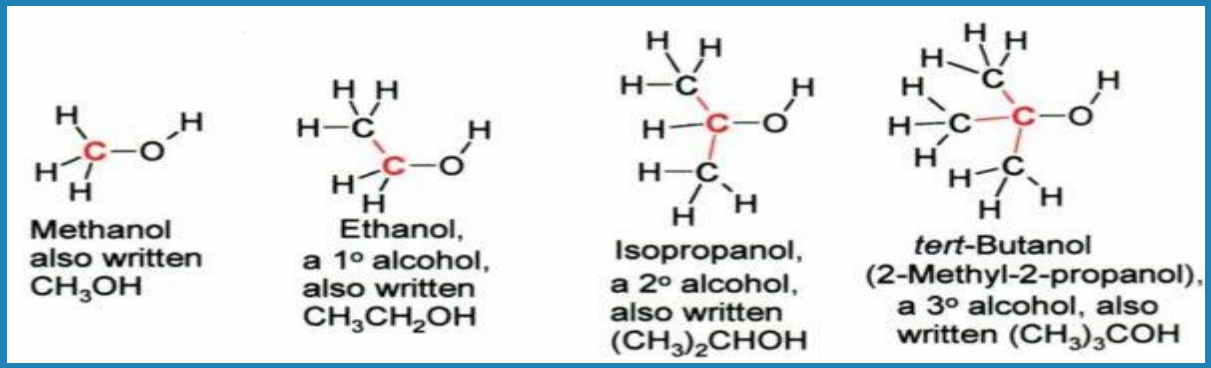
Lec 9,10,11,12

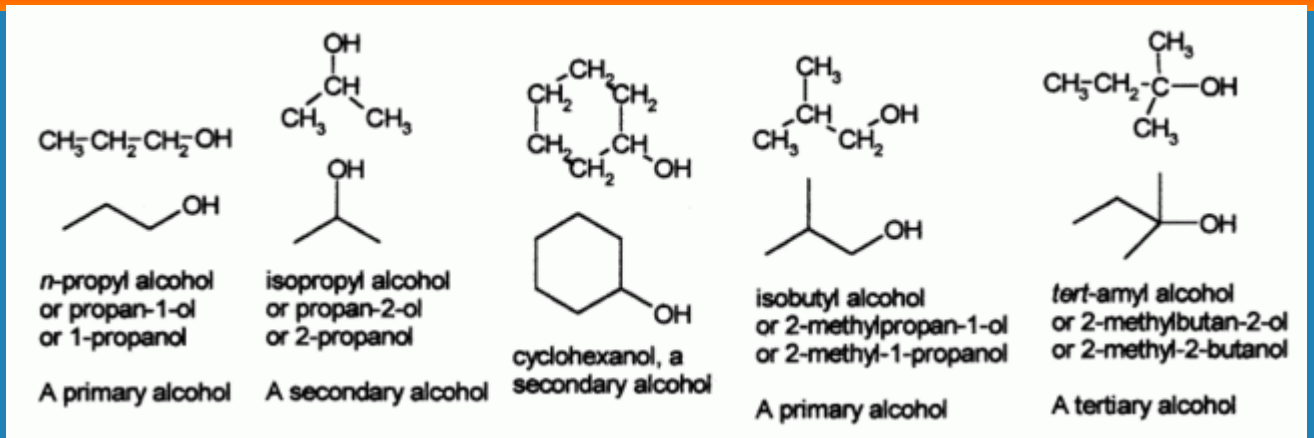
In chemistry ,an **alcohol** is any organic compound in which a hydroxyl group (*-OH)* is bound to a carbon atom of an alkyl or substituted alkyl group. The general formula for a simple acyclic alcohol is $C_nH_{2n+1}OH$. Generally, the word *alcohol*, when used alone, usually refers to ethanol, also known as *grain alcohol* or (older) *spirits of wine*. Ethanol is a very strong and unique smelling, colorless, volatile liquid formed by the fermentation of sugars. It also often refers to any beverage that contains ethanol. It is the most widely used depressant in the world, and has been for thousands of years. This sense underlies the term alcoholism (addiction to alcohol).

