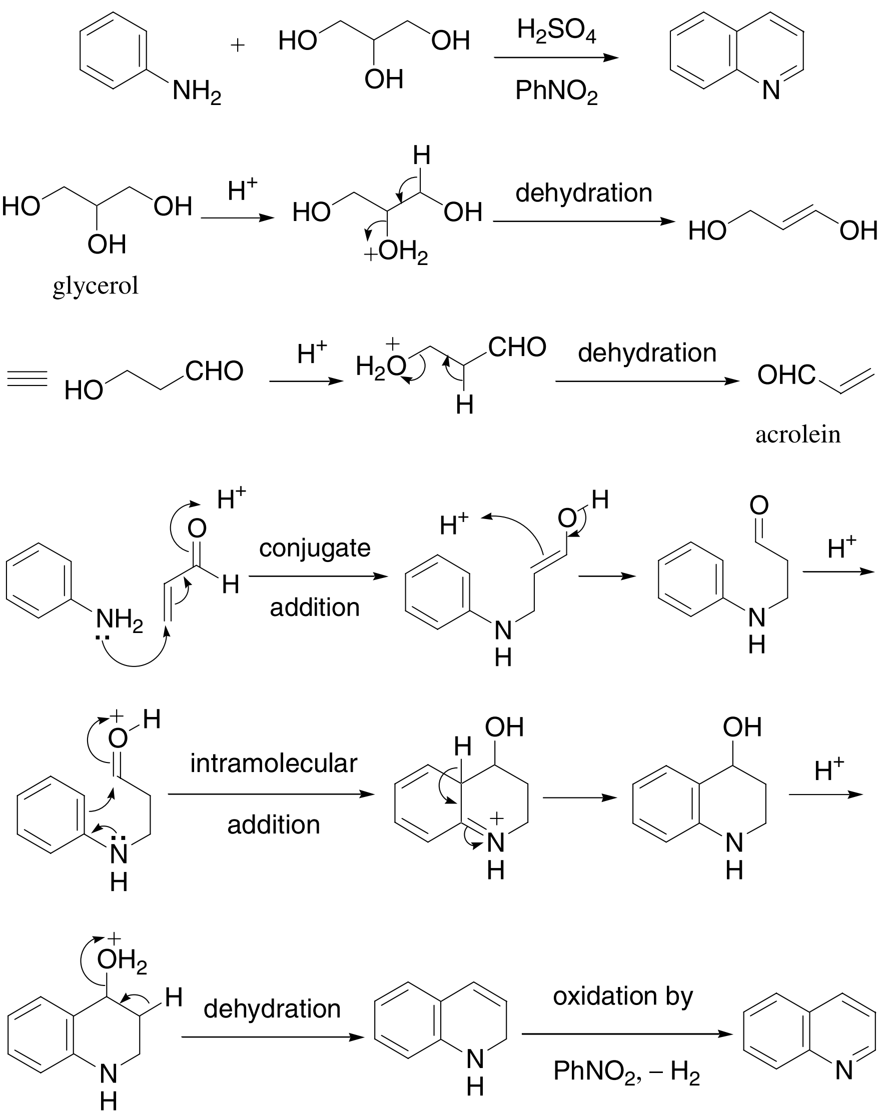


References

1. Simmons, H. E.; Smith, R. D. *J. Am. Chem. Soc.* **1958**, *80*, 5323. Howard E. Simmons (1929−1997) was born in Norfolk, Virginia. He carried out his graduate studies at MIT under John D. Roberts and Arthur Cope. After obtaining his Ph.D. in 1954, he joined the Chemical Department of the Dupont Company, where he discovered the Simmons–Smith reaction with his colleague, R. D. Smith. Simmons rose to be the vice president of the Central Research at Dupont in 1979. His views on physical exercise were the same as those of Alexander Woollcot's: "If I think about exercise, I know if I wait long enough, the thought will go away."
2. Limasset, J.-C.; Amice, P.; Conia, J.-M. *Bull. Soc. Chim. Fr.* **1969**, 3981.
3. Kaltenberg, O. P. *Wiad. Chem*. **1972**, *26*, 285.
4. Takai, K.; Kakiuchi, T.; Utimoto, K. *J. Org. Chem*. **1994**, *59*, 2671.
5. Takahashi, H.; Yoshioka, M.; Shibasaki, M.; Ohno, M.; Imai, N.; Kobayashi, S. *Tetrahedron* **1995**, *51*, 12013.
6. Nakamura, E.; Hirai, A.; Nakamura, M. *J. Am. Chem. Soc*. **1998**, *120*, 5844.
7. Kaye, P. T.; Molema, W. E. *Chem. Commun*. **1998**, 2479.
8. Kaye, P. T.; Molema, W. E. *Synth. Commun*. **1999**, *29*, 1889.
9. Loeppky, R. N.; Elomart, S. *J. Org. Chem*. **2000**, *65*, 96.
10. Baba, Y.; Saha, G.; Nakao, S.; Iwata, C.; Tanaka, T.; Ibuka, T.; Ohishi, H.; Takemoto, Y. *J. Org. Chem*. **2001**, *66*, 81.
11. Charette, A. B.; Beauchemin, A. *Org. React.* **2001**, *58*, 1−415. (Review).
12. Nakamura, M.; Hirai, A.; Nakamura, E. *J. Am. Chem. Soc*. **2003**, *125*, 2341.
13. Mahata, P. K.; Syam Kumar, U. K.; Sriram, V.; Ila, H.; Junjappa, H. *Tetrahedron* **2003**, *59*, 2631.
14. Long, J.; Yuan, Y.; Shi, Y. *J. Am. Chem. Soc*. **2003**, *125*, 13632.
15. Long, J.; Du, H.; Li, K.; Shi, Y. *Tetrahedron Lett.* **2005**, *46*, 2737.

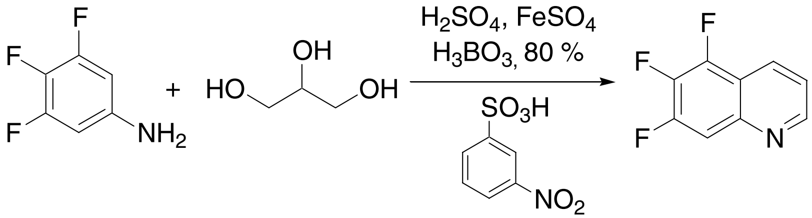
Skraup quinoline synthesis

Quinoline from aniline, glycerol, sulfuric acid and oxidizing agent (e.g. $PhNO_2$).

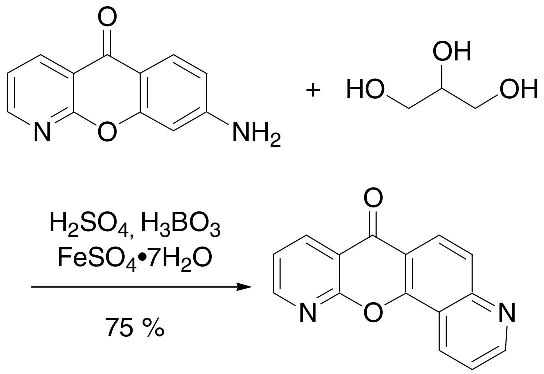


For an alternative mechanism, see that of the Doebner–von Miller reaction (page 547).

Example 1[9]



Example 2[10]

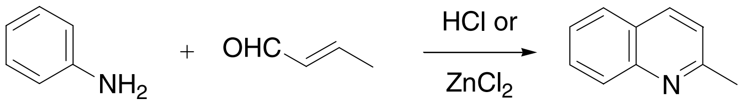


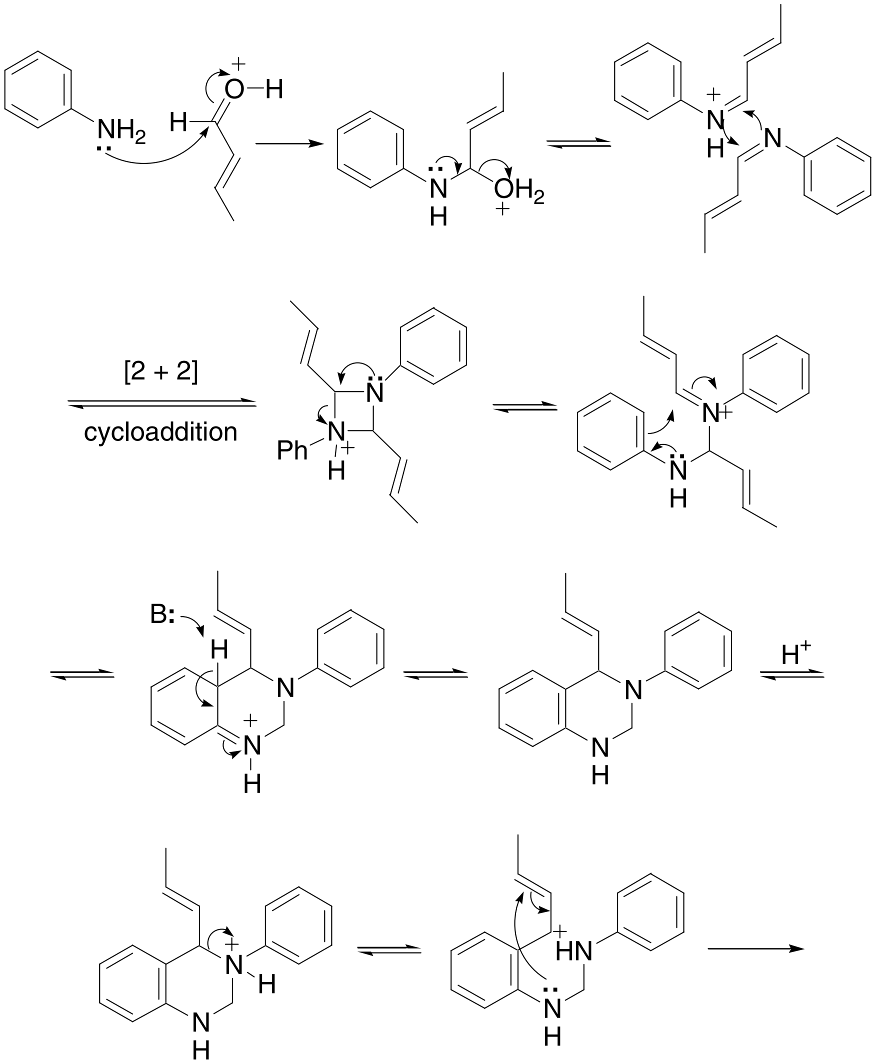
References

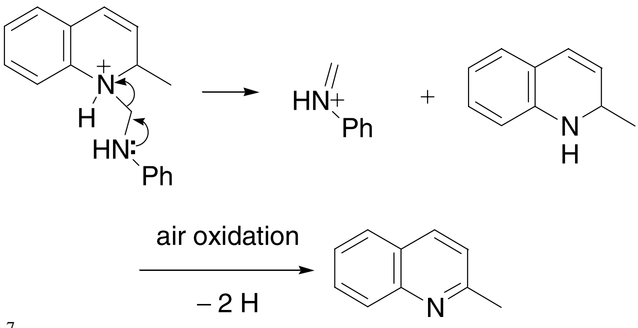
1. Skraup, Z. H. *Monatsh. Chem.* **1880**, *1*, 316. Zdenko Hans Skraup (1850–1910) was born in Prague, Czechoslovakia. He apprenticed under Lieben at the University of Vienna.
2. Skraup, Z. H. *Ber. Dtsch. Chem. Ges.* **1880**, *13*, 2086.
3. Manske, R. H. F.; Kulka, M. *Org. React*. **1953**, *7*, 80. (Review).
4. Bergstrom, F. W. *Chem. Rev.* **1944**, *35,* 152–153. (Review).
5. Eisch, J. J.; Dluzniewski, T. *J. Org. Chem.* **1989**, *54,* 1269.
6. Takeuchi, I.; Hamada, Y.; Hirota, M. *Chem. Pharm. Bull.* **1993**, *41*, 747.
7. Fujiwara, H.; Okabayashi, I. *Chem. Pharm. Bull*. **1994**, *42*, 1322.
8. Fujiwara, H. *Heterocycles* **1997**, *45*, 119.
9. Oleynik, I. I.; Shteingarts, V. D. *J. Fluorine Chem.* **1998**, *91*, 25.
10. Fujiwara, H.; Kitagawa, K. *Heterocycles* **2000**, *53*, 409.
11. Theoclitou, M.-E.; Robinson, L. A. *Tetrahedron Lett*. **2002**, *43,* 3907.
12. Ranu, B. C.; Hajra, A.; Dey, S. S.; Jana, U.; *Tetrahedron* **2003**, *59*, 813.
13. Moore, A. *Skraup Doebner–von Miller Reaction* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 488–494. (Review).

Doebner–von Miller reaction

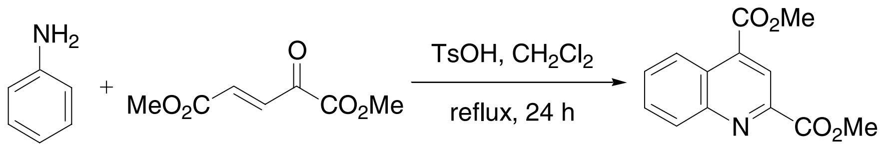
Doebner–von Miller reaction is a variant of the Skraup quinoline synthesis (page 545). Therefore, the mechanism for the Skraup reaction is also operative for the Doebner–von Miller reaction. An alternative mechanism shown below is based on the fact that the preformed imine (Schiff base) also gives 2-methylquinoline:



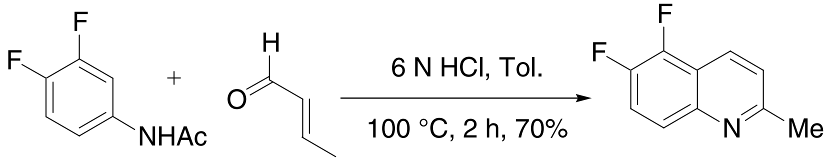




Example 1[7]



Example 2[8]

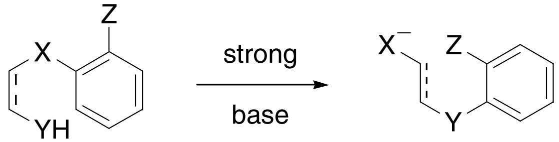


References

1. Doebner, O.; von Miller, W. *Ber. Dtsch. Chem. Ges.* **1883**, *16*, 2464.
2. Schindler, O.; Michaelis, W. *Helv. Chim. Acta* **1970**, *53*, 776.
3. Corey, E. J.; Tramontano, A. *J. Am. Chem. Soc*. **1981**, *103*, 5599.
4. Eisch, J. J.; Dluzniewski, T. *J. Org. Chem.* **1989**, *54*, 1269.
5. Zhang, Z. P.; Tillekeratne, L. M. V.; Hudson, R. A. *Synthesis* **1996**, 377.
6. Zhang, Z. P.; Tillekeratne, L. M. V.; Hudson, R. A. *Tetrahedron Lett.* **1998**, *39*, 5133.
7. Carrigan, C. N.; Esslinger, C. S.; Bartlett, R. D.; Bridges, R. J. *Bioorg. Med. Chem. Lett.* **1999**, *9*, 2607.
8. Sprecher, A.-v.; Gerspacher, M.; Beck, A.; Kimmel, S.; Wiestner, H.; Anderson, G. P.; Niederhauser, U.; Subramanian, N.; Bray, M. A. *Bioorg. Med. Chem. Lett.* **1998**, *8*, 965.
9. Matsugi, M.; Tabusa, F.; Minamikawa, J.-i. *Tetrahedron Lett.* **2000**, *41*, 8523.
10. Fürstner, A.; Thiel, O. R.; Blanda, G. *Org. Lett.* **2000**, *2*, 3731.
11. Kavitha, J.; Vanisree, M.; Subbaraju, G. V. *Indian J. Chem., Sect. B* **2001**, *40B*, 522.
12. Li, X.-G.; Cheng, X.; Zhou, Q.-L. *Synth. Commun*. **2002**, *32*, 2477.
13. Moore, A. *Skraup Doebner–von Miller Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 488–494. (Review).

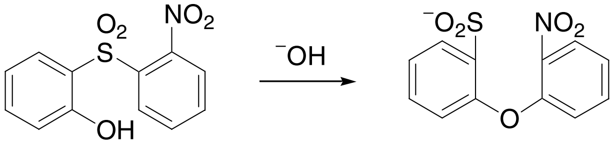
Smiles rearrangement

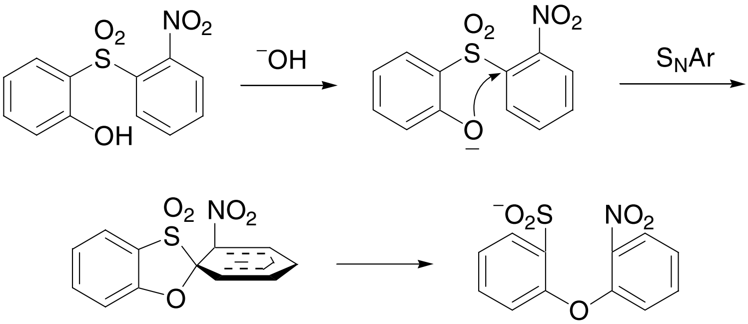
Intramolecular nucleophilic aromatic rearrangement. General scheme:



X = S, SO, SO_2, O, CO_2
YH = OH, NHR, SH, CH_2R, CONHR
Z = NO_2, SO_2R

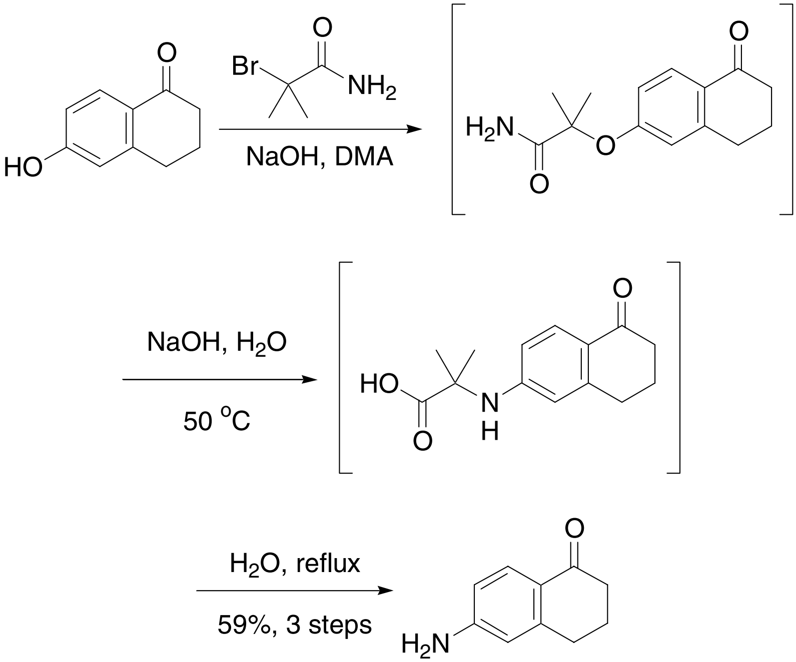
e.g.:





spirocyclic anion intermediate
(Meisenheimer complex)

Example[8]

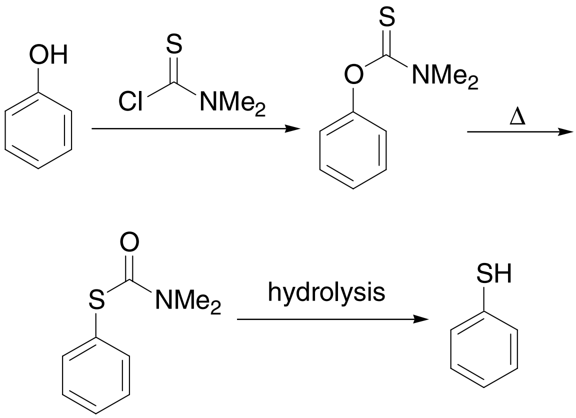


References

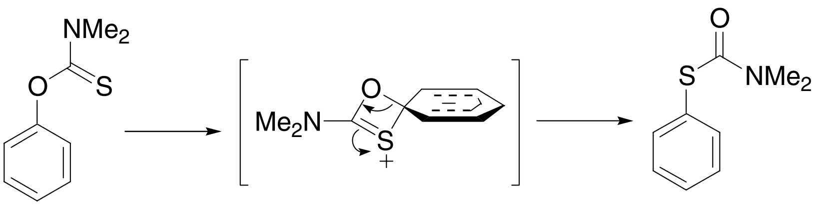
1. Evans, W. J.; Smiles, S. *J. Chem. Soc.* **1935**, 181. Samuel Smiles began his career at King's College London as an assistant professor. He later became professor and chair there. He was elected Fellow of the Royal Society (FRS) in 1918.
2. Truce, W. E.; Kreider, E. M.; Brand, W. W. *Org. React.* **1970**, *18*, 99–215. (Review).
3. Gerasimova, T. N.; Kolchina, E. F. *J. Fluorine Chem.* **1994**, *66*, 69–74. (Review).
4. Boschi, D.; Sorba, G.; Bertinaria, M.; Fruttero, R.; Calvino, R.; Gasco, A. *J. Chem. Soc., Perkin Trans. 1* **2001**, 1751.
5. Hirota, T.; Tomita, K.-I.; Sasaki, K.; Okuda, K.; Yoshida, M.; Kashino, S. *Heterocycles* **2001**, *55*, 741.
6. Selvakumar, N.; Srinivas, D.; Azhagan, A. M. *Synthesis* **2002**, 2421.
7. Kumar, G.; Gupta, V.; Gautam, D. C.; Gupta, R. R. *Heterocyclic Commun.* **2002**, *8*, 447.
8. Mizuno, M.; Yamano, M. *Org. Lett.* **2005**, *7*, 3629.
9. Bacque, E.; El Qacemi, M.; Zard, S. Z. *Org. Lett.* **2005**, *7*, 3817.

Newman–Kwart reaction

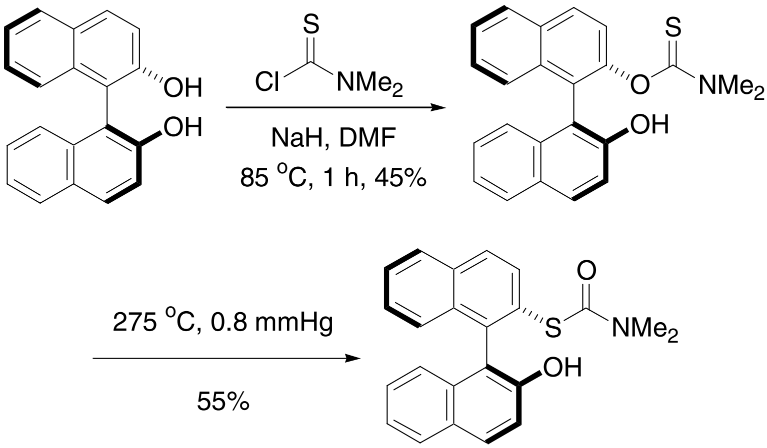
Transformation of phenol to the corresponding thiophenol, a variant of the Smile reaction (page 549).



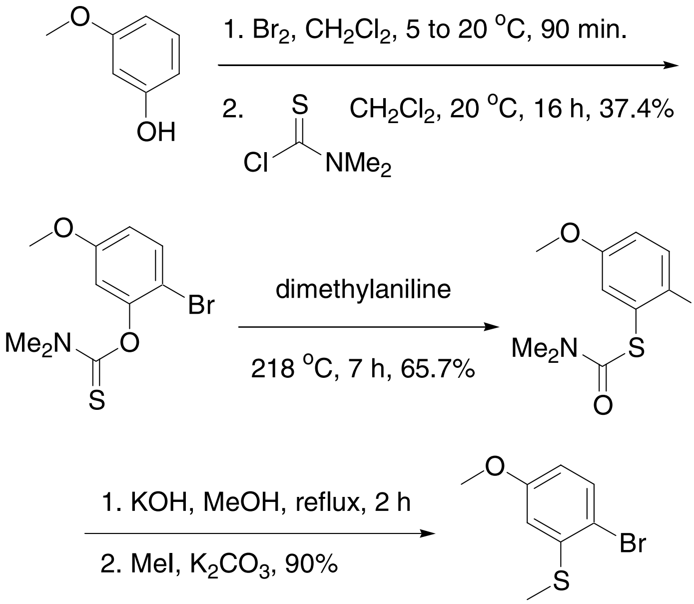
Mechanism:



Example 1[8]



Example 2[9]

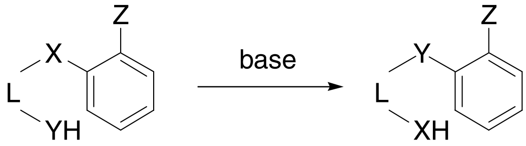


References

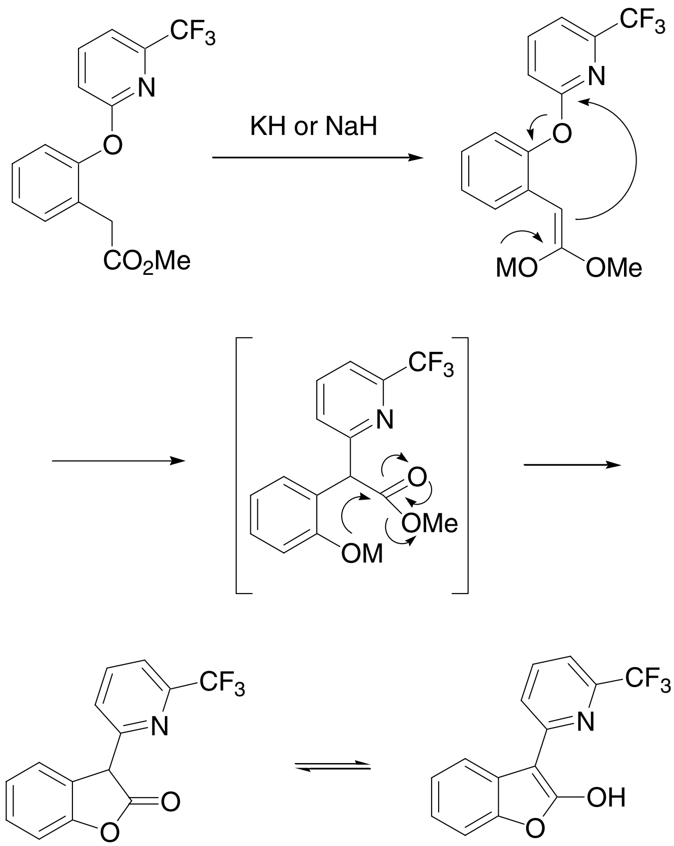
1. Kwart, H.; Evans, E. R. *J. Org. Chem.* **1966**, *31*, 410.
2. Newman, M. S.; Karnes, H. A. *J. Org. Chem.* **1966**, *31*, 3980.
3. Newman, M. S.; Hetzel, F. W. *J. Org. Chem.* **1969**, *34*, 3604.
4. Cossu, S.; De Lucchi, O.; Fabbri, D.; Valle, G.; Painter, G. F.; Smith, R. A. J. *Tetrahedron* **1997**, *53*, 6073.
5. Lin, S.; *et al. Org. Prep. Proc. Int.* **2000**, *32*, 547.
6. Ponaras, A. A.; Zairn, Ö. in *Encyclopedia of Reagents for Organic Synthesis,* Paquette, L. A. (ed.), Wiley & Sons: New York, **1995**, 2174. (Review).
7. Kane, V. V.; Gerdes, A.; Grahn, W.; Ernst, L.; Dix, I.; Jones, P. G.; Hopf, H. *Tetrahedron Lett.* **2001**, *42*, 373.
8. Albrow, V.; Biswas, K.; Crane, A.; Chaplin, N.; Easun, T.; Gladiali, S.; Lygo, B.; Woodward, S. *Tetrahedron: Asymmetry* **2003**, *14*, 2813.
9. Bowden, S. A.; Burke, J. N.; Gray, F.; McKown, S.; Moseley, J. D.; Moss, W. O.; Murray, P. M.; Welham, M. J.; Young, M. J. *Org. Proc. Res. Dev.* **2004**, *8*, 33.
10. Kusch, D. *Speciality Chemicals Magazine* **2004**, *23*, 41. (Review).

Truce–Smile rearrangement

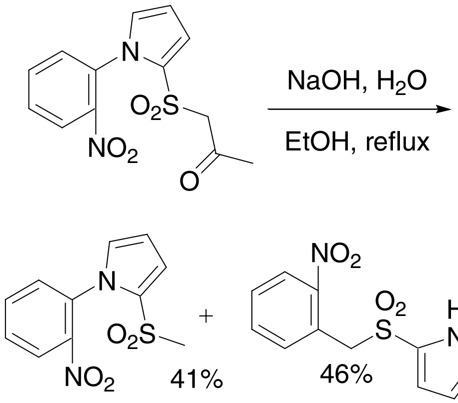
Smiles rearrangement where Y is carbon:



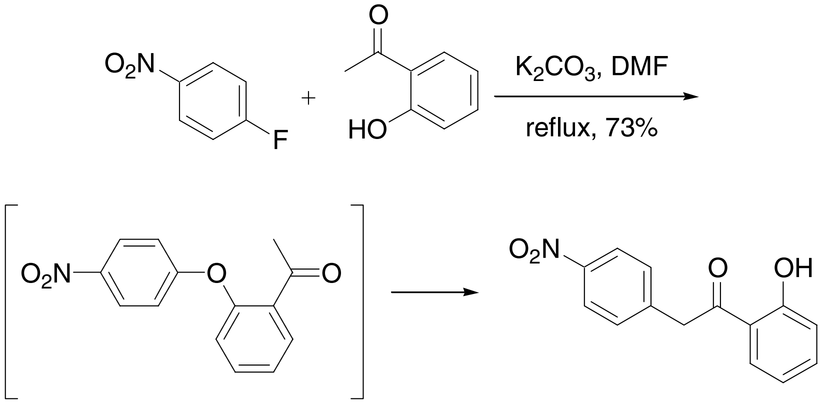
Example 1[6]



Example 2[8]



Example 3[9]

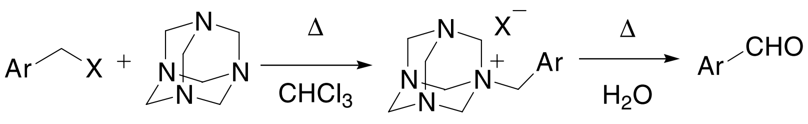


References

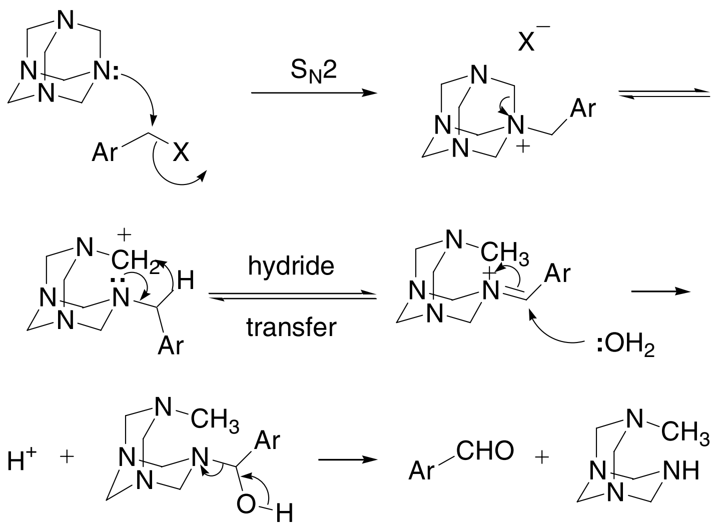
1. Truce, W. E.; Ray, W. J. Jr.; Norman, O. L.; Eickemeyer, D. B. *J. Am. Chem. Soc.* **1958**, *80*, 3625.
2. Truce, W. E.; Hampton, D. C. *J. Org. Chem.* **1963**, *28*, 2276.
3. Bayne, D. W; Nicol, A. J.; Tennant, G. *J. Chem. Soc., Chem. Comm.* **1975**, *19*, 782.
4. Fukazawa, Y.; Kato, N.; Ito, S.; *Tetrahedron Lett.***1982**, *23*, 437.
5. Hoffman, R. V.; Jankowski, B. C.; Carr, C. S. *J. Org. Chem.* **1986**, *51*, 130.
6. Erickson, W. R.; McKennon, M. J.; *Tetrahedron Lett.* **2000**, *41*, 4541.
7. Hirota, T.; Tomita, K.; Sasaki, K.; Okuda, K.; Yoshida, M.; Kashino, S.; *Heterocycles* **2001**, *55*, 741.
8. Kimbaris, A.; Cobb, J.; Tsakonas, G.; Varvounis, G. *Tetrahedron* **2004**, *60*, 8807.
9. Mitchell, L. H.; Barvian, N. C. *Tetrahedron Lett.* **2004**, *45*, 5669.

