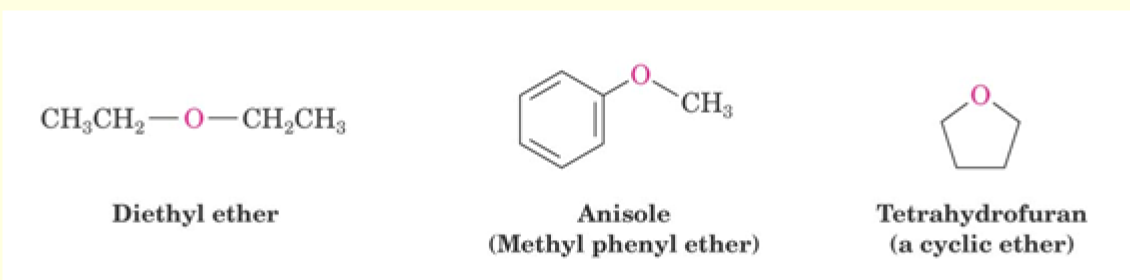
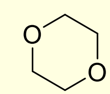
Ethers and Epoxides

- **Ether** have two organic groups (alkyl, aryl, or vinyl) bonded to the same oxygen atom [R–O–R′] may be they have the same structure (symmetric) or different (unsymmetric).
- Diethyl ether is used industrially as a solvent
- Tetrahydrofuran (THF) is a solvent that is a cyclic ether
- Dioxan is consider as an ether

