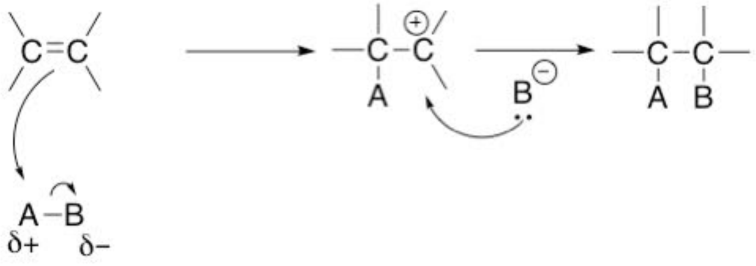
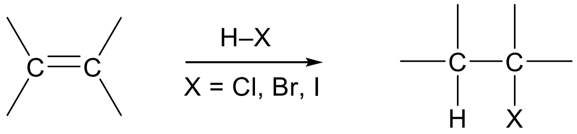
RECALL:

Addition Reactions

- Occurs on double bonds and triple bonds

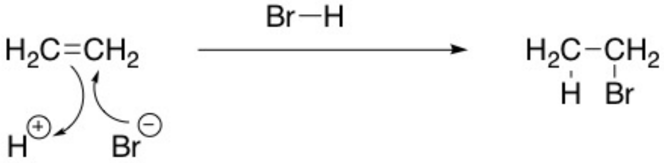


Hydrogen Halide (HX) Addition

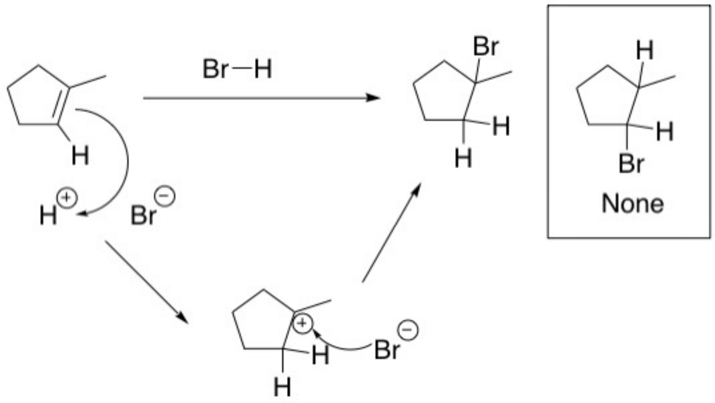


- Reaction generally leads to syn/cis addition

Example 1: Ethylene

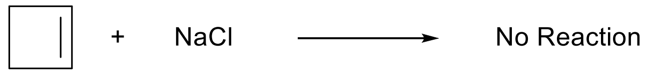


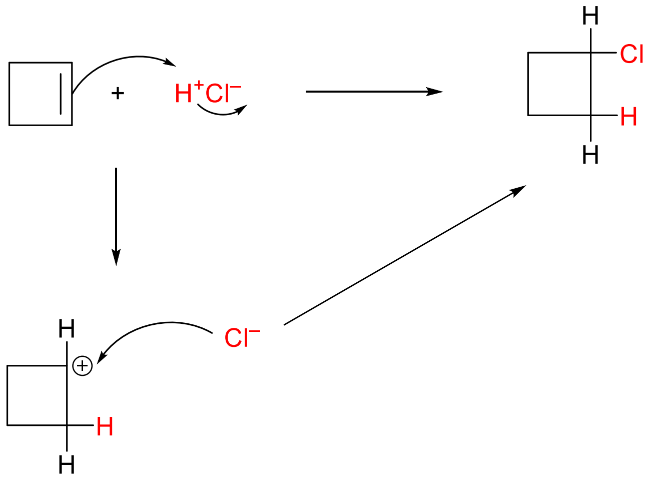
Example 2: 1-Methylcyclopent-1-ene



- Markovnikov addition
- H^+ would add to the less substituted C in the double bond to form the 3^o carbocation (more stable due to alkyl stabilization – inductive effect)

