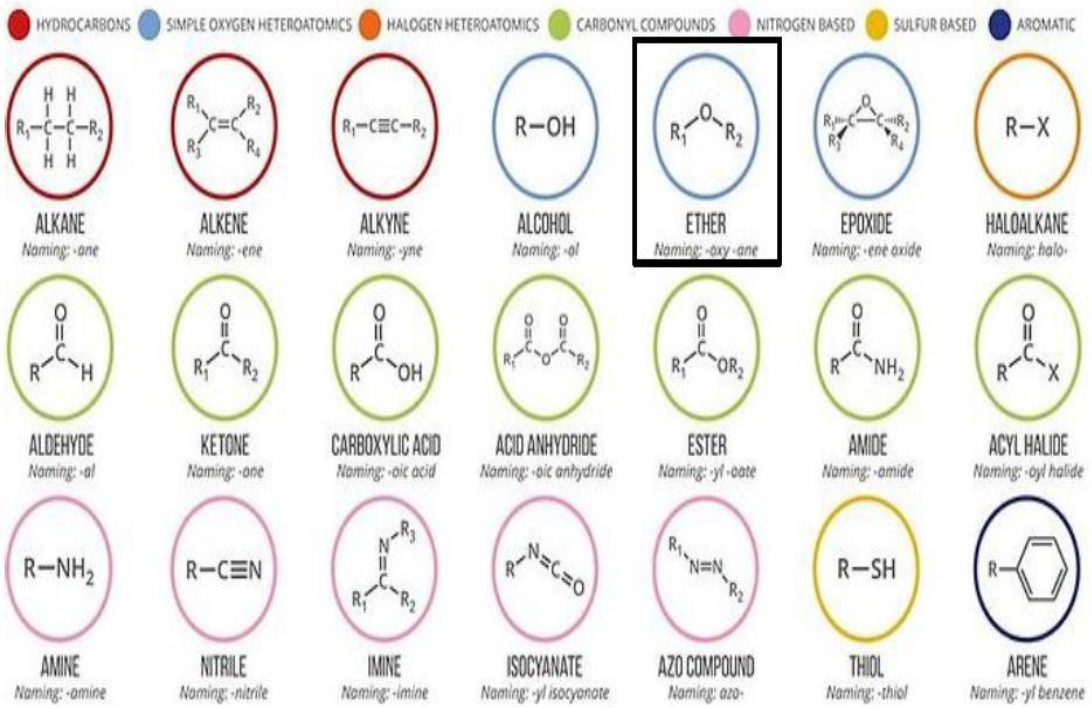
Ethers



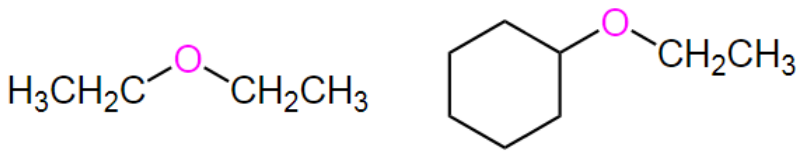
Ether is an organic compound containing an oxygen atom bonded to two same or different alkyl or aryl groups. The ***general formula for ethers can be R-O-R, R-O-Ar or Ar-O-Ar***, where R represents an alkyl group and Ar represents an aryl group.

Ethers are generally classified into two categories on the basis of substituent groups attached: ***symmetrical ether*** (when two identical groups are attached to the oxygen atom) and ***asymmetrical ether*** (when two different groups are attached to the oxygen atom). Ethers exhibit a wide range of physical and chemical properties.

Structure of Ethers

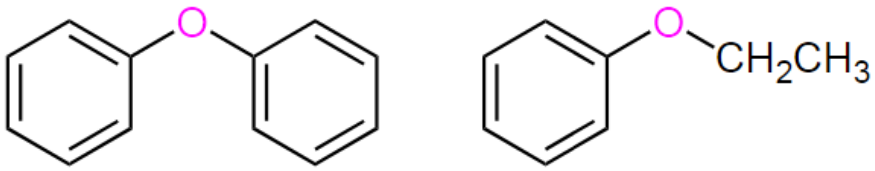
Ethers are a class of organic compounds have the formula R-O-R'. these compounds are used in dyes, perfumes, oils, waxes and other industrial uses.

Aliphatic ethers have no aryl groups directly attached to the ether oxygen.



Examples of Aliphatic Ethers

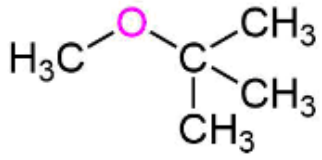
Aromatic ethers have at least one aryl ring directly attached to the ether oxygen. In aryl ethers, the lone pair elections on oxygen are conjugated with the aromatic ring which significantly changes the properties of the ether.