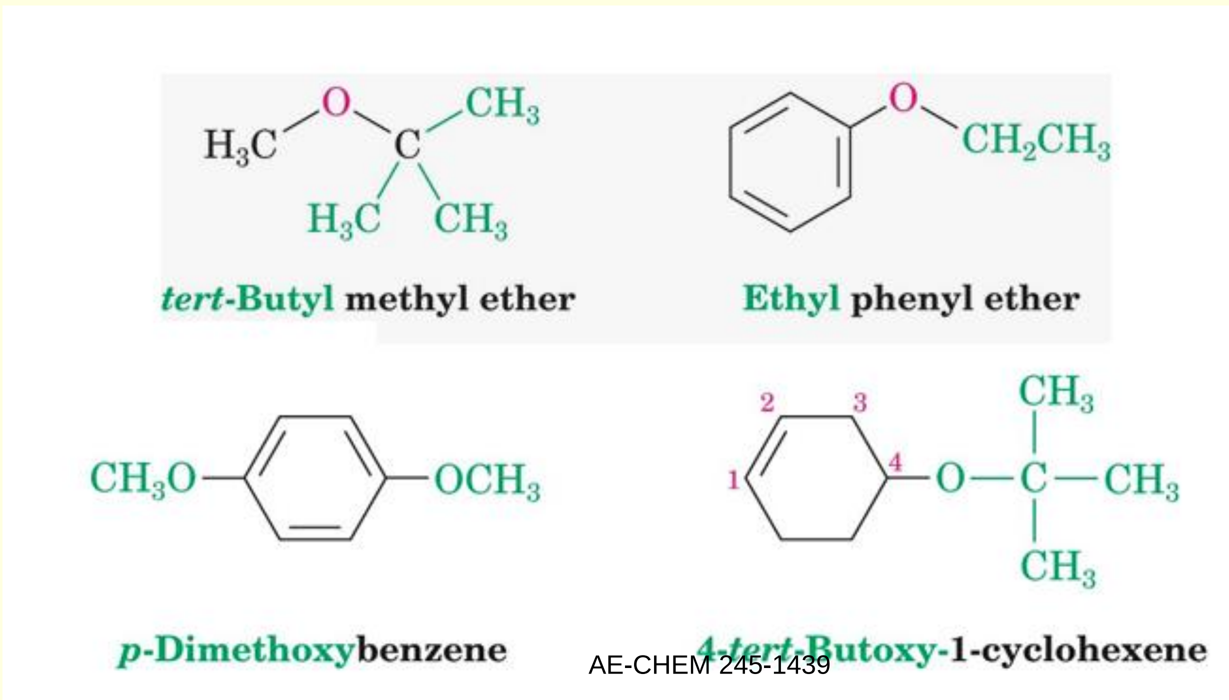




dioxan

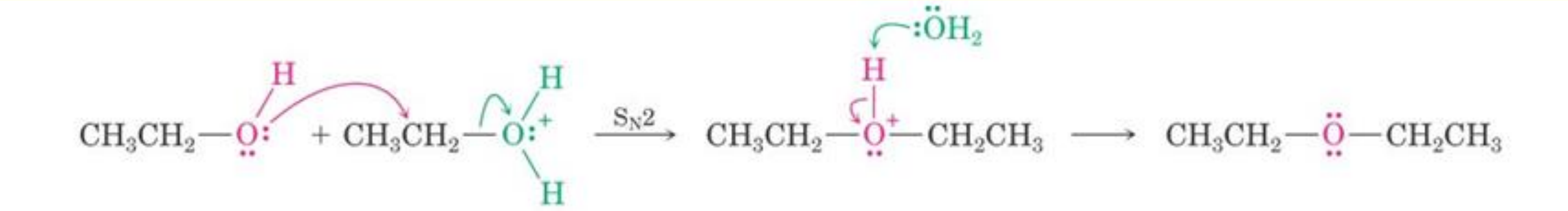
Naming of Ethers

- Simple ethers are named by identifying the two organic substituents and adding the word *ether*
- If other functional groups are present, the ether part is considered an alkoxy substituent



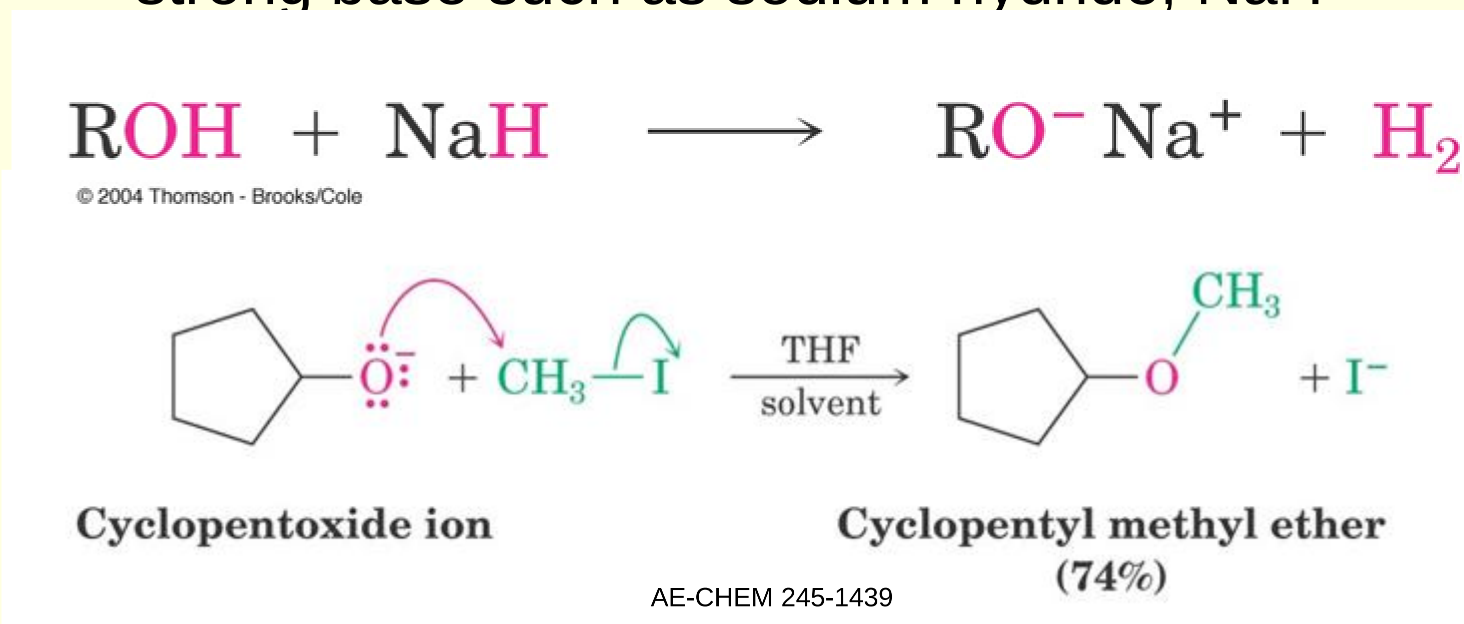
Structure, Properties, and Sources of Ethers

