

Name reactions, Mechanisms and Applications

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Syllabus

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Claisen, Cope and Related rear.
Claisen Rearrangement
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Actoacetic ester synthesis
Diekmann condensation
Robinson annulation
Acyloin Condensation
Bouveault Blank reduction
Friedel Crafts reaction
Aldol condensation
Bayer-Villiger oxidation
Hofmann rearrangement
Vilsmeier Haak formation
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Curtius rearrangement
Ritter reaction

Diels alder reaction
Doebner quinoline synthesis
Fries rearrangement
Grignard reagent
Lewessons reagent
Hantzsch reaction
Beckmann rearrangement

Name reactions, Mechanisms and Applications

In this section we provide a summary of Name Reactions. The format is slightly modified from our previous book, but maintains the essential features:

Reaction:

Summary reaction.

Proposed Mechanism:

Currently accepted mechanisms. We have tried to be complete in showing steps, intermediates and the necessary curly arrow notations.

Notes:

Additional comments and references from key sources.

Examples:

Current examples if possible.

General Bibliography:

B. P. Mundy, M. G. Ellerd, *Name Reactions and Reagents in Organic Synthesis*, John Wiley and Sons, Inc., New York, 1988; OR

M. B. Smith, J. March in *March's Advanced Organic Chemistry*, 5th ed., John Wiley and Sons, Inc., New York, 2001;

T. Laue, A. Plagens, *Named Organic Reactions*, John Wiley and Sons, Inc., New York, 1998; OR

V. K. Ahluwalia, R. K. Parashar, *Organic Reaction Mechanisms*, Alpha Science International Ltd, Pangbourne, U.K., 2002;

J. J. Li, *Name Reactions*, Springer, Berlin, 2002; OR

Comprehensive Organic Synthesis, B. M. Trost, ed-in-chief, Pergamon Press, Oxford, 1991;

M. B. East, D. J. Ager, *Desk Reference for Organic Chemists*, Krieger Publishing Company, Malabar, FL, 1995;

Strategic Applications of Names Reactions in Organic Synthesis. Kurti, L.; Czako, B.
Advanced Organic Chemistry, Part B: Reactions and Synthesis. Carey, F. A.;
Sundberg, R. J.

2005
Advanced Organic Chemistry · Part A: Structure and Mechanisms Carey, F. A.;
Sundberg, R. J.

March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition Smith, M. B.; March, J.

M. Orchin, F. Kaplan, R. S. Macomber, R. M. Wilson, H. Zimmer, *The Vocabulary of Organic Chemistry*, John Wiley and Sons, Inc., New York, 1980;

A. Hassner, C. Stumer, *Organic Syntheses Based on Name Reactions and Unnamed Reactions*, Pergamon, Oxford, 1994;

The Merck Index, Merck & CO., Inc., Whitehouse Station, N. J. (now in the 13th Edition) Each edition has an updated list of Named Reactions.

See also: <http://themerckindex.cambridgesoft.com/TheMerckIndex/NameReactions/TOC.asp>

Other URL's to Name Reaction Websites:

www.monomerchem.com/display4.html

www.chempensoftware.com/organicreactions.htm

www.organic-chemistry.org/namedreactions/

<http://orgchem.chem.uconn.edu/namereact/named.html>

8.3 REACTION CATEGORIES

REACTION CATEGORY	NAME OF REACTIONS	BRIEF DESCRIPTION OF SYNTHETIC USE	Page#
CARBOCYCLE FORMATION			
	Acyloin condensation	Formation of cyclic α -hydroxy ketones from diesters.	4
	Alkene metathesis	Formation of cyclic alkenes from dienes.	10
	Alkyne metathesis	Formation of cyclic alkynes from diynes.	12
	Danheiser cyclopentene annulation	Formation of cyclopentenes from enones and allenes.	124
	Danishefsky's diene cycloaddition	Formation of six-membered carbocycles using 1-methoxy-3-trimethylsilyloxy-1,3-butadiene.	126
	Dieckmann condensation	Formation of cyclic β -keto esters from diesters.	138
	Diels-Alder cycloaddition	The [4+2] cycloaddition of alkenes and dienes to afford substituted cyclohexenes.	140
	Hajos-Parrish reaction	Enantio-enriched bicyclic enones from 1,5-diketones.	192
	Nazarov cyclization	Cyclopentenones and cyclopentanones from divinyl ketones.	304
	Pauson-Khand reaction	Formation of cyclopentenones from alkenes, alkynes and CO.	334
	Robinson annulation	Formation of bicyclic enones from 1,5-diketones.	384
CYCLO-AROMATIZATION			
	Bergman cycloaromatization reaction	Thermal or photochemical cycloaromatization of enediyne to form substituted benzene rings.	56
	Danheiser benzannulation	Reaction of cyclobutenones with alkynes to give highly substituted benzene rings.	122
	Dötz benzannulation	Reaction of Fischer chromium carbenes with alkynes to give substituted hydroquinone derivatives.	148
DEGRADATION			
	Hofmann rearrangement	Conversion of primary carboxamides to one-carbon shorter primary amines.	210
	Hunsdiecker reaction	Conversion of carboxylic acids to one-carbon shorter alkyl, alkenyl or aryl halides.	218
	Lieben haloform reaction	Conversion of methyl ketones to one-carbon shorter carboxylic acids.	262

ELECTROPHILIC ADDITION TO C-C MULTIPLE BONDS			
Addition to alkenes			
cyclopropanation	Simmons-Smith cyclopropanation	Formation of cyclopropanes from alkenes.	412
epoxidation	Davis' oxaziridine oxidation	Formation of epoxides from alkenes using oxaziridines.	130
epoxidation	Jacobsen-Katsuki epoxidation	Formation of epoxides from alkenes using metal salen complexes.	222
epoxidation	Prilezhaev reaction	Formation of epoxides from alkenes using peracids.	362
epoxidation	Sharpless asymmetric epoxidation	Formation of epoxy alcohols from allylic alcohols.	408
epoxidation	Shi asymmetric epoxidation	Formation of epoxides from alkenes.	410
hydrogenation	Noyori asymmetric hydrogenation	Formation of enantio-enriched carboxylic acids, alcohols and amino acids from unsaturated carboxylic acids, allylic alcohols and enamides, respectively.	316
hydrometalation	Brown hydroboration reaction	Formation of alkylboranes from alkenes.	66
hydrometalation	Schwartz hydrozirconation	Formation of alkylzirconium compounds from alkenes.	400
Addition to alkynes			
hydrometalation	Brown hydroboration reaction	Formation of alkenylboranes from alkynes.	66
hydrometalation	Schwartz hydrozirconation	Formation of alkenylzirconium compounds from alkynes.	400
ELECTROPHILIC AROMATIC SUBSTITUTION			
	Bischler-Napieralski isoquinoline synthesis	Preparation of isoquinolines from acylated phenylethylamines.	62
	Combes Quinoline synthesis	Preparation of quinolines from aryl amines and 1,3-diketones.	94
	Friedel-Crafts acylation	Synthesis of aromatic ketones using acyl halides or anhydrides.	176
	Friedel-Crafts alkylation	Synthesis of alkylbenzenes using alkyl halides.	178
	Fries rearrangement	Synthesis of acylated phenols from O-acyl phenols.	180

8.4 AFFECTED FUNCTIONAL GROUPS

AFFECTED FUNCTIONAL GROUP	NEWLY FORMED FUNCTIONAL GROUP	NAME OF TRANSFORMATION
ACETAL		
	γ,δ -unsaturated amide	Eschenmoser-Claisen rearrangement
ALCOHOL		
1° alcohol	γ -hydroxy oxime	Barton nitrite ester reaction
1° alcohol	aldehyde	Corey-Kim oxidation, Dess-Martin oxidation, Ley oxidation, Oppenauer oxidation, Pfitzner-Moffatt oxidation, Swern oxidation
1° alcohol	alkane	Barton-McCombie radical deoxygenation
1° alcohol	alkene	Chugaev elimination
1° alcohol	amine	Mitsunobu reaction
1° alcohol	azide	Mitsunobu reaction
1° alcohol	carboxylic acid	Jones oxidation
1° alcohol	ester	Mitsunobu reaction
1° alcohol	ether	Mitsunobu reaction, Williamson ether synthesis
1° alcohol	lactone	Corey-Nicolaou macrolactonization, Keck macrolactonization, Yamaguchi macrolactonization
1° alcohol	nitrile	Mitsunobu reaction
1° alcohol	sulfide	Mitsunobu reaction
2° alcohol	γ -hydroxy oxime	Barton nitrite ester reaction
2° alcohol	alkane	Barton-McCombie radical deoxygenation
2° alcohol	alkene	Burgess dehydration, Chugaev elimination
2° alcohol	amine	Mitsunobu reaction
2° alcohol	azide	Mitsunobu reaction
2° alcohol	ester	Mitsunobu reaction, Schotten-Baumann reaction
2° alcohol	ether	Mitsunobu reaction, Williamson ether synthesis
2° alcohol	ketone	Corey-Kim oxidation, Dess-Martin oxidation, Jones oxidation, Ley oxidation, Oppenauer oxidation, Pfitzner-Moffatt oxidation, Swern oxidation
2° alcohol	lactone	Corey-Nicolaou macrolactonization, Keck macrolactonization, Yamaguchi macrolactonization
2° alcohol	nitrile	Mitsunobu reaction
2° alcohol	sulfide	Mitsunobu reaction