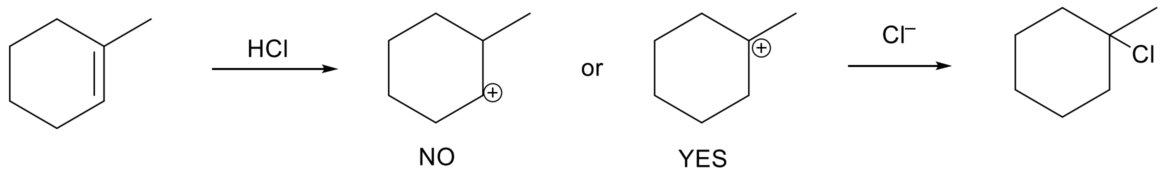
Example 3: Cyclobutene





Note: Need an acid (H^+) to pull out the electrons from the double bond

Example 4: 1-Methylcyclohex-1-ene

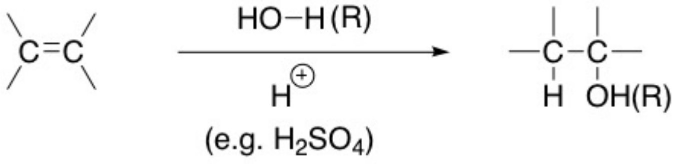


RECALL: Carbocation stability 3° > 2° > 1° > CH_3^+

Addition of H_2O and ROH (Hydration and Ether Formation)

HO–H or RO–H

Addition R = Alkyl

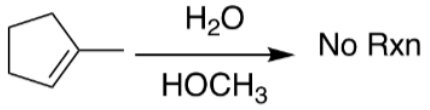


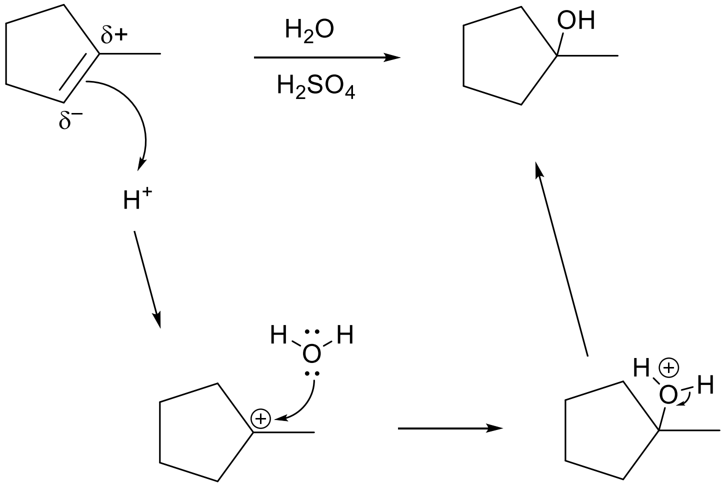
Not Stereospecific

Hydration formation

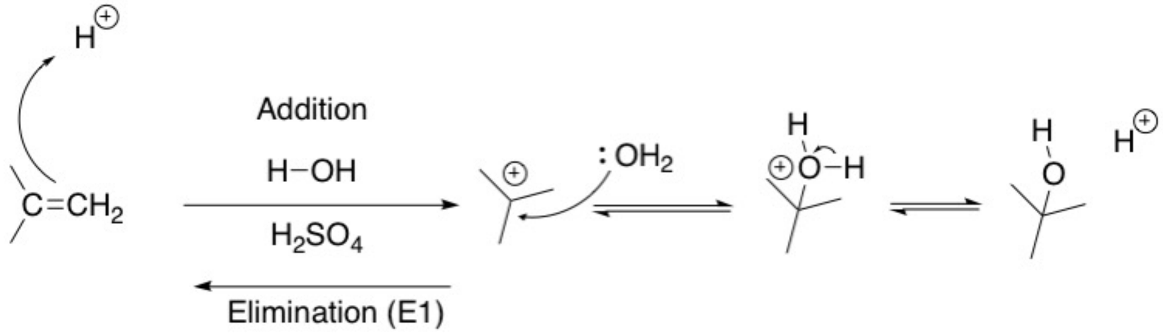
- H_2O or ROH by itself cannot add to the double bond. Need an acid (H^+) to pull the electrons from the double bond.
- H_2SO_4 (H^+) is a catalyst, meaning that it is not transformed or used up in the reaction but is present to lower the activation energy.