- R–O–R ~ tetrahedral bond angle (112° in dimethyl ether), they have **Lower boiling point than those of alcohols of comparable molecular weights**
- Oxygen is *sp*^{3}-hybridized
- Oxygen atom gives ethers a slight dipole moment
- Diethyl ether prepared industrially by sulfuric acid–catalyzed dehydration of ethanol – also with other primary alcohols



1. The Williamson Ether Synthesis

- Reaction of metal alkoxides and primary alkyl halides and tosylates
- Best method for the preparation of ethers
- Alkoxides prepared by reaction of an alcohol with a strong base such as sodium hydride, NaH



Summary of the Williamson synthesis

1. The Williamson synthesis is the preferred laboratory method for making ethers.

The reaction goes by an S_N2 mechanism.

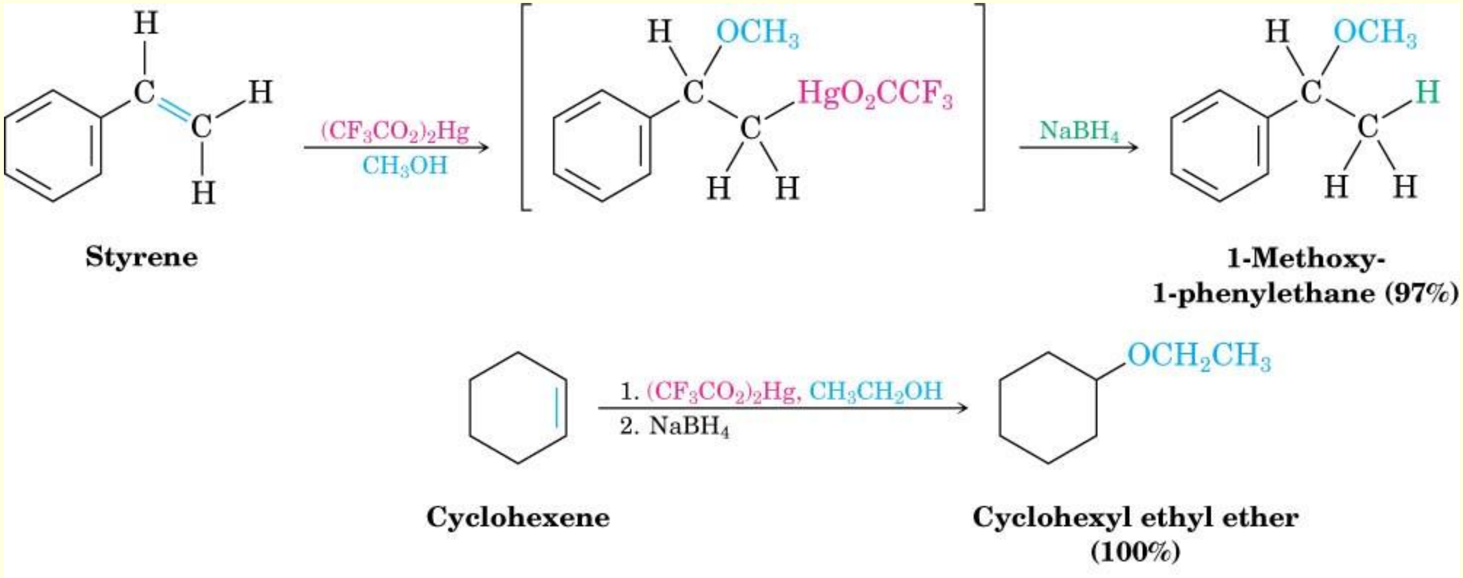
2. To prepare a mixed ether, it is necessary to choose the proper combination of reagents.

3. To obtain the best yields of mixed dialkyl ethers, we select a 1° rather than a 2°or 3°alkyl halide and react it with a sodium alkoxide

4. To prepare an alkyl aryl ether, we must be careful not to pick a combination in which one of the reagents has a halogen directly attached to an aromatic ring.