Sommelet reaction

Transformation of benzyl halides to the corresponding benzaldehydes with the aide of hexamethylenetetramine.

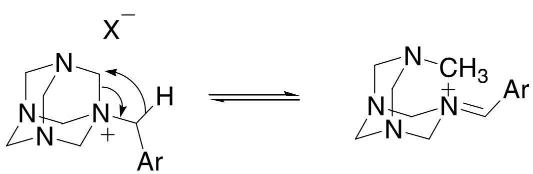


hexamethylenetetramine

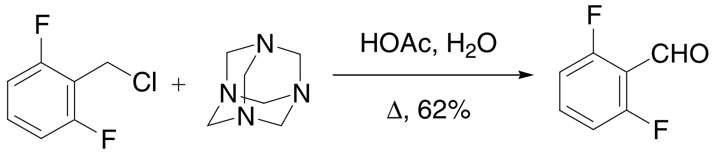


hemiaminal

The hydride transfer and the ring-opening of hexamethylenetetramine may occur in a synchronized fashion:



Example[9]

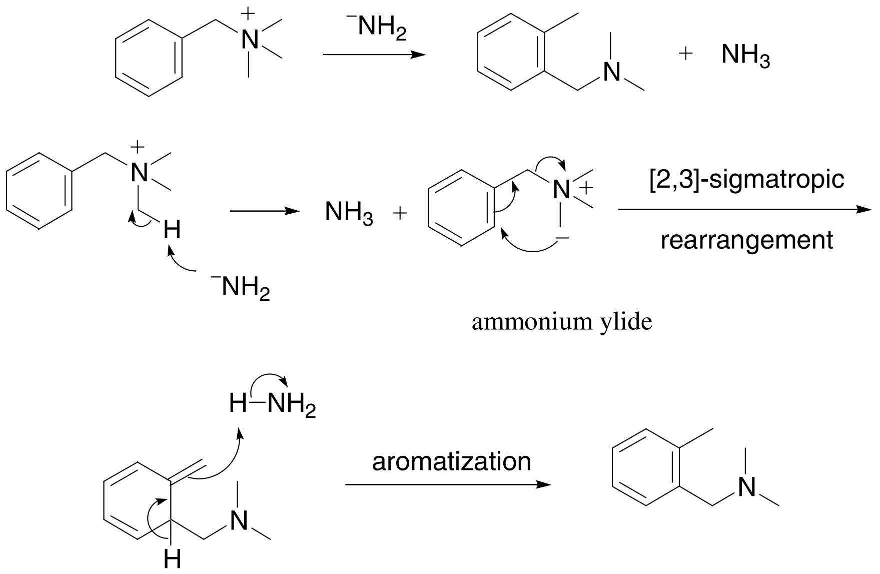


References

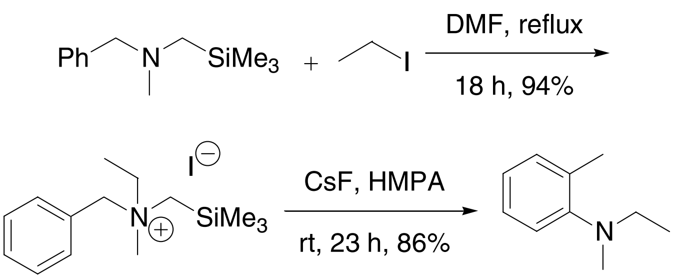
1. Sommelet, M. *Compt. Rend.* **1913**, *157*, 852. Marcel Sommelet (1877−1952) was born in Langes, France. He received his Ph.D. in 1906 at Paris where he joined the Faculté de Pharmacie after WWI and became the chair of organic chemistry in 1934.
2. Le Henaff, P. *Annals Chim. Phys.* **1962**, 367.
3. Zaluski, M. C.; Robba, M.; Bonhomme, M. *Bull. Soc. Chim. Fr*. **1970**, 1445.
4. Smith, W. E. *J. Org. Chem*. **1972**, *37*, 3972.
5. Simiti, I.; Chindris, E. *Arch. Pharm*. **1975**, *308*, 688.
6. Stokker, G. E.; Schultz, E. M. *Synth. Commun*. **1982**, *12*, 847.
7. Armesto, D.; Horspool, W. M.; Martin, J. A. F.; Perez-Ossorio, R. *Tetrahedron Lett.* **1985**, *26*, 5217.
8. Simiti, I.; Oniga, O. *Monatsh. Chem*. **1996**, *127*, 733.
9. Malykhin, E. V.; Steingarts, V. D. *J. Fluorine Chem*. **1998**, *91*, 19.
10. Liu, X.; He, W. *Huaxue Shiji* **2001**, *23*, 237.

Sommelet–Hauser rearrangement

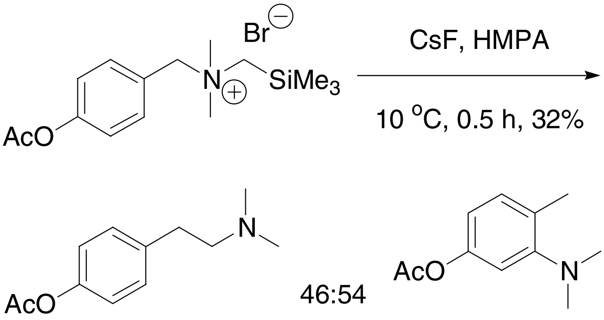
[2,3]-Wittig rearrangement of benzylic quaternary ammonium salts upon treatment with alkali metal amides *via* the ammonium ylide intermediates.



Example 1[5]



Example 2[6]

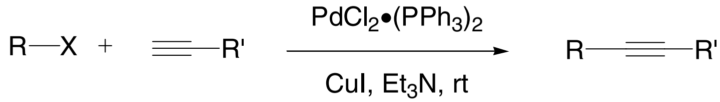


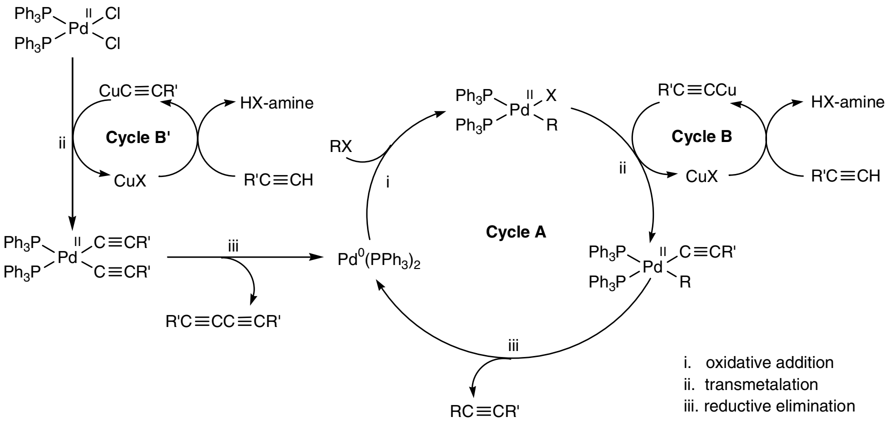
References

1. Sommelet, M. *Compt. Rend.* **1937**, *205*, 56.
2. Pine, S. H. *Tetrahedron Lett*. **1967**, 3393.
3. Wittig, G. *Bull. Soc. Chim. Fr.* **1971**, 1921.
4. Robert, A.; Lucas-Thomas, M. T. *J. Chem. Soc., Chem. Commun*. **1980**, 629.
5. Shirai, N.; Sato, Y. *J. Org. Chem. Soc.* **1988**, *53,* 194.
6. Shirai, N.; Watanabe, Y.; Sato, Y. *J. Org. Chem*. **1990**, *55*, 2767.
7. Tanaka, T.; Shirai, N.; Sugimori, J.; Sato, Y. *J. Org. Chem*. **1992**, *57*, 5034.
8. Klunder, J. M. *J. Heterocycl. Chem*. **1995**, *32*, 1687.
9. Maeda, Y.; Sato, Y. *J. Org. Chem*. **1996**, *61*, 5188.
10. Endo, Y.; Uchida, T.; Shudo, K. *Tetrahedron Lett*. **1997**, *38*, 2113.

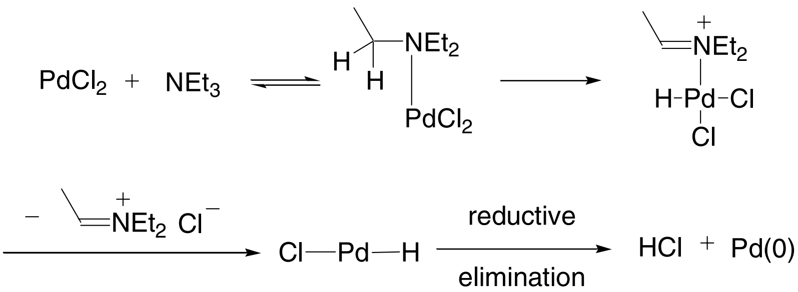
Sonogashira reaction

Pd/Cu-catalyzed cross-coupling of organohalides with terminal alkynes. *Cf.* Cadiot–Chodkiewicz coupling and Castro–Stephens reaction. The Castro–Stephens coupling uses stoichiometric copper, whereas the Sonogashira variant uses catalytic palladium and copper.

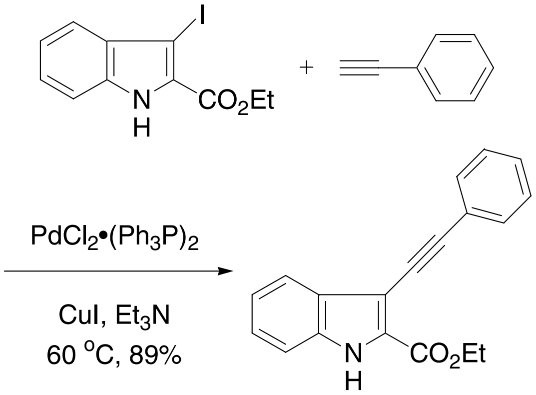




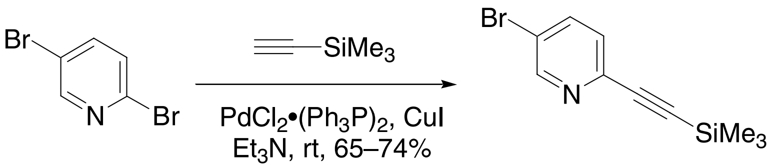
Note that Et_3N may reduce Pd(II) to Pd(0) as well, where Et_3N is oxidized to iminium ion at the same time:



Example 1[3]



Example 2[5]

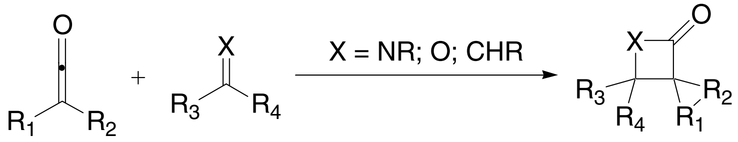


References

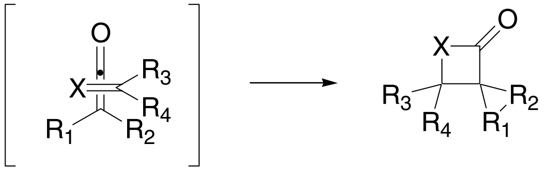
1. Sonogashira K.; Tohda, Y.; Hagihara, N. *Tetrahedron Lett.* **1975**, 4467. Richard Heck discovered the same transformation using palladium but without the use of copper: *J. Organomet. Chem.* **1975**, *93*, 259.
2. McCrindle, R.; Ferguson, G.; Arsenaut, G. J.; McAlees, A. J.; Stephenson, D. K. *J. Chem. Res. (S)* **1984**, 360.
3. Sakamoto, T.; Nagano, T.; Kondo, Y.; Yamanaka, H. *Chem. Pharm. Bull.* **1988**, *36*, 2248.
4. Rossi, R. Carpita, A.; Belina, F. *Org. Prep. Proc. Int.* **1995**, *27*, 129.
5. Ernst, A.; Gobbi, L.; Vasella, A. *Tetrahedron Lett.* **1996**, *37*, 7959.
6. Campbell, I. B. In *Organocopper Reagents*; Taylor, R. J. K. Ed.; IRL Press: Oxford, UK, **1994**, 217. (Review).
7. Hundermark, T.; Littke, A.; Buchwald, S. L.; Fu, G. C. *Org. Lett.* **2000**, *2*, 1729.
8. Dai, W.-M.; Wu, A. *Tetrahedron Lett.* **2001**, *42*, 81.
9. Alami, M.; Crousse, B.; Ferri, F. *J. Organomet. Chem.* **2001**, *624*, 114.
10. Bates, R. W.; Boonsombat, J. *J. Chem. Soc., Perkin Trans. 1* **2001**, 654.
11. Batey, R. A.; Shen, M.; Lough, A. J. *Org. Lett.* **2002**, *4*, 1411.
12. Balova, I. A.; Morozkina, S. N.; Knight, D. W.; Vasilevsky, S. F. *Tetrahedron Lett.* **2003**, *44*, 107.
13. Garcia, D.; Cuadro, A. M.; Alvarez-Builla, J.; Vaquero, J. J. *Org. Lett.* **2004**, *6*, 4175.
14. Li, P.; Wang, L.; Li, H. *Tetrahedron* **2005**, *61*, 8633.
15. Lemhadri, M.; Doucet, H.; Santelli, M. *Tetrahedron* **2005**, *61*, 9839.

Staudinger ketene cycloaddition

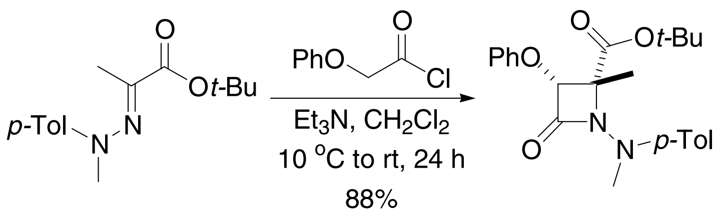
[2 + 2] Cycloaddition of ketene and imine to form β-lactam. Other coupling partners for ketene also include: olefin to give cyclobutanone and carbonyl to give β-lactone.



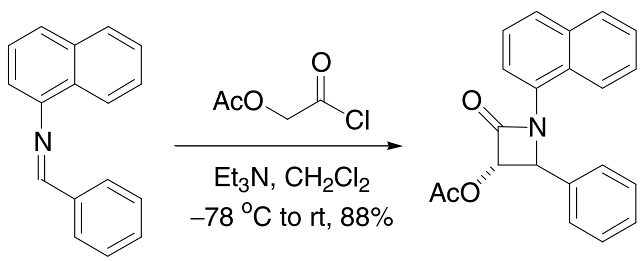
puckered transition state:



Example 1[8]



Example 2[9]

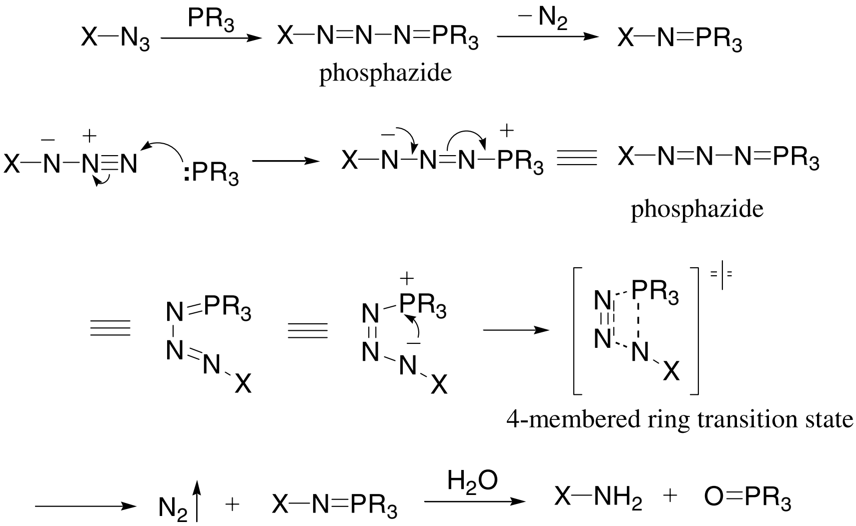


References

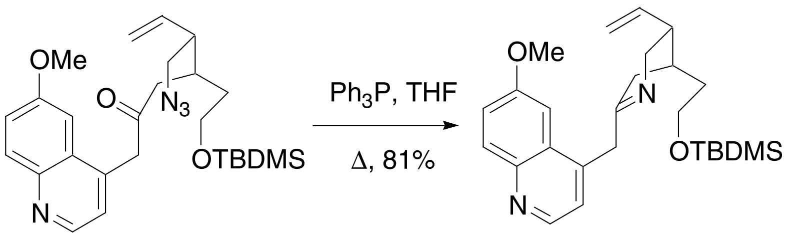
1. Staudinger, H. *Ber. Dtsch. Chem. Ges.* **1907**, *40*, 1145. Hermann Staudinger (Germany, 1881−1965) won the Nobel Prize in Chemistry in 1953 for his discoveries in the area of macromolecular chemistry.
2. Cooper, R. D. G.; Daugherty, B. W.; Boyd, D. B. *Pure Appl. Chem.* **1987**, *59*, 485–492. (Review).
3. Snider, B. B. *Chem. Rev.* **1988**, *88,* 793−811. (Review).
4. Hyatt, J. A.; Raynolds, P. W. *Org. React.* **1994**, *45,* 159−646. (Review).
5. Venturini, A.; Gonzalez, Jr. *J. Org. Chem.* **2002**, *67,* 9089.
6. Orr, R. K.; Calter, M. A. *Tetrahedron* **2003**, *59,* 3545−3565. (Review).
7. Hevia, E.; Perez, J.; Riera, V.; Miguel, D.; Campomanes, P.; Menendez, M. I; Sordo, T. L.; Garcia-Granda, S. *J. Am. Chem. Soc.* **2003**, *125,* 3706.
8. Bianchi, L.; Dell'Erba, C.; Maccagno, M.; Mugnoli, A.; Novi, M.; Petrillo, G.; Sancassan, F.; Tavani, C. *Tetrahedron* **2003**, *59,* 10195.
9. Becker, F. F.; Banik, I.; Banik, B. K. *J. Med. Chem.* **2003**, *46,* 505.
10. Cremonesi, G.; Dalla Croce, P.; La Rosa, C. *Tetrahedron* **2004**, *60,* 93.
11. Botman, P. N. M.; David, O.; Amore, A.; Dinkelaar, J.; Vlaar, M.; Goubitz, K.; Fraanje, J.; Schenk, H.; Hiemstra, H.; van Maarseveen, J. H. *Angew. Chem., Int. Ed.* **2004**, *43*, 3471.
12. Liang, Y.; Jiao, L.; Zhang, S.; Xu, J. *J. Org. Chem.* **2005**, *70,* 334.
13. Banik, B. K.; Banik, I.; Becker, F. F. *Bioorg. Med. Chem. Lett.* **2005**, *13*, 3611.

Staudinger reduction

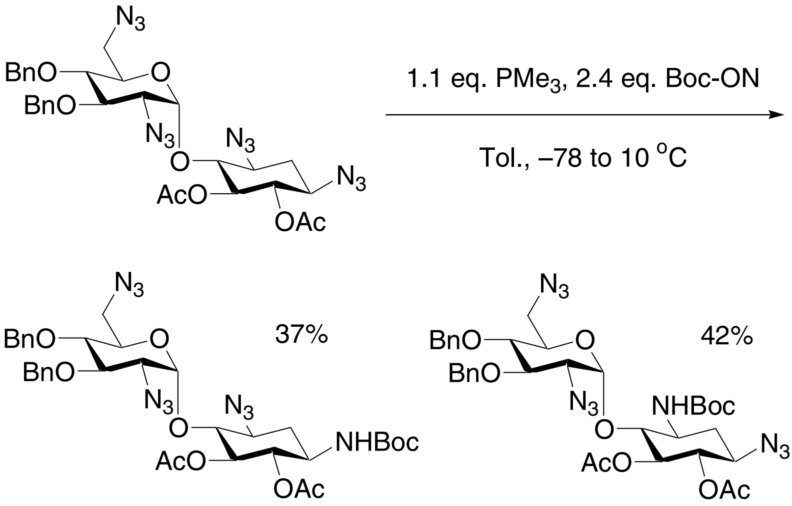
Phosphazo compounds (e.g. iminophosphoranes) from the reaction of tertiary phosphine (Example Ph_3P) with organic azides.



Example 1[7]



Example 2[12]

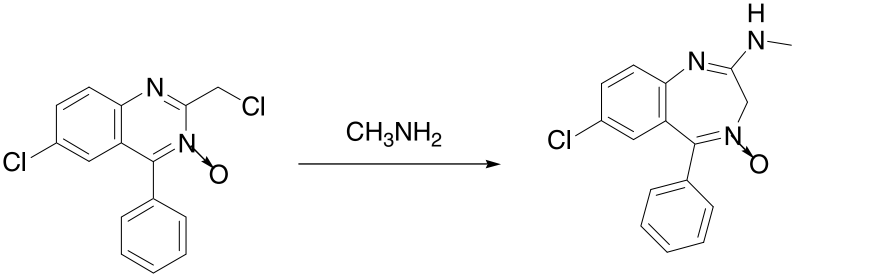


References

1. Staudinger, H.; Meyer, J. *Helv. Chim. Acta* **1919**, *2*, 635.
2. Leffler, J. E.; Temple, R. D. *J. Am. Chem. Soc.* **1967**, *89*, 5235.
3. Gololobov, Y. G.; Zhmurova, I. N.; Kasukhin, L. F. *Tetrahedron* **1981**, *37*, 437.
4. Gololobov, Y. G.; Kasukhin, L. F. *Tetrahedron* **1992**, *48*, 1353.
5. Velasco, M. D.; Molina, P.; Fresneda, P. M.; Sanz, M. A. *Tetrahedron* **2000**, *56*, 4079.
6. Balakrishna, M. S.; Abhyankar, R. M.; Walawalker, M. G. *Tetrahedron Lett.* **2001**, *42,* 2733.
7. Stork, G.; Niu, D.; Fujimoto, R. A.; Koft, E. R.; Bakovec, J. M.; Tata, J. R.; Dake, G. R. *J. Am. Chem. Soc.* **2001**, *123,* 3239.
8. Conroy, K. D.; Thompson, A. *Chemtracts* **2002**, *15,* 514.
9. Venturini, A.; Gonzalez, Jr. *J. Org. Chem.* **2002**, *67,* 9089.
10. Chen, J.; Forsyth, C. J. *Org. Lett.* **2003**, *5,* 1281.
11. Fresneda, P. M.; Castaneda, M.; Sanz, M. A.; Molina, P. *Tetrahedron Lett.* **2004**, *45,* 1655.
12. Li, J.; Chen, H.-N.; Chang, H.; Wang, J.; Chang, C.-W. T. *Org. Lett.* **2005**, *7,* 3061.

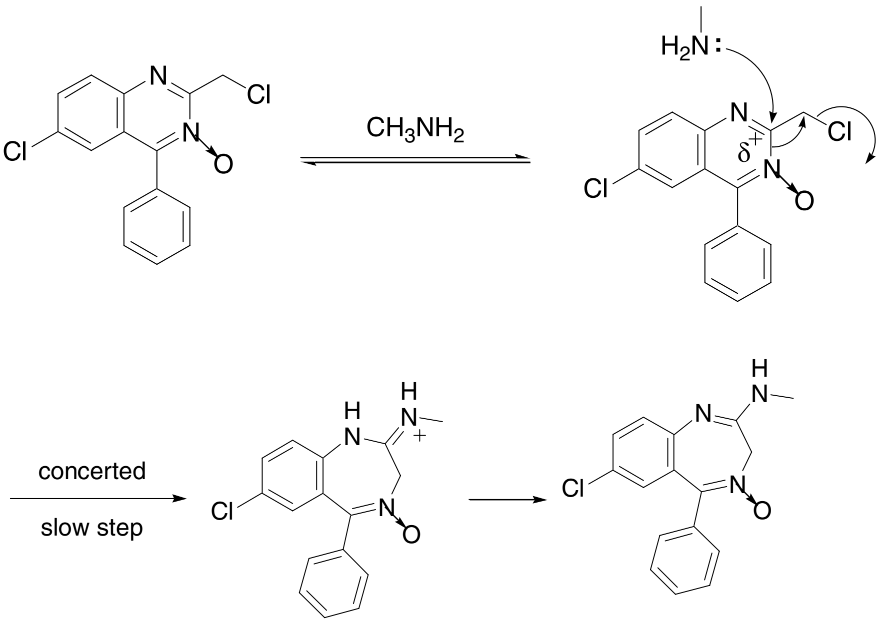
Sternbach benzodiazepine synthesis

Treatment of quinazoline 3-oxide with amines gives the rearrangement product, 1,4-benzodiazepine.



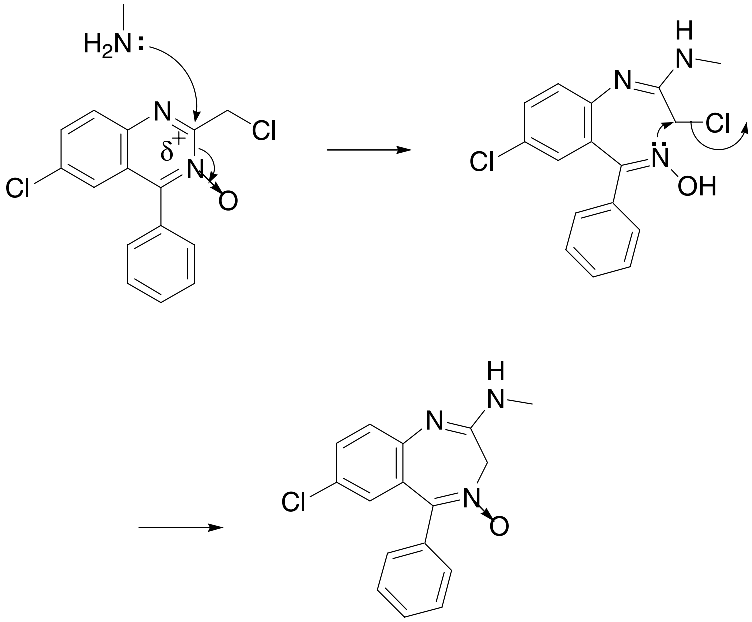
quinazoline 3-oxide

chlordiazepoxide (Librium)



chlordiazepoxide (Librium)

A step-wise mechanism is also possible:



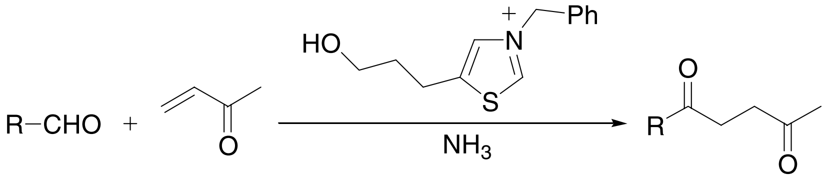
chlordiazepoxide (Librium)

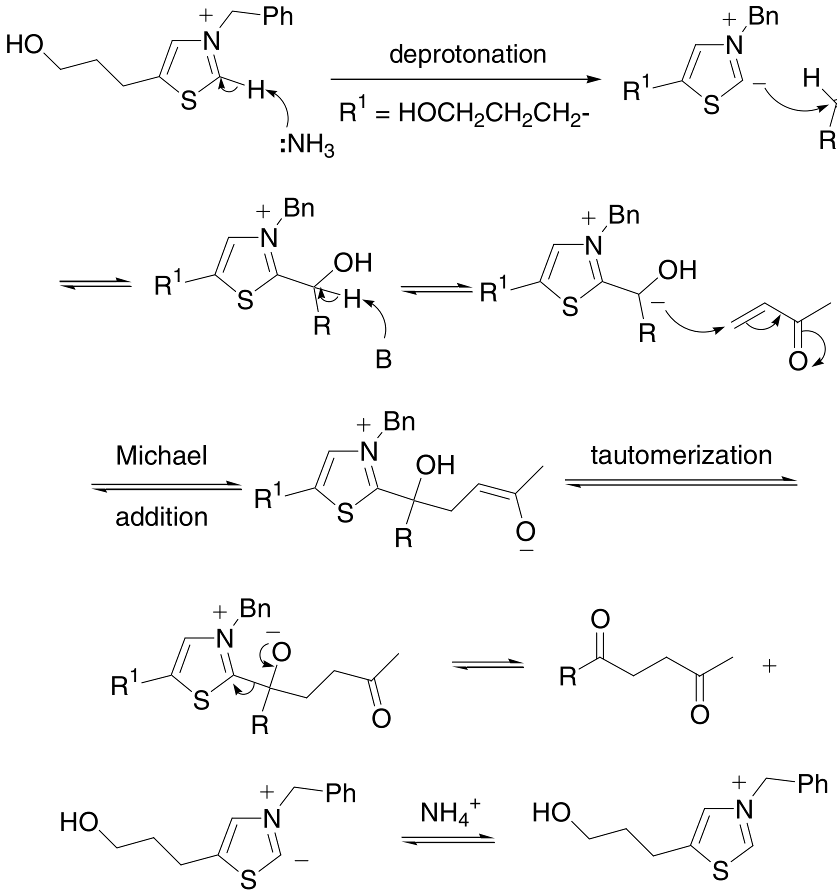
References

1. Sternbach, L. H.; Kaiser, S.; Reeder, E. *J. Am. Chem. Soc.* **1960**, *82*, 475.
2. Sternbach, L. H.; Archer, G.; Reeder, E. *J. Org. Chem.* **1963**, *28*, 3013.
3. Stempel, A.; Reeder, E.; Sternbach, L. H. *J. Org. Chem.* **1965**, *30*, 4267. (Mechanism).
4. Sternbach, L. H. *Angew. Chem., Int. Ed.* **1971**, *10*, 34. (Review).
5. Sternbach, L. H. In *The Benzodiazepines,* Garattini, S.; Mussini, E.; Randall, L. O. eds., Raven Press: New York, 1973, pp1−26. (Review).
6. Sternbach, L. H. In *The Benzodiazepines: From Molecular Biology to Clinical Practice,* Costa, Erminio, ed.; Raven Press: New York, 1983, pp 1−20. (Review).