Other forms of alcohol are usually described with a clarifying adjective, as in *isopropyl alcohol* (*propan-2-ol*) or *wood alcohol* (*methyl alcohol*, or methanol). The suffix *-ol* appears in the official chemical name of all alcohols.

There are three major, subsets of alcohols: 'primary' (1°), 'secondary' (2°) and 'tertiary' (3°), based upon the number of carbons the C-OH carbon is bonded to. Methanol is the simplest 'primary' . The simplest secondary alcohol is isopropyl alcohol (propan-2-ol), and a simple tertiary alcohol is *tert*-butyl alcohol (2-methylpropan-2-ol).



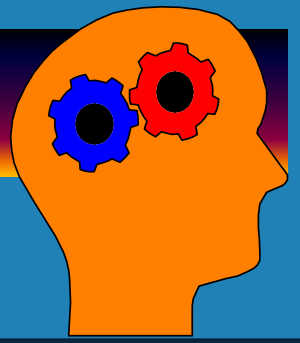
In the IUPAC system, the name of the alkane chain loses the terminal "e" and adds "ol", e.g. "methanol" and "ethanol". When necessary, the position of the hydroxyl group is indicated by a number between the alkane name and the "ol :"propan-1-ol for **CH3CH2CH2OH** ,propan-2-ol for **CH3CH(OH)CH3** .Sometimes, the position number is written before the IUPAC name: 1-propanol and 2-propanol. If a higher priority group is present (such as an aldehyde ,ketone or carboxylic acid ,(then it is necessary to use the prefix "hydroxy", for example: 1-hydroxy-2-propanone **CH3COCH2OH**.



for alcohols usually takes name of the corresponding alkyl group and add the word "alcohol", e.g .methyl alcohol ,ethyl alcohol or *tert*-butyl alcohol .Propyl alcohol may be *n*-propyl alcohol or isopropyl alcohol depending on whether the hydroxyl group is bonded to the 1st or 2nd carbon on the propane chain. Isopropyl alcohol is also occasionally called *sec*-propyl alcohol.

As mentioned above alcohols are classified as primary (1°), secondary (2°) or tertiary (3°), and common names often indicate this in the alkyl group prefix. For example $(CH_3)_3COH$ is a tertiary alcohol is commonly known as *tert*-butyl alcohol. This would be named 2-methylpropan-2-ol under IUPAC rules, indicating a propane chain with methyl and hydroxyl groups both attached to the middle (#2) carbon.

Physical properties



- Alcohols are present as liguids and solids.
- The hydroxyl group generally makes the alcohol molecule polar.
- Those groups can form hydrogen bonds to one another and to other compounds.
- This hydrogen bonding means that alcohols can be olubility in water, methanol, ethanol, and propanol are miscible in water, butanol ,with a four-carbon chain, is moderately soluble, Alcohols of five or more carbons (Pentanol and higher) are effectively insoluble in water because of the hydrocarbon chain's dominance.
- Because of hydrogen bonding ,alcohols tend to have higher boiling points than comparable hydrocarbons and ethers

Chemical properties

Alcohols, like water, can show either acidic or basic properties at the O-H group. They are generally slightly weaker acids than water ,but they are still able to react with strong bases such as sodium hydride or reactive metals such as sodium, lithium, etc. .The salts that result are called alkoxides ,with the general formula RO^-M^+.

The basicity of the conjugate base depends on the class of parent alcohol.

Tertiary alkoxide > Secondary alkoxide > Primary alkoxide

Increase in basicity

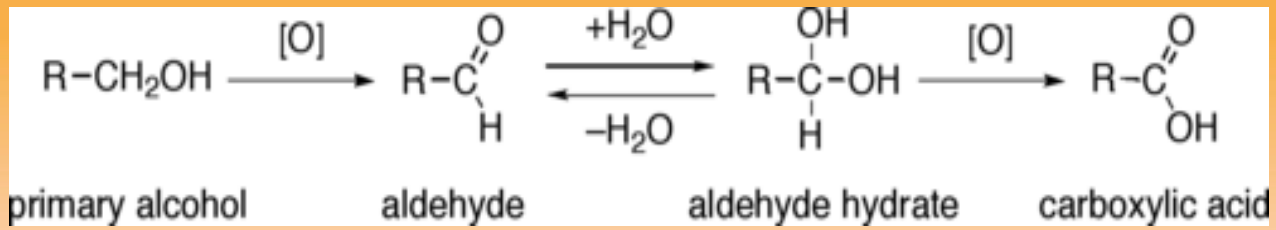
$$2R\text{-}OH + 2Na \longrightarrow 2R\text{-}ONa + H_2$$