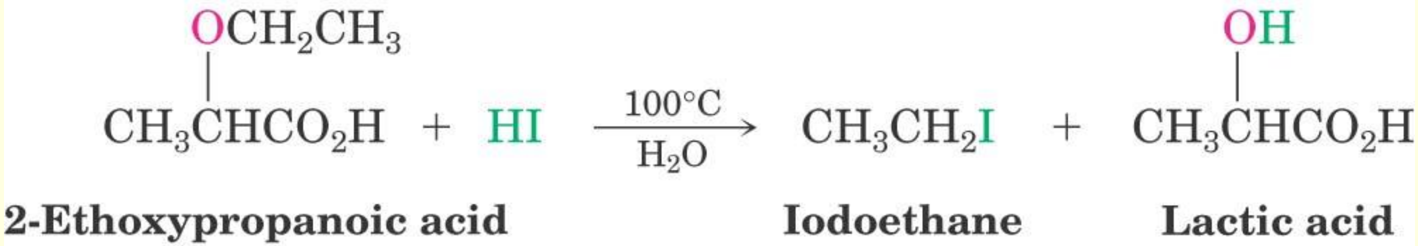
2. Alkoxymercuration of Alkenes

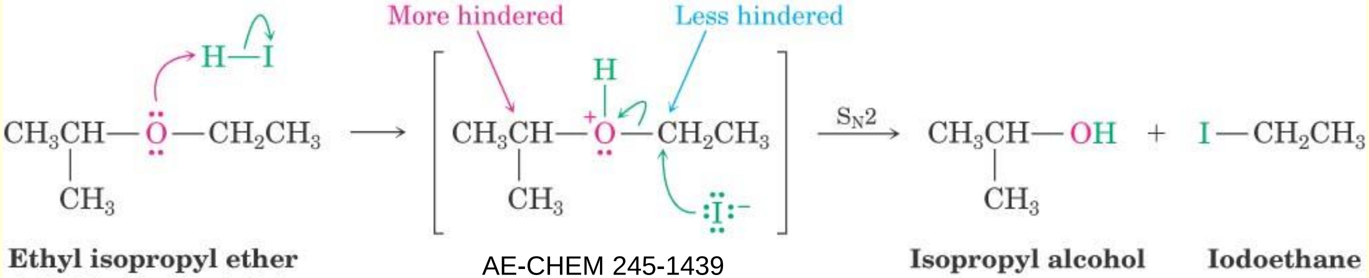
- React alkene with an alcohol and mercuric acetate or trifluoroacetate
- Demercuration with $NaBH_4$ yields an ether
- Overall Markovnikov addition of alcohol to alkene



Reactions of Ethers: Acidic Cleavage

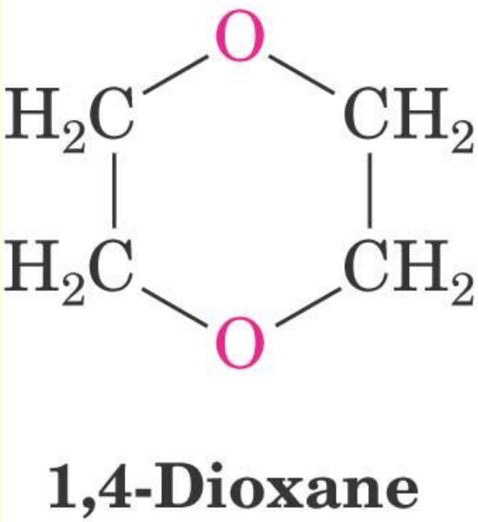
- Ethers are generally unreactive
- Strong acid will cleave an ether at elevated temperature
- HI, HBr produce an alkyl halide from less hindered component by S_N2 (tertiary ethers undergo S_N1)