Example 1:



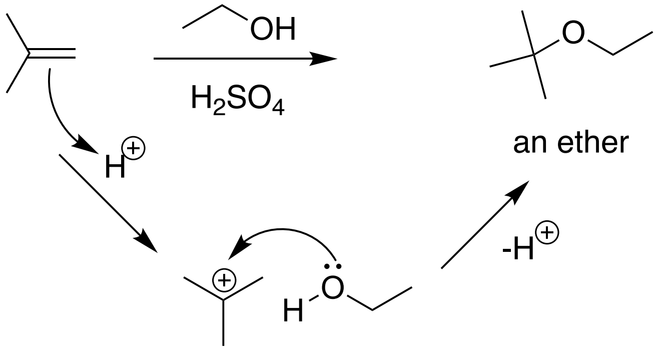


Example 2:

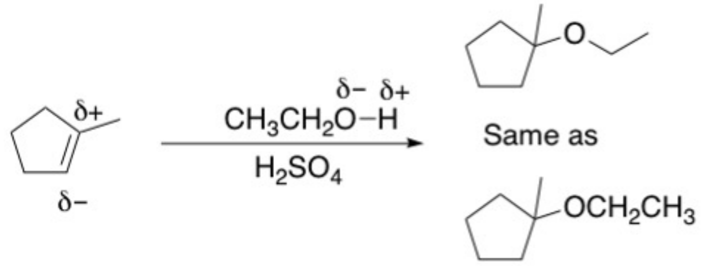


Ether formation

Example 1:

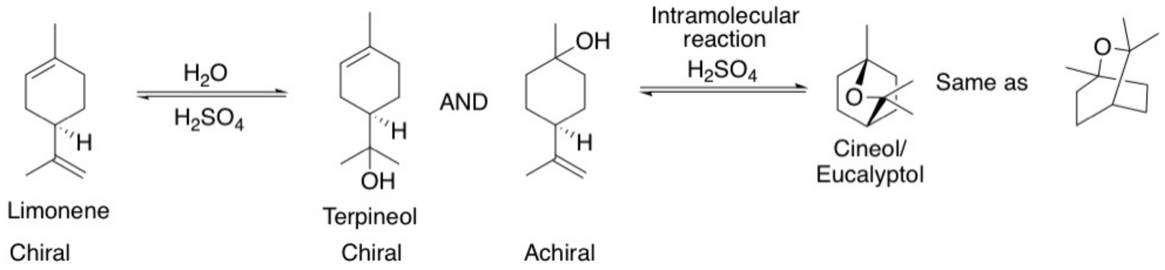


Example 2:

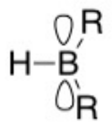


Rxn will not proceed without cat. H_2SO_4

Example 3:



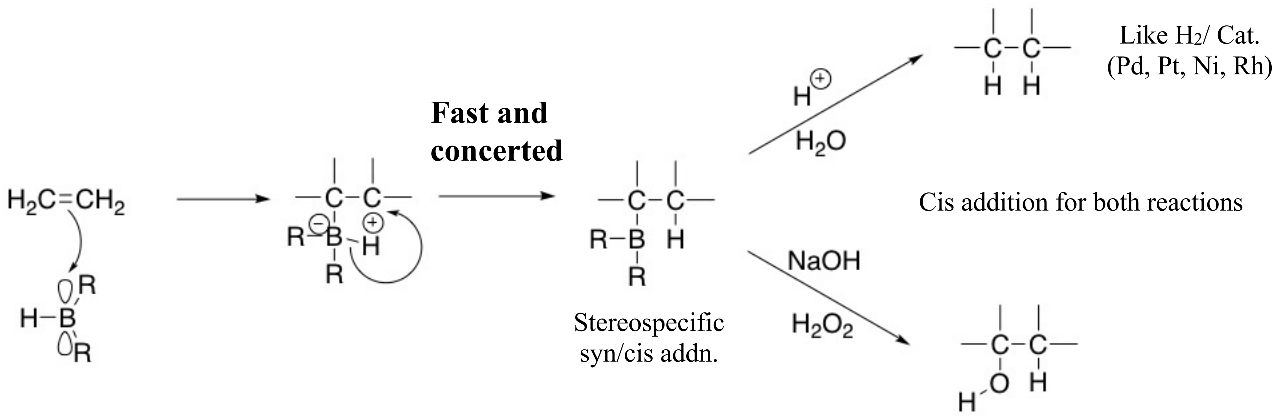
Hydroboration



R = H Borane

Lewis acid
Empty orbitals allow it to accept a pair of e⁻

- B when stable and uncharged has 3 bonds and no lone pairs
- Borane forms partial bonds with another borane molecule to form B_2H_6 (diborane)
- Borane is a hydride (H^-) donor



Fast and concerted

Like H_2/ Cat. (Pd, Pt, Ni, Rh)

Cis addition for both reactions

Stereospecific syn/cis addn.

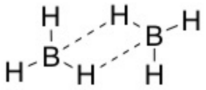
Concerted reaction: bond breaking and bond formation happens in a single step
Anti-Markovnikov: the hydrogen ends up on the more substituted C in a double bond.

Structure of borane

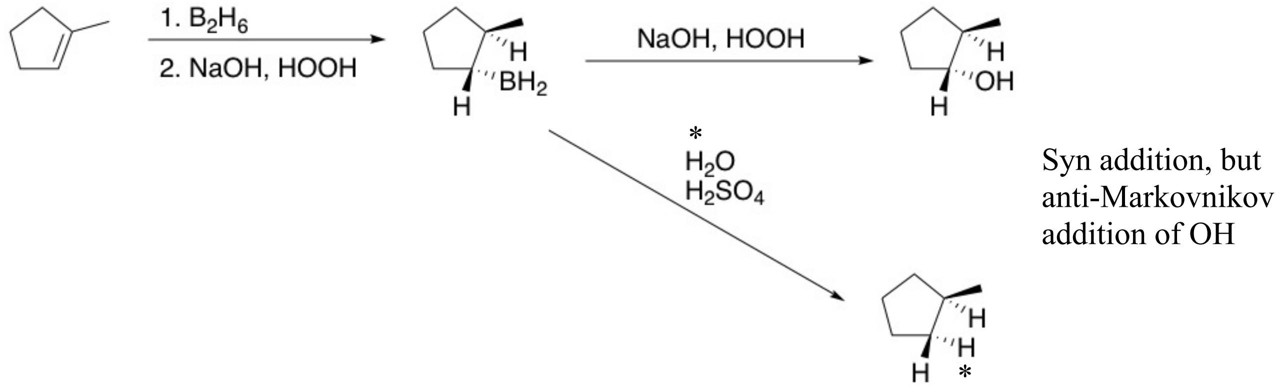
Exists as Diborane (B_2H_6), but behaves like BH_3