2° alcohol	γ -hydroxy oxime	Barton nitrite ester reaction
2° alcohol	alkane	Barton-McCombie radical deoxygenation
2° alcohol	alkene	Burgess dehydration, Chugaev elimination
2° alcohol	amine	Mitsunobu reaction
2° alcohol	azide	Mitsunobu reaction
2° alcohol	ester	Mitsunobu reaction, Schotten-Baumann reaction
2° alcohol	ether	Mitsunobu reaction, Williamson ether synthesis
2° alcohol	ketone	Corey-Kim oxidation, Dess-Martin oxidation, Jones oxidation, Ley oxidation, Oppenauer oxidation, Pfitzner-Moffatt oxidation, Swern oxidation
2° alcohol	lactone	Corey-Nicolaou macrolactonization, Keck macrolactonization, Yamaguchi macrolactonization
2° alcohol	nitrile	Mitsunobu reaction
2° alcohol	sulfide	Mitsunobu reaction
3° alcohol	γ -hydroxy oxime	Barton nitrite ester reaction
3° alcohol	alkane	Barton-McCombie radical deoxygenation
3° alcohol	alkene	Burgess dehydration, Chugaev elimination, Grob fragmentation
3° alcohol	amide	Ritter reaction
3° alcohol	ester	Schotten-Baumann reaction
3° alcohol	ether	Williamson ether synthesis
3° alcohol	lactone	Corey-Nicolaou macrolactonization, Keck macrolactonization, Yamaguchi macrolactonization
allylic alcohol	γ,δ -unsaturated amide	Eschenmoser-Claisen rearrangement
allylic alcohol	γ,δ -unsaturated ester	Johnson-Claisen rearrangement
allylic alcohol	allylic amide	Overman rearrangement
allylic alcohol	epoxy alcohol	Sharpless asymmetric epoxidation
allylic alcohol	saturated enantio-enriched alcohol	Noyori asymmetric hydrogenation
propargylic alcohol	α,β -unsaturated ketone	Meyer-Schuster and Rupe rearrangement
propargylic alcohol	propargyl-substituted compound	Nicholas reaction

ALDEHYDE

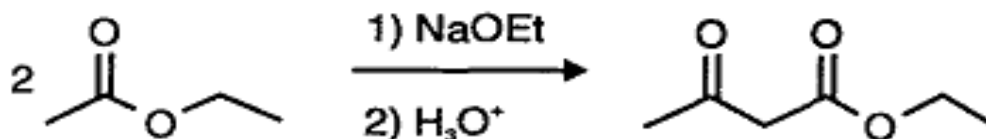
	α,β -epoxy ester	Darzens glycidic ester condensation
	α,β -unsaturated carboxylic acid	Perkin reaction
	α -amino nitrile	Strecker reaction
	β -nitro alcohol	Henry reaction
	γ -oxo ester	Stetter reaction
	γ -oxo nitrile	Stetter reaction
	1,3-diol	Prins reaction
	1,4,7-triketone	Stetter reaction
	1,4-diketone	Stetter reaction
	alkane	Tsuji-Wilkinson decarbonylation

8.5 PREPARATION OF FUNCTIONAL GROUPS

TARGET FUNCTIONAL GROUP	SUBSTRATE FUNCTIONAL GROUP	NAME OF TRANSFORMATION
ALCOHOL		
	α,β -epoxy alcohol	Payne rearrangement
	aldehyde	Grignard reaction, Barbier coupling reaction, Nozaki-Hiyama-Kishi reaction, Baylis-Hillman reaction, Cannizzaro reaction, Henry reaction, Keck asymmetric allylation, MPV reduction, Prins reaction, Roush asymmetric allylation, Sakurai allylation, Kagan-Molander coupling
	alkene	Sharpless asymmetric aminohydroxylation
	alkenyl halide or triflate	Nozaki-Hiyama-Kishi coupling
	aryl alkyl ether	Wittig-[1,2]-rearrangement
	enol ether and silyl enol ether	Davis' oxaziridine oxidation
	ketone	Grignard reaction, Barbier coupling reaction, Nozaki-Hiyama-Kishi reaction, Baylis-Hillman reaction, Henry reaction, Keck asymmetric allylation, MPV reduction, Prins reaction, Roush asymmetric allylation, Sakurai allylation, CBS reduction, Luche reduction, Midland Alpine borane reduction, Molander-Kagan coupling, Noyori asymmetric hydrogenation
	nitroalkane	Henry reaction
	organomagnesium species	Grignard reaction
	2° alcohol	Mitsunobu reaction
	silane	Fleming-Tamao oxidation
allylic alcohol	aldehyde	Baylis-Hillman reaction, Grignard reaction, Prins reaction, Nozaki-Hiyama-Kishi coupling
allylic alcohol	alkene	Prins reaction, Riley selenium dioxide oxidation
allylic alcohol	allylic sulfoxide	Mislow-Evans rearrangement
allylic alcohol	enone	Luche reduction, Baylis-Hillmann reaction
allylic alcohol	epoxyhydrazone	Wharton olefin synthesis
allylic alcohol	epoxyketone	Wharton olefin synthesis
allylic alcohol	ketone	Baylis-Hillman reaction, Grignard reaction, Nozaki-Hiyama-Kishi coupling, Wharton olefin synthesis

allylic alcohol	ketone	Baylis-Hillman reaction, Grignard reaction, Nozaki-Hiyama-Kishi coupling, Wharton olefin synthesis
homoallylic alcohol	aldehyde	Grignard reaction, Barbier coupling reaction, Keck asymmetric allylation, Roush asymmetric allylation, Sakurai allylation
homoallylic alcohol	alkyl allyl ether	Wittig-[2,3]-rearrangement
homoallylic alcohol	ketone	Grignard reaction, Barbier coupling reaction, Keck asymmetric allylation, Roush asymmetric allylation, Sakurai allylation
propargylic alcohol	aldehyde	Barbier reaction, Grignard reaction
propargylic alcohol	ketone	Barbier reaction, Grignard reaction
ALDEHYDE		
aliphatic	aliphatic nitro compound	Nef reaction
aliphatic	cyclic epoxy hydrazone	Eschenmoser-Tanabe fragmentation
aliphatic	cyclic epoxy ketone	Eschenmoser-Tanabe fragmentation
aliphatic	3° amine <i>N</i> -oxide	Polonovski reaction
aliphatic/aromatic	1° or 2° alkyl halide	Kornblum oxidation
aliphatic/aromatic	1,2-diol	Criegee oxidation
aliphatic/aromatic	nitrile	Stephen aldehyde synthesis
aliphatic/aromatic	1° alcohol	Corey-Kim oxidation, Dess-Martin oxidation, Ley oxidation, Swern oxidation, Oppenauer oxidation, Pfitzner-Moffatt oxidation
aromatic	activated benzyl halide	Kornblum oxidation
aromatic	electron-rich heteroaromatic ring	Vilsmeier-Haack formylation
aromatic	electron-rich substituted benzene	Vilsmeier-Haack formylation, Reimer-Tiemann reaction
aromatic	<i>N,N</i> -disubstituted formamide	Vilsmeier-Haack formylation
aromatic	substituted benzene	Gatterman formylation and Gatterman-Koch formylation
ALKENE		
	α -halo sulfone	Ramberg-Bäcklund rearrangement
	1,2-diol	Corey-Winter olefination
	1,3-diol monosulfonate ester	Wharton fragmentation, Grob fragmentation
	1,5-diene	Cope rearrangement
	2° or 3° alcohol	Burgess dehydration, Chugaev elimination

Claisen Condensation



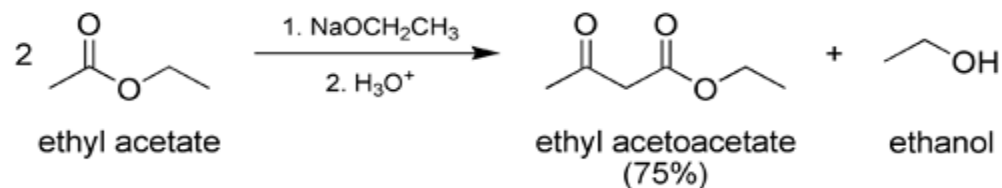
The Claisen Condensation between esters containing α -hydrogens, promoted by a base such as sodium ethoxide, affords β -ketoesters. The driving force is the formation of the stabilized anion of the β -keto ester. If two different esters are used, an essentially statistical mixture of all four products is generally obtained, and the preparation does not have high synthetic utility.