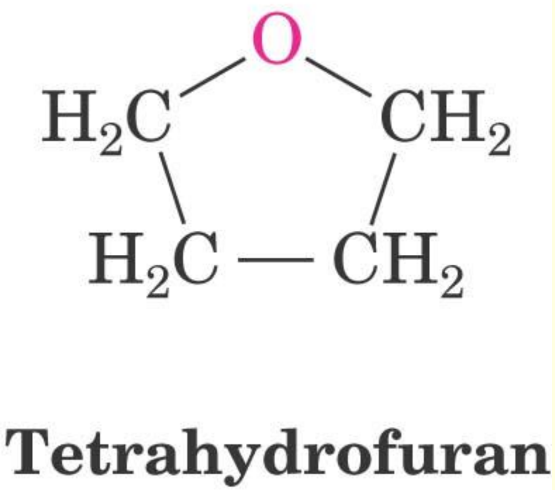




Cyclic Ethers: Epoxides

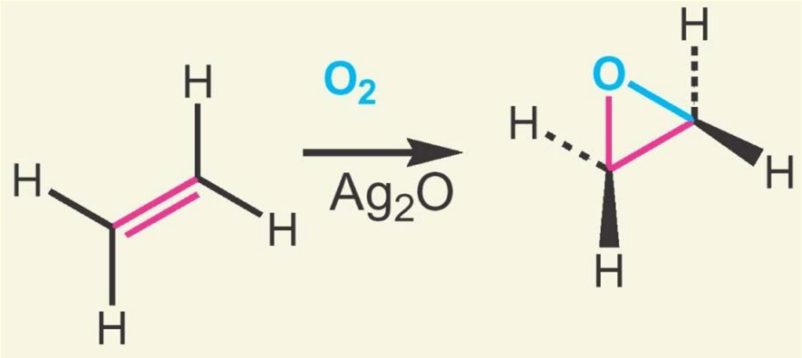
- Cyclic ethers behave like acyclic ethers, except if ring is 3-membered
- Dioxane and tetrahydrofuran are used as solvents





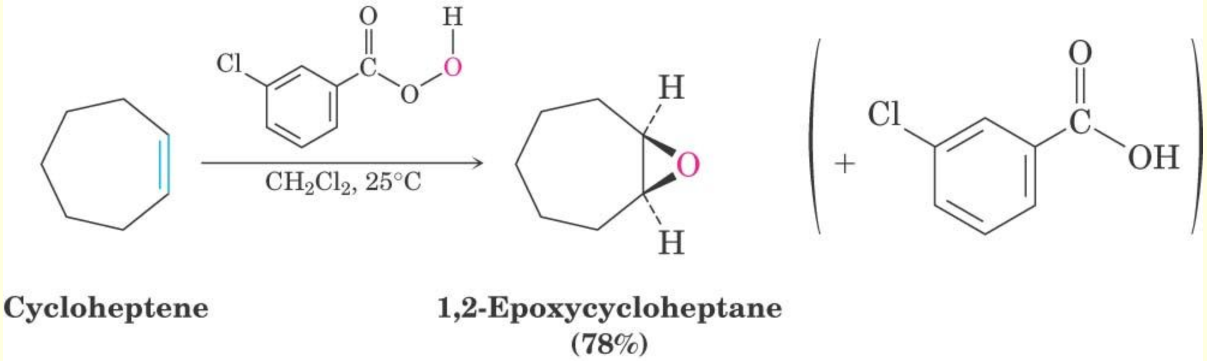
Epoxides (Oxiranes)

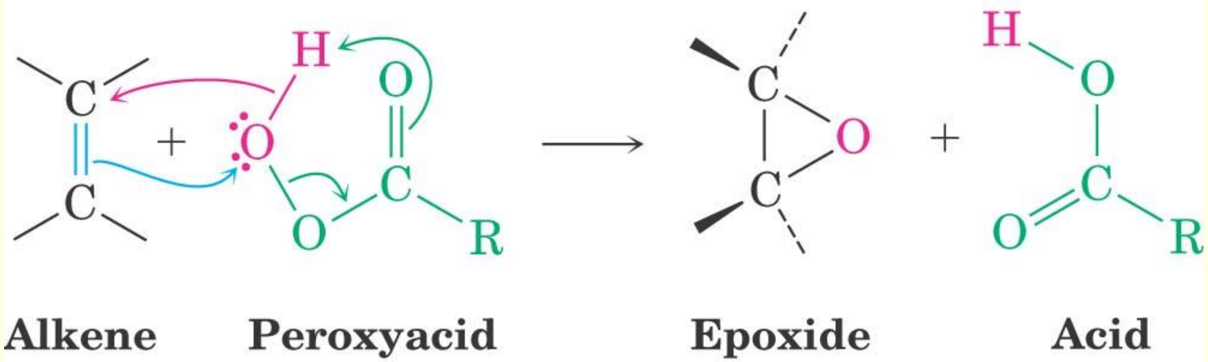
- Three membered ring ether is called an oxirane (root “ir” from “tri” for 3-membered; prefix “ox” for oxygen; “ane” for saturated)
- Also called epoxides
- Ethylene oxide (oxirane; 1,2-epoxyethane) is industrially important as an intermediate
- Prepared by reaction of ethylene with oxygen at 300 °C and silver oxide catalyst