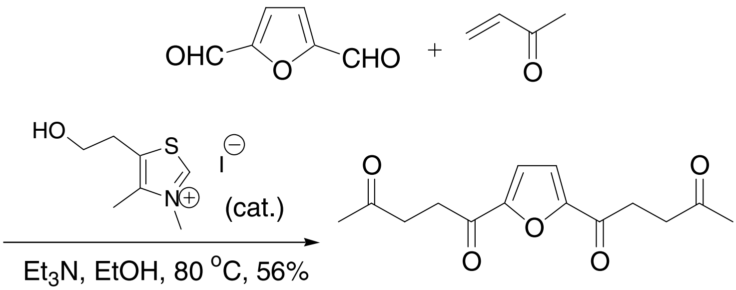
Stetter reaction

1,4-Dicarbonyl derivatives from aldehydes and α,β-unsaturated ketones. The thiazolium catalyst serves as a safe surrogate for $^{-}$CN. Also known as the Michael–Stetter reaction. *Cf*. Benzoin condensation.

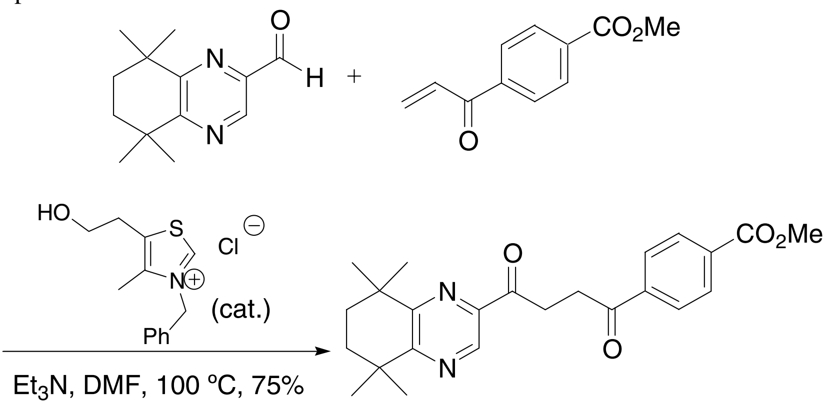




Example 1[4]



Example 2[11]

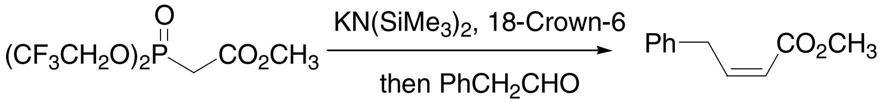


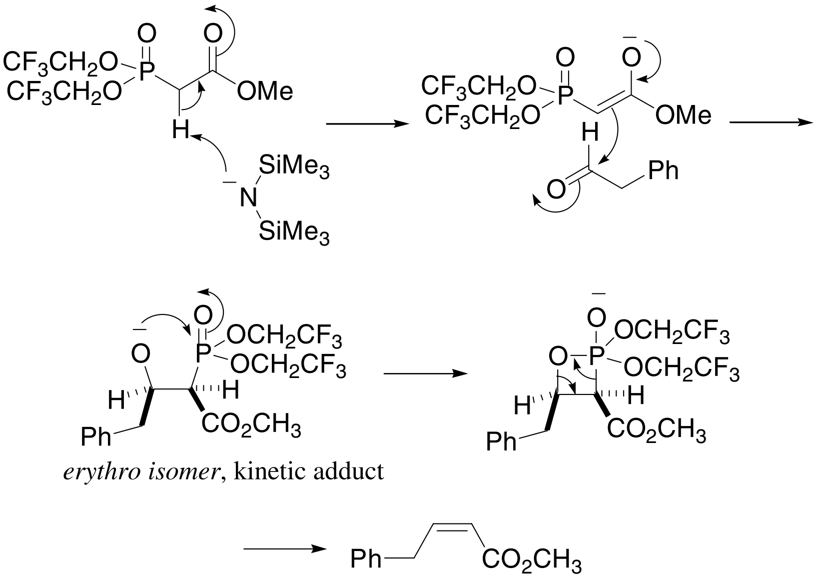
References

1. Stetter, H. *Angew. Chem.* **1973**, *85*, 89. Hermann Stetter (1917−1993), born in Bonn, Germany, was a chemist at Technische Hochschule Aachen in West Germany.
2. Stetter, H. *Angew. Chem., Int. Ed.* **1976**, *15*, 639.
3. Castells, J.; Dunach, E.; Geijo, F.; Lopez-Calahorra, F.; Prats, M.; Sanahuja, O.; Villanova, L. *Tetrahedron Lett*. **1980**, *21*, 2291.
4. El-Haji, T.; Martin, J. C.; Descotes, G. *J. Heterocycl. Chem*. **1983**, *20*, 233.
5. Ho, T. L.; Liu, S. H. *Synth. Commun*. **1983**, *13*, 1125.
6. Phillips, R. B.; Herbert, S. A.; Robichaud, A. J. *Synth. Commun*. **1986**, *16*, 411.
7. Stetter, H.; Kuhlmann, H.; Haese, W. *Org. Synth*. **1987**, *65*, 26.
8. Ciganek, E. *Synthesis* **1995**, 1311.
9. Enders, D.; Breuer, K.; Runsink, J.; Teles, J. H. *Helv. Chim. Acta* **1996**, *79*, 1899.
10. Harrington, P. E.; Tius, M. A. *Org. Lett*. **1999**, *1*, 649.
11. Kikuchi, K.; Hibi, S.; Yoshimura, H.; Tokuhara, N.; Tai, K.; Hida, T.; Yamauchi, T.; Nagai, M. *J. Med. Chem.* **2000**, *43*, 409.
12. Kobayashi, N.; Kaku, Y.; Higurashi, K.; Yamauchi, T.; Ishibashi, A.; Okamoto, Y. *Bioorg. Med. Chem. Lett*. **2002**, *12*, 1747.
13. Read de Alaniz, J.; Rovis, T. *J. Am. Chem. Soc*. **2005**, *127*, 6284.
14. Reynolds, N. T.; Rovis, T. *Tetrahedron* **2005**, *61*, 6368.

Still–Gennari phosphonate reaction

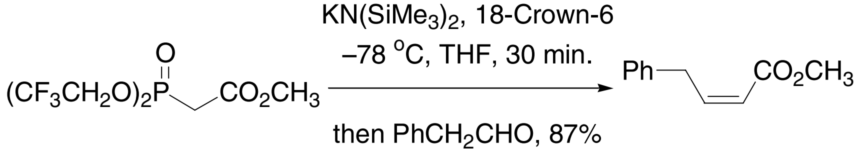
A variant of the Horner–Emmons reaction using bis(trifluoroethyl)phosphonate to give *Z*-olefins.



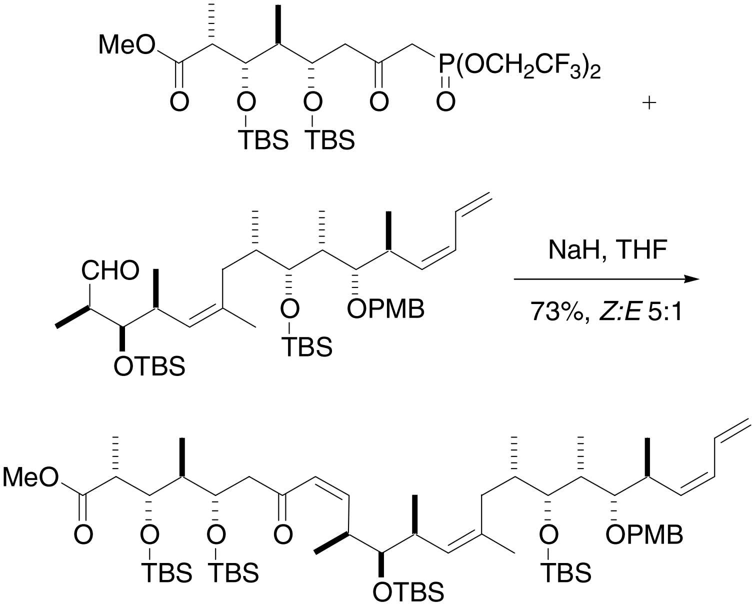


erythro isomer, kinetic adduct

Example 1[3]



Example 2[12]



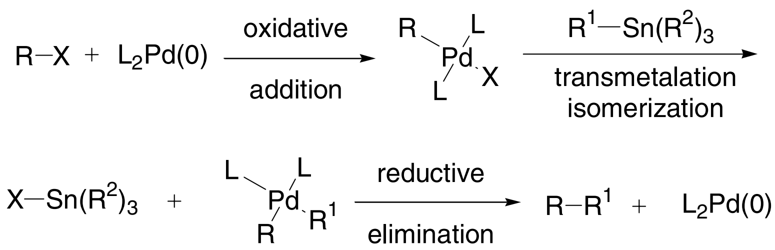
References

1. Still, W. C.; Gennari, C. *Tetrahedron Lett.* **1983**, *24,* 4405. W. Clark Still (1946−) was born in Augusta, Georgia. He was a professor at Columbia University.
2. Ralph, J.; Zhang, Y. *Tetrahedron* **1998**, *54*, 1349.
3. Nicolaou, K. C.; Nadin, A.; Leresche, J. E.; LaGreca, S.; Tsuri, T.; Yue, E. W.; Yang, Z. *Angew. Chem., Int. Ed. Engl*. **1994**, *33*, 2187.
4. Mulzer, J.; Mantoulidis, A.; Ohler, E. *Tetrahedron Lett*. **1998**, *39*, 8633.
5. Jung, M. E.; Marquez, R. *Org. Lett.* **2000**, *2,* 1669.
6. White, J. D.; Blakemore, P. R.; Browder, C. C. *et al. J. Am. Chem. Soc*. **2001**, *123*, 8593.
7. Paterson, I.; Florence, G. J.; Gerlach, K.; Scott, J. P.; Sereinig, N. *J. Am. Chem. Soc.* **2001**, *123*, 9535.
8. Mulzer, J.; Ohler, E. *Angew. Chem., Int. Ed. Engl*. **2001**, *40*, 3842.
9. Beaudry, C. M.; Trauner, D. *Org. Lett*. **2002**, *4*, 2221.
10. Sano, S.; Yokoyama, K.; Shiro, M.; Nagao, Y. *Chem. Pharm. Bull.* **2002**, *50*, 706.
11. Dakin, L. A.; Langille, N. F.; Panek, J. S. *J. Org. Chem.* **2002**, *67,* 6812.
12. Paterson, I.; Lyothier, I. *J. Org. Chem.* **2005**, *70,* 5494.

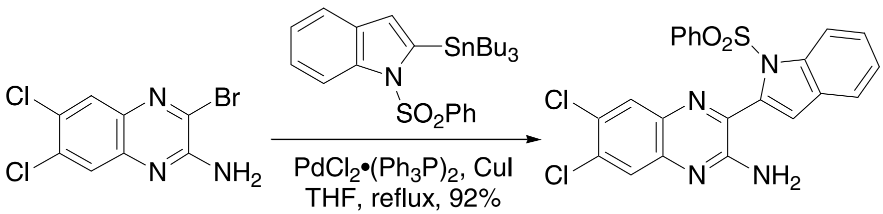
Stille coupling

Palladium-catalyzed cross-coupling reaction of organostannanes with organic halides, triflates, *etc*. For the catalytic cycle, see Kumada coupling on page 345.

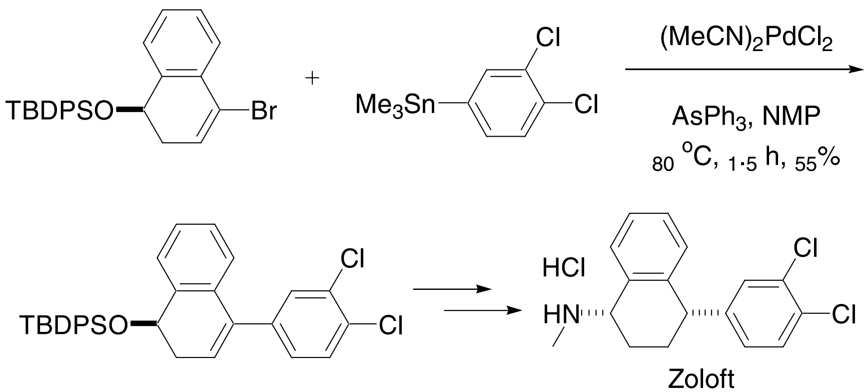
$$R{-}X \;+\; R^1{-}Sn(R^2)_3 \xrightarrow{\text{Pd(0)}} R{-}R^1 \;+\; X{-}Sn(R^2)_3$$



Example 1[6]



Example 2[7]

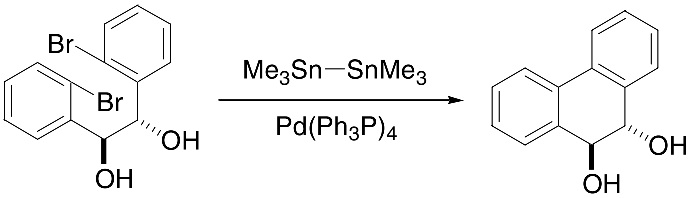


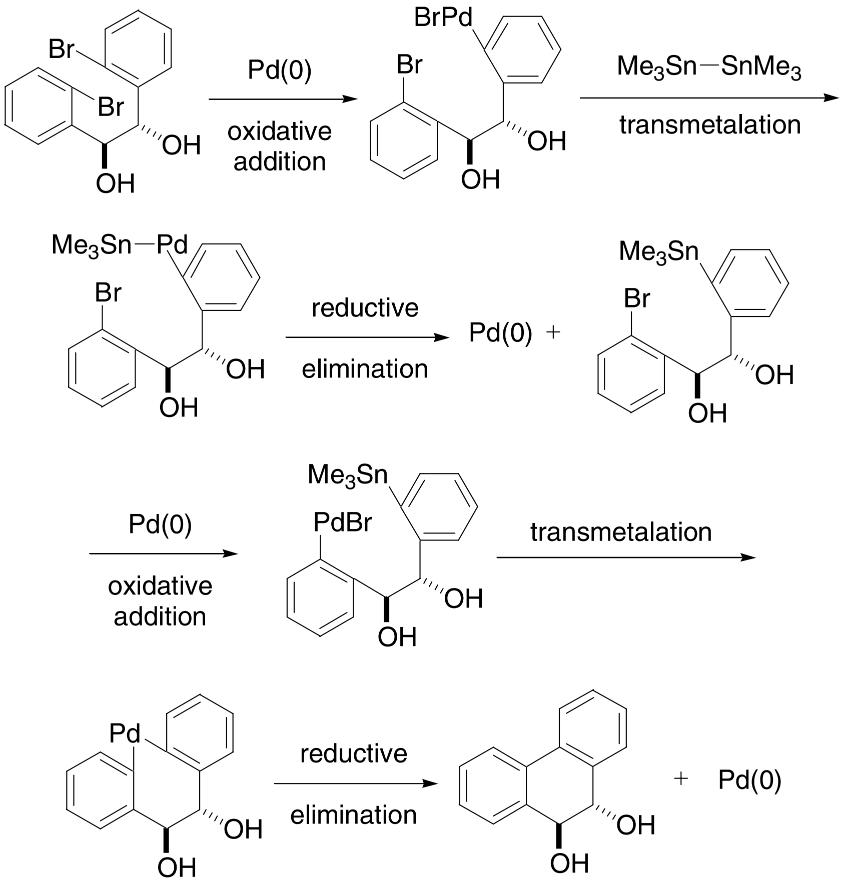
References

1. Milstein, D.; Stille, J. K. *J. Am. Chem. Soc.* **1978**, *100*, 3636. John Kenneth Stille (1930−1989) was born in Tucson, Arizona. He developed the reaction bearing his name at Colorado State University. At the height of his career, Stille unfortunately died of an airplane accident returning from an ACS meeting.
2. Milstein, D.; Stille, J. K. *J. Am. Chem. Soc.* **1979**, *101*, 4992.
3. Stille, J. K. *Angew. Chem., Int. Ed. Engl.* **1986**, *25*, 508.
4. Farina, V.; Krishnamurphy, V.; Scott, W. J. *Org. React.* **1997**, *50*, 1–652. (Review).
5. For an excellent review on the intramolecular Stille reaction, see, Duncton, M. A. J.; Pattenden, G. *J. Chem. Soc., Perkin Trans. 1* **1999**, 1235. (Review).
6. Li, J. J.; Yue, W. S. *Tetrahedron Lett.* **1999**, *40*, 4507.
7. Lautens, M.; Rovis, T. *Tetrahedron*, **1999**, *55*, 8967.
8. Nakamura, H.; Bao, M.; Yamamoto, Y. *Angew. Chem., Int. Ed.* **2001**, *40*, 3208.
9. Heller, M.; Schubert, U. S. *J. Org. Chem.* **2002**, *67,* 8269.
10. Lin, S.-Y.; Chen, C.-L.; Lee, Y.-J. *J. Org. Chem.* **2003**, *68,* 2968.
11. Samuelsson, L.; Langstrom, B. *J. Labelled Comd. Radiopharm.* **2003**, 46, 263.
12. Mitchell, T. N. *Organotin Reagents in Cross-Coupling Reactions.* In *Metal-Catalyzed Cross-Coupling Reactions* (2nd edn) De Meijere, A.; Diederich, F. eds., **2004**, 1, 125-161. Wiley-VCH: Weinheim, Germany. (Review).
13. Schröter, S.; Stock, C.; Bach, T. *Tetrahedron* **2005**, *61,* 2245−2267. (Review).

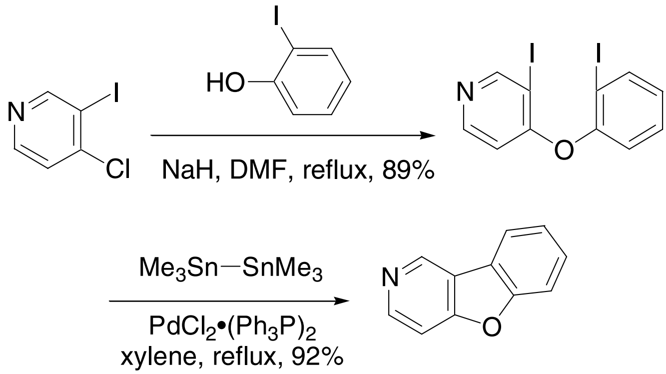
Stille–Kelly reaction

Palladium-catalyzed intramolecular cross-coupling reaction of bis-aryl halides using ditin reagents.





Example[8]

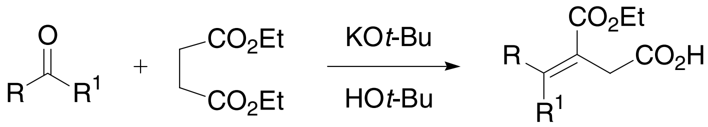


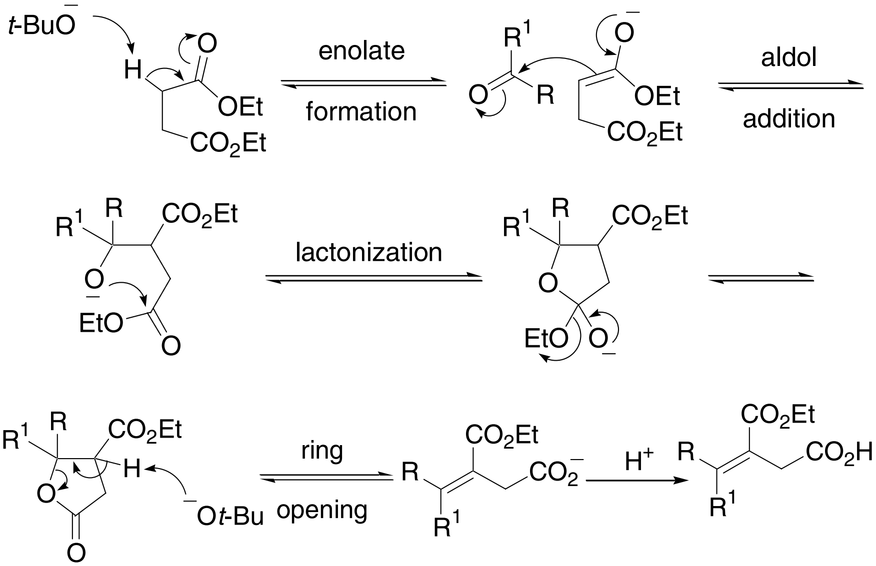
References

1. Kelly, T. R.; Li, Q.; Bhushan, V. *Tetrahedron Lett.* **1990**, *31*, 161.
2. Grigg, R.; Teasdale, A.; Sridharan, V. *Tetrahedron Lett.* **1991**, *32*, 3859.
3. Sakamoto, T.; Yasuhara, A.; Kondo, Y.; Yamanaka, H. *Heterocycles* **1993**, *36*, 2597.
4. Iyoda, M.; Miura, M.i; Sasaki, S.; Kabir, S. M. H.; Kuwatani, Y.; Yoshida, M. *Heterocycles* **1997**, *38*, 4581.
5. Fukuyama, Y.; Yaso, H.; Nakamura, K.; Kodama, M. *Tetrahedron Lett.* **1999**, *40*, 105.
6. Iwaki, T.; Yasuhara, A.; Sakamoto, T. *J. Chem. Soc., Perkin Trans. 1* **1999**, 1505.
7. Fukuyama, Y.; Yaso, H.; Mori, T.; Takahashi, H.; Minami, H.; Kodama, M. *Heterocycles* **2001**, *54*, 259.
8. Yue, W. S.; Li, J. J. *Org. Lett.* **2002**, *4,* 2201.
9. Olivera, R.; SanMartin, R.; Tellitu, I.; Dominguez, E. *Tetrahedron* **2002**, *58,* 3021.

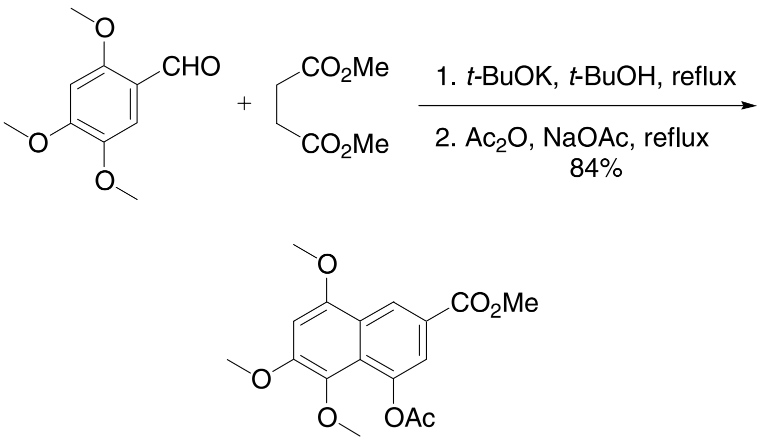
Stobbe condensation

Condensation of diethyl succinate and its derivatives with carbonyl compounds in the presence of a base.

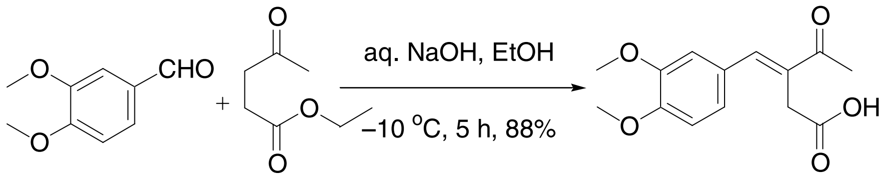




Example 1[12]



Example 2[13]

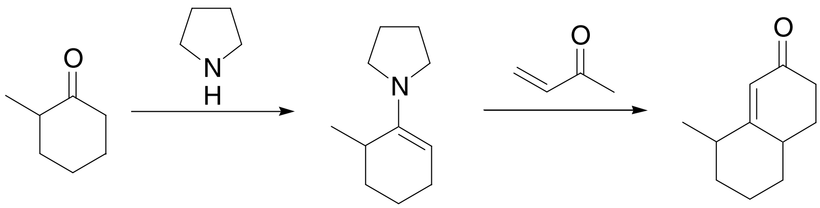


References

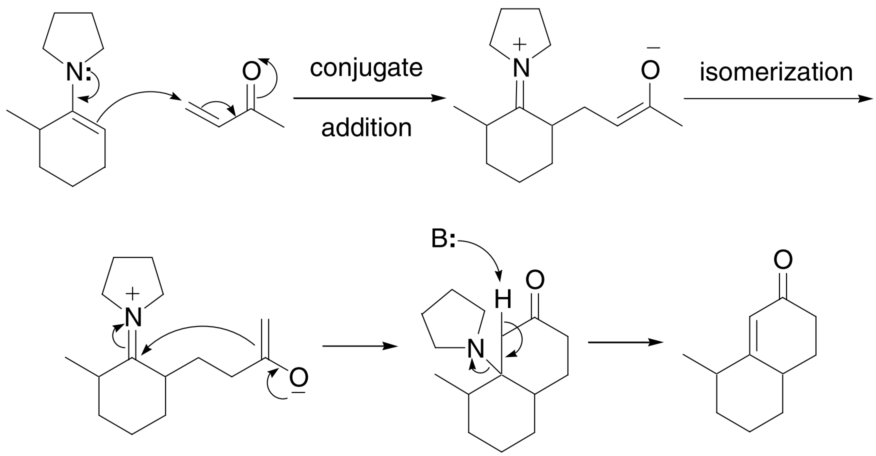
1. Stobbe, H. *Ber. Dtsch. Chem. Ges.* **1893**, *26*, 2312. Hans Stobbe (1860−1938) was born in Tiehenhof, Germany. He earned his Ph.D. in 1889 at the University of Leipzig where he became a professor in 1894.
2. El-Rayyes, N. R.; Al-Salman, Mrs. N. A. *J. Heterocycl. Chem.* **1976**, *13*, 285.
3. Baghos, V. B.; Nasr, F. H.; Gindy, M. *Helv. Chim. Acta* **1979**, *62*, 90.
4. Welch, W. M.; Harbert, C. A.; Koe, K. B.; Kraska, A. R. US 4536518 (**1985**).
5. Zerrer, R.; Simchen, G. *Synthesis* **1992**, 922.
6. Baghos, V. B.; Doss, S. H.; Eskander, E. F. *Org. Prep. Proced. Int.* **1993**, *25*, 301.
7. Moldvai, I.; Temesvari-Major, E.; Balazs, M.; Gacs-Baitz, E.; Egyed, O.; Szantay, C. *J. Chem. Res., (S)* **1999**, 3018.
8. Moldvai, I.; Temesvari-Major, E.; Gacs-Baitz, E.; Egyed, O.; Gomory, A.; Nyulaszi, L.; Szantay, C. *Heterocycles* **2001**, *53*, 759.
9. Yvon, B. L.; Datta, P. K.; Le, T. N.; Charlton, J. L. *Synthesis* **2001**, 1556.
10. Liu, J.; Brooks, N. R. *Org. Lett.* **2002**, *4*, 3521.
11. Moldvai, I.; Temesvari-Major, E.; Incze, M.; Platthy, T.; Gacs-Baitz, E.; Szantay, C. *Heterocycles* **2003**, *60*, 309.
12. Giles, R. G. F.; Green, I. R.; van Eeden, N. *Eur. J. Org. Chem.* **2004**, 4416.
13. Mahajan, V. A.; Shinde, P. D.; Borate, H. B.; Wakharkar, R. D. *Tetrahedron Lett.* **2005**, *46*, 1009.

Stork enamine reaction

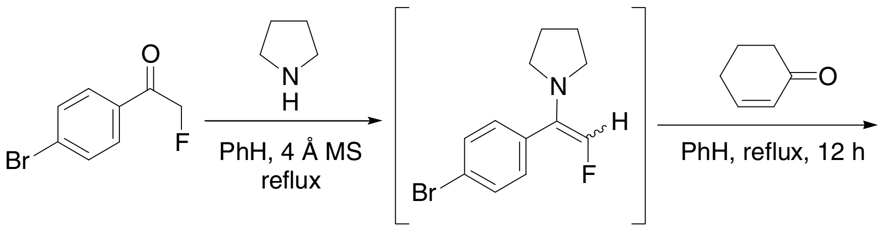
A variant of the Robinson annulation, where bulky amines such as pyrrolidine are used, making the conjugate addition to methyl vinyl ketone (MVK) take place at the less hindered side of two possible enamines.