However, if one of the ester partners has enolizable α -hydrogens and the other does not (e.g., aromatic esters or carbonates), the mixed reaction (or crossed Claisen) can be synthetically useful. If ketones or nitriles are used as the donor in this condensation reaction, a β -diketone or a β -ketonitrile is obtained, respectively.

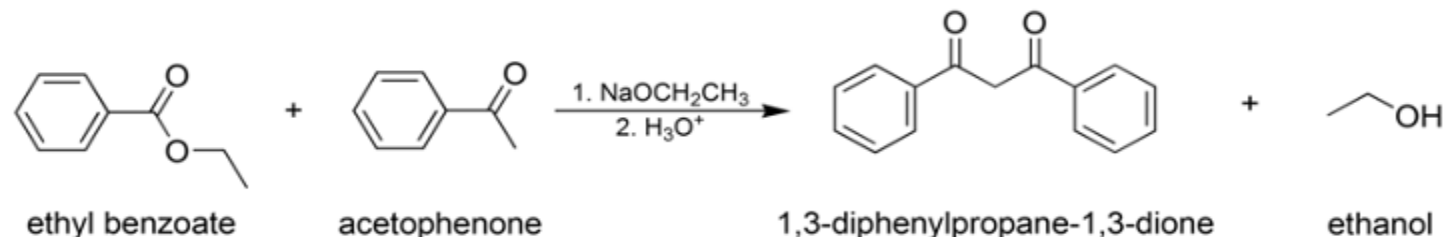
The use of stronger bases, e.g. sodium amide or sodium hydride instead of sodium ethoxide, often increases the yield.

The intramolecular version is known as Dieckmann Condensation.

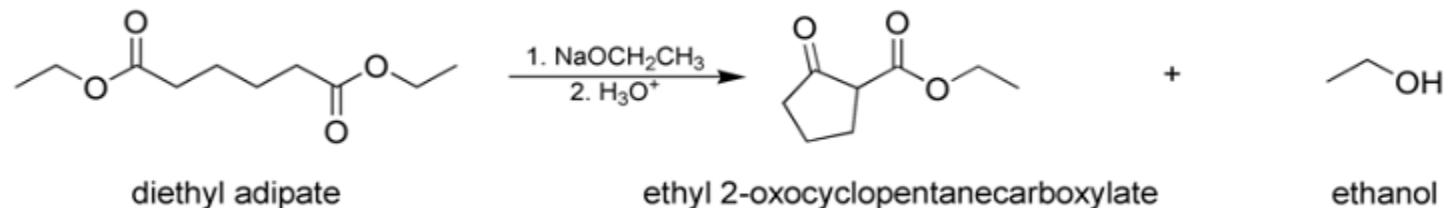
Types



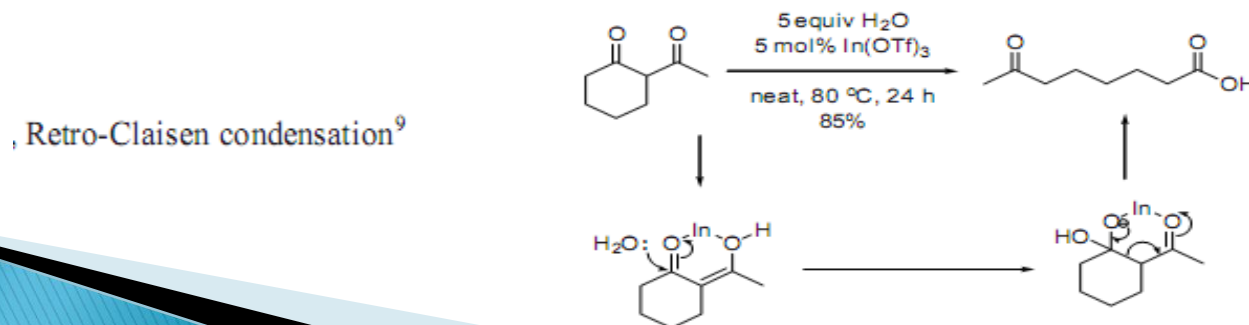
The classic Claisen condensation, where only one enolizable ester is used.



The mixed (or "crossed") Claisen condensation, where an enolizable ester or ketone and a nonenolizable ester are used.

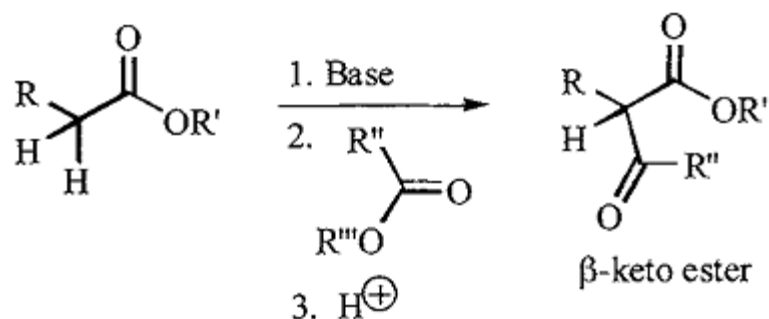


The Dieckmann condensation, where a molecule with two ester groups reacts intramolecularly, forming a cyclic β -keto ester. In this case, the ring formed must not be strained, usually a 5- or 6-membered chain or ring.

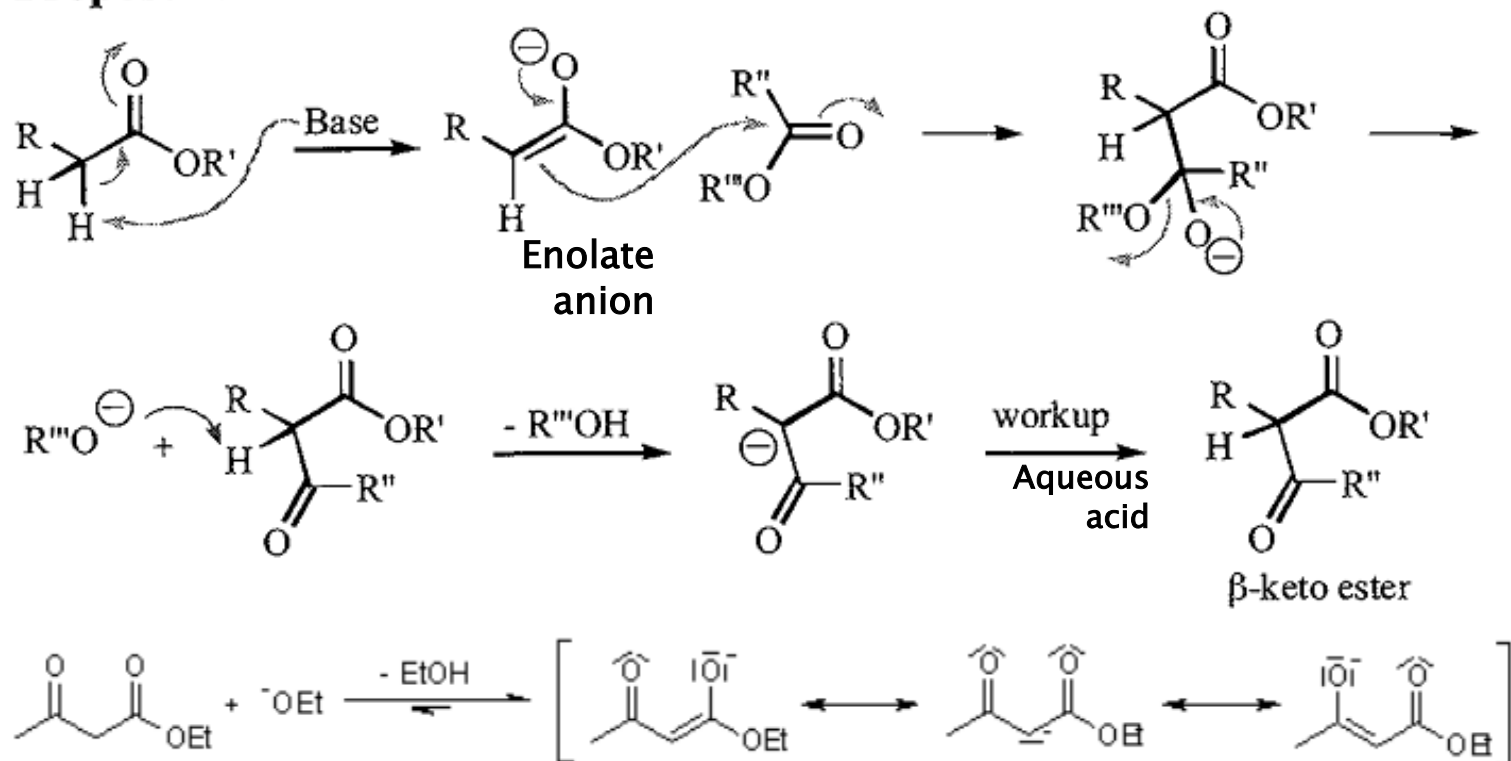


Claisen Condensation (ester attacking ester)

The Reaction:



Proposed Mechanism:



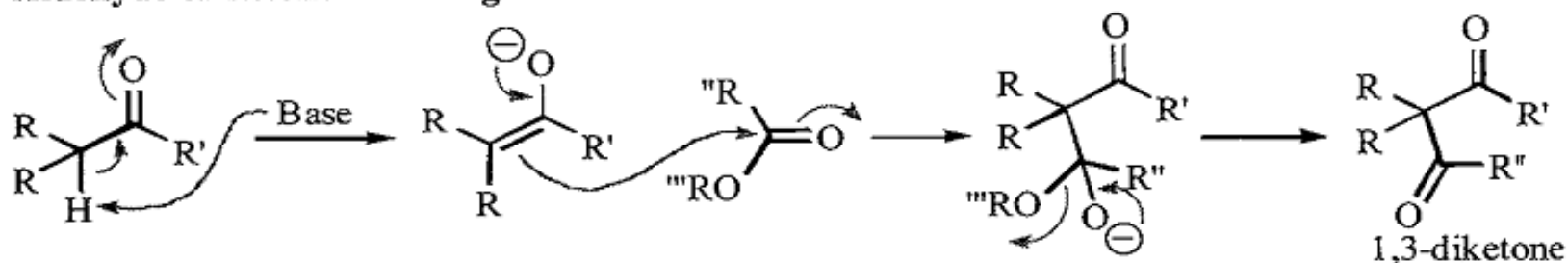
Notes:

R'' is usually a group that cannot form an enolate, such as a phenyl ring.

It is important to note that an equivalent of base must be used for this reaction; unlike the Aldol Condensation, this cannot be used catalytically.

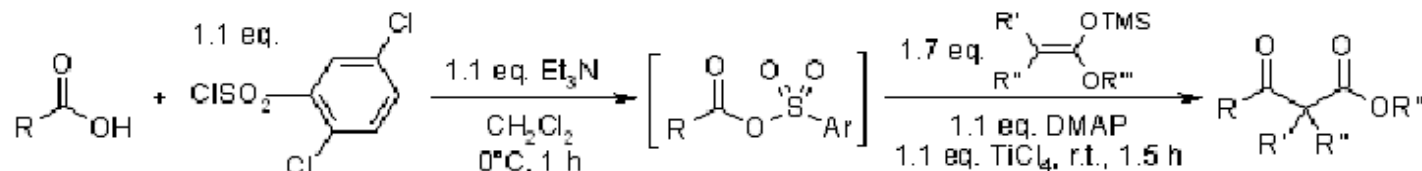
See: T. Laue, A. Plagens, *Named Organic Reactions*, John Wiley and Sons, Inc., New York, 1998, pp. 45-48.

Aldehyde or ketone attacking ester



R'' is usually a group that cannot form an enolate.

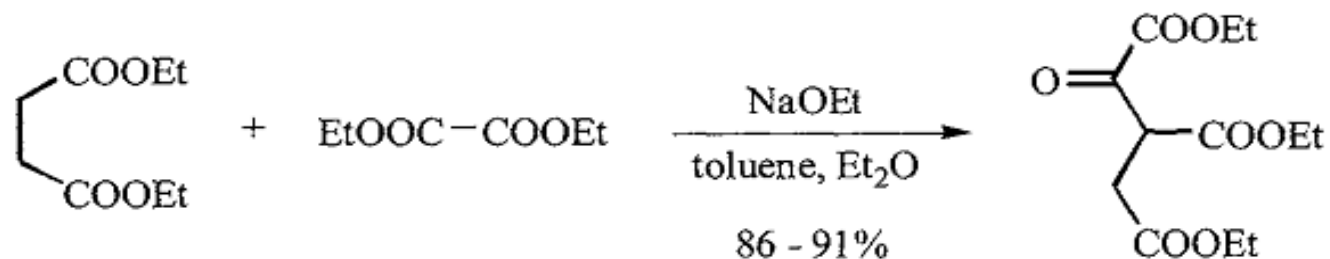
Recent Literature



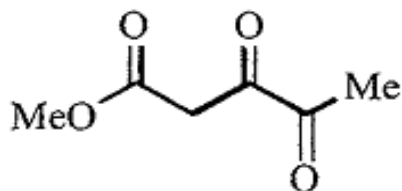
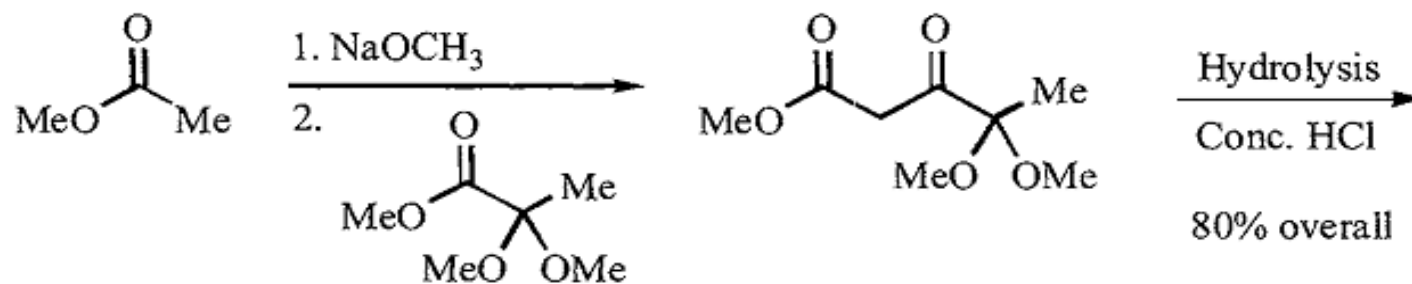
Powerful Ti-Crossed Claisen Condensation between Ketene Silyl Acetals or Thioacetals and Acid Chlorides or Acids

A. Iida, S. Nakazawa, T. Okabayashi, A. Horii, T. Misako, Y. Tanabe, *Org. Lett.*, **2006**, *8*, 5215-5218.

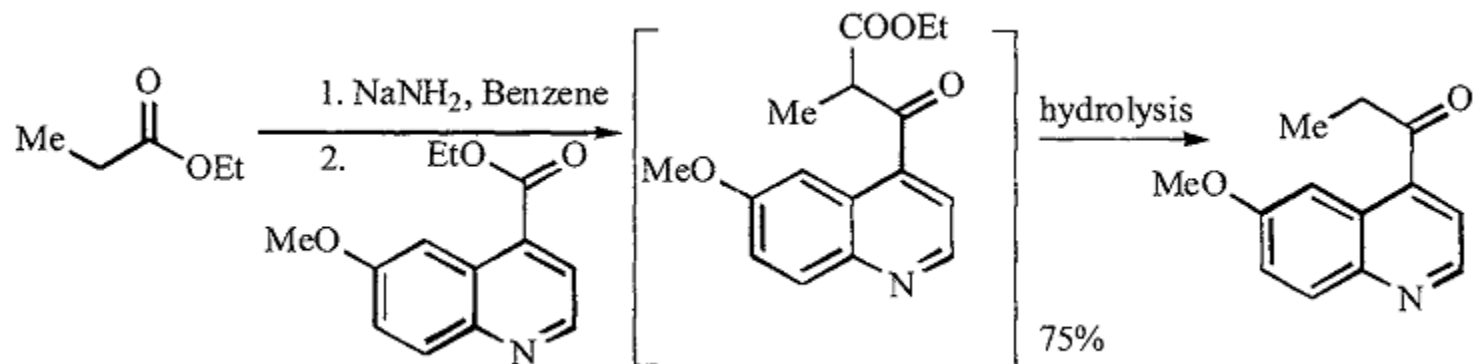
Examples:



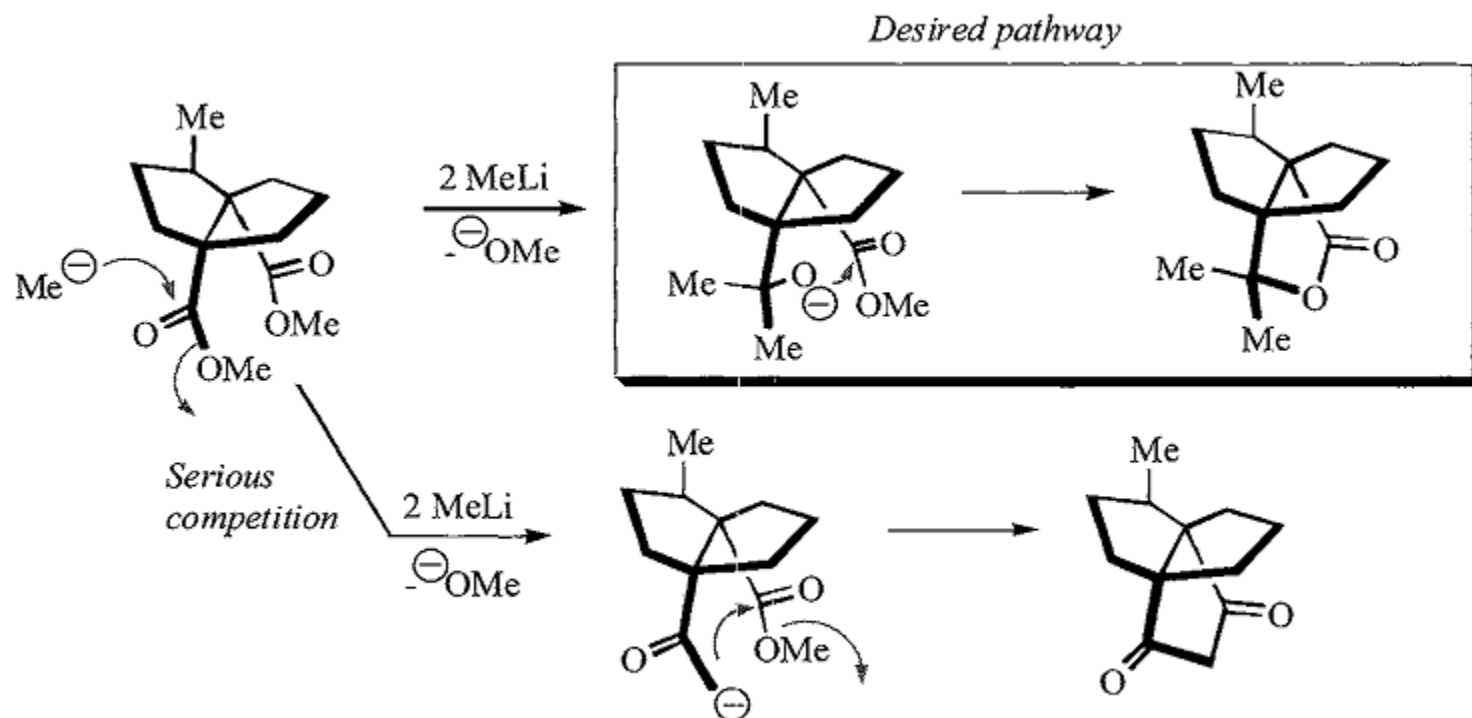
L. Friedman, E. Kosower, *Organic Syntheses*, CV3, 510



A. G. Cameron, A. T. Hewson, M. I. Osammur *Tetrahedron Letters* **1984**, 25, 2267



J. W. Cornforth, R. H. Cornforth, *Journal of the Chemical Society* **1948**, 93



B. P. Mundy, D. Wilkening, K. B. Lipkowitz *Journal of Organic Chemistry* **1985**, 50, 5727

Claisen, Cope and Related Rearrangements

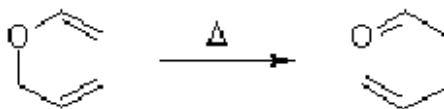
Claisen-Type Reactions:



Cope-Type Reactions:

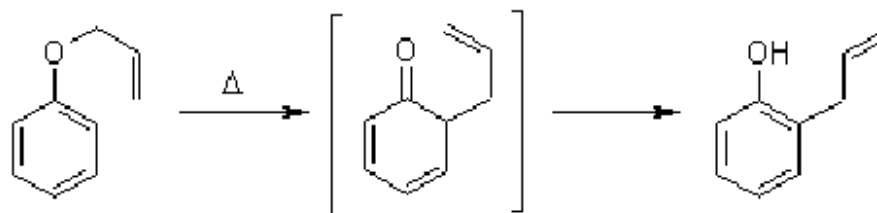


Claisen Rearrangement



The aliphatic Claisen Rearrangement is a [3,3]-sigmatropic rearrangement in which an allyl vinyl ether is converted thermally to an unsaturated carbonyl compound.

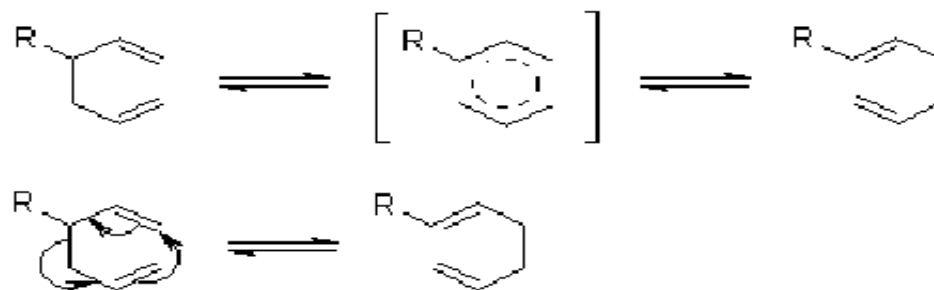
The aromatic Claisen Rearrangement is accompanied by a rearomatization:



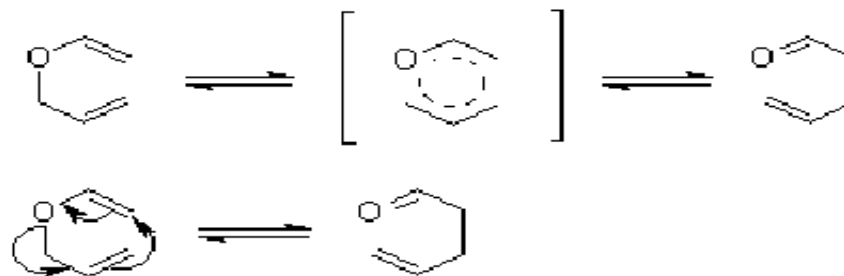
The etherification of alcohols or phenols and their subsequent Claisen Rearrangement under thermal conditions makes possible an extension of the carbon chain of the molecule.

Mechanism

The Claisen Rearrangement may be viewed as the oxa-variant of the [Cope Rearrangement](#):

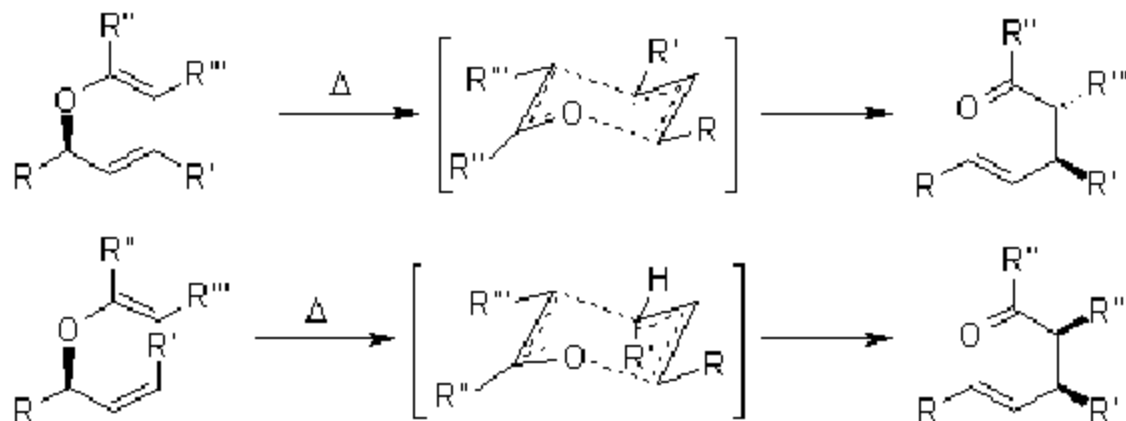


Mechanism of the Cope Rearrangement

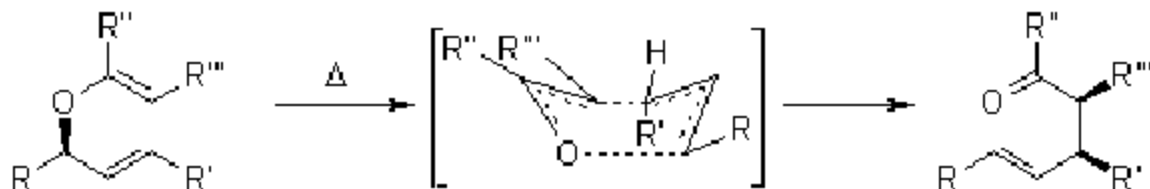


Mechanism of the Claisen Rearrangement

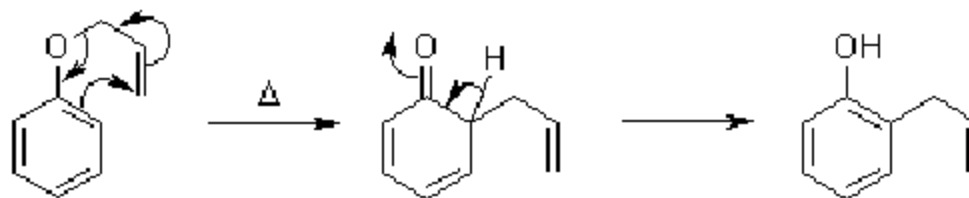
The reaction proceeds preferably *via* a chair transition state. Chiral, enantiomerically enriched starting materials give products of high optical purity.