Preparation of Epoxides Using a Peroxyacid

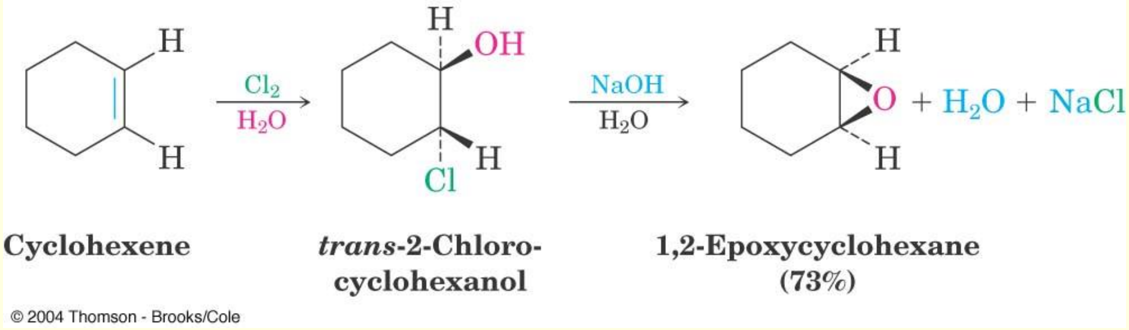
- Treat an alkene with a peroxyacid

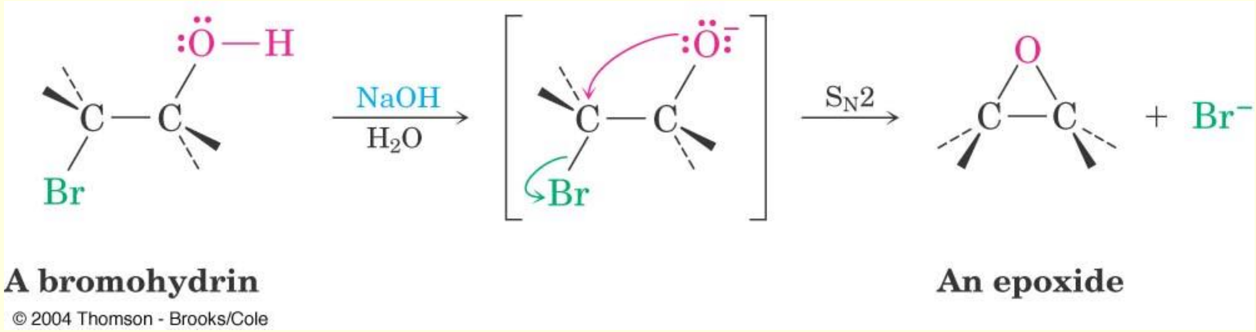




Epoxides from Halohydrins

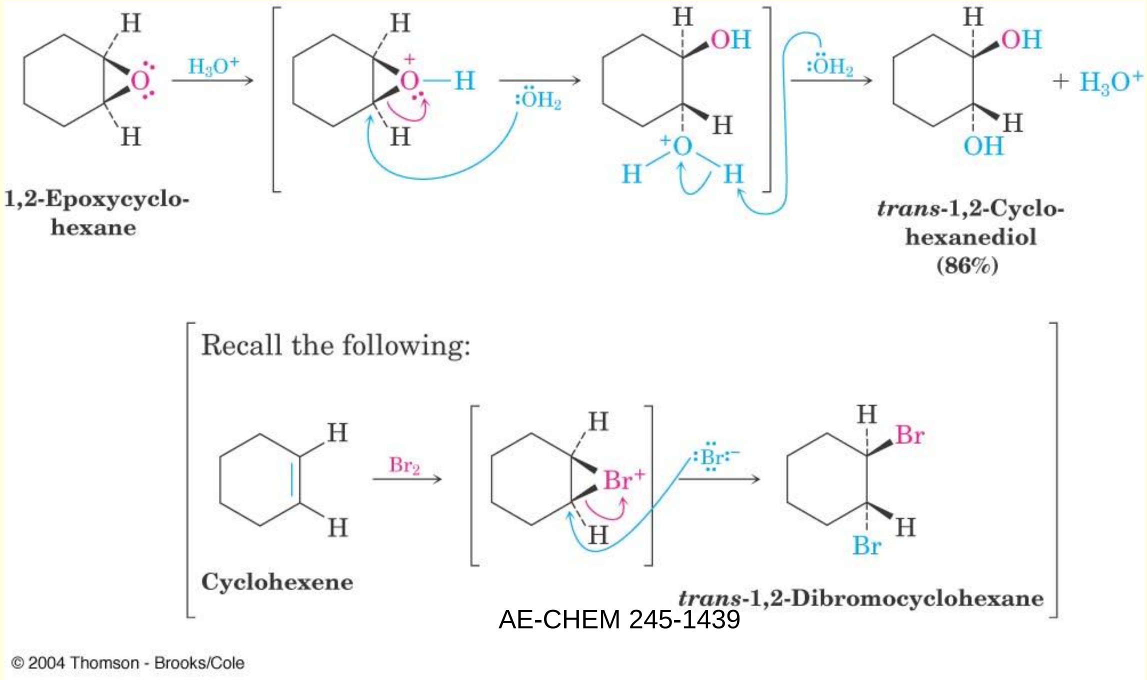
- Addition of HO-X to an alkene gives a halohydrin
- Treatment of a halohydrin with base gives an epoxide
- Intramolecular Williamson ether synthesis