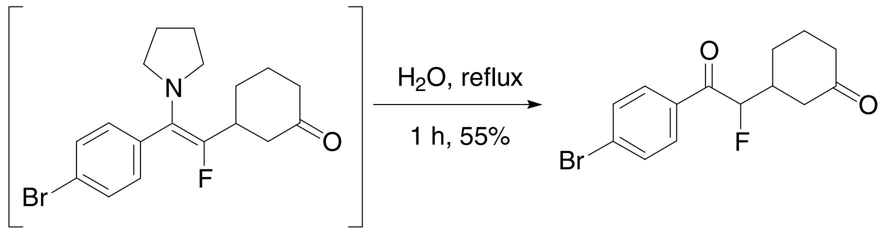


methyl vinyl ketone (MVK)

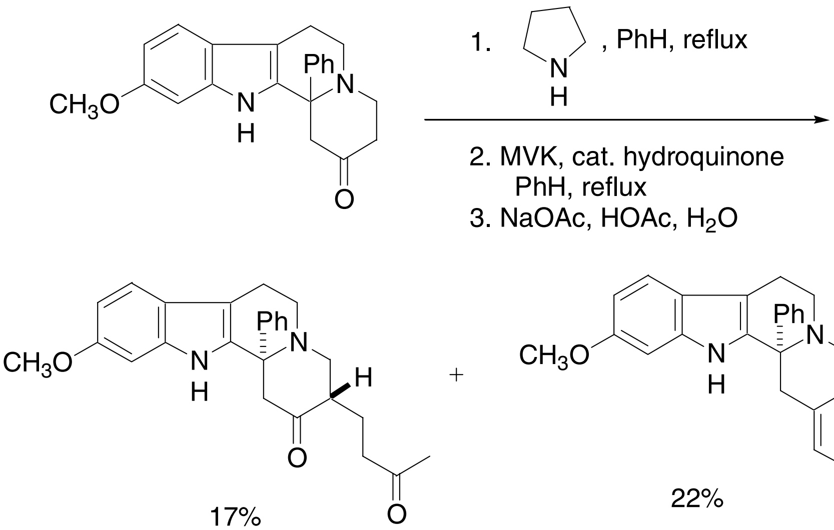


Example 1[7]





Example 2[8]

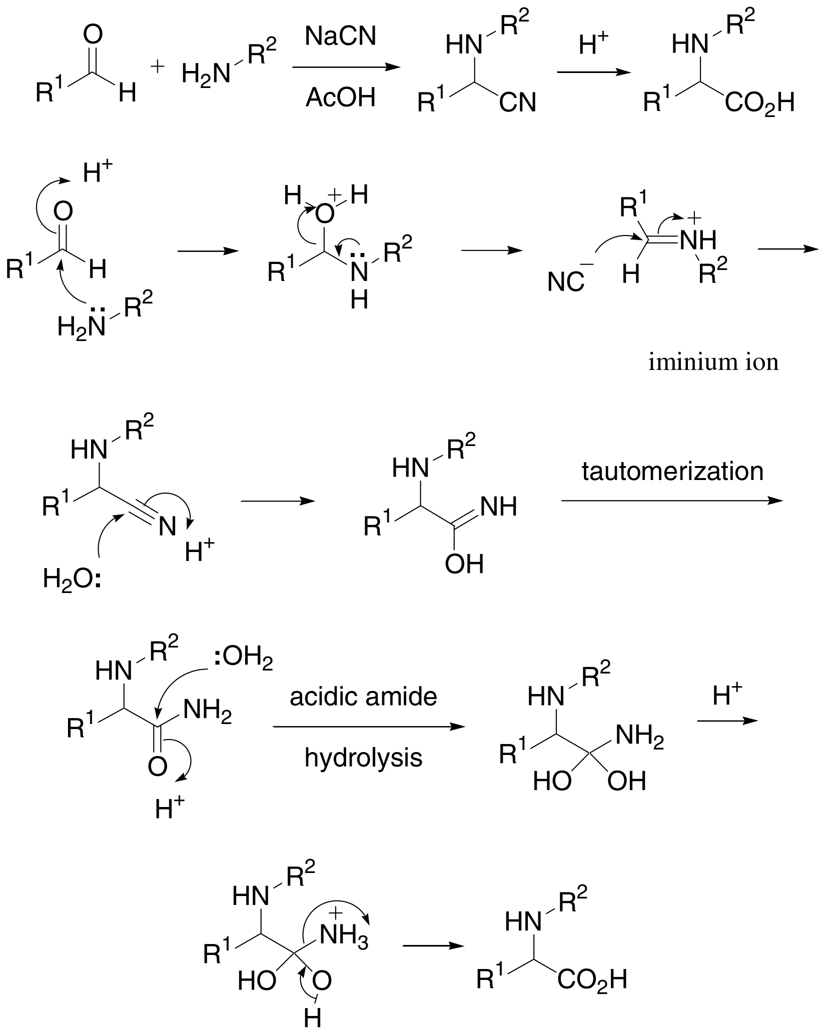


References

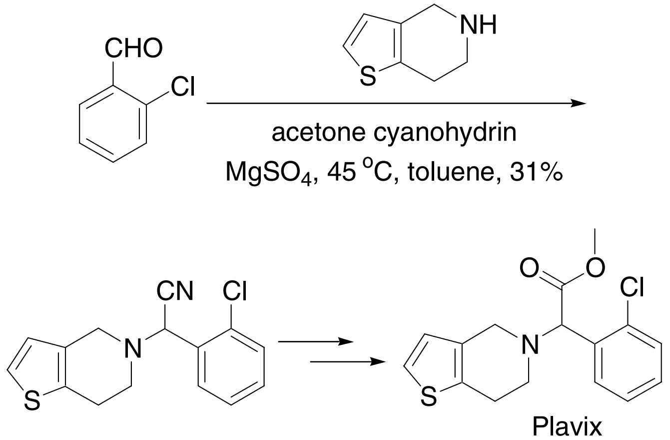
1. Stork, G.; Terrell, R.; Szmuszkovicz, J. *J. Am. Chem. Soc.* **1954**, *76*, 2029. Gilbert J. Stork (1921−) was born in Brussels, Belgium. Being Jewish, he immigrated to the US due to rising antisemitism. He earned his Ph.D. at Wisconsin in 1945 and later became an assistant professor at Harvard. Since he was not awarded tenure in 1953, Stork moved to Columbia University where he has taught ever since.
2. Singerman, G.; Danishefsky, S. *Tetrahedron Lett.* **1964**, *5,* 2249.
3. *Enamines: Synthesis, Structure, and Reactions;* Cook, A. G., Ed.; Dekker: New York, **1969**, 514. (Review).
4. Autrey, R. L.; Tahk, F. C. *Tetrahedron* **1968**, *24*, 3337.
5. Hickmott, P. W. *Tetrahedron* **1982**, *38*, 1975. (Review).
6. Hammadi, M.; Villemin, D. *Synth. Commun*. **1996**, *26*, 2901.
7. Bridge, C. F.; O'Hagan, D. *J. Fluorine Chem*. **1997**, *82*, 21.
8. Li, J. J.; Trivedi, B. K.; Rubin, J. R.; Roth, B. D. *Tetrahedron Lett.* **1998**, *39,* 6111.
9. Yehia, N. A. M.; Polborn, K.; Muller, T. J. J. *Tetrahedron Lett.* **2002**, *43*, 6907.

Strecker amino acid synthesis

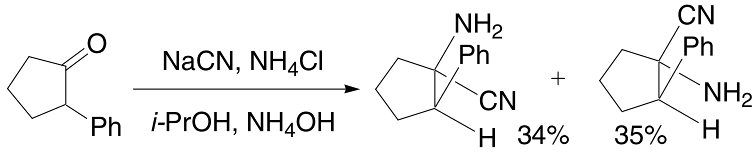
Sodium cyanide-promoted condensation of aldehyde and amine to afford α-amino nitrile, which may be hydrolyzed to α-amino acid.



Example 1[6]



Example 2[13]

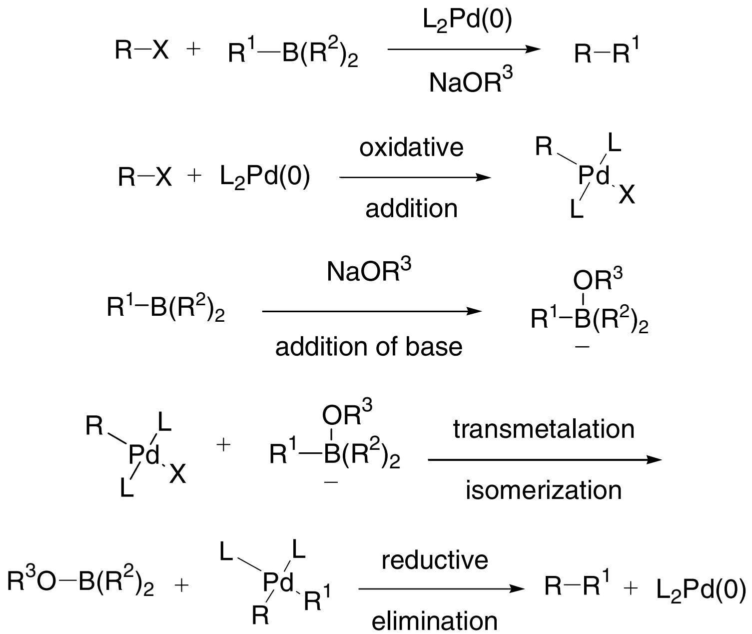


References

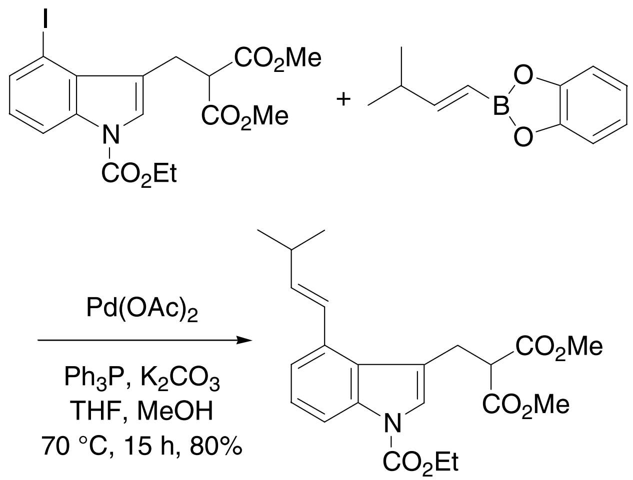
1. Strecker, A. *Justus Liebigs Ann. Chem.* **1850**, *75*, 27.
2. Chakraborty, T. K.; Hussain, K. A; Reddy, G. V. *Tetrahedron* **1995**, *51*, 9179.
3. Iyer, M. S.; Gigstad, K. M.; Namdev, N. D.; Lipton, M. *J. Am. Chem. Soc*. **1996**, *118*, 4910.
4. Iyer, M. S.; Gigstad, K. M.; Namdev, N. D.; Lipton, M. *Amino Acids* **1996**, *11*, 259.
5. Mori, A.; Inoue, S. *Compr. Asymmetric Catal. I-III* **1999**, *2*, 983. (Review).
6. Burgos, A.; Herbert, J. M.; Simpson, I. *J. Labelled. Compd. Radiopharm.* **2000**, *43*, 891.
7. Ishitani, H.; Komiyama, S.; Hasegawa, Y.; Kobayashi, S. *J. Am. Chem. Soc.* **2000**, *122*, 762.
8. Ding, K.; Ma, D. *Tetrahedron* **2001**, *57*, 6361.
9. Matsumoto, K.; Kim, J. C.; Hayashi, N.; Jenner, G. *Tetrahedron Lett.* **2002**, *43*, 9167.
10. Yet, L. *Recent Developments in Catalytic Asymmetric Strecker-Type Reactions,* in *Organic Synthesis Highlights V,* Schmalz, H.-G.; Wirth, T. eds., Wiley-VCH: Weinheim, Germany, **2003**, pp 187−193. (Review).
11. Meyer, U.; Breitling, E.; Bisel, P.; Frahm, A. W. *Tetrahedron: Asymmetry* **2004**, *15*, 2029.
12. Huang, J.; Corey, E. J. *Org. Lett.* **2004**, *6*, 5027.
13. Cativiela, C.; Lasa, M.; Lopez, P. *Tetrahedron: Asymmetry* **2005**, *16*, 2613.

Suzuki coupling

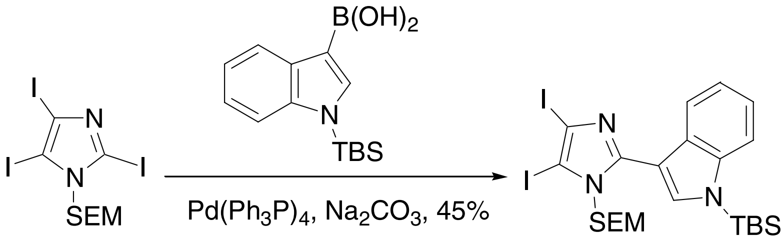
Palladium-catalyzed cross-coupling reaction of organoboranes with organic halides, triflates, *etc*. in the presence of a base (transmetalation is reluctant to occur without the activating effect of a base). For the catalytic cycle, see Kumada coupling on page 345.



Example 1[1]



Example 2[4]

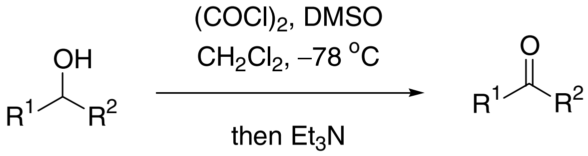


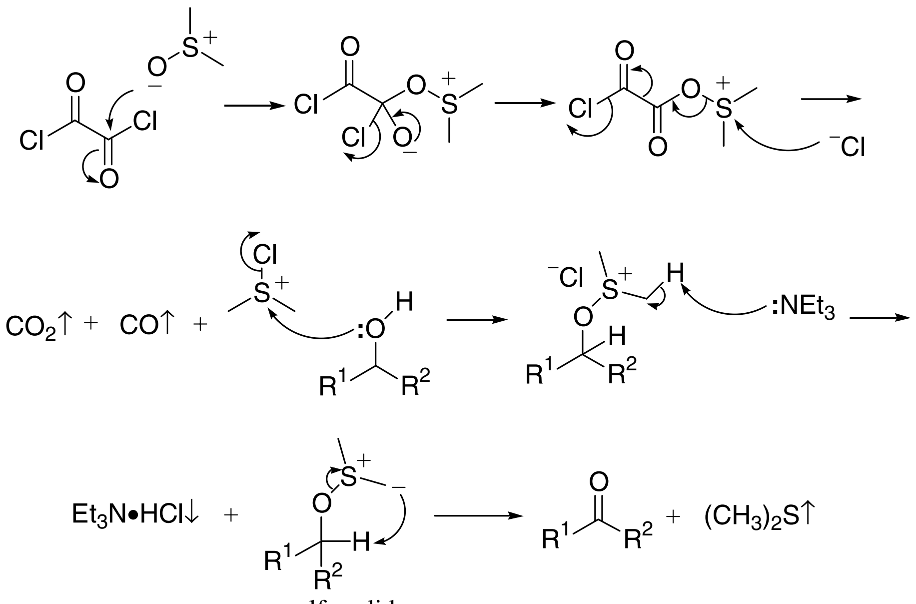
References

1. Tidwell, J. H.; Peat, A. J.; Buchwald, S. L. *J. Org. Chem.* **1994**, *59*, 7164.
2. Miyaura, N.; Suzuki, A. *Chem. Rev.* **1995**, *95*, 2457–2483. (Review).
3. Suzuki, A. In *Metal-catalyzed Cross-coupling Reactions*; Diederich, F.; Stang, P. J., Eds.; Wiley–VCH: Weinhein, Germany, **1998**, 49–97. (Review).
4. Kawasaki, I.; Katsuma, H.; Nakayama, Y.; Yamashita, M.; Ohta, S. *Heterocycles* **1998**, *48,* 748
5. Stanforth, S. P. *Tetrahedron* **1998**, *54*, 263. (Review).
6. Li, J. J. *Alkaloids: Chem. Biol. Perspect*. **1999**, *14*, 437. (Review).
7. Groger, H. *J. Prakt. Chem.* **2000**, *342*, 334.
8. Franzen, R. *Can. J. Chem*. **2000**, *78*, 957.
9. LeBlond, C. R.; Andrews, A. T.; Sun, Y.; Sowa, J. R., Jr. *Org. Lett.* **2001**, *3*, 1555.
10. Collier, P. N.; Campbell, A. D.; Patel, I.; Raynham, T. M.; Taylor, R. J. K. *J. Org. Chem*. **2002**, *67*, 1802.
11. Urawa, Y.; Ogura, K. *Tetrahedron Lett*. **2003**, 44, 271.
12. Zapf, A. *Coupling of Aryl and Alkyl Halides With Organoboron Reagents (Suzuki Reaction)*. In *Transition Metals for Organic Synthesis* (2nd edn), Beller, M.; Bolm, C. eds., **2004**, 1, 211–229. Wiley-VCH: Weinheim, Germany. (Review).
13. Leadbeater, N. E. *Chem. Commun*. **2005**, 2881.

Swern oxidation

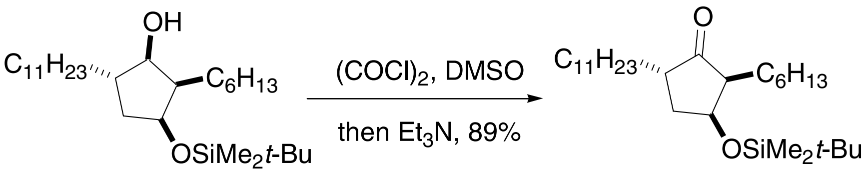
Oxidation of alcohols to the corresponding carbonyl compounds using $(COCl)_2$, DMSO, and quenching with Et_3N.



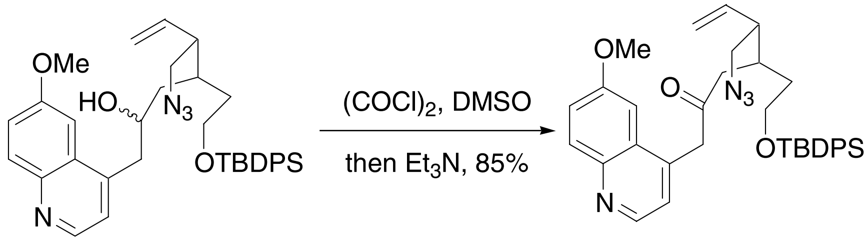


sulfur ylide

Example 1[5]



Example 2[11]

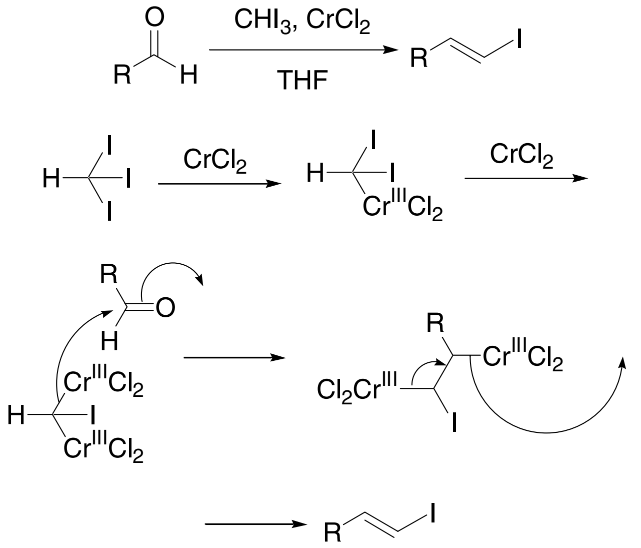


References

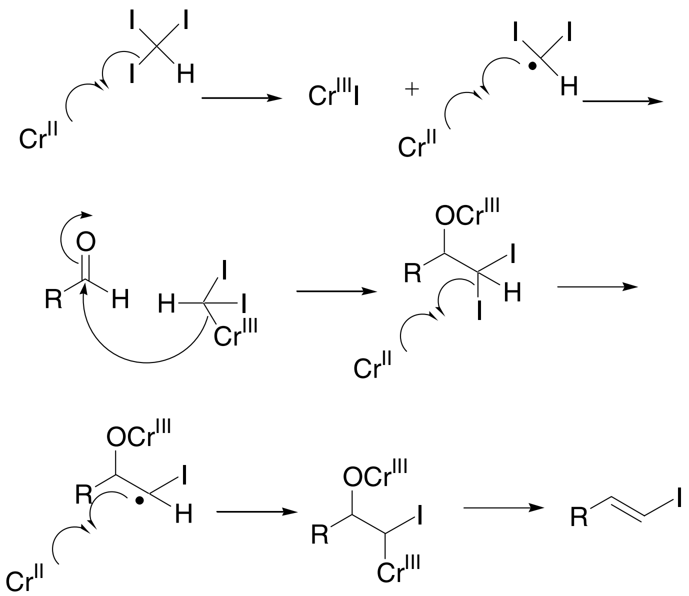
1. Huang, S. L.; Omura, K.; Swern, D. *J. Org. Chem.* **1976**, *41*, 3329.
2. Huang, S. L.; Omura, K.; Swern, D. *Synthesis* **1978**, *4*, 297.
3. Mancuso, A. J.; Huang, S.-L.; Swern, D. *J. Org. Chem.* **1978**, *43*, 2480.
4. Tidwell, T. T. *Org. React.* **1990**, *39*, 297. (Review).
5. Chadka, N. K.; Batcho, A. D.; Tang P. C.; Courtney, L. F.; Cook C. M.; Wovliulich, P. M.; Usković, M. R. *J. Org. Chem.* **1991**, *56*, 4714
6. Nakajima, N.; Ubukata, M. *Tetrahedron Lett.* **1997**, *38*, 2099.
7. Harris, J. M.; Liu, Y.; Chai, S.; Andrews, M. D.; Vederas, J. C. *J. Org. Chem.* **1998**, *63*, 2407. (odorless protocol).
8. Bailey, P. D.; Cochrane, P. J.; Irvine, F.; Morgan, K. M.; Pearson, D. P. J.; Veal, K. T. *Tetrahedron Lett.* **1999**, *40*, 4593.
9. Rodriguez, A.; Nomen, M.; Spur, B. W.; Godfroid, J. J. *Tetrahedron Lett.* **1999**, *40*, 5161.
10. Dupont, J.; Bemish, R. J.; McCarthy, K. E.; Payne, E. R.; Pollard, E. B.; Ripin, D. H. B.; Vanderplas, B. C.; Watrous, R. M. *Tetrahedron Lett.* **2001**, *42*, 1453.
11. Stork, G.; Niu, D.; Fujimoto, R. A.; Koft, E. R.; Bakovec, J. M.; Tata, J. R.; Dake, G. R. *J. Am. Chem. Soc.* **2001**, *123,* 3239.
12. Nishide, K.; Ohsugi, S.-i.; Fudesaka, M.; Kodama, S.; Node, M. *Tetrahedron Lett.* **2002**, *43*, 5177. (New odorless protocols).
13. Firouzabadi, H.; Hassani, H.; Hazarkhani, H. *Phosphorus, Sulfur Silicon Related Elements* **2003**, *178*, 149.
14. Nishide, K.; Patra, P. K.; Matoba, M.; Shanmugasundaram, K.; Node, M. *Green Chem.* **2004**, *6*, 142.
15. Kawaguchi, T.; Miyata, H.; Ataka, K.; Mae, K.; Yoshida, J.-i. *Angew. Chem., Int. Ed. Engl.* **2005**, *44*, 2413.

Takai iodoalkene synthesis

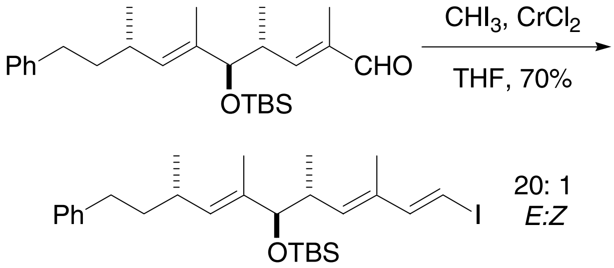
Stereoselective conversion of an aldehyde to the corresponding *E*-vinyl iodide using CHI_3 and $CrCl_2$.



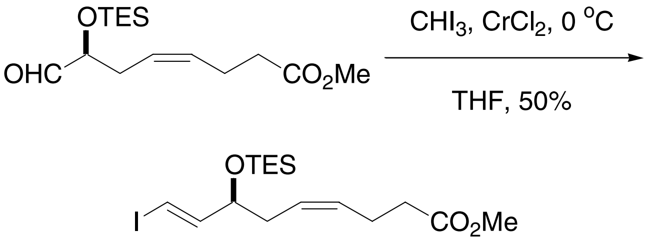
A radical mechanism is recently proposed[10]



Example 1[2]



Example 2[5]

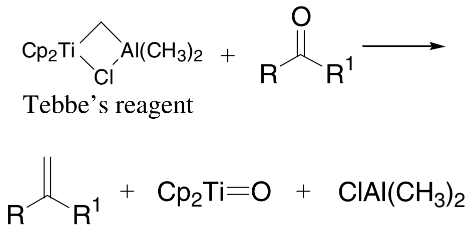


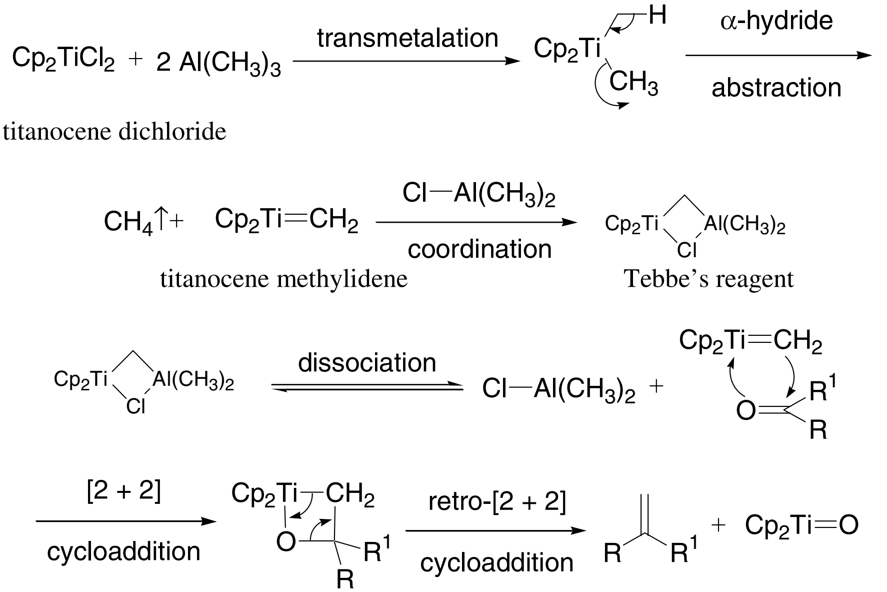
References

1. Takai, K.; Nitta, Utimoto, K. *J. Am. Chem. Soc*. **1986**, *108*, 7408.
2. Andrus, M. B.; Lepore, S. D.; Turner, T. M. *J. Am. Chem. Soc*. **1997**, *119*, 12159.
3. Arnold, D. P.; Hartnell, R. D. *Tetrahedron* **2001**, *57*, 1335.
4. Solsona, J. G.; Romea, P.; Urpi, F. *Org. Lett.* **2003**, *5*, 4681.
5. Rodriguez, A. R.; Spur, B. W. *Tetrahedron Lett.* **2004**, *45*, 8717.
6. Dineen, T. A.; Roush, W. R. *Org. Lett.* **2004**, *6*, 2043.
7. Lipomi, D. J.; Langille, N. F.; Panek, J. S. *Org. Lett.* **2004**, *6*, 3533.
8. Paterson, I.; Mackay, A. C. *Synlett* **2004**, 1359.
9. Mulzer, J.; Berger, M. *J. Org. Chem.* **2004**, *69*, 891.
10. Concellón, J. M.; Bernad, P. L.; Méjica, C. *Tetrahedron Lett.* **2005**, *46*, 569.

Tebbe olefination

Transformation of a carbonyl compound to the corresponding *exo*-olefin using Tebbe's reagent.





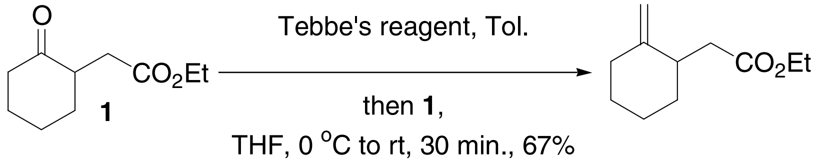
oxatitanacyclobutane

formation of the strong Ti=O is the driving force.

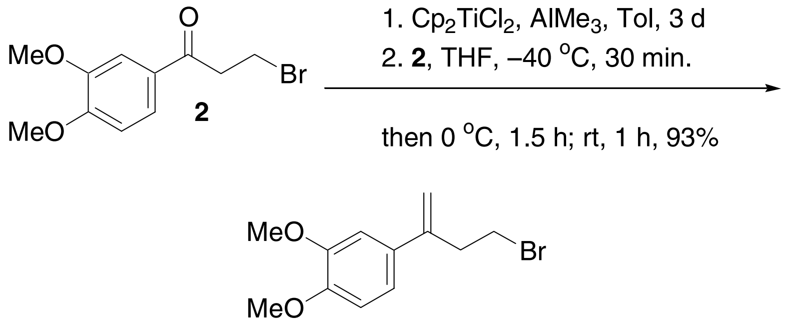
Petasis alkenylation

The Petasis reagent (Me_2TiCp_2, dimethyltitanocene) undergoes similar olefination reactions with ketones and aldehydes. The originally proposed mechanism[5] was very different from that of Tebbe olefination. However, later experimental data seem to suggest that both Petasis and Tebbe olefination share the same mechanism, i.e., the carbene mechanism involving a four-membered titanium oxide ring intermediate.[9]

Example 1[3]



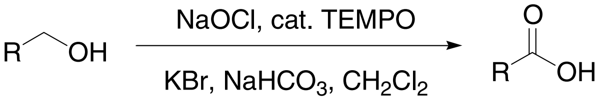
Example 2[4]



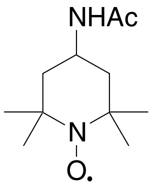
References

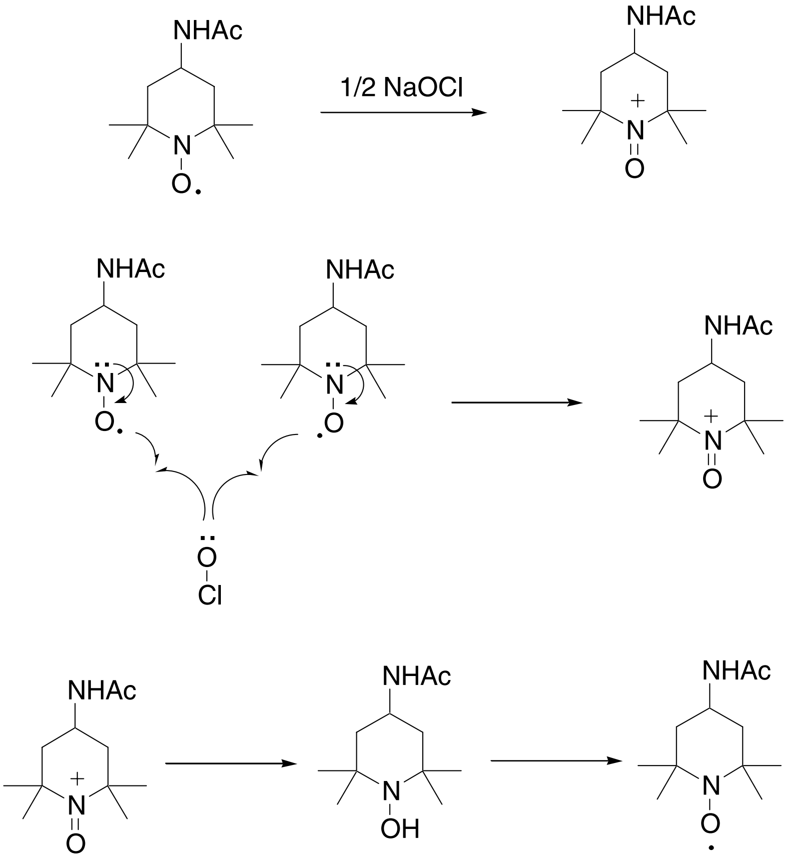
1. Tebbe, F. N.; Parshall, G. W.; Reddy, G. S. *J. Am. Chem. Soc.* **1978**, *100*, 3611.
2. Chou, T. S.; Huang, S. B. *Tetrahedron Lett.* **1983**, *24*, 2169.
3. Pine, S. H.; Pettit, R. J.; Geib, G. D.; Cruz, S. G.; Gallego, C. H.; Tijerina, T.; Pine, R. D. *J. Org. Chem.* **1985**, *50*, 1212.
4. Winkler, J. D.; Muller, C. L.; Scott, R. D. *J. Am. Chem. Soc.* **1988**, *101*, 4831.
5. Petasis, N. A.; Bzowej, E. I. *J. Am. Chem. Soc.* **1990**, *112*, 6392.
6. Schioett, B.; Joergensen, K. A. *J. Chem. Soc., Dalton Trans.* **1993**, 337.
7. Pine, S. H. *Org. React.* **1993**, *43*, 1–98. (Review).
8. Nicolaou, K. C.; Postema, M. H. D.; Claiborne, C. F. *J. Am. Chem. Soc.* **1996**, *118*, 1565.
9. Hughes, D. L.; Payack, J. F.; Cai, D.; Verhoeven, T. R.; Reider, P. J. *Organometallics* **1996**, *15*, 663.
10. Godage, H. Y.; Fairbanks, A. J. *Tetrahedron Lett*. **2000**, *41*, 7589.
11. Hartley, R. C.; McKiernan, G. J. *J. Chem. Soc., Perkin 1* **2002**, 2763–2793. (Review).
12. Jung, M. E.; Pontillo, J. *Tetrahedron* **2003**, *59*, 2729.