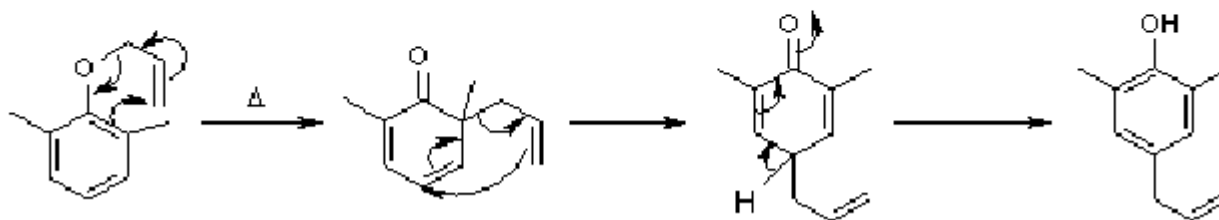
A boat transition state is also possible, and can lead to side products:



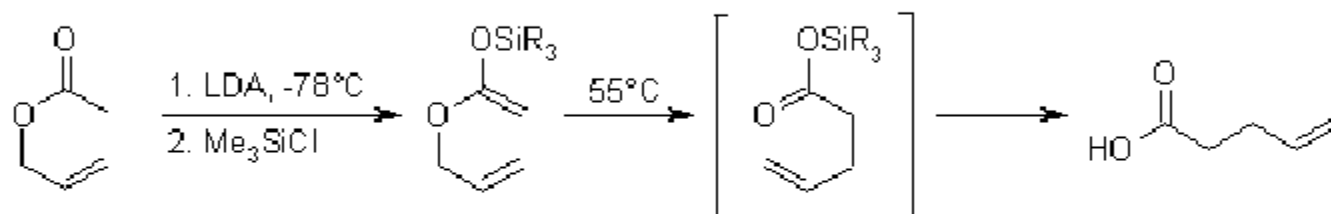
The aromatic Claisen Rearrangement is followed by a rearomatization:



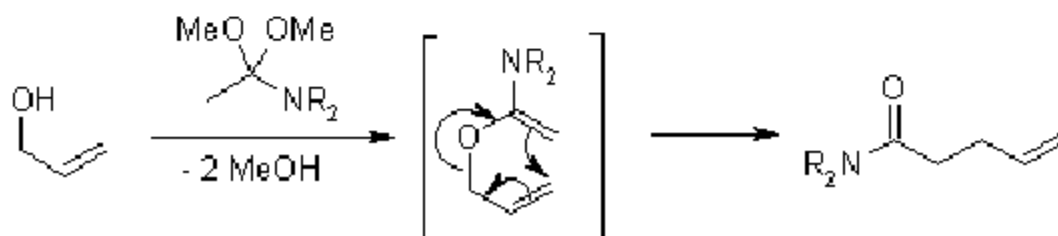
When the *ortho*-position is substituted, rearomatization cannot take place. The allyl group must first undergo a **Cope Rearrangement** to the *para*-position before tautomerization is possible.



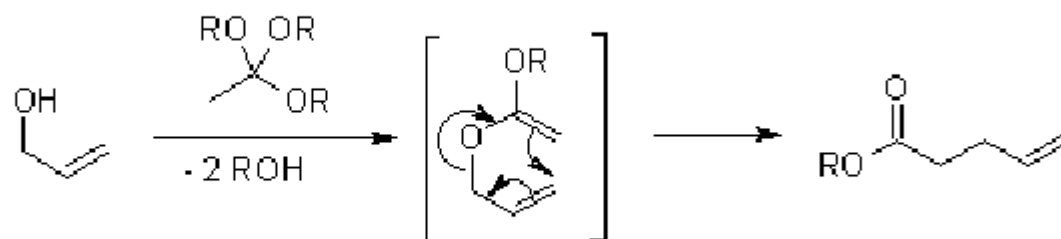
All Claisen Rearrangement reactions described to date require temperatures of $> 100\text{ }^{\circ}\text{C}$ if uncatalyzed. The observation that electron withdrawing groups at C-1 of the vinyl moiety exert a positive influence on the reaction rate and the yield has led to the development of the following variations:



Ireland-Claisen Rearrangement



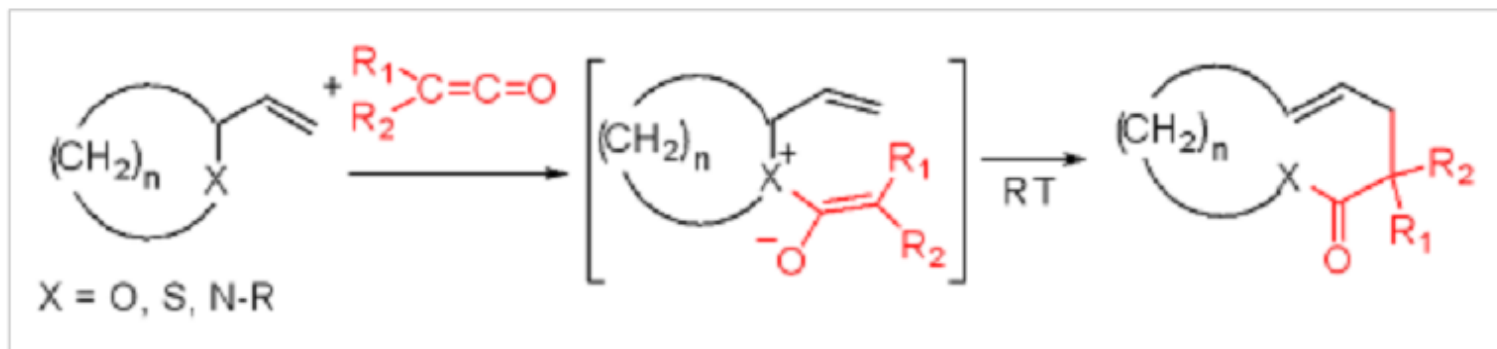
Eschenmoser-Claisen Rearrangement



Johnson-Claisen Rearrangement

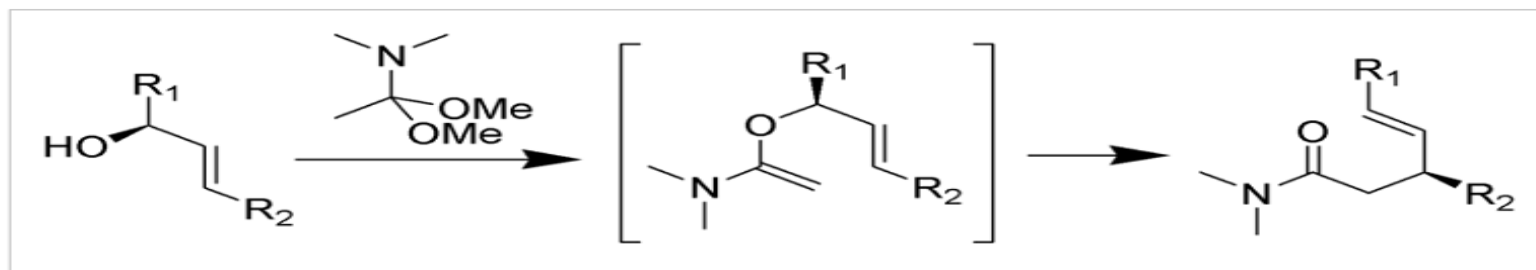
Bellus-Claisen rearrangement

The *Bellus-Claisen rearrangement* is the reaction of allylic ethers, amines, and thioethers with ketenes to give γ,δ -unsaturated esters, amides, and thioesters. ^{[11] [12] [13]}

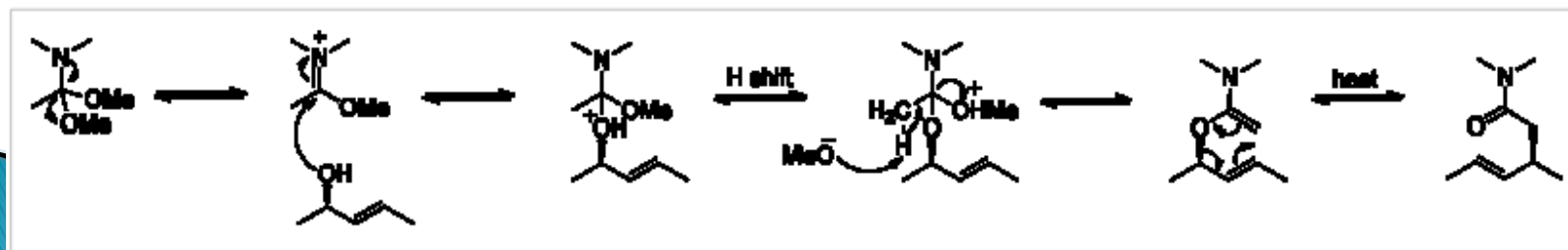


Eschenmoser-Claisen rearrangement

The *Eschenmoser-Claisen rearrangement* proceeds from an allylic alcohol to a γ,δ -unsaturated amide, and was developed by Albert Eschenmoser in 1964. ^{[14] [15]}