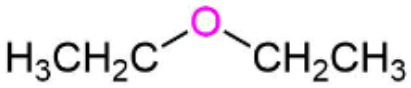
Example of Aromatic Ethers

Naming of Ethers

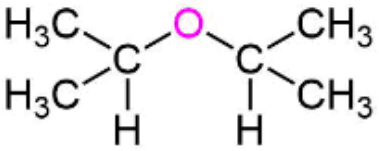
When no other functional group is present, simple ethers are often given common functional class names. Both alkyl groups attached to the oxygen atom are named as substituents (in alphabetical order) and then the word *ether* is added.



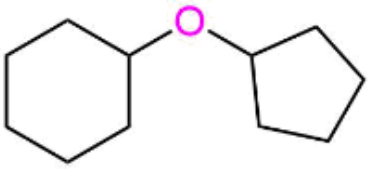
Methyl *tert*-butyl ether



Diethyl ether



Diisopropyl ether

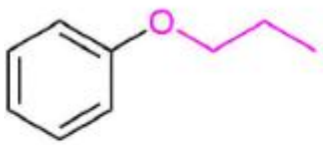


Cyclohexyl cyclopentyl ether

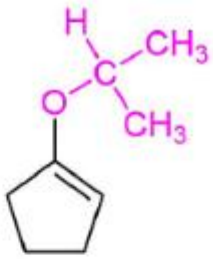
IUPAC nomenclature for ethers should be used for complicated ethers, compounds with more than one ether linkage, and compounds where other functional groups are present with an ether. In these cases, an RO group of the ether is named as an alkoxy substituent.

Table : Common Alkyl and Alkoxy Groups

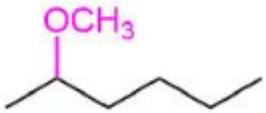
Alkyl Group	Name	Alkoxy Group	Name
CH_3–	Methyl	CH_3O–	Methoxy
CH_3CH_2–	Ethyl	CH_3CH_2O–	Ethoxy
$(CH_3)_2CH$–	Isopropyl	$(CH_3)_2CHO$–	Isopropoxy
$(CH_3)_3C$–	tert-Butyl	$(CH_3)_3CO$–	tert-Butoxy
C_6H_5–	Phenyl	C_6H_5O–	Phenoxy



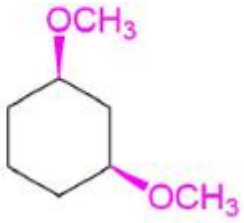
Propoxybenzene



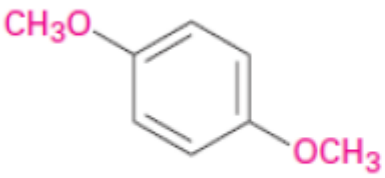
1-Isopropoxycyclopentene



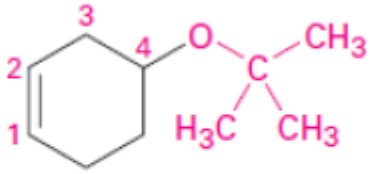
2-Methoxyhexane



Cis-1,3-Dimethoxycyclohexane



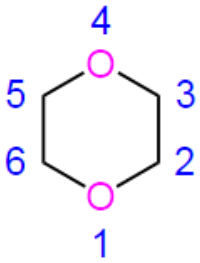
p-Dimethoxybenzene



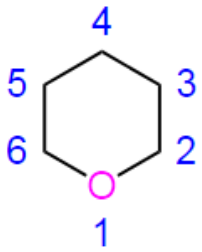
4-*tert*-Butoxy-1-cyclohexene

Cyclic Ethers

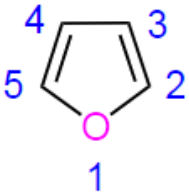
In cyclic ethers are a type of heterocycle with one or more oxygens located in the ring. Many cyclic ethers have common names and are often used as solvents due to their inert nature. These ring structures are often found in biological molecules such as sugars and DNA. The rings are numbered so that an oxygen gets position 1.