Borane BH_3

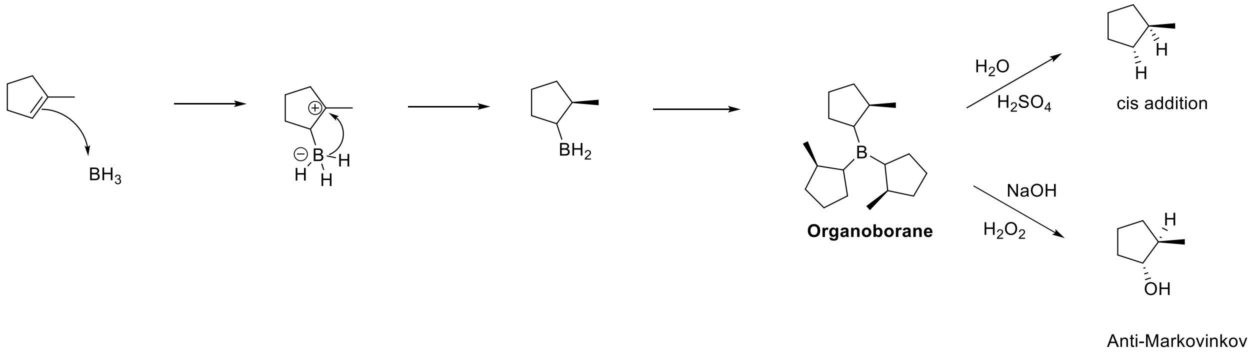
Diborane



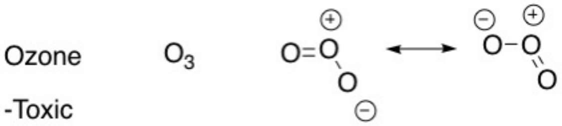
Example



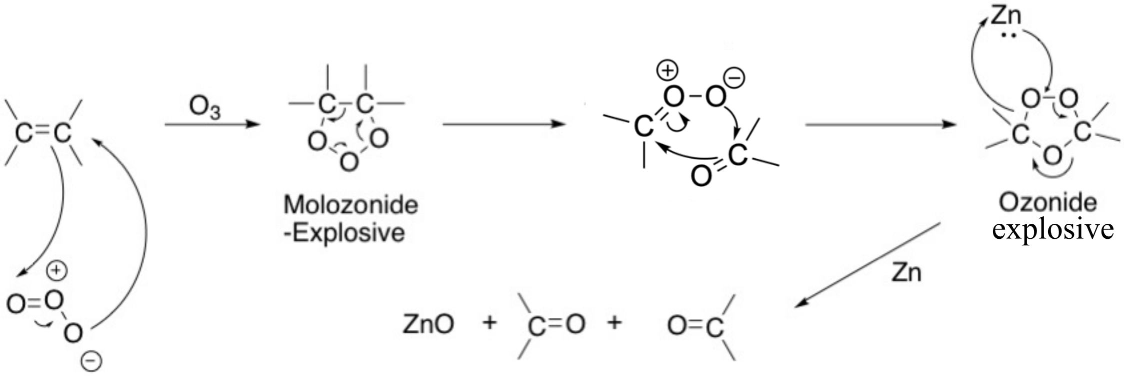
Syn addition, but anti-Markovnikov addition of OH



Ozonolysis (lysis = cleavage) – cleavage by ozone (O_3)

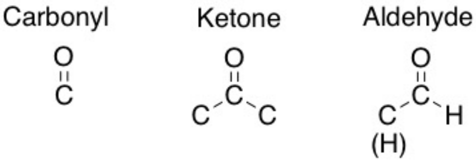


- Use double-headed arrow to indicate resonance (↔)
- Highly reactive (always looking for negative charge such as the negative charge in a double bond)
- Concerted and stereospecific