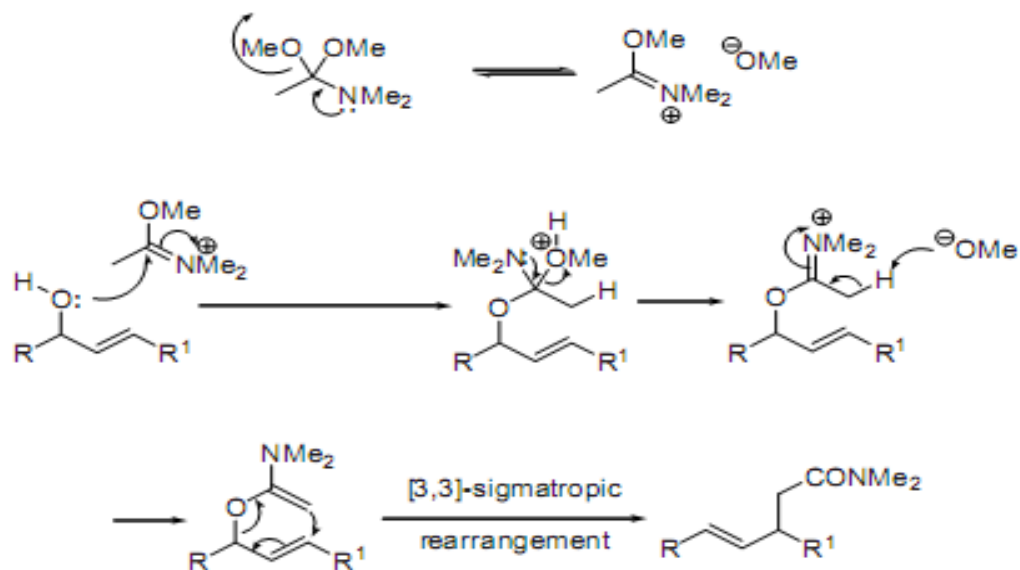
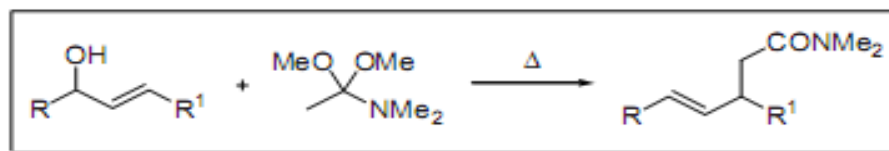


Mechanism: ^[10]

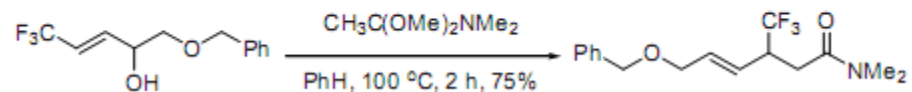


Eschenmoser–Claisen amide acetal rearrangement

[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.

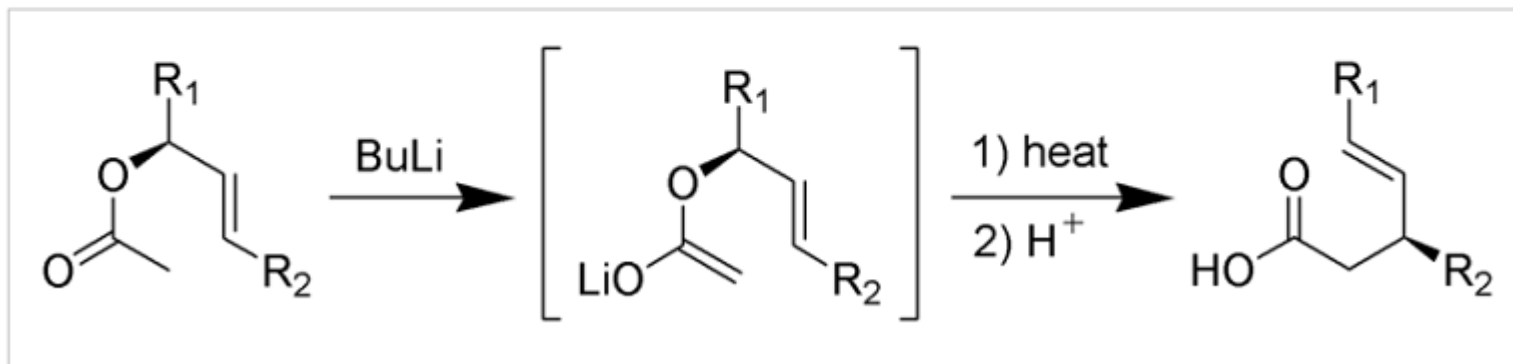


Example 1⁴



Ireland-Claisen rearrangement

The *Ireland-Claisen rearrangement* is the reaction of an allylic acetate with strong base (such as Lithium diisopropylamide) to give a γ,δ -unsaturated carboxylic acid.^{[16] [17] [18]}

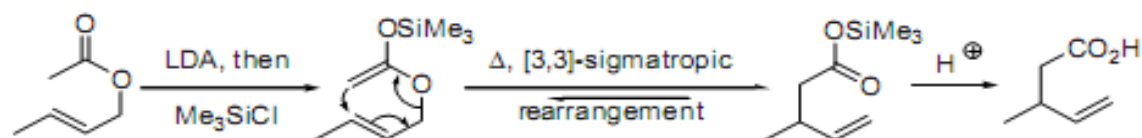
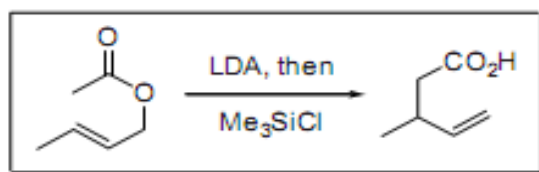


Mechanism:^[10]

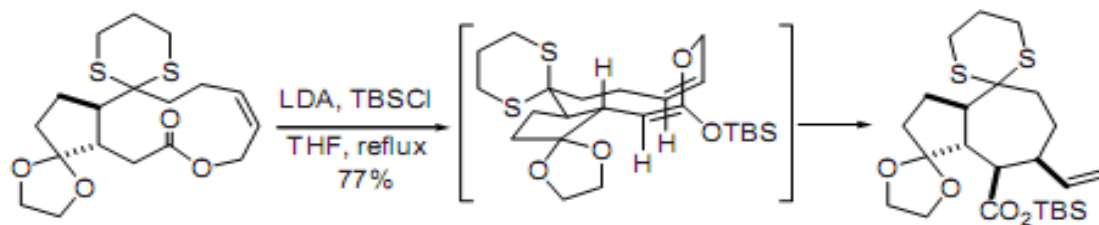


Ireland–Claisen (silyl ketene acetal) rearrangement

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.

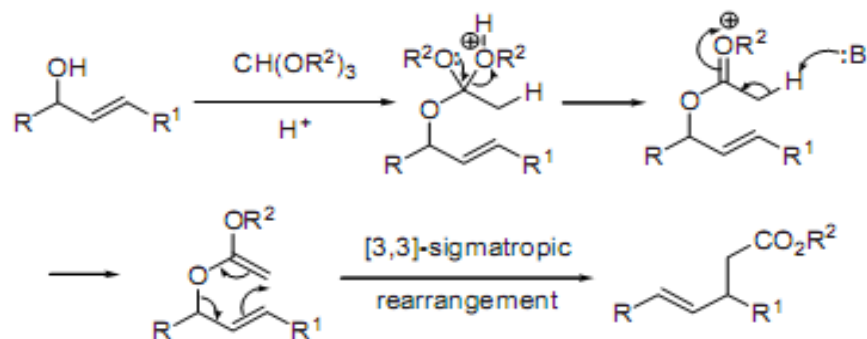
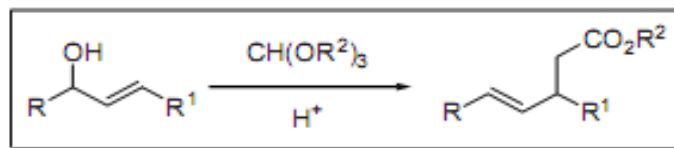