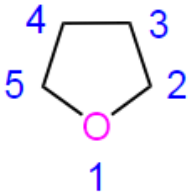
Dioxane



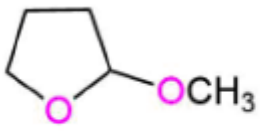
Tetrahydropyan



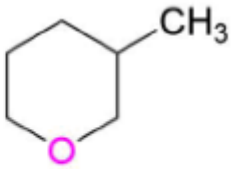
Furan



Tetrahydrofuran



2-Methoxytetrahydrofuran



3-Methyltetrahydropyran

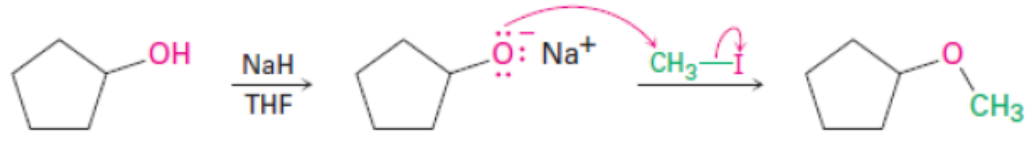
Physical Properties of Ethers

1. An ether molecule has a net dipole moment due to the polarity of C-O bonds.
2. The boiling point of ethers is comparable to the alkanes but much lower than that of alcohols of comparable molecular mass despite the polarity of the C-O bond. The miscibility of ethers with water resembles those of alcohols.
3. Ether molecules are miscible in water. This is attributed to the fact that like alcohol, the oxygen atom of ether can also form hydrogen bonds with a water molecule.

Synthesis of Ethers

1. The Williamson Ether Synthesis

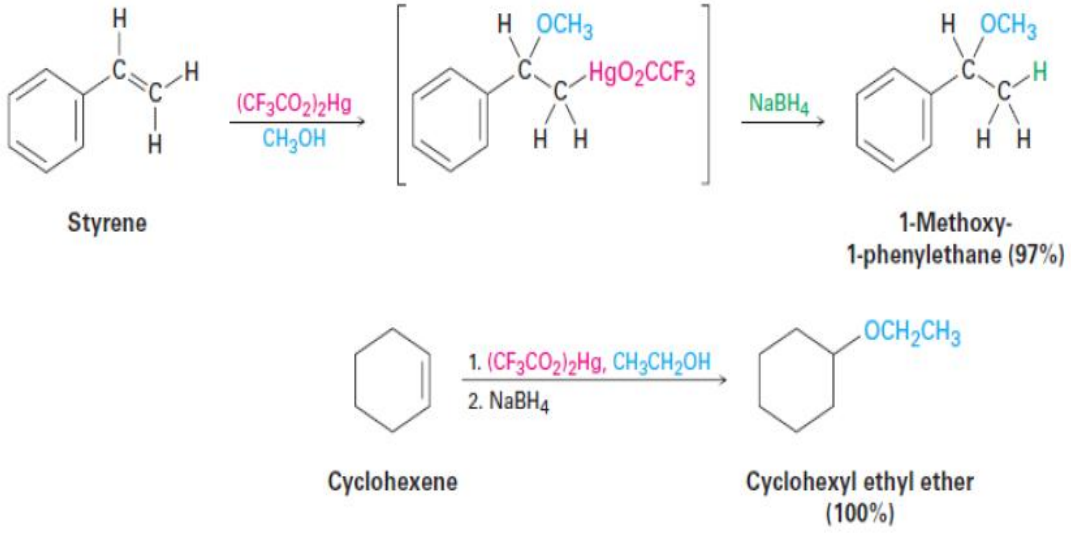
The most generally useful method of preparing ethers is by the Williamson ether synthesis, in which an alkoxide ion reacts with a primary alkyl halide or tosylate. As we saw earlier in the alkoxide ion is normally prepared by reaction of an alcohol with a strong base such as sodium hydride, NaH.



Cyclopentanol — Alkoxide ion — Cyclopentyl methyl ether (74%)

2. Alkoxymercuration of Alkenes

Alkenes react with water in the presence of mercuric acetate to yield a hydroxymercuration product. Subsequent treatment with NaBH4 breaks the C -Hg bond and yields the alcohol. A similar alkoxymercuration reaction occurs when an alkene is treated with an *alcohol* in the presence of mercuric acetate or, even better, mercuric trifluoroacetate, (CF3CO2)2Hg. Demercuration by reaction with NaBH4 then yields an ether. The net result is Markovnikov addition of the alcohol to the alkene.