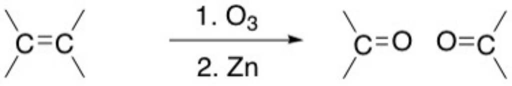


- Reaction is irreversible

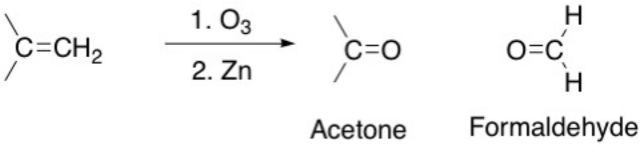
Examples of carbonyl groups

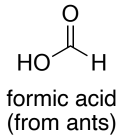


Reaction scheme of ozone

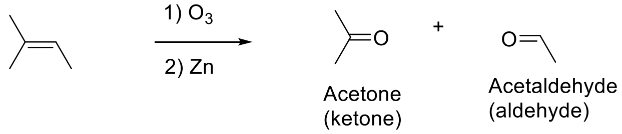


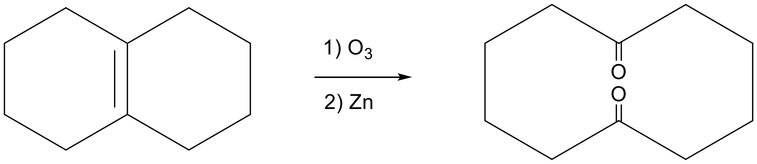
Example

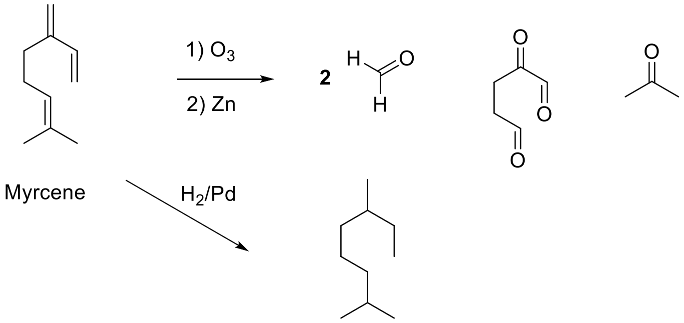




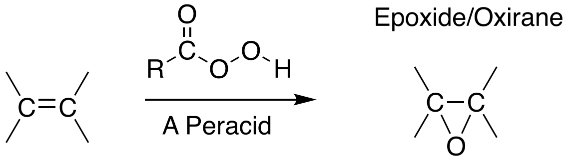
More examples





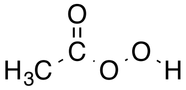


Epoxidation:



Syn/Cis Addition
Stereospecific

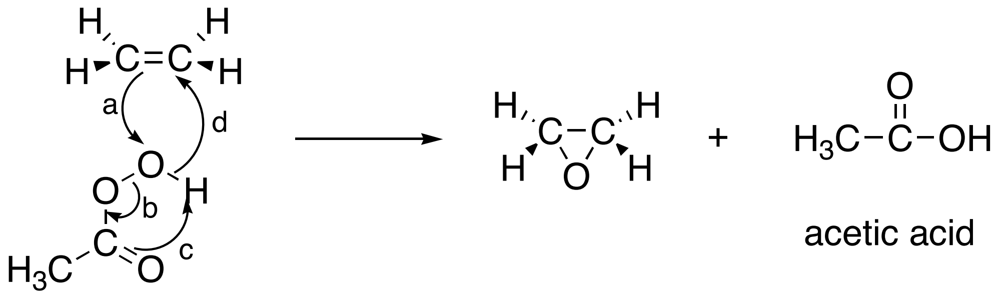
Example of
a peracid



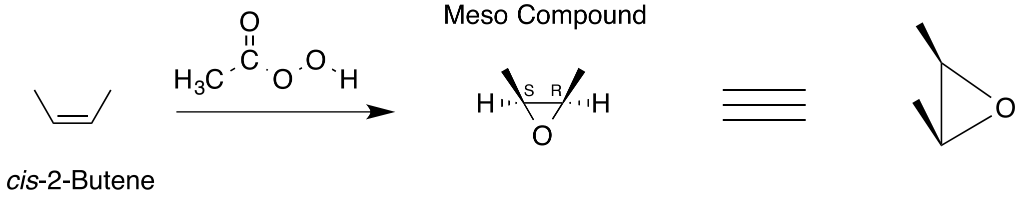
$CH_3C(=O)OOH$

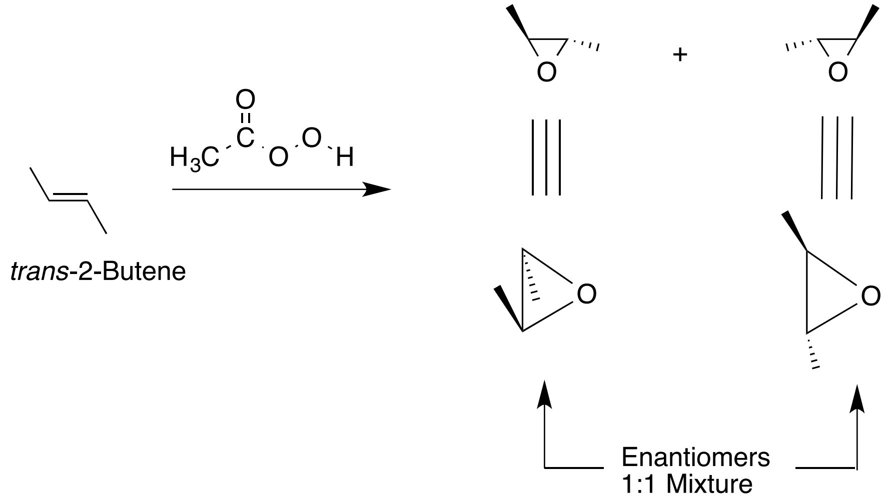
Concerted (bonds break and form at the same time)

Mechanism:



Example 1: *trans*- vs *cis*-Butene

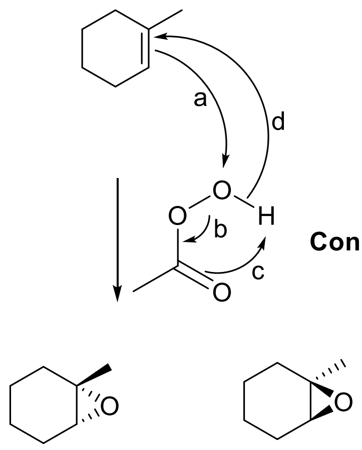




Racemic mixture

The possibility of epoxidation from the top is 50% and from the bottom is 50% so a 1:1 mixture of enantiomers is form (racemic mixture).

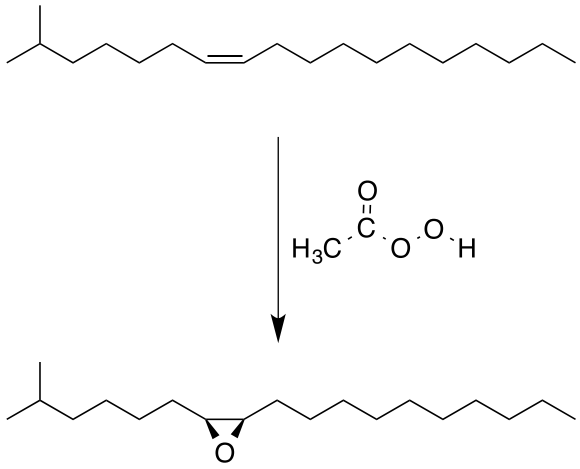
Example: 1-methyl-1-cyclohexene



Concerted Stereospecific

Racemic mixture (1:1)
cis/syn addition

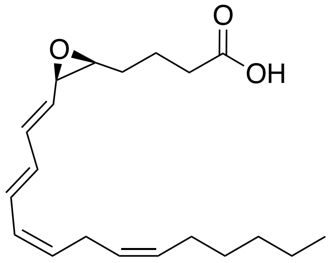
Example 2: 2-Methyl-7-octadecene



Sex pheromone for Gypsy Moth

biologically, only one enantiomer is active (one shown) – racemate produced by peracetic acid

Example 3:



Leukotriene A_4