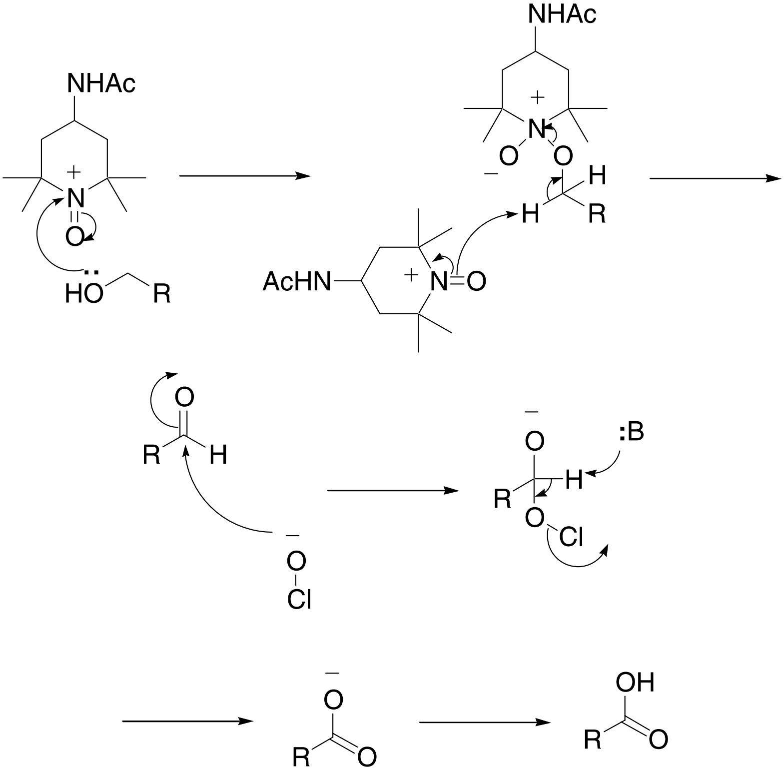
TEMPO-mediated oxidation



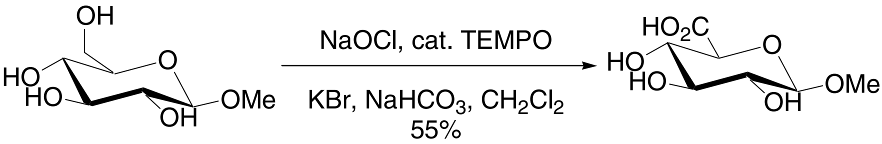
TEMPO = **te**tra**m**ethyl **p**entahydropyridine **o**xide:



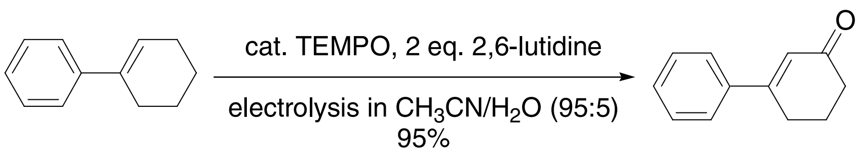




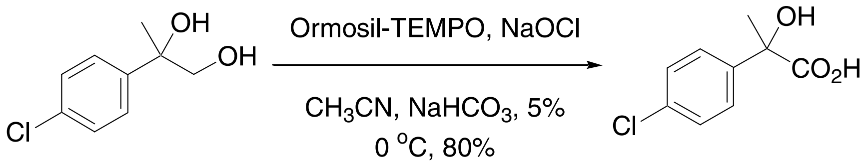
Example 1[7]



Example 2[10]



Example 3[12]



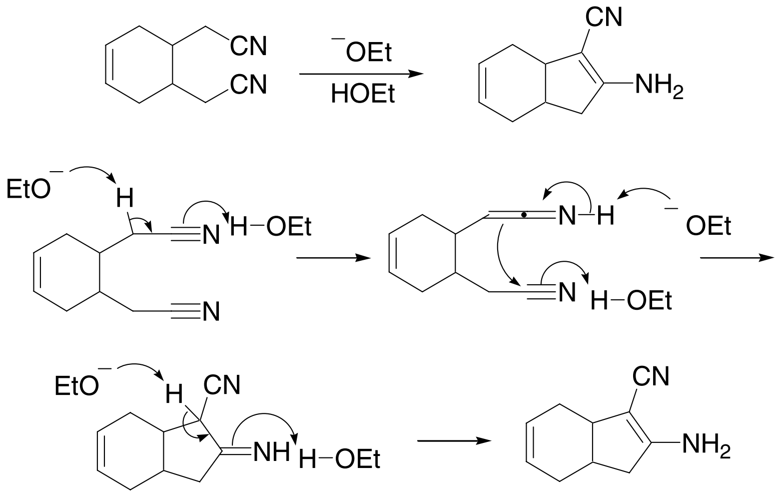
"Ormosil-TEMPO" is a sol-gel hydrophobized nanostructured silica matrix doped with TEMPO

References

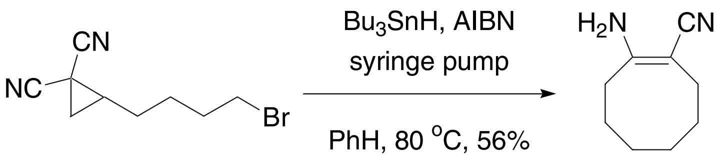
1. Garapon, J.; Sillion, B.; Bonnier, J. M. *Tetrahedron Lett.* **1970**, *11,* 4905.
2. Yamaguchi, M.; Miyazawa, T.; Takata, T.; Endo, T. *Pure Appl. Chem.* **1990**, *62*, 217.
3. Adams, G. W.; Bowie, J. H.; Hayes, R. N.; Gross, M. L. *J. Chem. Soc., Perkin Trans. 2* **1992**, 897.
4. de Nooy, A. E.; Besemer, A. C.; van Bekkum, H. *Synthesis* **1996**, 1153. (Review).
5. Rychnovsky, S.D.; Vaidyanathan, R. *J. Org. Chem.* **1999**, *64*, 310.
6. Bakunov, S. A.; Rukavishnikov, A. V.; Tkachev, A. V. *Synthesis* **2000**, 1148.
7. Fabbrini, M.; Galli, C.; Gentili, P.; Macchitella, D. *Tetrahedron Lett.* **2001**, *42*, 7551.
8. Ciriminna, R.; Pagliaro, M. *Tetrahedron Lett.* **2004**, *45*, 6381.
9. Tashino, Y.; Togo, H. *Synlett* **2004**, 2010.
10. Breton, T.; Liaigre, D.; Belgsir, E. M. *Tetrahedron Lett.* **2005**, *46*, 2487.
11. Chauvin, A.-L.; Nepogodiev, S. A.; Field, R. A. *J. Org. Chem.* **2005**, *47*, 960.
12. Gancitano, P.; Ciriminna, R.; Testa, M. L.; Fidalgo, A.; Ilharco, L. M.; Pagliaro, M. *Org. Biomol. Chem.* **2005**, *3,* 2389.

Thorpe–Ziegler reaction

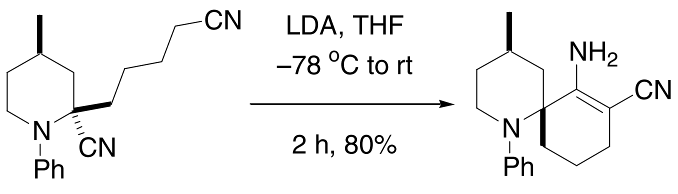
The intramolecular version of the Thorpe reaction, which is base-catalyzed self-condensation of nitriles to yield imines that tautomerize to enamine.



Example 1, a radical Thorpe–Ziegler reaction[5]



Example 2[10]

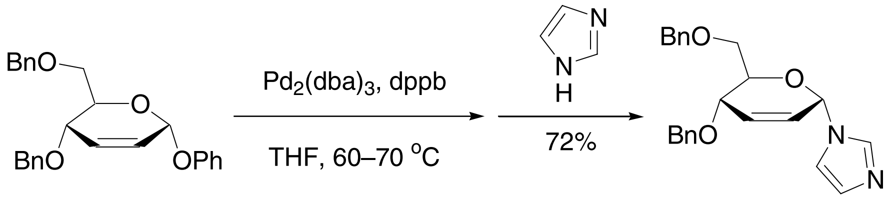


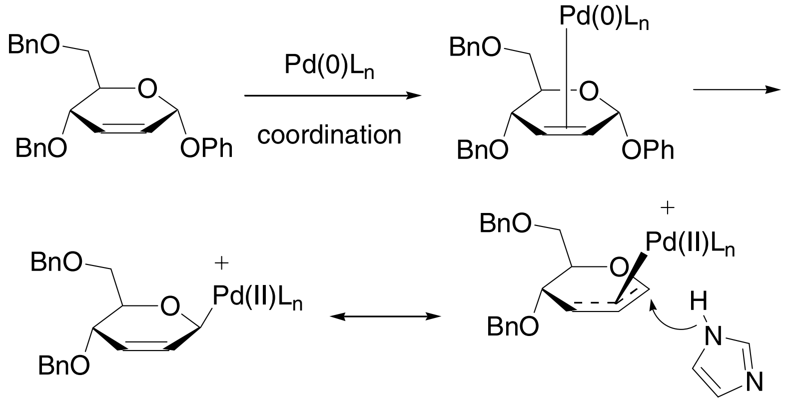
References

1. Baron, H.; Remfry, F. G. P.; Thorpe, Y. F. *J. Chem. Soc.* **1904**, *85*, 1726.
2. Ziegler, K. *et al. Justus Liebigs Ann. Chem.* **1933**, *504,* 94. Karl Ziegler (1898−1973), born in Helsa, Germany, received his Ph.D. in 1920 from von Auwers at the University of Marburg. He became the director of the Max-Planck-Institut für Kohlenforschung at Mülheim/Ruhr in 1943. He shared the Nobel Prize in Chemistry in 1963 with Giulio Natta (1903−1979) for their work in polymer chemistry. The Ziegler−Natta catalyst is widely used in polymerization.
3. Rodriguez-Hahn, L.; Parra M., M.; Martinez, M. *Synth. Commun*. **1984**, *14,* 967.
4. Yakovlev, M. Yu.; Kadushkin, A. V.; Solov'eva, N. P.; Granik, V. G. *Heterocyclic Commun.* **1998**, *4*, 245.
5. Curran, D. P.; Liu, W. *Synlett* **1999**, 117.
6. Dansou, B.; Pichon, C.; Dhal, R.; Brown, E.; Mille, S. *Eur. J. Org. Chem*. **2000**, 1527.
7. Kovacs, L. *Molecules* **2000**, *5*, 127.
8. Gutschow, M.; Powers, J. C. *J. Heterocycl. Chem*. **2001**, *38*, 419.
9. Keller, L.; Dumas, F.; Pizzonero, M.; d'Angelo, J.; Morgant, G.; Nguyen-Huy, D. *Tetrahedron Lett*. **2002**, *43,* 3225.
10. Malassene, R.; Toupet, L.; Hurvois, J.-P.; Moinet, C. *Synlett* **2002**, 895.
11. Malassene, R.; Vanquelef, E.; Toupet, L.; Hurvois, J.-P.; Moinet, C. *Org. Biomol. Chem*. **2003**, *1,* 547.
12. Satoh, T.; Wakasugi, D. *Tetrahedron Lett.* **2003**, *44,* 7517.
13. Wakasugi, D.; Satoh, T. *Tetrahedron* **2005**, *61,* 1245.

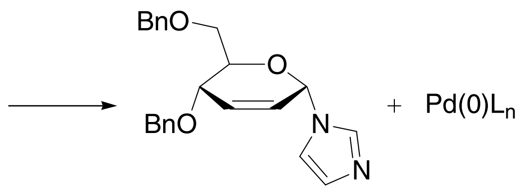
Tsuji–Trost reaction

Palladium-catalyzed allylation using nucleophiles with allylic halides, acetates, carbonates, *etc*. via intermediate allylpalladium complexes, and typically with overall retention of stereochemistry.

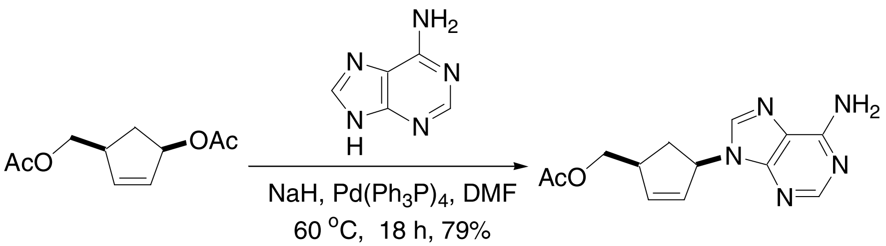




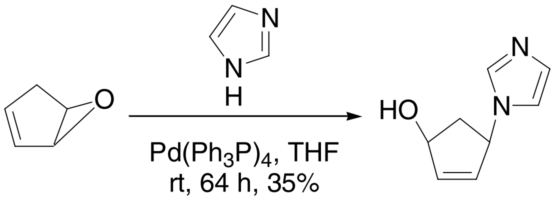
π-allyl complex



Example 1[4]



Example 2[7]

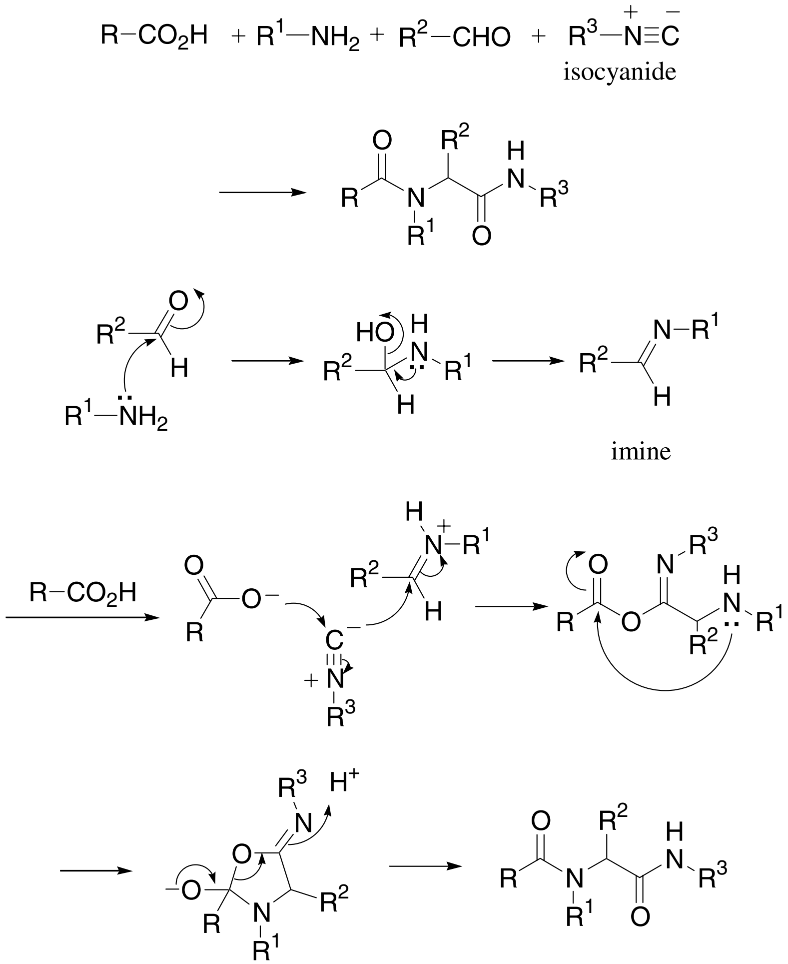


References

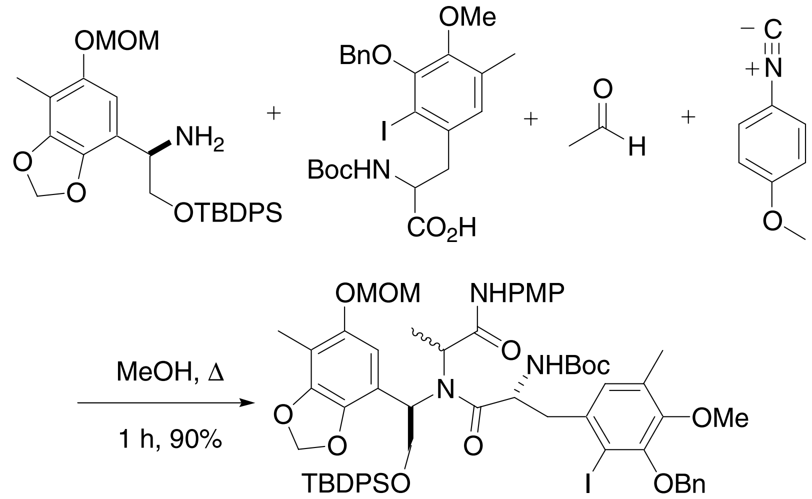
1. Tsuji, J.; Takahashi, H.; Morikawa, M. *Tetrahedron Lett.* **1965**, *6,* 4387.
2. Tsuji, J. *Acc. Chem. Res.* **1969**, *2*, 144. (Review).
3. Godleski, S. A. In *Comprehensive Organic Synthesis;* Trost, B. M.; Fleming, I., eds.; *Vol. 4*. Chapter 3.3. Pergamon: Oxford, **1991**. (Review).
4. Saville-Stones, E. A.; Lindell, S. D.; Jennings, N. S.; Head, J. C.; Ford, M. J. *J. Chem. Soc., Perkin Trans. 1* **1991**, 2603.
5. Bolitt, V.; Chaguir, B.; Sinou, D. *Tetrahedron Lett.* **1992**, *33*, 2481.
6. Moreno-Mañas, M.; Pleixats, R. In *Advances in Heterocyclic Chemistry;* Katritzky, A. R., ed.; Academic Press: San Diego, **1996**, *66*, 73. (Review).
7. Arnau, N.; Cortes, J.; Moreno-Mañas, M.; Pleixats, R.; Villarroya, M. *J. Heterocycl. Chem.* **1997**, *34*, 233.
8. Tietze, L. F.; Nordmann, G. *Eur. J. Org. Chem.* **2001**, 3247.
9. Sato, Y.; Yoshino, T.; Mori, M. *Org. Lett.* **2003**, *5*, 31.
10. Page, P. C. B.; Heaney, H.; Reignier, S.; Rassias, G. A. *Synlett* **2003**, 22.
11. Behenna, D. C.; Stoltz, B. M. *J. Am. Chem. Soc.* **2004**, *126,* 15044.

Ugi reaction

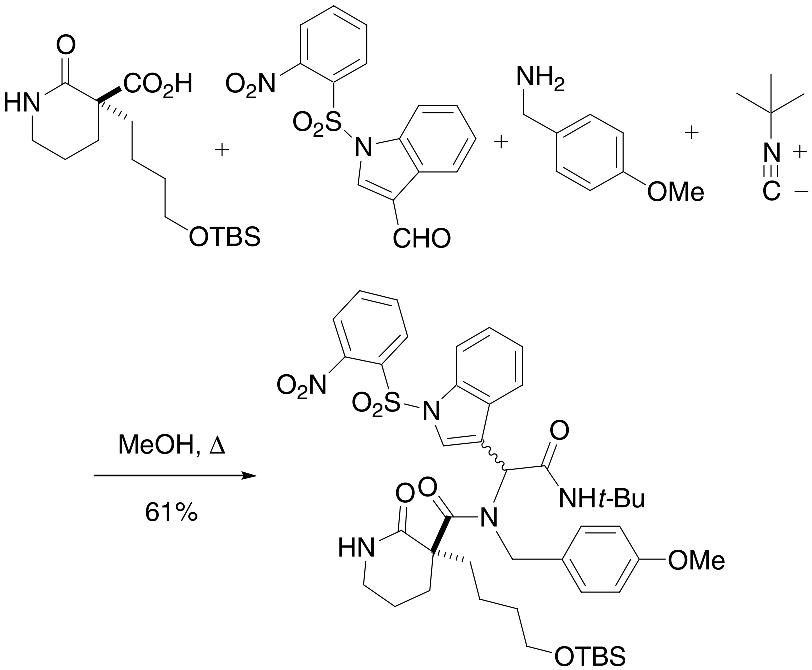
Four-component condensation (4CC) of carboxylic acids, *C*-isocyanides, amines, and carbonyl compounds to afford diamides. *Cf.* Passerini reaction.



Example 1[10]



Example 2[13]

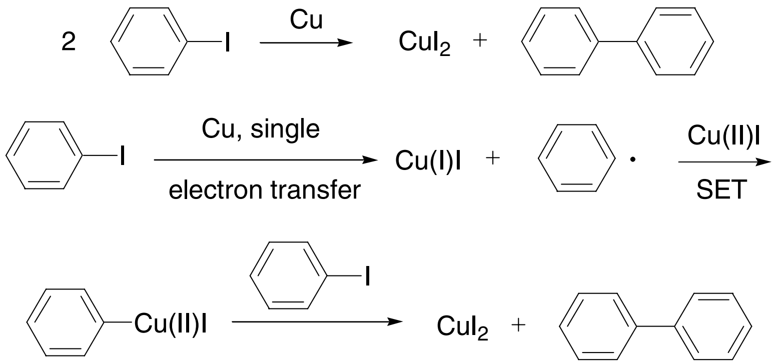


References

1. Ugi, I. *Angew. Chem., Int. Ed. Engl.* **1962**, *1*, 8.
2. Skorna, G.; Ugi, I. *Chem. Ber*. **1979**, *112,* 776.
3. Hoyng, C. F.; Patel, A. D. *Tetrahedron Lett*. **1980**, *21,* 4795.
4. Ugi, I.; Lohberger, S.; Karl, R. In *Comprehensive Organic Synthesis*; Trost, B. M.; Fleming, I., Eds.; Pergamon: Oxford, **1991**, *Vol. 2*, 1083. (Review).
5. Dömling, A.; Ugi, I. *Angew. Chem., Int. Ed.* **2000**, *39*, 3168. (Review).
6. Ugi, I. *Pure Appl. Chem.* **2001**, *73*, 187. (Review).
7. Zimmer, R.; Ziemer, A.; Grunner, M.; Brüdgam, I.; Hartl, H.; Reissig, H.-U. *Synthesis* **2001**, 1649.
8. Kennedy, A. L.; Fryer, A. M.; Josey, J. A. *Org. Lett.* **2002**, *4*, 1167.
9. Baldoli, C.; Maiorana, S.; Licandro, E.; Zinzalla, G.; Perdicchia, D. *Org. Lett.* **2002**, *4*, 4341.
10. Portlock, D. E.; Ostaszewski, R.; Naskar, D.; West, L. *Tetrahedron Lett*. **2003**, *44,* 603.
11. Beck, B.; Larbig, G.; Mejat, B.; Magnin-Lachaux, M.; Picard, A.; Herdtweck, E.; Doemling, A. *Org. Lett.* **2003**, *5*, 1047.
12. Hebach, C.; Kazmaier, U. *Chem. Commun*. **2003**, 596.
13. Oguri, H.; Schreiber, S. L. *Org. Lett.* **2005**, *7*, 47.

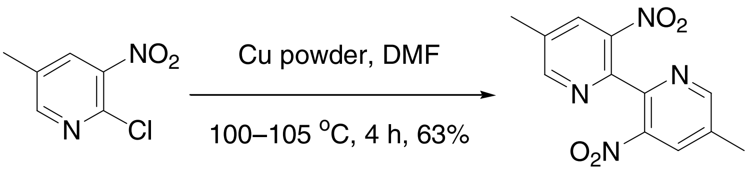
Ullmann reaction

Homocoupling of aryl halides in the presence of Cu or Ni or Pd to afford biaryls.

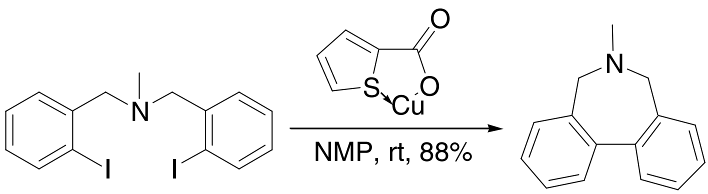


The overall transformation of PhI to PhCuI is an oxidative addition process.

Example 1[5]



Example 2[6]



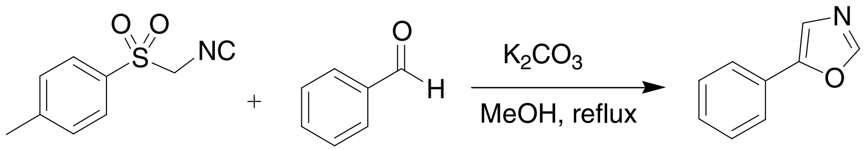
References

1. Ullmann, F.; Bielecki, J. *Chem. Ber.* **1901**, *34,* 2174. Fritz Ullmann (1875−1939), born in Fürth, Bavaria, studied under Graebe at Geneva. He taught at the Technische Hochschule in Berlin and the University of Geneva.
2. Ullmann, F. *Justus Liebigs Ann. Chem.* **1904**, *332,* 38.
3. Fanta, P. E. *Chem. Rev.* **1946**, *38,* 139. (Review).
4. Fanta, P. E. *Synthesis* **1974**, 9. (Review).
5. Dhal, R.; Landais, Y.; Lebrun, A.; Lenain, V.; Robin, J.-P. *Tetrahedron* **1994**, *50,* 1153.

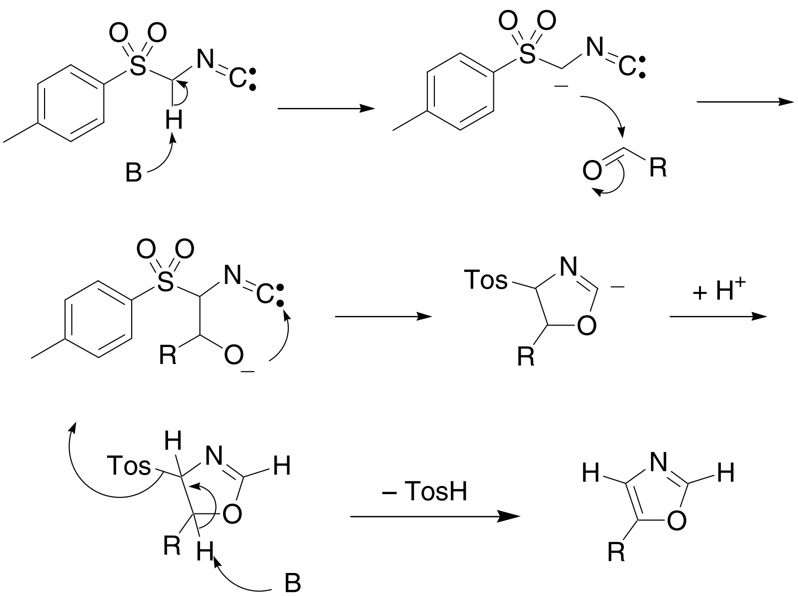
6. Zhang, S.; Zhang, D.; Liebskind, L. S. *J. Org. Chem.* **1997**, *62,* 2312.
7. Stark, L. M.; Lin, X.-F.; Flippin, L. A. *J. Org. Chem.* **2000**, *65,* 3227.
8. Belfield, K. D.; Schafer, K. J.; Mourad, W.; Reinhardt, B. A. *J. Org. Chem.* **2000**, *65,* 4475.
9. Venkatraman, S.; Li, C.-J. *Tetrahedron Lett.* **2000**, *41,* 4831.
10. Farrar, J. M.; Sienkowska, M.; Kaszynski, P. *Synth. Commun.* **2000**, *30,* 4039.
11. Ma, D.; Xia, C. *Org. Lett*. **2001**, *3,* 2583.
12. Buck, E.; Song, Z. J.; Tschaen, D.; Dormer, P. G.; Volante, R. P.; Reider, P. J. *Org. Lett.* **2002**, *4*, 1623.
13. Hameurlaine, A.; Dehaen, W. *Tetrahedron Lett.* **2003**, *44,* 957.
14. Nelson, T. D.; Crouch, R. D. *Org. React.* **2004**, *63,* 265−556. (Review).

van Leusen oxazole synthesis

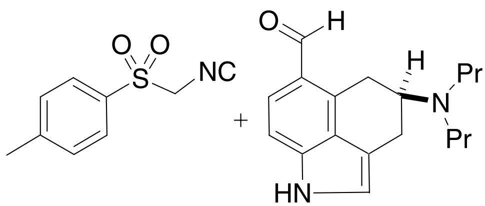
5-Substituted oxazoles through the reaction of *p*-tolylsulfonylmethyl isocyanide (TosMIC) with aldehydes in protic solvents at refluxing temperatures.

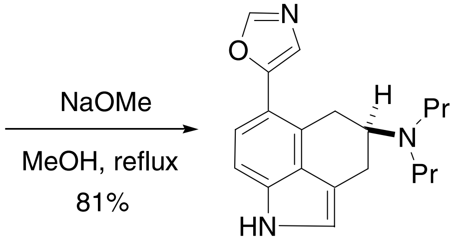


p-tolylsulfonylmethyl isocyanide (TosMIC)

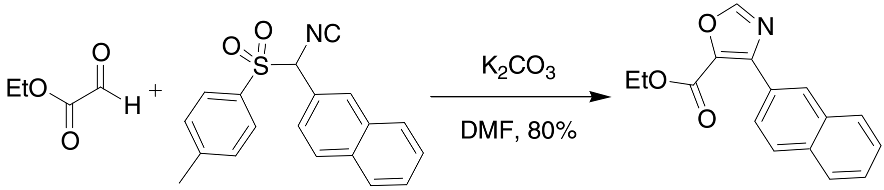


Example 1[7]





Example 2[10]

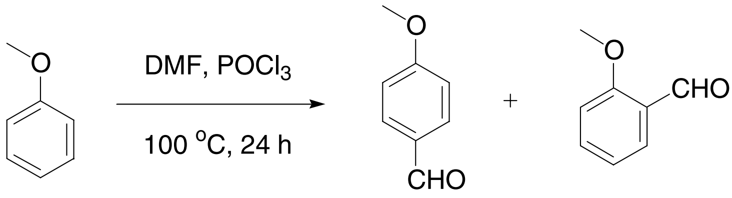


References

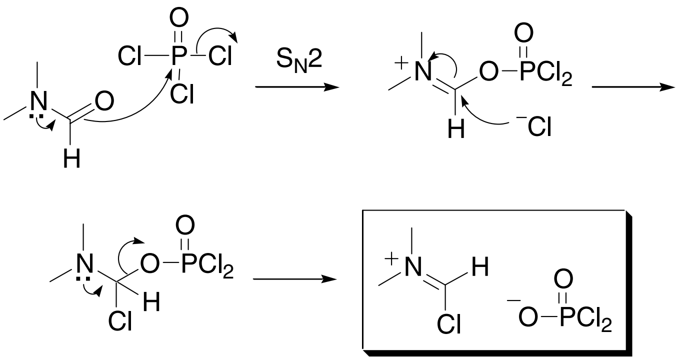
1. van Leusen, A. M.; Hoogenboom, B. E.; Siderius, H. *Tetrahedron Lett.* **1972,** *13,* 2369.
2. Possel, O.; van Leusen, A. M. *Heterocycles* **1977**, *7*, 77.
3. Saikachi, H.; Kitagawa, T.; Sasaki, H.; van Leusen, A. M. *Chem. Pharm. Bull.* **1979**, *27*, 793.
4. van Nispen, S. P. J. M.; Mensink, C.; van Leusen, A. M. *Tetrahedron Lett.* **1980**, *21*, 3723.
5. van Leusen, A. M.; van Leusen, D. In *Encyclopedia of Reagents of Organic Synthesis*; Paquette, L. A., Ed.; Wiley: New York, **1995**; Vol. 7, 4973−4979. (Review).
6. Sisko, J.; Mellinger, M.; Sheldrake, P. W.; Baine, N. *Tetrahedron Lett.* **1996**, *37*, 8113;
7. Anderson, B. A.; Becke, L. M.; Booher, R. N.; Flaugh, M. E.; Harn, N. K.; Kress, T. J.; Varie, D. L.; Wepsiec, J. P. *J. Org. Chem.* **1997**, *62*, 8634.
8. Kulkarni, B. A.; Ganesan, A. *Tetrahedron Lett.* **1999**, *40*, 5633.
9. Kulkarni, B. A.; Ganesan, A. *Tetrahedron Lett.* **1999**, *40*, 5637.
10. Sisko, J.; Kassick, A. J.; Mellinger, M.; Filan, J. J.; Allen, A.; Olsen, M. A. *J. Org. Chem.* **2000**, *65*, 1516.
11. Barrett, A. G. M.; Cramp, S. M.; Hennessy, A. J.; Procopiou, P. A.; Roberts, R. S. *Organic Lett.* **2001**, *3*, 271.
12. Herr, R. J.; Fairfax, D. J., Meckler, H.; Wilson, J. D. *Org. Process Rec. Dev.* **2002**, *6*, 677.
13. Brooks, D. A. *van Leusen Oxazole Synthesis* in *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 254–259. (Review).