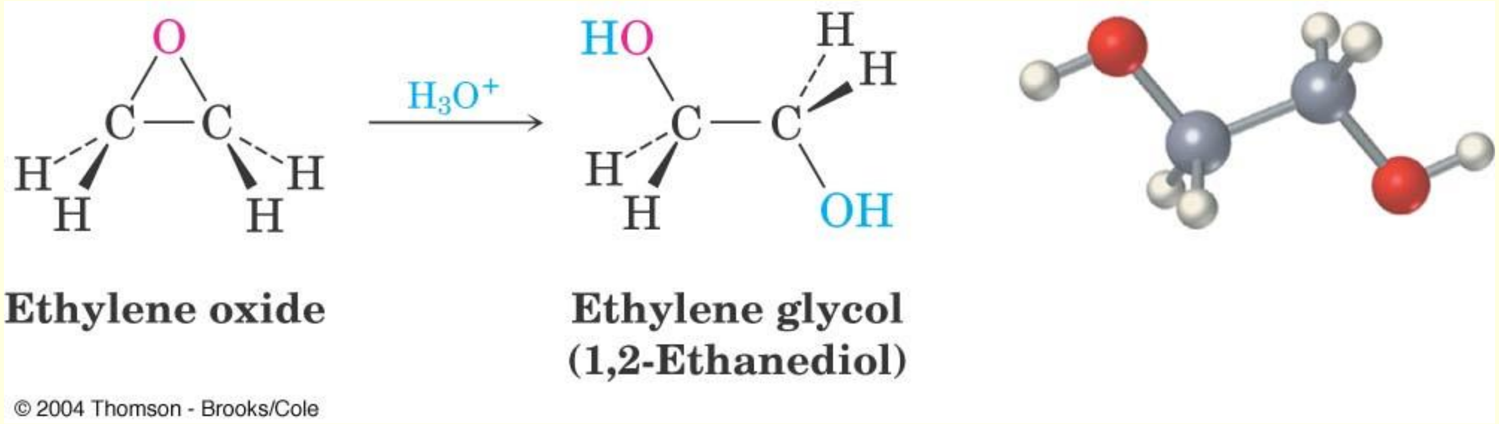
Ring-Opening Reactions of Epoxides

- Water adds to epoxides with dilute acid at room temperature
- Product is a 1,2-diol (on adjacent C's: *vicinal*)
- Mechanism: acid protonates oxygen and water adds to opposite side (trans addition)



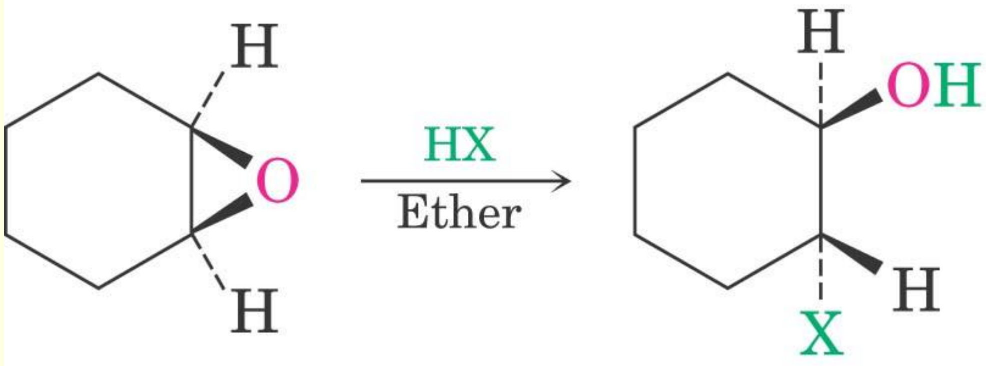
Ethylene Glycol

- 1,2-ethanediol from acid catalyzed hydration of ethylene
- Widely used as automobile antifreeze (lowers freezing point of water solutions)