3. Dehydration of Alcohols to Make Ethers

Diethyl ether and other simple symmetrical ethers are prepared industrially by the sulfuric acid–catalyzed reaction of alcohols. The reaction occurs by displacement of water from a protonated ethanol molecule by the oxygen atom of a second ethanol. Unfortunately, the method is limited to use with primary alcohols because secondary and tertiary alcohols dehydrate by a certain mechanism to yield alkenes.

$$2\,CH_3CH_2{-}OH + H_2SO_4 \xrightarrow{130\,^oC} CH_3CH_2{-}O{-}CH_2CH_3 + H_2O$$

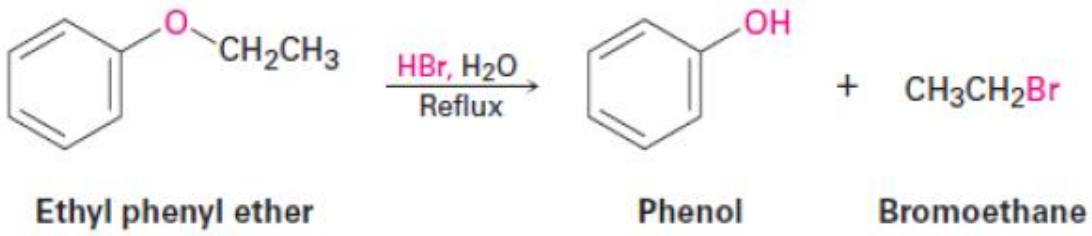
$$CH_3CH_2{-}OH + H_2SO_4 \xrightarrow{150\,^oC} CH_2{=}CH_2 + H_2O$$

Reactions of Ethers

1. Acidic Cleavage

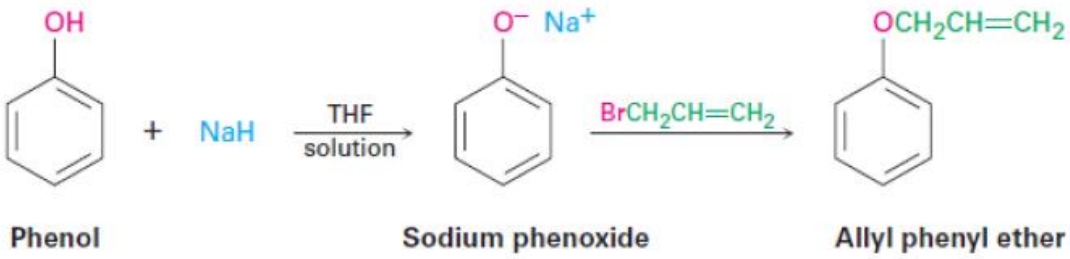
Ethers are unreactive to many reagents used in organic chemistry, a property that accounts for their wide use as reaction solvents. Halogens, dilute acids, bases, and nucleophiles have no effect on most ethers. In fact, ethers undergo only one truly general reaction they are cleaved by

strong acids. Aqueous HBr and HI both work well, but HCl does not cleave ethers

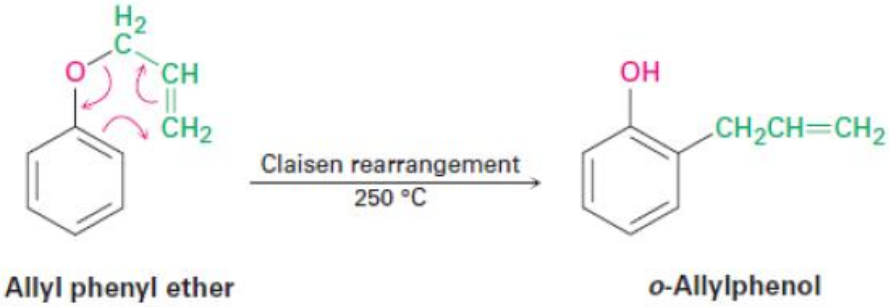


Ethyl phenyl ether Phenol Bromoethane

2. Claisen Rearrangement



Phenol Sodium phenoxide Allyl phenyl ether



Allyl phenyl ether *o*-Allylphenol

Uses of Ethers

- Ethers are organic compounds with a *sweet smell* at room temperature. They are colourless and evaporate quickly when exposed to air.
- It is *flammable* and hence catches fire very easily and therefore should be handled with care.

- Being flammable and volatile it is used in cold weather to start a diesel or petrol engine. It is also used as a *refrigerant*.
- Ethers are used as an *antiseptic* in order to prevent infection when an injection is administered into the body.
- A cotton ball is dipped in ether and skin is *disinfected* before an injection is allowed to pierce the skin.
- Diethyl ether is used as an *anaesthetic* in hospitals. Anaesthetics help in making people go to sleep or become unconscious during surgery.
- The discovery of ether allowed physicians to use more refined techniques of surgery and medications. They got a better idea of human physiology.
- But due to the flammable nature of ether, it has now been replaced with safer alternatives. Since diethyl ether can be used as an anaesthetic, it is an *appealing recreational drug*.
- It is basically a controlled substance and can be inhaled by the users to *induce euphoria and sedation*. But overdose of diethyl ether can cause respiratory paralysis and also result in death.