Vilsmeier–Haack reaction

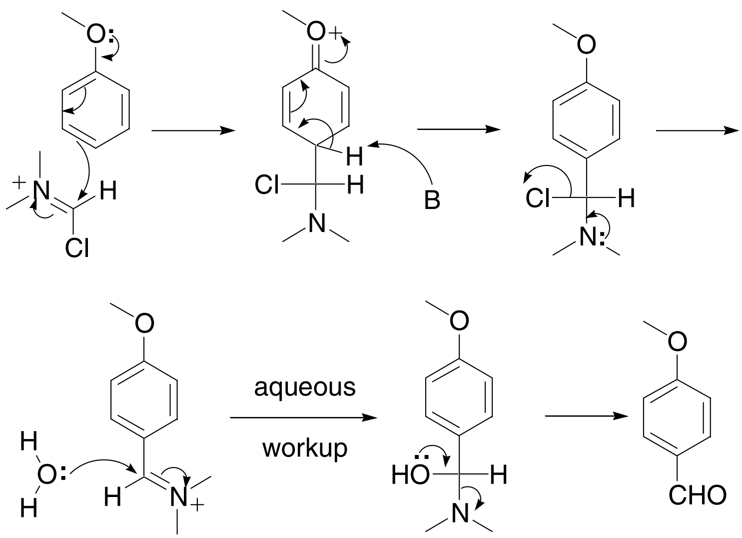
The Vilsmeier–Haack reagent, a chloroiminium salt, is a weak electrophile. Therefore, the Vilsmeier–Haack reaction works better with electron-rich carbocycles and heterocycles.



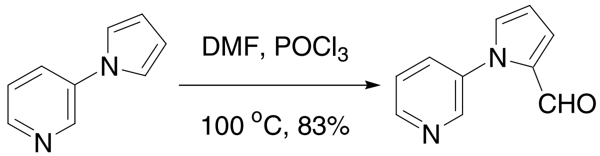
34% 4%



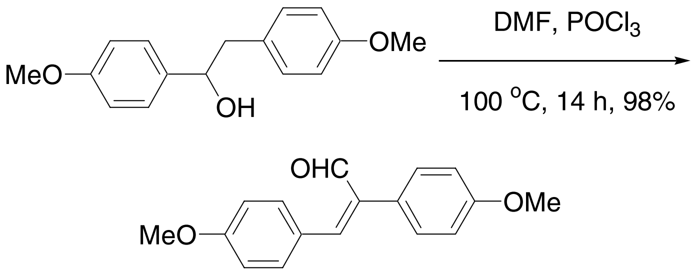
Vilsmeier–Haack reagent



Example 1[3]



Example 2[2]

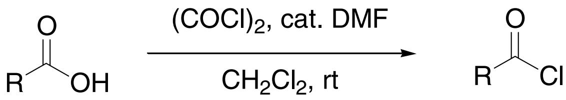


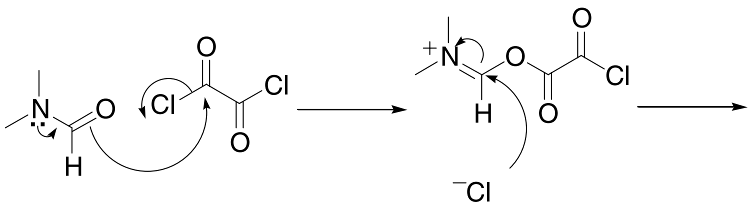
References

1. Vilsmeier, A.; Haack, A. *Ber. Dtsch. Chem. Ges.* **1927**, *60*, 119.
2. Reddy, M. P.; Rao, G. S. K. *J. Chem. Soc., Perkin Trans. 1* **1981**, 2662.
3. Lancelot, J.-C.; Ladureé, D.; Robba, M. *Chem. Pharm. Bull. Jpn.* **1985**, *33*, 3122.
4. Marson, C. M.; Giles, P. R. *Synthesis Using Vilsmeier Reagents* CRC Press, **1994**. (Book).
5. Seybold, G. *J. Prakt. Chem.* **1996**, *338,* 392−396 (Review).
6. Jones, G.; Stanforth, S. P. *Org. React.* **1997**, *49*, 1. (Review).
7. Jones, G.; Stanforth, S. P. *Org. React.* **2000**, *56*, 1. (Review).
8. Ali, M. M.; Tasneem; Rajanna, K. C.; Sai Prakash, P. K. *Synlett* **2001**, 251.
9. Thomas, A. D.; Asokan, C. V. *J. Chem. Soc., Perkin Trans. 1* **2001**, 2583.
10. Tasneem, *Synlett* **2003**, 138. (Review of the Vilsmeier–Haack reagent).

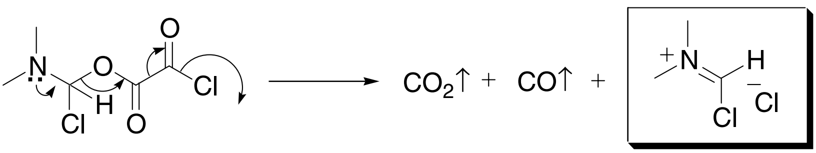
Vilsmeier mechanism for acid chloride formation

Transformation of a carboxylic acid to the corresponding acid chloride using oxalyl chloride and catalytic amount of dimethyl formamide (DMF). It is a lot faster than without DMF, which generally needs reflux.

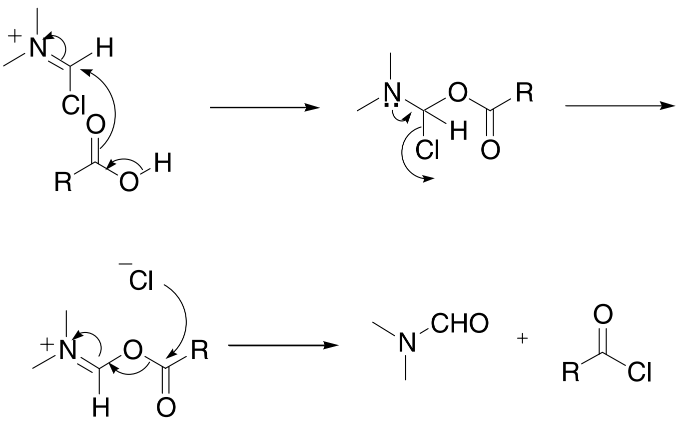




DMF oxalyl chloride



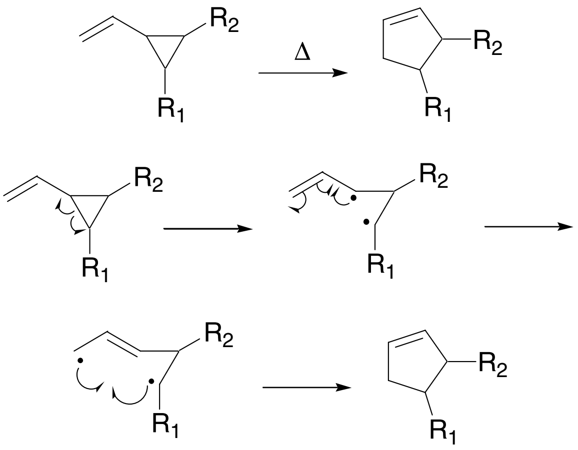
Vilsmeier–Haack reagent



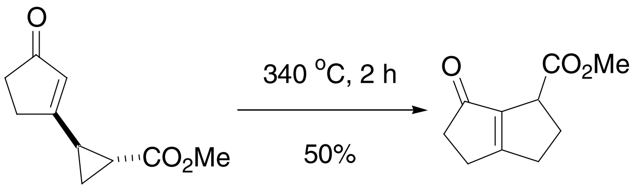
DMF recovered, therefore only catalytic amount is required

Vinylcyclopropane–cyclopentene rearrangement

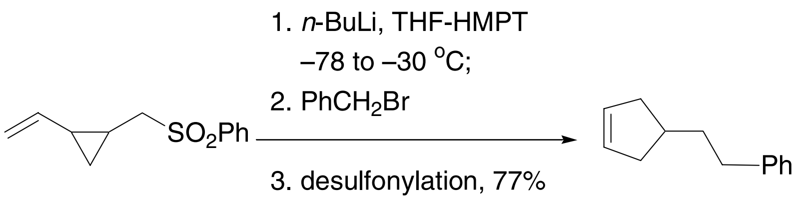
Transformation of vinylcyclopropane to cyclopentene *via* a diradical intermediate.



Example 1[5]



Example 2[6]



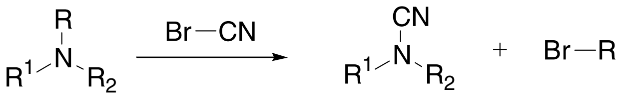
References

1. Neureiter, N. P. *J. Org. Chem.* **1959**, *24*, 2044.
2. Vogel, E. *Angew. Chem.* **1960**, *72*, 4.
3. Overberger, C. G.; Borchert, A. E. *J. Am. Chem. Soc.* **1960**, *82,* 1007, 4896.
4. Flowers, M. C.; Frey, H. M. *J. Chem. Soc.* **1961**, 3547.
5. Brule, D.; Chalchat, J. C.; Garry, R. P.; Lacroix, B.; Michet, A.; Vessier, R. *Bull. Soc. Chim. Fr.* **1981**, 57.

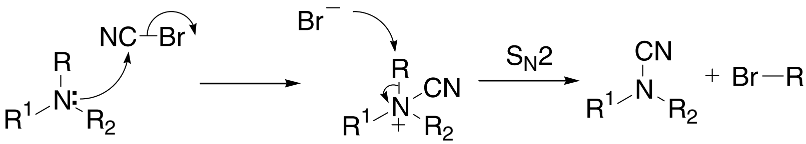
6. Danheiser, R. L.; Bronson, J. J.; Okano, K. *J. Am. Chem. Soc*. **1985**, *107,* 4579.
7. Hudlický, T.; Kutchan, T. M.; Naqvi, S. M. *Org. React.* **1985**, *33*, 247−335. (Review).
8. Goldschmidt, Z.; Crammer, B. *Chem. Soc. Rev.* **1988**, *17*, 229−267. (Review).
9. Sonawane, H. R.; Bellur, N. S.; Kulkarni, D. G.; Ahuja, J. R. *Synlett* **1993**, 875−884. (Review).
10. Hiroi, K.; Arinaga, Y. *Tetrahedron Lett.* **1994**, *35*, 153.
11. Chuang, S.-C.; Islam, A.; Huang, C.-W.; Shih, H.-T.; Cheng, C.-H. *J. Org. Chem*. **2003**, *68*, 3811.
12. Baldwin, J. E. *Chem. Rev*. **2003**, *103*, 1197−1212. (Review).
13. Smart, B. E.; Krusic, P. J.; Roe, D. C.; Yang, Z.-Y. *J. Fluorine Chem*. **2004**, *117*, 199.

von Braun reaction

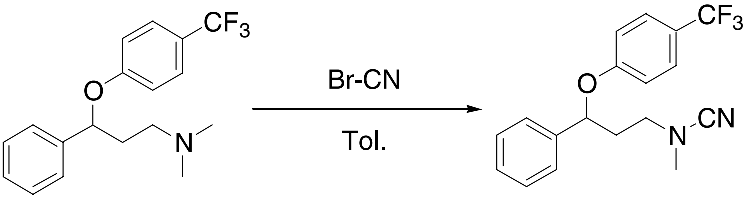
Treatment of tertiary amines with cyanogen bromide, resulting in a substituted cyanamide and alkyl halides.

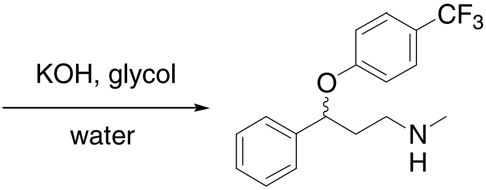


Cyanogen bromide (BrCN) is a *counterattack reagent*.



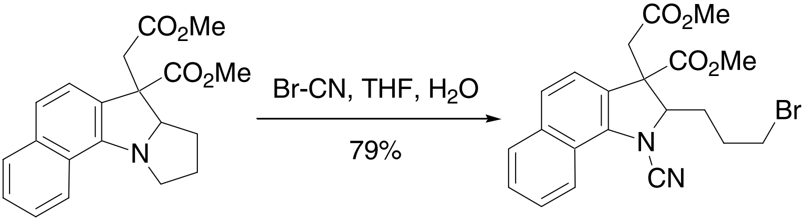
Example 1[6]





Prozac

Example 2[7]

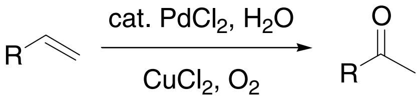


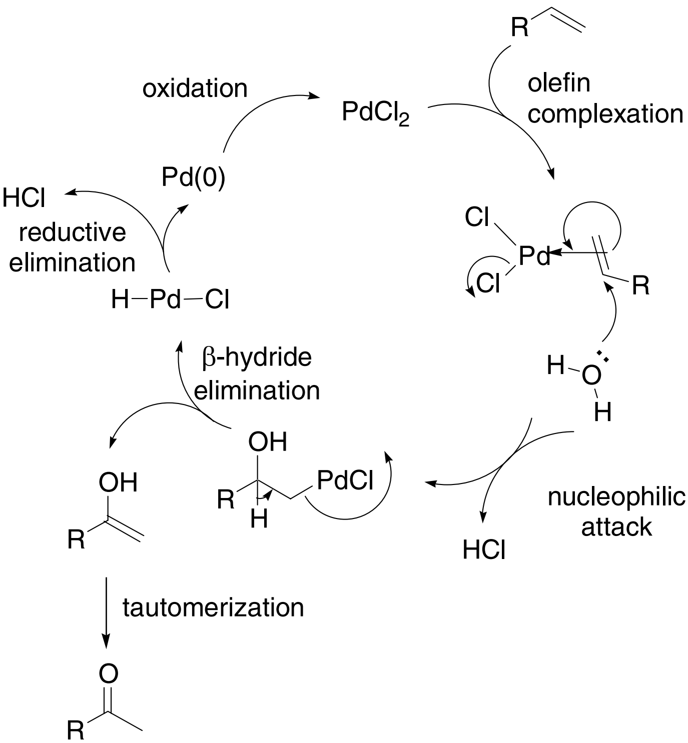
References

1. von Braun, J. *Ber. Dtsch. Chem. Ges.* **1907**, *40*, 3914. Julius von Braun (1875−1940) was born in Warsaw, Poland. He was a Professor of Chemistry at Frankfurt.
2. Hageman, H. A. *Org. React.* **1953**, *7*, 198. (Review).
3. Fodor, G.; Abidi, S.-Y.; Carpenter, T. C. *J. Org. Chem.* **1974**, *39*, 1507.
4. Nakahara, Y.; Niwaguchi, T.; Ishii, H. *Tetrahedron* **1977**, *33*, 1591.
5. Fodor, G.; Nagubandi, S. *Tetrahedron* **1980**, *36*, 1279−1300. (Review).
6. Perni, R. B.; Gribble, G. W. *Org. Prep. Proced. Int.* **1980**, *15*, 297.
7. Verboom, W.; Visser, G. W.; Reinhoudt, D. N. *Tetrahedron* **1982**, *38*, 1831.
8. McLean, S.; Reynolds, W. F.; Zhu, X. *Can. J. Chem.* **1987**, *65*, 200.
9. Cooley, J. H.; Evain, E. J. *Synthesis* **1989**, 1.
10. Aguirre, J. M.; Alesso, E. N.; Ibanez, A. F.; Tombari, D. G.; Moltrasio Iglesias, G. Y. *J. Heterocycl. Chem.* **1989**, *26*, 25.
11. Laabs, S.; Scherrmann, A.; Sudau, A.; Diederich, M.; Kierig, C.; Nubbemeyer, U. *Synlett* **1999**, 25.
12. Chambert, S.; Thomasson, F.; Décout, J.-L. *J. Org. Chem.* **2002**, *67*, 1898.
13. Hatsuda, M.; Seki, M. *Tetrahedron* **2005**, *61*, 9908.

Wacker oxidation

Palladium-catalyzed oxidation of olefins to ketones.





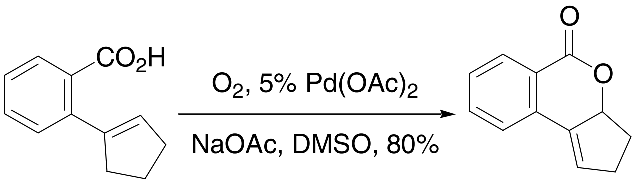
Regeneration of Pd(II):

$$Pd(0) + 2\,CuCl_2 \longrightarrow PdCl_2 + 2\,CuCl$$

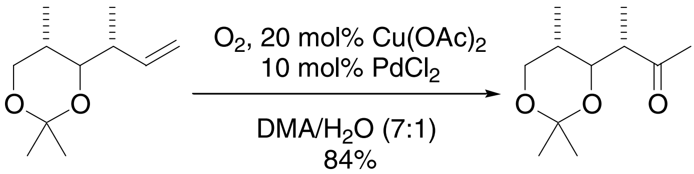
Regeneration of Cu(II):

$$CuCl + O_2 \longrightarrow CuCl_2 + H_2O$$

Example 1[6]



Example 2[10]

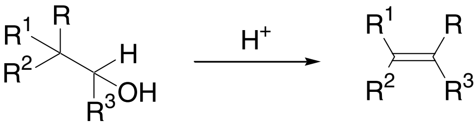


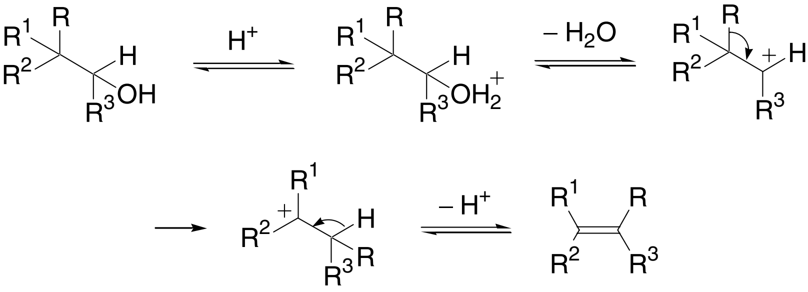
References

1. Smidt, J.; Sieber, R. *Angew. Chem., Int. Ed.* **1962**, *1*, 80.
2. Tsuji, J. *Synthesis* **1984**, 369. (Review).
3. Miller, D. G.; Wayner, D. D. M. *J. Org. Chem.* **1990**, *55*, 2924.
4. Hegedus, L. S. In *Comp. Org. Syn.* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 4*, 552. (Review).
5. Tsuji, J. In *Comp. Org. Syn.* Trost, B. M.; Fleming, I., Eds.; Pergamon, **1991**, *Vol. 7*, 449. (Review).
6. Larock, R. C.; Hightower, T. R. *J. Org. Chem.* **1993**, *58*, 5298.
7. Hegedus, L. S. *Transition Metals in the Synthesis of Complex Organic Molecule* **1994**, University Science Books: Mill Valley, CA, pp 199−208. (Review).
8. Kang, S.-K.; Jung, K.-Y.; Chung, J.-U.; Namkoong, E.-Y.; Kim, T.-H. *J. Org. Chem.* **1995**, *60*, 4678.
9. Feringa, B. L. *Wacker oxidation.* In *Transition Met. Org. Synth.* Beller, M.; Bolm, C., eds., Wiley-VCH: Weinheim, Germany. **1998**, *2*, 307−315. (Review).
10. Smith, A. B.; Friestad, G. K.; Barbosa, J.; Bertounesque, E.; Hull, K. G.; Iwashima, M.; Qiu, Y.; Salvatore, B. A.; Spoors, P. G.; Duan, J. J.-W. *J. Am. Chem. Soc.* **1999**, *121*, 10468.
11. Gaunt, M. J.; Yu, J.; Spencer, J. B. *Chem. Commun.* **2001**, 1844.
12. Barker, D.; Brimble, M. A.; McLeod, M.; Savage, G. P.; Wong, D. J. *J. Chem. Soc., Perkin Trans. 1*, **2002**, 924.
13. Thadani, A. N.; Rawal, V. H. *Org. Lett.* **2002**, *4,* 4321.
14. Ho, T.-L.; Chang, M. H.; Chen, C. *Tetrahedron Lett.* **2003**, *44,* 6955.
15. Hintermann, L. *Wacker-type Oxidations.* In *Transition Met. Org. Synth. (2nd edn.)* Beller, M.; Bolm, C., eds., Wiley-VCH: Weinheim, Germany. **2004**, *2*, 379−388. (Review).
16. Cornell, C. N.; Sigman, M. S. *J. Am. Chem. Soc.* **2005**, *127,* 2796.

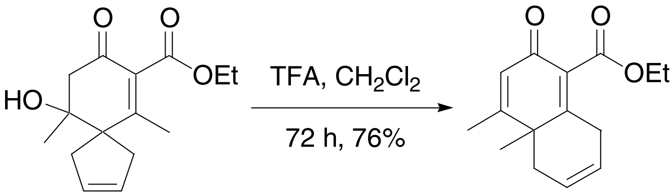
Wagner–Meerwein rearrangement

Acid-catalyzed alkyl group migration of alcohols to give more substituted olefins.

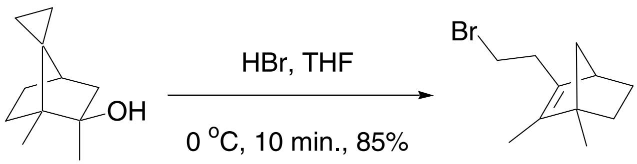




Example 1[13]



Example 2[14]



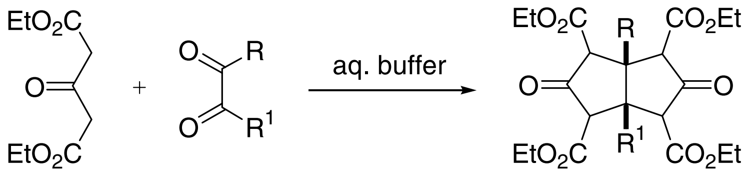
References

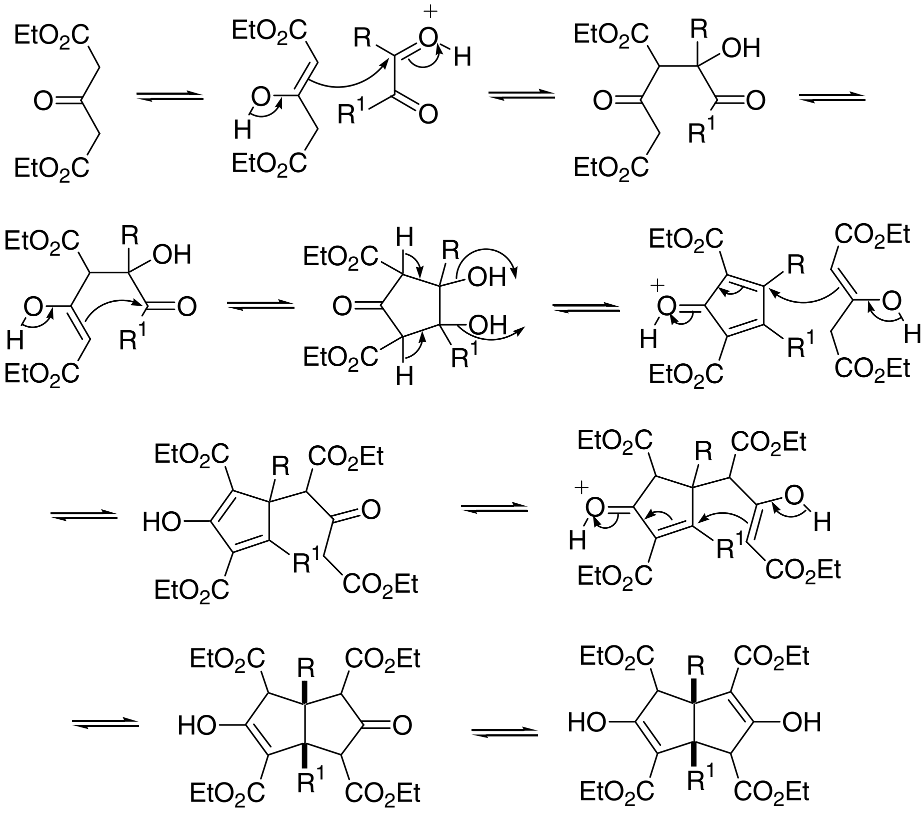
1. Wagner, G. *J. Russ. Phys. Chem. Soc.* **1899**, *31,* 690.
2. Hogeveen, H.; Van Kruchten, E. M. G. A. *Top. Curr. Chem.* **1979**, *80,* 89. (Review).
3. Martinez, A. G.; Vilar, E. T.; Fraile, A. G.; Fernandez, A. H.; De La Moya Cerero, S.; Jimenez, F. M. *Tetrahedron* **1998**, *54,* 4607.
4. Birladeanu, L. *J. Chem. Educ.* **2000**, *77,* 858.
5. Kobayashi, T.; Uchiyama, Y. *J. Chem. Soc., J. Chem. Soc., Perkin 1* **2000**, 2731.
6. Trost, B. M.; Yasukata, T. *J. Am. Chem. Soc.* **2001**, *123,* 7162.

7. Cerda-Garcia-Rojas, C. M.; Flores-Sandoval, C. A.; Roman, L. U.; Hernandez, J. D.; Joseph-Nathan, P. *Tetrahedron* **2002**, *58,* 1061.
8. Colombo, M. I.; Bohn, M. L.; Ruveda, E. A. *J. Chem. Educ.* **2002**, *79,* 484.
9. Román, L. U.; Cerda-Garcia-Rojas, C. M.; Guzmán, R.; Armenta, C.; Hernández, J. D.; Joseph-Nathan, P. *J. Nat. Products* **2002**, *65,* 1540.
10. Martinez, A. G.; Vilar, E. T.; Fraile, A. G.; Martinez-Ruiz, P. *Tetrahedron* **2003**, *59,* 1565.
11. Guizzardi, B.; Mella, M.; Fagnoni, M.; Albini, A. *J. Org. Chem.* **2003**, *68*, 1067.
12. Zubkov, F. I.; Nikitina, E. V.; Turchin, K. F.; Aleksandrov, G. G.; Safronova, A. A.; Borisov, R. S.; Varlamov, A. V. *J. Org. Chem.* **2004**, *69*, 432.
13. Bose, G.; Ullah, E.; Langer, P. *Chem. Eur. J.* **2004**, *10*, 6015.
14. Li, W.-D. Z.; Yang, Y.-R. *Org. Lett.* **2005**, *7*, 3107.

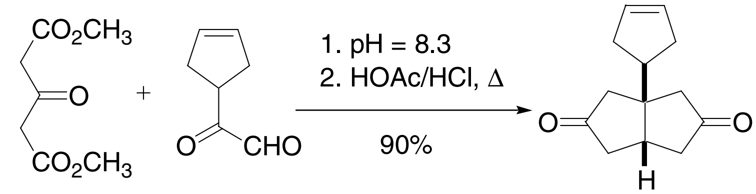
Weiss–Cook reaction

Synthesis of *cis*-bicyclo[3.3.0]octane-3,7-dione.