Example 1²

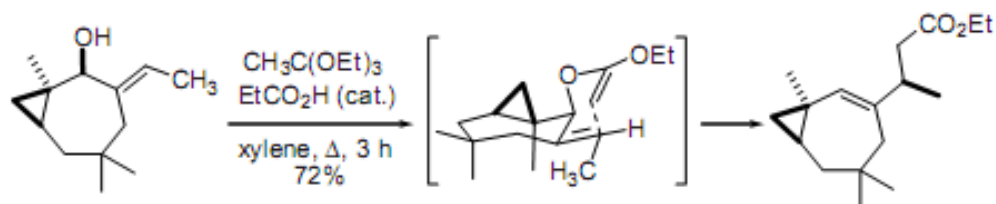


Johnson–Claisen orthoester rearrangement

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

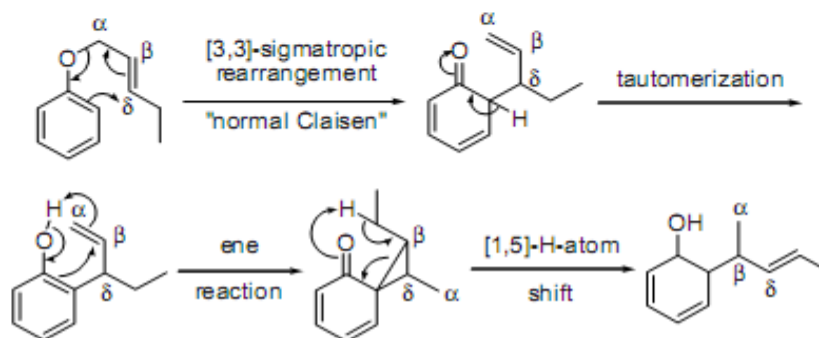
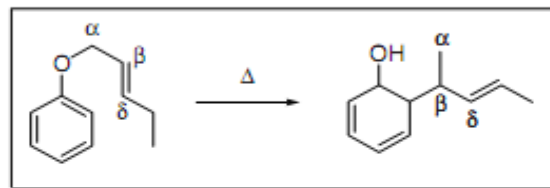


Example 1²

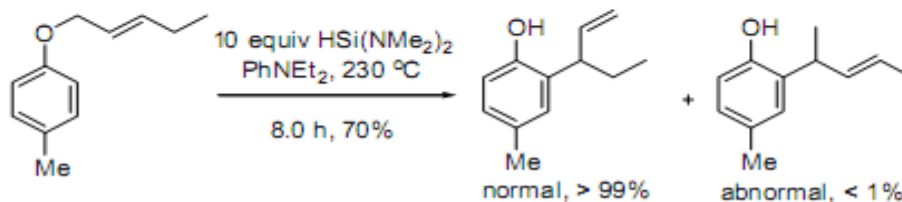
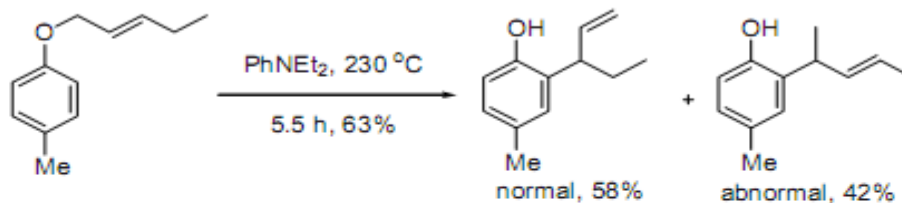


Abnormal Claisen rearrangement

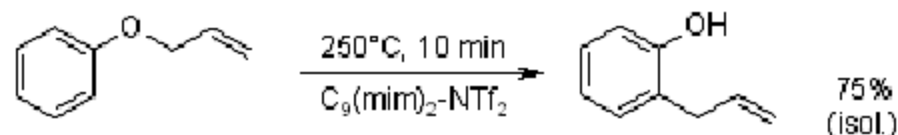
Further rearrangement of the normal Claisen rearrangement product with the β -carbon becoming attached to the ring.



Example 1³



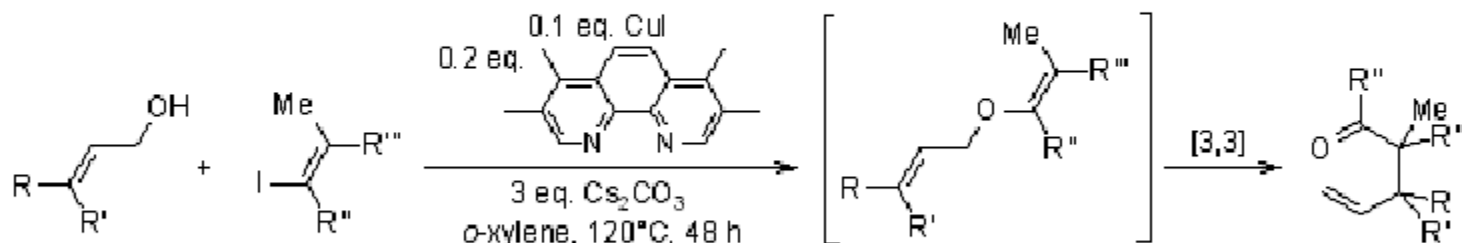
Recent Literature



Using Geminal Dicationic Ionic Liquids as Solvents for High-Temperature

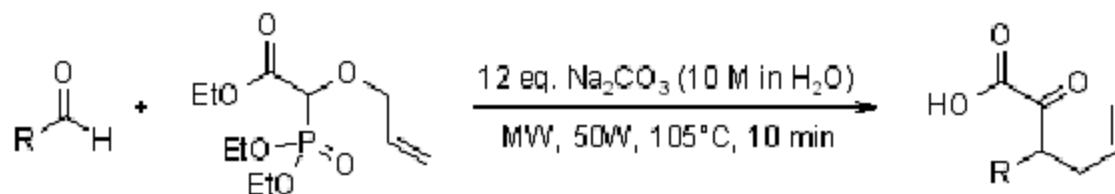
Organic Reactions

X. Han, D. W. Armstrong, *Org. Lett.*, **2005**, 7, 4205-4208.



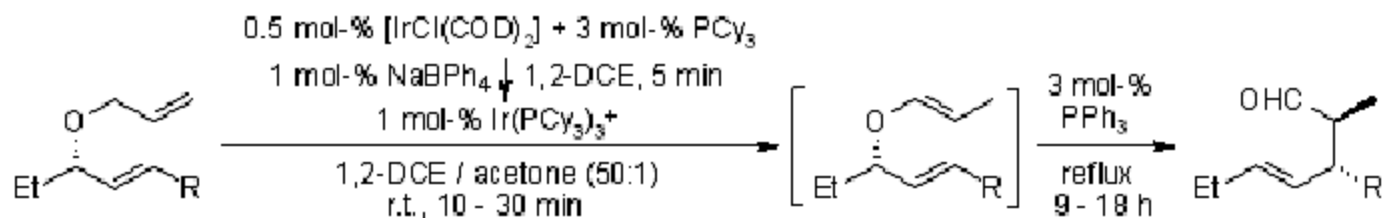
A Domino Copper-Catalyzed C-O Coupling-Claisen Rearrangement Process

G. Nordmann, S. L. Buchwald, *J. Am. Chem. Soc.*, **2003**, 125, 4978-4979.



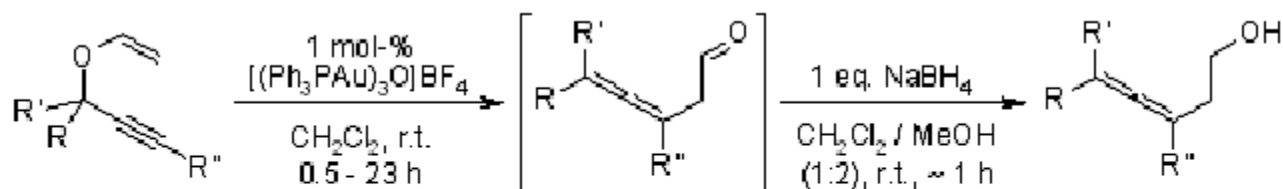
Tandem Horner-Wadsworth-Emmons Olefination/Claisen Rearrangement/Hydrolysis Sequence: Remarkable Acceleration in Water with Microwave Irradiation

E. Quesada, R. J. K. Taylor, *Synthesis*, **2005**, 3193-3195.



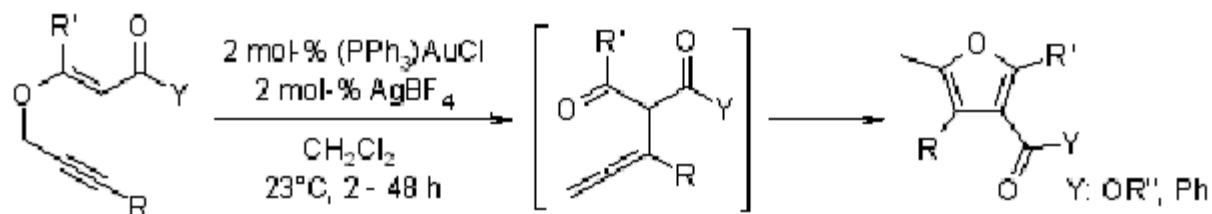
Asymmetric Claisen Rearrangements Enabled by Catalytic Asymmetric Di(allyl) Ether Synthesis

S. G. Nelson, K. Wang, *J. Am. Chem. Soc.*, **2006**, 128, 4232-4233.



Gold(I)-Catalyzed Propargyl Claisen Rearrangement

B. D. Sherry, F. D. Toste, *J. Am. Chem. Soc.*, **2004**, *126*, 15978-15979.



Gold(I)-Catalyzed Synthesis of Highly Substituted Furans

M. H. Suhre, M. Reif, S. F. Kirsch, *Org. Lett.*, **2005**, *7*, 3873-3876.