Halohydrins from Epoxides

- Anhydrous HF, HBr, HCl, or HI combines with an epoxide
- Gives trans product

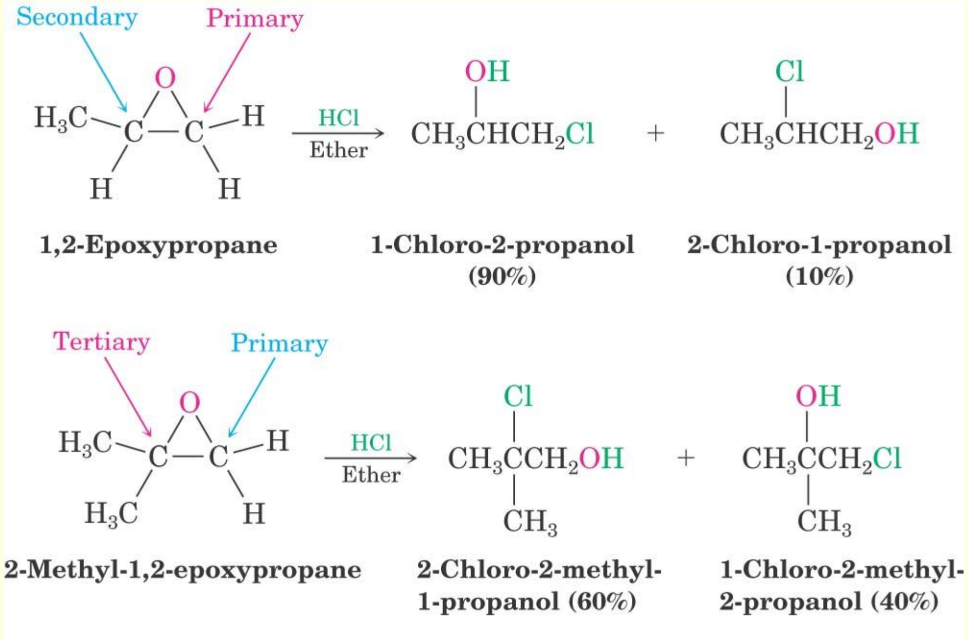


A trans 2-halocyclohexanol

where X = F, Br, Cl, or I

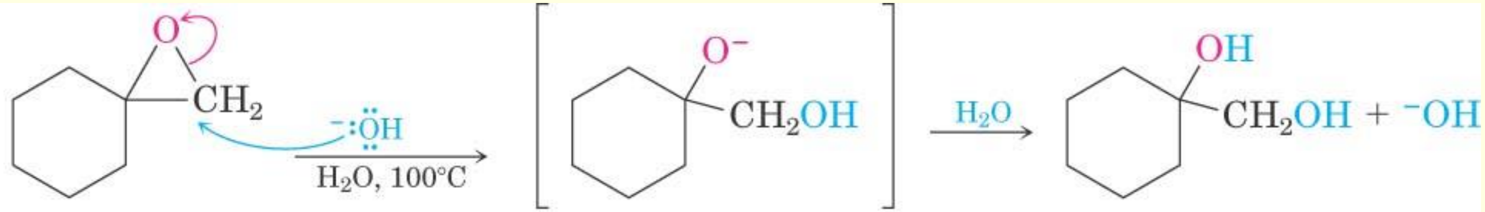
Regiochemistry of Acid-Catalyzed Opening of Epoxides

- Nucleophile preferably adds to less hindered site if primary and secondary C's
- Also at tertiary because of carbocation character



Base-Catalyzed Epoxide Opening

- Strain of the three-membered ring is relieved on ring-opening
- Hydroxide cleaves epoxides at elevated temperatures to give trans 1,2-diols



Methylenecyclohexane oxide

1-Hydroxymethyl-cyclohexanol (70%)

Addition of Grignards to Ethylene Oxide

- Adds $–CH_2CH_2OH$ to the Grignard reagent's hydrocarbon chain
- Acyclic and other larger ring ethers do not react