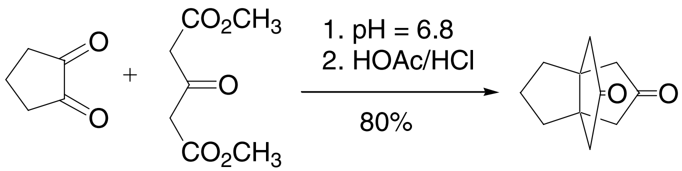




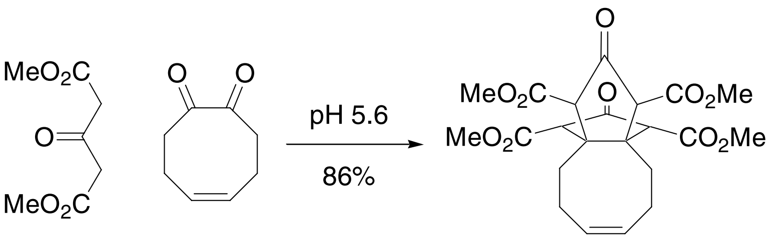
Example 1[2]



Example 2[3]



Example 3[6]

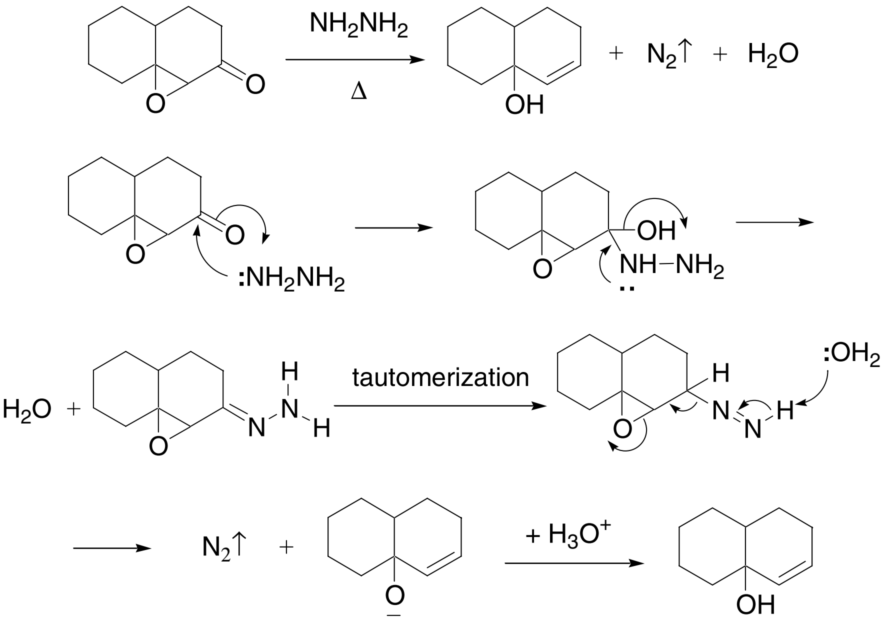


References

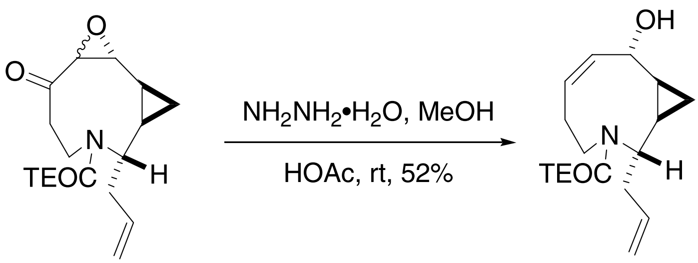
1. Weiss, U.; Edwards, J. M. *Tetrahedron Lett*. **1968**, *9*, 4885.
2. Kubiak, G.; Fu, X.; Gupta, A. K.; Cook, J. M. *Tetrahedron Lett*. **1990**, *31*, 4285.
3. Wrobel, J.; Takahashi, K.; Honkan, V.; Lannoye, G.; Bertz, S. H.; Cook, J. M. *J. Org Chem.* **1983**, *48*, 139.
4. Gupta, A. K.; Fu, X.; Snyder, J. P.; Cook, J. M. *Tetrahedron* **1991**, *47*, 3665.
5. Reissig, H. U. *Org. Synth. Highlights* **1991**, 121. (Review).
6. Paquette, L. A.; Kesselmayer, M. A.; Underiner, G. E.; House, S. D.; Rogers, R. D.; Meerholz, K.; Heinze, J. *J. Am. Chem. Soc.* **1992**, *114*, 2644.
7. Fu, X.; Cook, J. M. *Aldrichimica Acta* **1992**, *25*, 43. (Review).
8. Fu, X.; Kubiak, G.; Zhang, W.; Han, W.; Gupta, A. K.; Cook, J. M. *Tetrahedron* **1993**, *49*, 1511.
9. van Ornum, S. G.; Li, J.; Kubiak, G. G.; Cook, J. M. *J. Chem. Soc., Perkin Trans. 1* **1997**, 3471.
10. Cadieux, J. A.; Buller, J. D.; Wilson, P. D. *Org. Lett.* **2003**, *5*, 3983.

Wharton oxygen transposition reaction

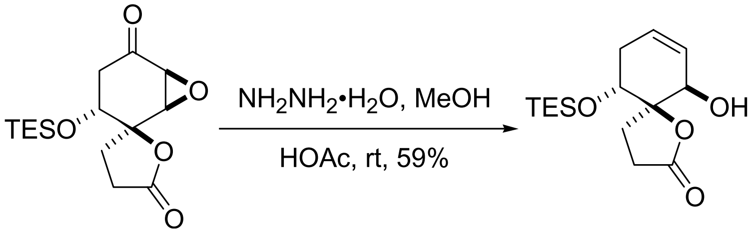
Reduction of α,β-epoxy ketones by hydrazine to allylic alcohols.



Example 1[5]



Example 2[7]

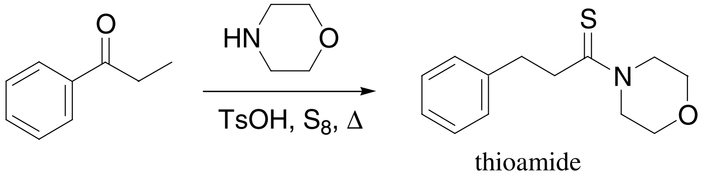


References

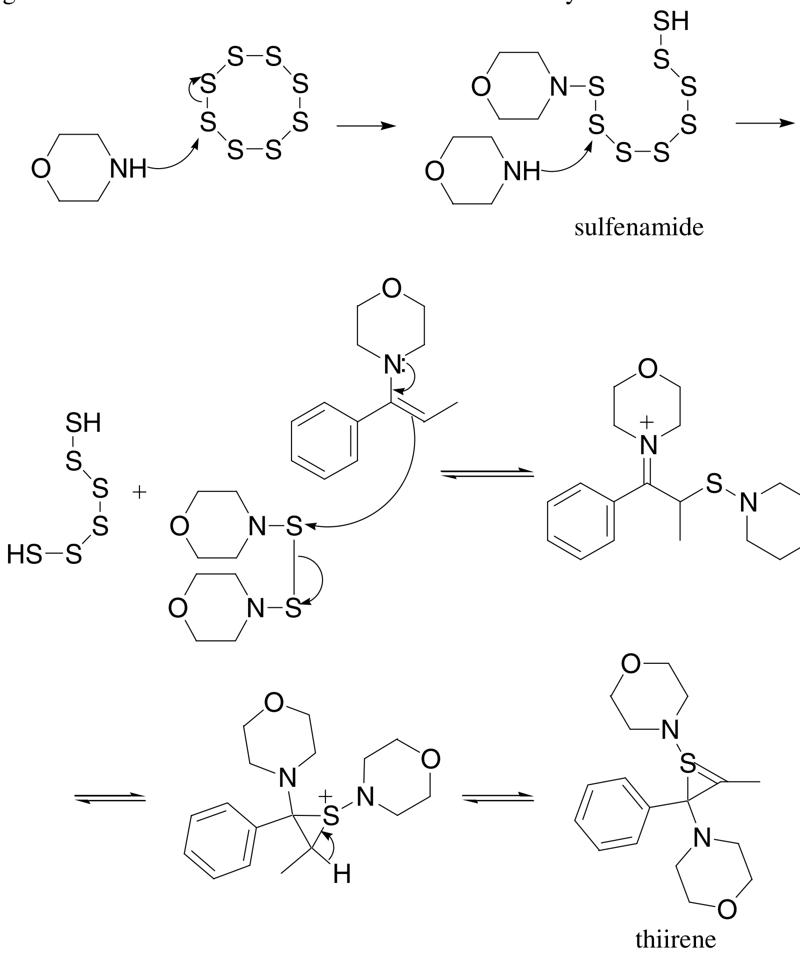
1. Wharton, P. S.; Bohlen, D. H. *J. Org. Chem.* **1961**, *26*, 3615.
2. Wharton, P. S. *J. Org. Chem.* **1961**, *26*, 4781.
3. Caine, D. *Org. Prep. Proced. Int.* **1988**, *20*, 1. (Review).
4. Dupuy, C.; Luche, J. L. *Tetrahedron* **1989**, *45*, 3437–3444. (Review).
5. Kim, G.; Chu-Moyer, M. Y.; Danishefsky, S. J. *J. Am. Chem. Soc.* **1990**, *112*, 2003.
6. Di Filippo, M.; Fezza, F.; Izzo, I.; De Riccardis, F.; Sodano, G. *Eur. J. Org. Chem.* **2000**, 3247.
7. Takagi, R.; Tojo, K.; Iwata, M.; Ohkata, K. *Org. Biomol. Chem.* **2005**, *3,* 2031.

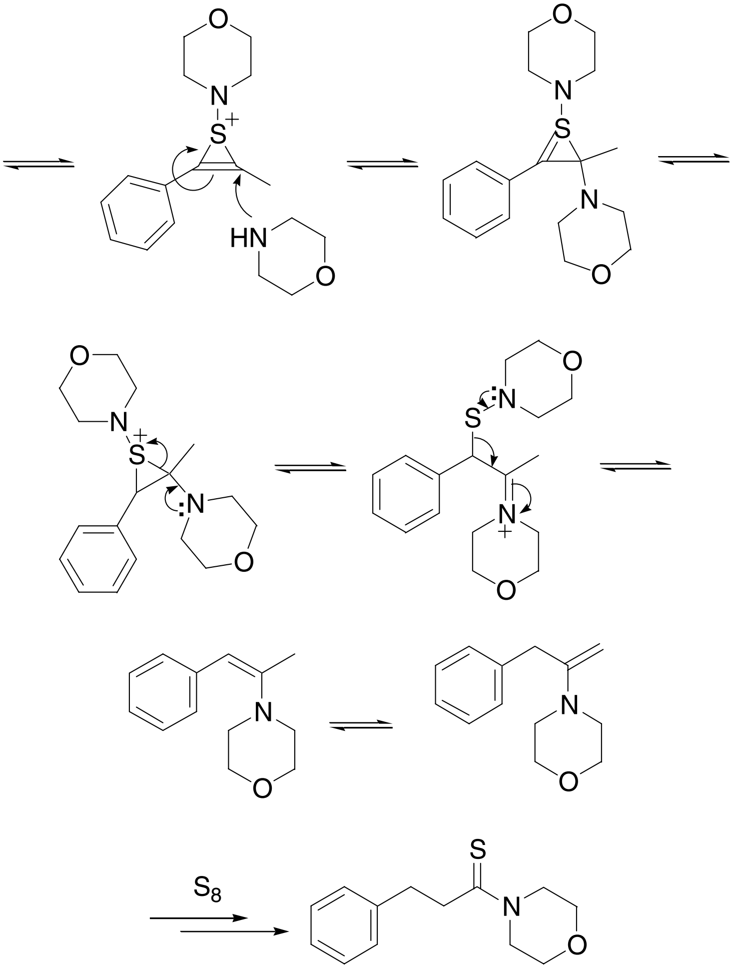
Willgerodt–Kindler reaction

Conversion of ketones to the corresponding thioamide and/or ammonium salt.

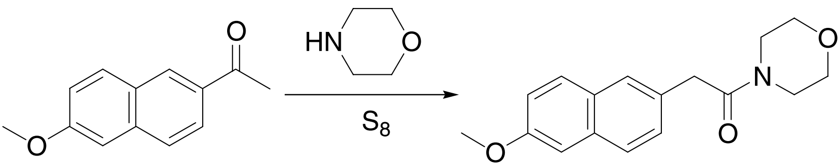


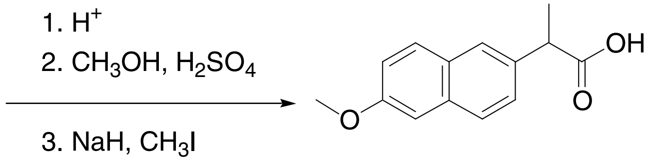
In Carmack's mechanism,[8] the most unusual movement of a carbonyl group from methylene carbon to methylene carbon was proposed to go through an intricate pathway *via* a highly reactive intermediate with a sulfur-containing heterocyclic ring. The sulfenamide serves as the isomerization catalyst:





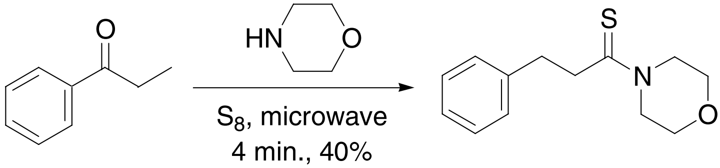
Example 1, the Willgerodt–Kindler reaction was a key operation in the initial synthesis of racemic Naproxen:[6]





naproxen

Example 2[11]

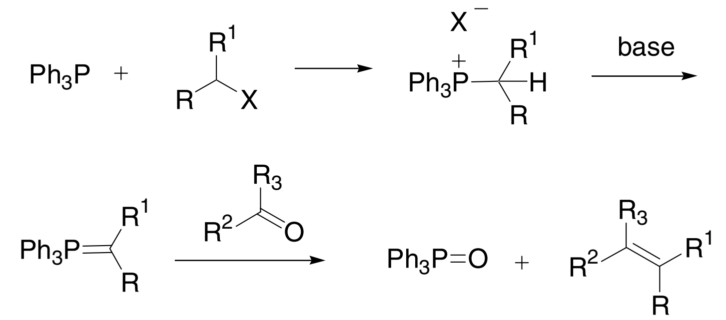


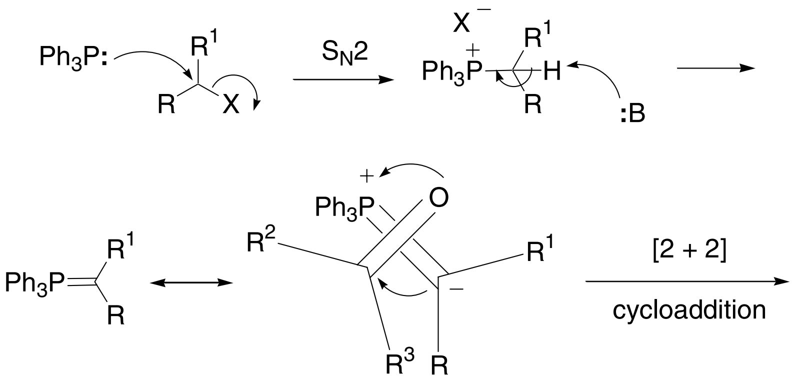
References

1. Willgerodt, C. *Ber. Dtsch. Chem. Ges.* **1887**, *20*, 2467. Conrad Willgerodt (1841–1930), born in Harlingerode, Germany, was a son of a farmer. He worked to accumulate enough money to support his study toward his doctorate, which he received from Claus. He became a professor at Freiburg, where he taught for 37 years.
2. Kindler, K. *Arch. Pharm.* **1927**, *265,* 389.
3. Carmack, M. *Org. React.* **1946**, *3,* 83. (Review).
4. Schneller, S. W. *Int. J. Sulfur Chem. B* **1972**, *7,* 155.
5. Schneller, S. W. *Int. J. Sulfur Chem.* **1973**, *8,* 485.
6. Harrison, I. T.; Lewis, B.; Nelson, P.; Rooks, W.; Roskowski, A.; Tomolonis, A.; Fried, J. H. *J. Med. Chem.* **1970**, *13,* 203.
7. Schneller, S. W. *Int. J. Sulfur Chem.* **1976**, *8,* 579.
8. Carmack, M. *J. Heterocycl. Chem.* **1989**, *26,* 1319.
9. You, Q.; Zhou, H.; Wang, Q.; Lei, X. *Org. Prep. Proced. Int*. **1991**, *23,* 435.
10. Chatterjea, J. N.; Singh, R. P.; Ojha, N.; Prasad, R. *J. Inst. Chem. (India)* **1998**, *70,* 108.
11. Nooshabadi, M.; Aghapoor, K.; Darabi, H. R.; Mojtahedi, M. M. *Tetrahedron Lett.* **1999**, *40*, 7549.
12. Moghaddam, F. M.; Ghaffarzadeh, M.; Dakamin, M. G. *J. Chem. Res., (S)* **2000**, 228.
13. Poupaert, J. H.; Bouinidane, K.; Renard, M.; Lambert, D. M.; Isa, M. *Org. Prep. Proced. Int*. **2001**, *33,* 335.
14. Alam, M. M.; Adapa, S. R. *Synth. Commun.* **2003**, *33,* 59.
15. Reza Darabi, H.; Aghapoor, K.; Tajbakhsh, M. *Tetrahedron Lett.* **2004**, *45*, 4167.
16. Purrello, G. "Some aspects of the Willgerodt–Kindler reaction and connected reactions." *Heterocycles* **2005**, *65*, 411–449. (Review).

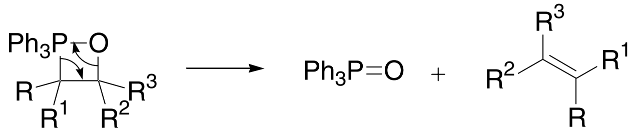
Wittig reaction

Olefination of carbonyls using phosphorus ylides.



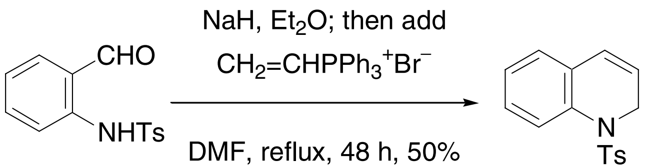


"puckered" transition state, irreversible and concerted

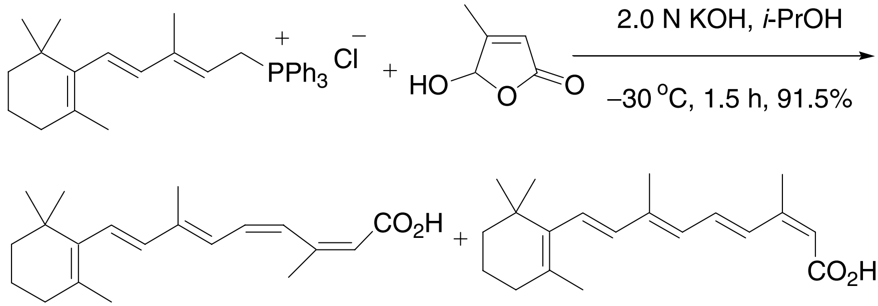


oxaphosphetane intermediate

Example 1[3]



Example 2[4]

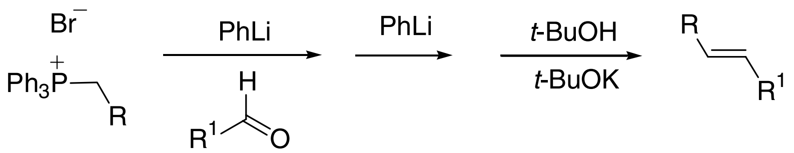


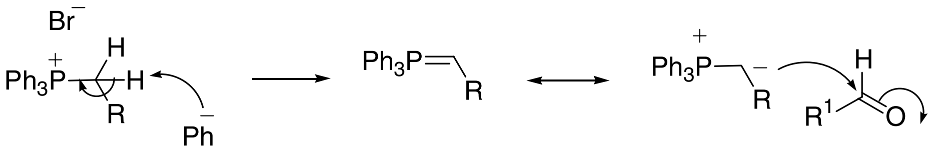
2-*cis*-4-*cis*-vitamin A acid

Accutane

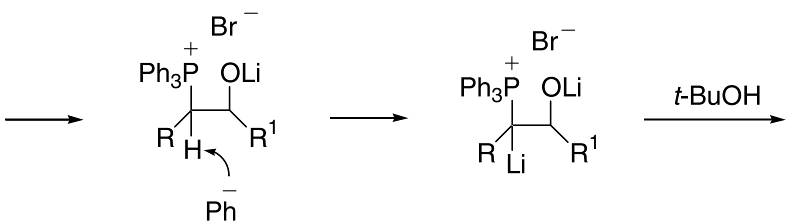
Schlosser modification of the Wittig reaction[11–17]

The normal Wittig reaction of nonstabilized ylides with aldehydes gives *Z*-olefins. The Schlosser modification of the Wittig reaction of nonstabilized ylides furnishes *E*-olefins instead.

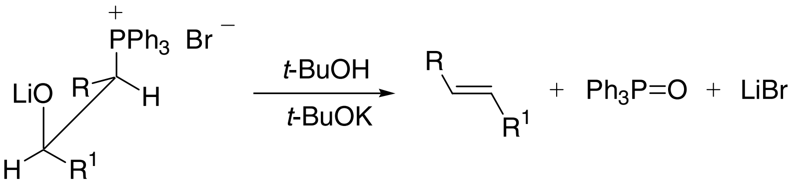




phosphorus ylide



LiBr complex of β-oxo ylide



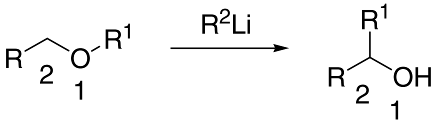
LiBr complex of *threo*-betaine

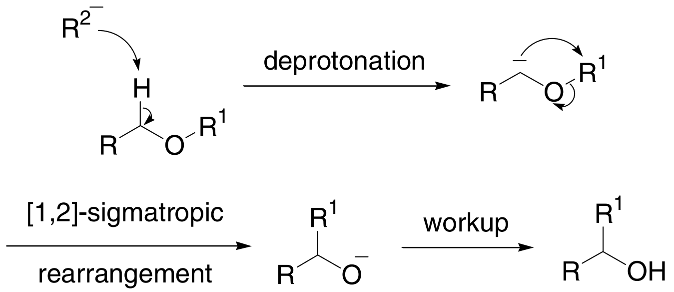
References

1. Wittig, G.; Schöllkopf, U. *Ber. Dtsch. Chem. Ges.* **1954**, *87*, 1318. Georg Wittig (Germany, 1897−1987), born in Berlin, Germany, received his Ph.D. from K. von Auwers. He shared the Nobel Prize in Chemistry in 1981 with Herbert C. Brown (USA, 1912–2004) for their development of organic boron and phosphorous compounds.
2. Maercker, A. *Org. React.* **1965**, *14,* 270–490. (Review).
3. Schweizer, E. E.; Smucker, L. D. *J. Org. Chem.* **1966**, *31*, 3146.
4. Garbers, C. F.; Schneider, D. F.; van der Merwe, J. P. *J. Chem. Soc. (C)* **1968**, 1982
5. Murphy, P. J.; Brennan, J. *Chem. Soc. Rev.* **1988**, *17,* 1−30. (Review).
6. Maryanoff, B. E.; Reitz, A. B. *Chem. Rev.* **1988**, *89,* 863−927. (Review).
7. Vedejs, E.; Peterson, M. J. *Top. Stereochem.* **1994**, *21,* 1. (Review).
8. Heron, B. M. *Heterocycles* **1995**, *41,* 2357.
9. Murphy, P. J.; Lee, S. E. *J. Chem. Soc., Perkin Trans. 1* **1999**, 3049.
10. Blackburn, L.; Kanno, H.; Taylor, R. J. K. *Tetrahedron Lett.* **2003**, *44*, 115.
11. Schlosser, M.; Christmann, K. F. *Angew. Chem., Int. Ed. Engl.* **1966**, *5*, 126.
12. Schlosser, M.; Christmann, K. F. *Justus Liebigs Ann. Chem.* **1967**, *708*, 35.
13. Schlosser, M.; Christmann, K. F.; Piskala, A.; Coffinet, D. *Synthesis* **1971**, 29.
14. Deagostino, A.; Prandi, C.; Tonachini, G.; Venturello, P. *Trends Org. Chem.* **1995**, *5*, 103. (Review).
15. Celatka, C. A.; Liu, P.; Panek, J. S. *Tetrahedron Lett.* **1997**, *38*, 5449.
16. Duffield, J. J.; Pettit, G. R. *J. Nat. Products* **2001**, *64*, 472.

[1,2]-Wittig rearrangement

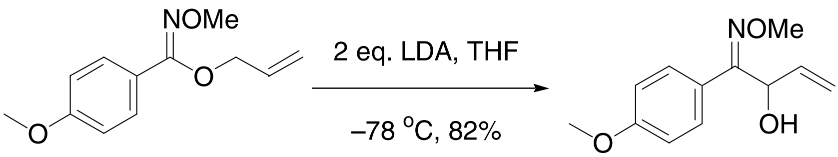
Treatment of ethers with alkyl lithium results in alcohols.



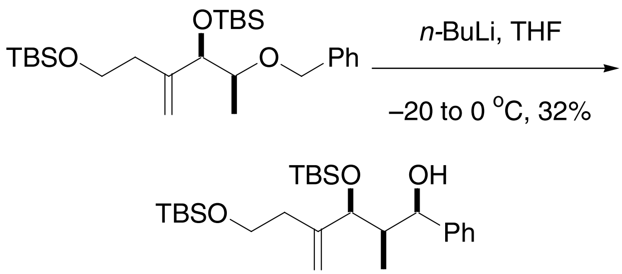


The radical mechanism is also possible as radical intermediates have been identified.

Example 1[4]



Example 2[5]

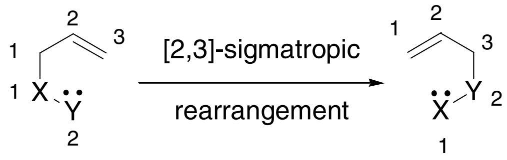


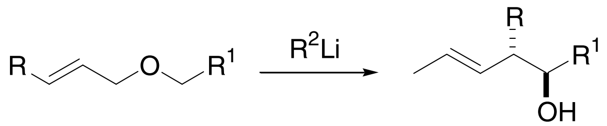
References

1. Wittig, G.; Löhmann, L. *Justus Liebigs Ann. Chem.* **1942**, *550*, 260.
2. Tomooka, K.; Yamamoto, H.; Nakai, T. *Justus Liebigs Ann. Chem.* **1997**, 1275.
3. Maleczka, R. E., Jr.; Geng, F. *J. Am. Chem. Soc*. **1998**, *120*, 8551.
4. Miyata, O.; Asai, H.; Naito, T. *Synlett* **1999**, 1915.
5. Tomooka, K.; Kikuchi, M.; Igawa, K.; Suzuki, M.; Keong, P.-H.; Nakai, T. *Angew. Chem., Int. Ed*. **2000**, *39*, 4502.
6. Katritzky, A. R.; Fang, Y. *Heterocycles* **2000**, *53*, 1783.
7. Kitagawa, O.; Momose, S.; Yamada, Y.; Shiro, M.; Taguchi, T. *Tetrahedron Lett*. **2001**, *42*, 4865.
8. Barluenga, J.; Fañanás, F. J.; Sanz, R.; Trabada, M. *Org. Lett.* **2002**, *4*, 1587.
9. Lemiègre, L.; Regnier, T.; Combret, J.-C.; Maddaluno, J. *Tetrahedron Lett*. **2003**, *44*, 373.
10. Wipf, P.; Graham, T. H. *J. Org. Chem.* **2003**, *68*, 8798.
11. Miyata, O.; Koizumi, T.; Asai, H.; Iba, R.; Naito, T. *Tetrahedron* **2004**, *60*, 3893.
12. Miyata, O.; Hashimoto, J.; Iba, R.; Naito, T. *Tetrahedron Lett*. **2005**, *46*, 4015.

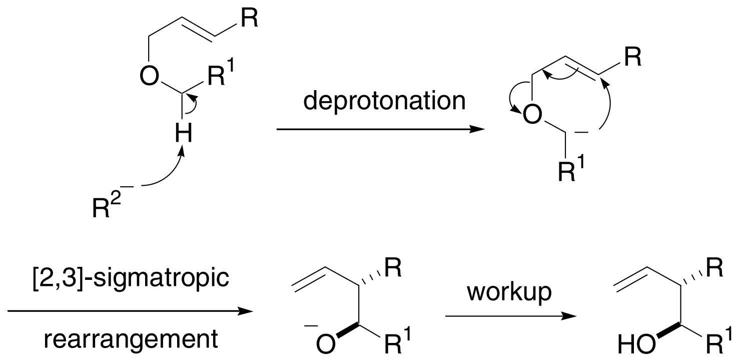
[2,3]-Wittig rearrangement

Transformation of allyl ethers into homoallylic alcohols by treatment with base. Also known as Still–Wittig rearrangement. *Cf.* Sommelet–Hauser rearrangement

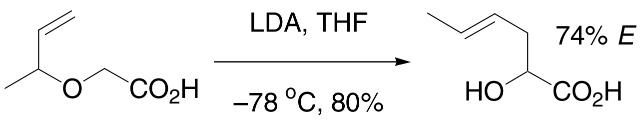




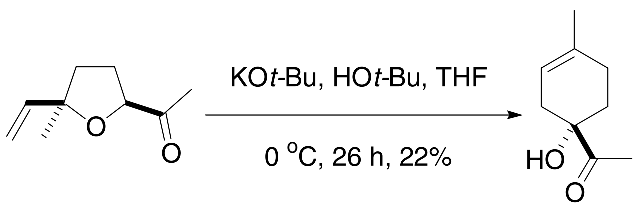
R^1 = alkynyl, alkenyl, Ph, COR, CN.



Example 1[3]



Example 2[2]

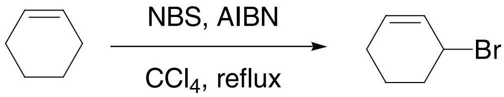


References

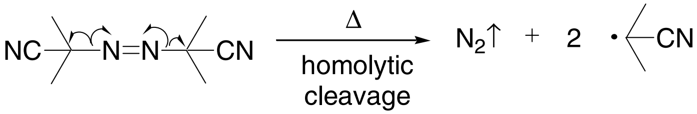
1. Cast, J.; Stevens, T. S.; Holmes, J. *J. Chem. Soc.* **1960**, 3521.
2. Thomas, A. F.; Dubini, R. *Helv. Chim. Acta* **1974**, *57*, 2084.
3. Nakai, T.; Mikami, K.; Taya, S.; Kimura, Y.; Mimura, T. *Tetrahedron Lett.* **1981**, *22*, 69.
4. Nakai, T.; Mikami, K. *Org. React.* **1994**, *46*, 105−209. (Review).
5. Bertrand, P.; Gesson, J.-P.; Renoux, B.; Tranoy, I. *Tetrahedron Lett*. **1995**, *36*, 4073.
6. Maleczka, R. E., Jr.; Geng, F. *Org. Lett*. **1999**, *1*, 1111.
7. Tsubuki, M.; Kamata, T.; Nakatani, M.; Yamazaki, K.; Matsui, T.; Honda, T. *Tetrahedron: Asymmetry* **2000**, *11*, 4725.
8. Itoh, T.; Kudo, K. *Tetrahedron Lett*. **2001**, *42*, 1317.
9. Pévet, I.; Meyer, C.; Cossy, J. *Tetrahedron Lett*. **2001**, *42*, 5215.
10. Anderson, J. C.; Skerratt, S. *J. Chem. Soc., Perkin 1* **2002**, 2871.
11. Schaudt, M.; Blechert, S. *J. Org. Chem.* **2003**, *68*, 2913.

Wohl–Ziegler reaction

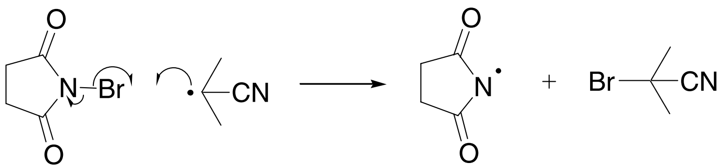
Radical-initiated allylic bromination using NBS, and catalytic AIBN as initiator or NBS under photolysis.



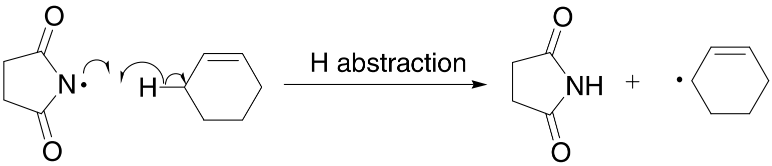
Initiation:

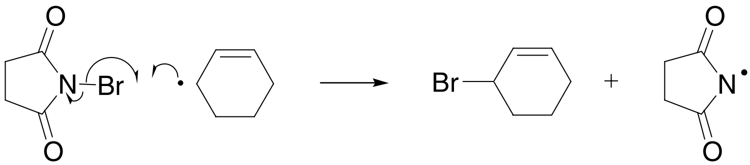


2,2'-azobisisobutyronitrile (AIBN)



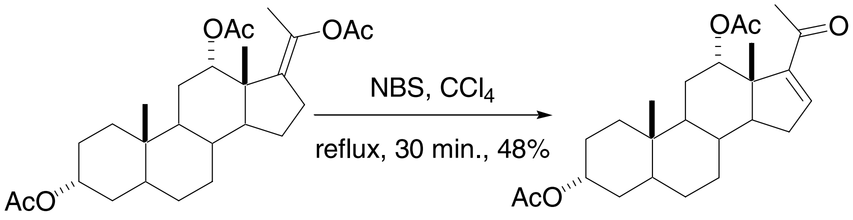
Propagation:



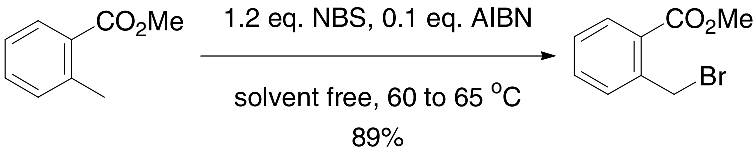


The succinimidyl radical is now available for the next cycle of the radical chain reaction.

Example 1[3]



Example 2[13]

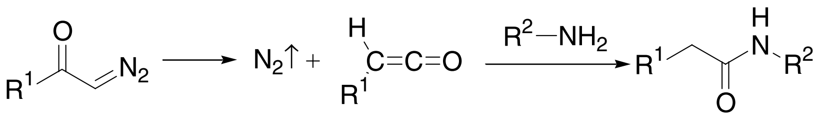


References

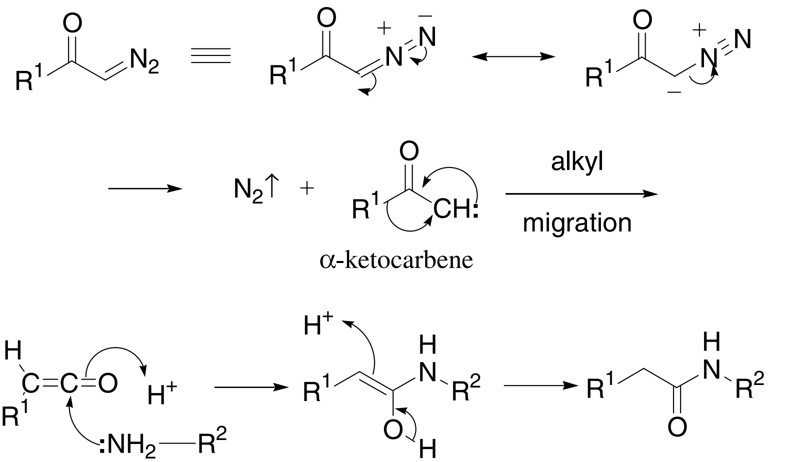
1. Wohl, A. *Ber. Dtsch. Chem. Ges.* **1919**, *52*, 51. Alfred Wohl (1863–1939), born in Graudenz, Germany, received his Ph.D. from A. W. Hofmann. In 1904, he was appointed Professor of Chemistry at the Technische Hochschule in Danzig.
2. Ziegler, K. *et al. Justus Liebigs Ann. Chem.* **1942**, *551*, 30. Karl Ziegler (1898–1973), born in Helsa, Germany, received Ph.D. in 1920 from von Auwers at the University of Marburg. He became the director of the Max-Planck-Institut für Kohlenforschung at Mülheim/Ruhr in 1943 and stayed there until 1969. He shared the Nobel Prize in Chemistry in 1963 with Giulio Natta (1903–1979) for their work in polymer chemistry. The Ziegler–Natta catalyst is widely used in polymerization.
3. Djerassi, C.; Scholz, C. R. *J. Org. Chem.* **1949**, *14*, 660.
4. Wolfe, S.; Awang, D. V. C. *Can. J. Chem.* **1971**, *49*, 1384.
5. Ito, I.; Ueda, T. *Chem. Pharm. Bull.* **1975**, *23*, 1646.
6. Pennanen, S. I. *Heterocycles* **1978**, *9*, 1047.
7. Rose, U. *J. Heterocycl. Chem.* **1991**, *28*, 2005.
8. Greenwood, J. R.; Vaccarella, G.; Capper, H. R.; Mewett, K. N.; Allan, R. D.; Johnston, G. A. R. *THEOCHEM* **1996**, *368*, 235.
9. Allen, J. G.; Danishefsky, S. J. *J. Am. Chem. Soc.* **2001**, *123*, 351.
10. Jeong, I. H.; Park, Y. S.; Chung, M. W.; Kim, B. T. *Synth. Commun.* **2001**, *31*, 2261.
11. Detterbeck, R.; Hesse, M. *Tetrahedron Lett.* **2002**, *43*, 4609.
12. Stevens, C. V.; Van Heecke, G.; Barbero, C.; Patora, K.; De Kimpe, N.; Verhe, R. *Synlett* **2002**, 1089.
13. Togo, H.; Hirai, T. *Synlett* **2003**, 702.

Wolff rearrangement

One-carbon homologation *via* the intermediacy of α-diazoketone and ketene.

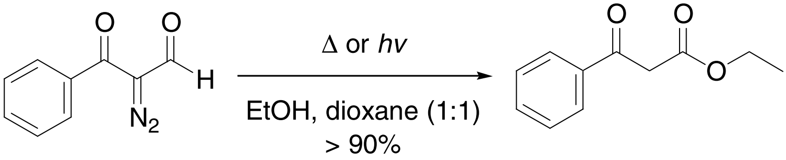


α-diazoketone ketene intermediate

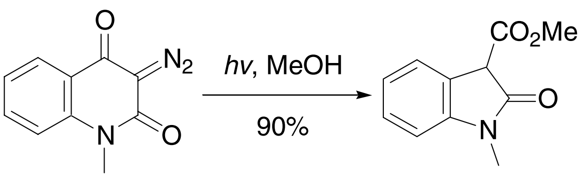


Treatment of the ketene with water would give the corresponding homologated carboxylic acid.

Example 1[2]



Example 2[4]

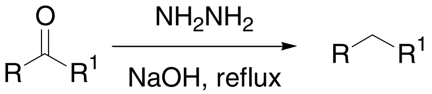


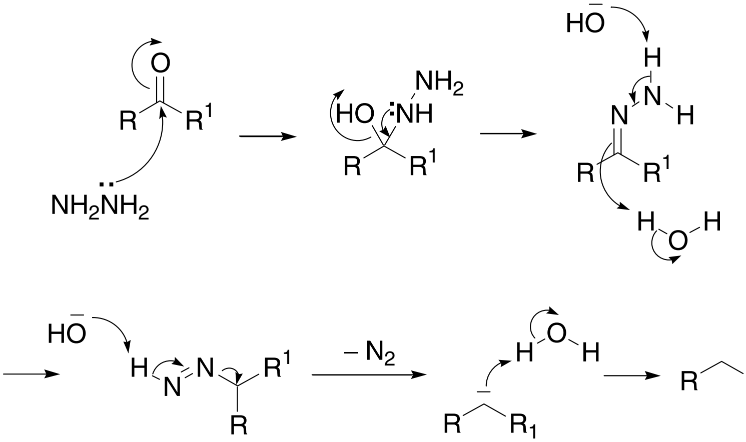
References

1. Wolff, L. *Justus Liebigs Ann. Chem.* **1912**, *394*, 25. Johann Ludwig Wolff (1857−1919) obtained his doctorate in 1882 under Fittig at Strasbourg, where he later became an instructor. In 1891, Wolff joined the faculty of Jena, where he collaborated with Knorr for 27 years.
2. Zeller, K.-P.; Meier, , H.; Müller, E. *Tetrahedron* **1972**, *28,* 5831.
3. Meier, H.; Zeller, K. P. *Angew. Chem., Int. ed. Engl.* **1975**, *14*, 32.
4. Kappe, C.; Fäber, G.; Wentrup, C.; Kappe, T. *Chem. Ber.* **1993**, *126,* 2357.
5. Podlech, J.; Linder, M. R. *J. Org. Chem*. **1997**, *62,* 5873.
6. Wang, J.; Hou, Y. *J. Chem. Soc., Perkin Trans. 1* **1998**, 1919.
7. Müller, A.; Vogt, C.; Sewald, N. *Synthesis* **1998**, 837.
8. Lee, Y. R.; Suk, J. Y.; Kim, B. S. *Tetrahedron Lett*. **1999**, *40,* 8219.
9. Tilekar, J. N.; Patil, N. T.; Dhavale, D. D. *Synthesis* **2000**, 395.
10. Yang, H.; Foster, K.; Stephenson, C. R. J.; Brown, W.; Roberts, E. *Org. Lett*. **2000**, *2,* 2177.
11. Xu, J.; Zhang, Q.; Chen, L.; Chen, H. *J. Chem. Soc., Perkin Trans. 1* **2001**, 2266.
12. Kirmse, W. "100 years of the Wolff Rearrangement" *Eur. J. Org. Chem*. **2002**, 2193. (Review).
13. Bogdanova, A.; Popik, V. V. *J. Am. Chem. Soc*. **2003**, *125*, 1456.
14. Julian, R. R.; May, J. A.; Stoltz, B. M.; Beauchamp, J. L. *J. Am. Chem. Soc*. **2003**, *125*, 4478.
15. Zeller, K.-P.; Blocher, A.; Haiss, P. "Oxirene participation in the Photochemical Wolff Rearrangement" *Mini-Reviews in Organic Chemistry* **2004**, *1*, 291−308. (Review).

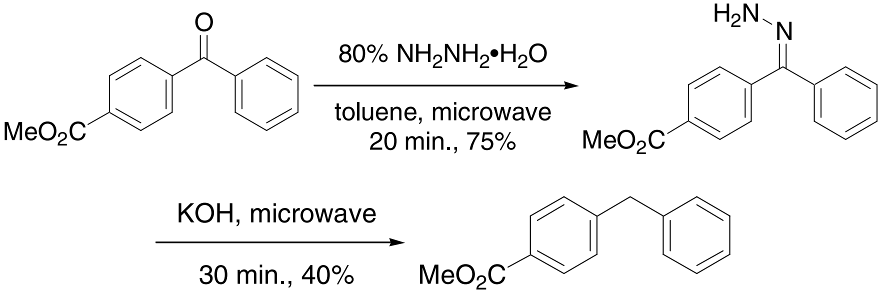
Wolff–Kishner reduction

Carbonyl reduction to methylene using basic hydrazine.

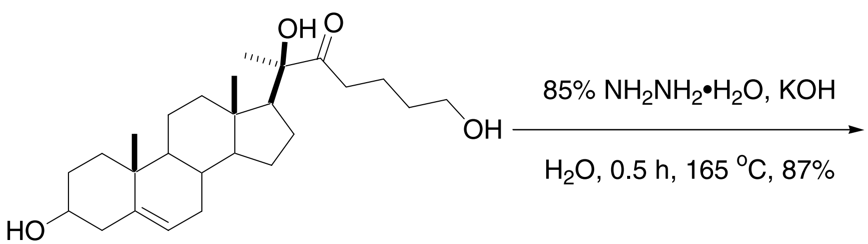


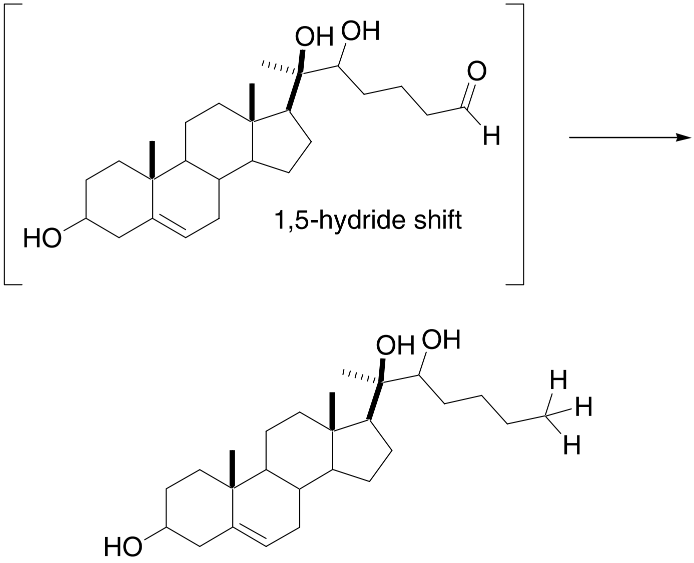


Example 1[11]



Example 2[12]



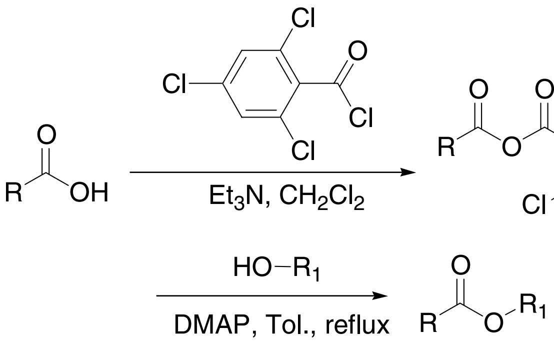


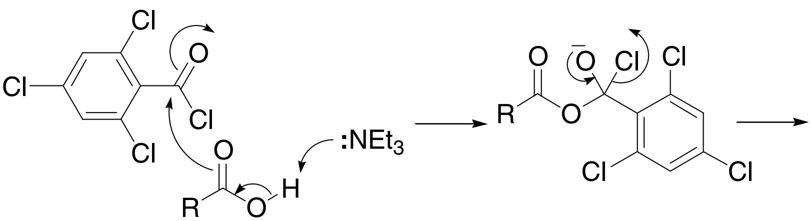
References

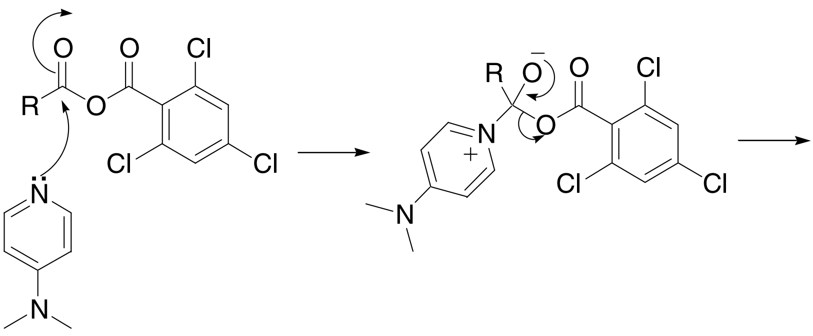
1. Kishner, N. *J. Russ. Phys. Chem. Soc.* **1911**, *43,* 582.
2. Wolff, L. *Justus Liebigs Ann. Chem.* **1912**, *394*, 86.
3. Huang-Minlon *J. Am. Chem. Soc.* **1946**, *68*, 2487. (the Huang-Minlon modification).
4. Todd, D. *Org. React.* **1948**, *4*, 378. (Review).
5. Cram, D. J.; Sahyun, M. R. V.; Knox, G. R. *J. Am. Chem. Soc.* **1962**, *84*, 1734.
6. Szmant, H. H. *Angew. Chem., Int. Ed. Engl.* **1968**, *7*, 120.
7. Murray, R. K., Jr.; Babiak, K. A. *J. Org. Chem.* **1973**, *38*, 2556.
8. Akhila, A.; Banthorpe, D. V. *Indian J. Chem.* **1980**, *19B*, 998.
9. Bosch, J.; Moral, M.; Rubiralta, M. *Heterocycles* **1983**, *20*, 509.
10. Taber, D. F.; Stachel, S. J. *Tetrahedron Lett.* **1992**, *33*, 903.
11. Gadhwal, S.; Baruah, M.; Sandhu, J. S. *Synlett* **1999**, 1573.
12. Szendi, Z.; Forgó, P.; Tasi, G.; Böcskei, Z.; Nyerges, L.; Sweet, F. *Steroids* **2002**, *67*, 31.
13. Bashore, C. G.; Samardjiev, I. J.; Bordner, J.; Coe, J. W. *J. Am. Chem. Soc.* **2003**, *125*, 3268.

Yamaguchi esterification

Esterification using 2,4,6-trichlorobenzoyl chloride (the Yamaguchi reagent).

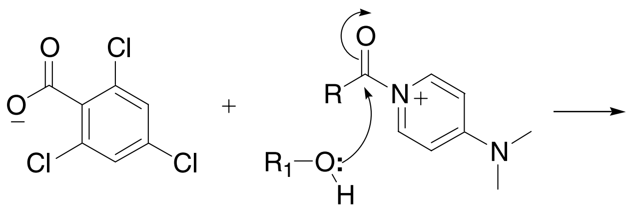


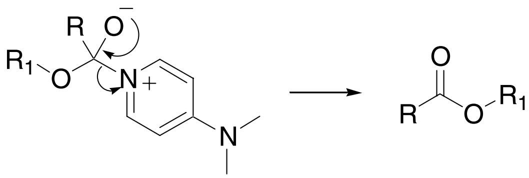




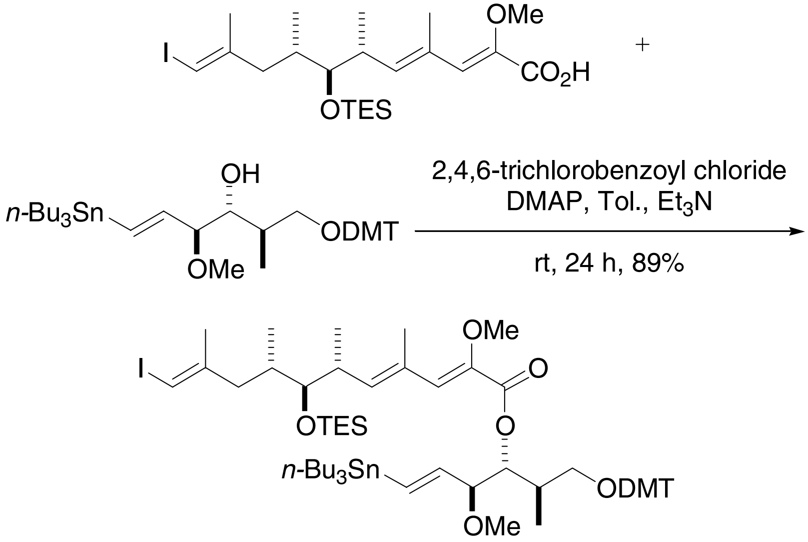
DMAP (Dimethylaminopyridine)

Steric hindrance of the chloro substituents blocks attack of the other carbonyl.

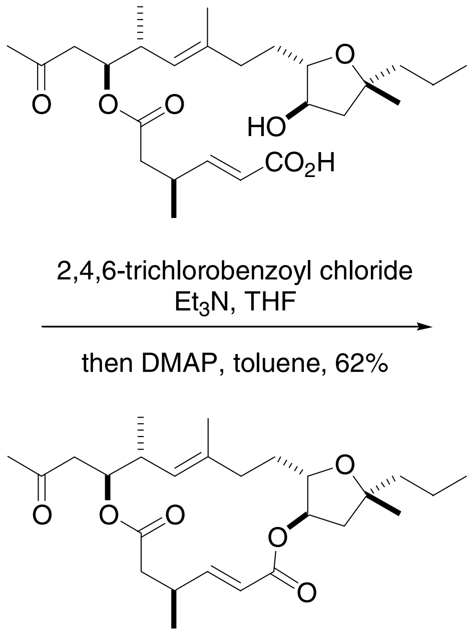




Example 1[9]



Example 2[11]

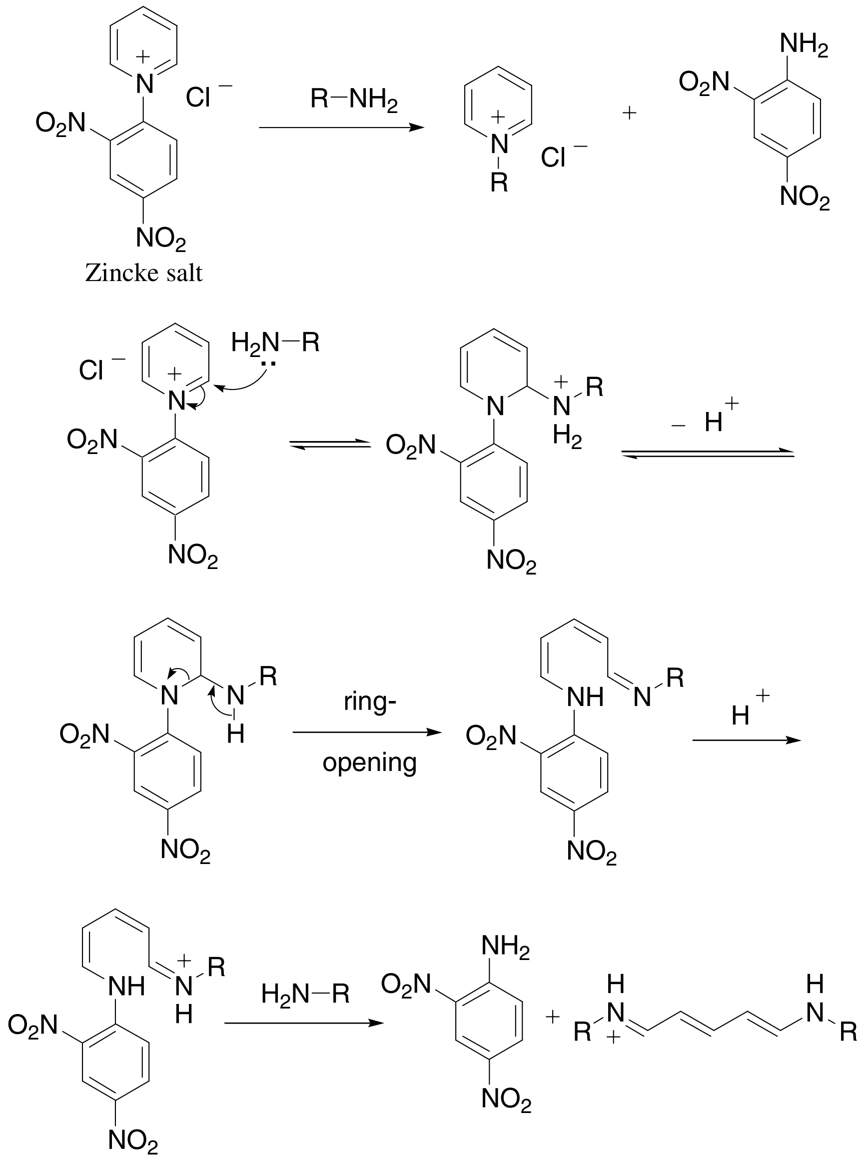


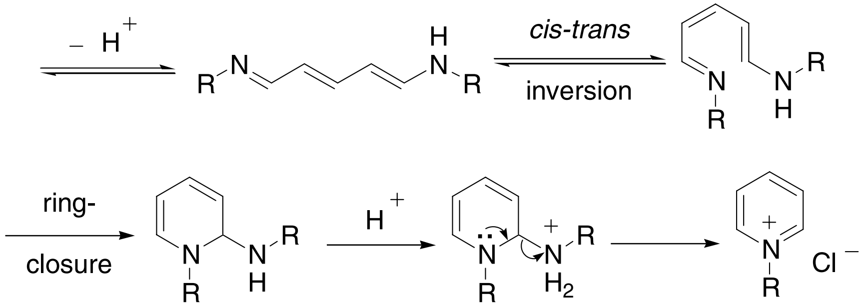
References

1. Inanaga, J.; Hirata, K.; Saeki, H.; Katsuki, T.; Yamaguchi, M. *Bull. Chem. Soc. Jpn.* **1979**, *52*, 1989.
2. Kawanami, Y.; Dainobu, Y.; Inanaga, J.; Katsuki, T.; Yamaguchi, M. *Bull. Chem. Soc. Jpn.* **1981**, *54*, 943.
3. Bartra, M.; Vilarrasa, J. *J. Org. Chem.* **1991**, *56*, 5132.
4. Richardson, T. I.; Rychnovsky, S. D. *Tetrahedron* **1999**, *55*, 8977.
5. Berger, M.; Mulzer, J. *J. Am. Chem. Soc.* **1999**, *121*, 8393.
6. Paterson, I.; Chen, D. Y.-K.; Aceña, J. L.; Franklin, A. S. *Org. Lett.* **2000**, *2*, 1513.
7. Hamelin, O.; Wang, Y.; Deprés, J.-P.; Greene, A. E. *Angew. Chem., Int. Ed.* **2000**, *39*, 4314.
8. Tian, Z.; Cui, H.; Wang, Y. *Synth. Commun.* **2002**, *32*, 3821.
9. Quéron, E.; Lett, R. *Tetrahedron Lett.* **2004**, *45*, 4533.
10. Mlynarski, J.; Ruiz-Caro, J.; Fürstner, A. *Chem., Eur. J.* **2004**, *10*, 2214.
11. Lepage, O.; Kattnig, E.; Fürstner, A. *J. Am. Chem. Soc.* **2004**, *126*, 15970.
12. Nakajima, N.; Ubukata, M. *Heterocycles* **2004**, *64*, 333.

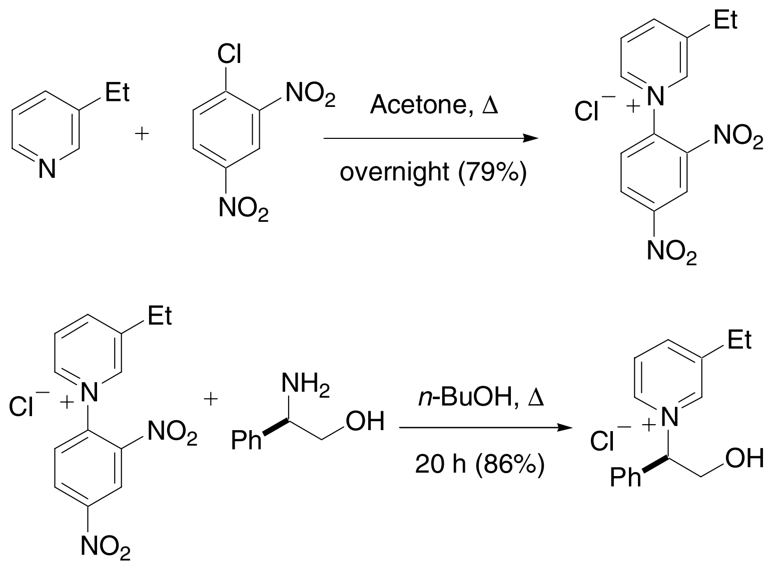
Zincke reaction

The Zincke reaction is an overall amine exchange process that converts *N*-(2,4-dinitrophenyl)pyridinium salts, known as Zincke salts, to *N*-aryl or *N*-alkyl pyridiniums upon treatment with the appropriate aniline or alkyl amine.

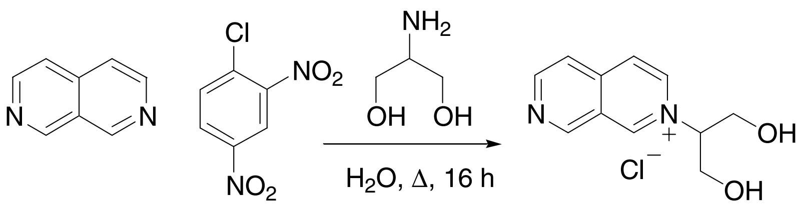


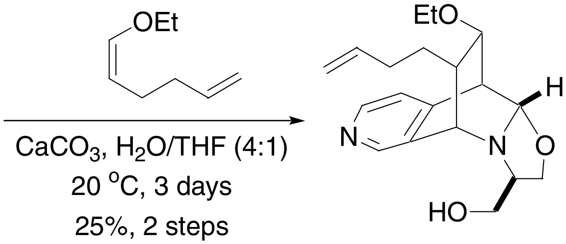


Example 1[13]



Example 2[16]





References

1. Zincke, T. *Justus Liebigs Ann. Chem.* **1903**, *330*, 361.
2. Zincke, Th.; Heuser, G.; Möller, W. *Justus Liebigs Ann. Chem.* **1904**, *333*, 296.
3. Zincke, Th.; Würker, W. *Justus Liebigs Ann. Chem.* **1905**, *338*, 107.
4. Zincke, Th.; Würker, W. *Justus Liebigs Ann. Chem.* **1905**, *341*, 365.
5. Zincke, Th.; Weisspfenning, G. *Justus Liebigs Ann. Chem.* **1913**, *396*, 103.
6. Marvell, E. N.; Caple, G.; Shahidi, I. *Tetrahedron Lett.* **1967**, *8,* 277.
7. Marvell, E. N.; Caple, G.; Shahidi, I. *J. Am. Chem. Soc.* **1970**, *92*, 5641.
8. Epszju, J.; Lunt, E.; Katritzky, A. R. *Tetrahedron* **1970**, *26*, 1665. (Review).
9. de Gee, A. J.; Sep, W. J.; Verhoeven, J. W.; de Boer, T. J. *J. Chem. Soc., Perkin Trans. 1* **1974**, 676.
10. Becher, J. *Synthesis* **1980**, 589. (Review).
11. Kost, A. N.; Gromov, S. P.; Sagitullin, R. S. *Tetrahedron* **1981**, *37*, 3423. (Review).
12. Barbier, D.; Marazano, C.; Das, B. C.; Potier, P. *J. Org. Chem.* **1996**, *61*, 9596.
13. Wong, Y.-S.; Marazano, C.; Gnecco, D.; Génisson, Y.; Chiaroni, A.; Das, B. C. *J. Org. Chem.* **1997**, *62*, 729.
14. Barbier, D.; Marazano, C.; Riche, C.; Das, B. C.; Potier, P. *J. Org. Chem.* **1998**, *63*, 1767.
15. Magnier, E.; Langlois, Y. *Tetrahedron Lett.* **1998**, *39*, 837.
16. Urban, D.; Duval, E.; Langlois, Y. *Tetrahedron Lett.* **2000**, *41*, 9251.
17. Eda, M.; Kurth, M. J. *J. Chem. Soc., Chem. Commun*. **2001**, 723.
18. Cheng, W.-C.; Kurth, M. J. *Org. Prep. Proced. Int*. **2002**, *34*, 585. (Review).
19. Rojas, C. M. *Zincke Reaction* In *Name Reactions in Heterocyclic Chemistry*, Li, J. J.; Corey, E. J., Eds.; Wiley & Sons: Hoboken, NJ, **2005**, 355–375. (Review).

This page intentionally left blank

Subject index

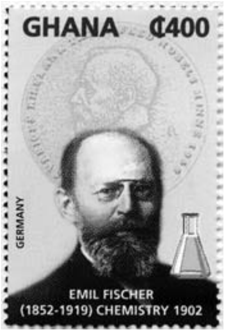
D

Q

R

T

Emil Fischer
1852–1919
Nobel Prize, 1902



Robert Robinson
1886–1975
Nobel Prize, 1947

Otto Wallach
1847–1931
Nobel Prize, 1910

Victor Grignard
1871–1935
Nobel Prize, 1912

Hermann Staudinger
1881–1965
Nobel Prize, 1953

Georg Wittig
1897–1987
Nobel Prize, 1979

Karl Ziegler
1898–1973
Nobel Prize, 1963