$$2CH_3OH + Li \longrightarrow 2CH_3OLi + H_2$$

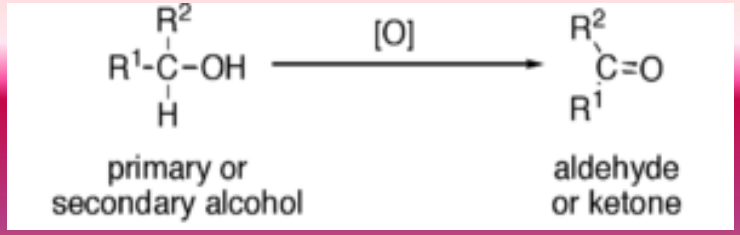
$$R\text{-}OH + NaNH_2 \longrightarrow R\text{-}ONa + NH_3$$

Oxidation of Alcohols

- Primary alcohols (R-CH2-OH) can be oxidized either to aldehydes (R-CHO) or to carboxylic acids (R-CO2H).



- The oxidation of secondary alcohols (R^1R^2CH-OH) normally terminates at the ketone ($R^1R^2C=O$) stage.

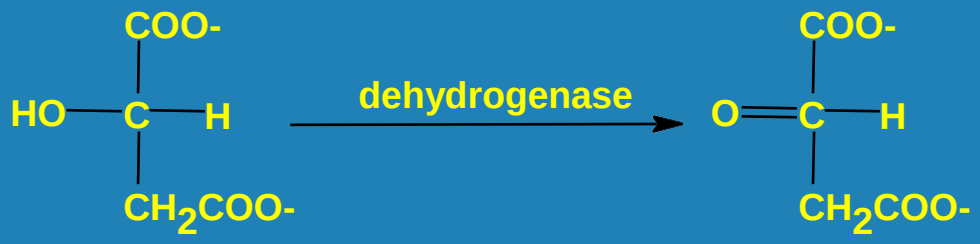


- Tertiary alcohols (R^1R^2RtC-OH) are resistant to oxidation.

Oxidation of alcohols

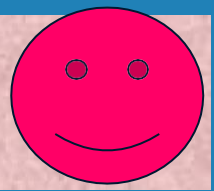
(In living system)

Malate is oxidized to oxalacetate which occurs in the citric cycle using an enzyme dehydrogenase that catalyses such reactions



Thise reaction is known to reguire the presence of nicotinamide, which links itself to the enzyme. The enzyme is then called *pyridine – linked dehydrogenase*.

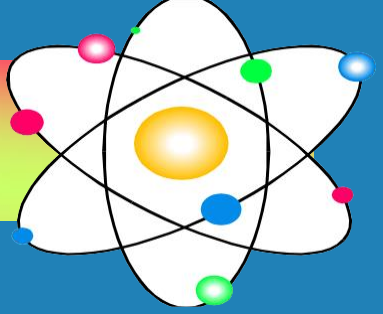
Toxicity



Alcohols often have an odor described as 'biting' that 'hangs' in the nasal passages .Ethanol in the form of alcoholic beverages has been consumed by humans since pre-historic times. The consumption of large doses result in drunkenness or intoxication may lead to a hangover as the effect wears off) and, depending on the dose and regularity of use, can cause acute respiratory failure or death and with chronic use has medical repercussions.such as deterloration of liver, and loss of memory.

Aqueous solution of 60 -70% ethanol are often used to clean skin before an injection or minor surgery.

Toxicity



Other alcohols are substantially more poisonous than ethanol, partly because they take much longer to be metabolized, and often their metabolism produces even more toxic substances. Methanol, or *wood alcohol* ,for instance, is oxidized by alcohol dehydrogenase enzymes in the liver to the poisonous formaldehyde ,which can cause blindness or death. An effective treatment to prevent formaldehyde toxicity after methanol ingestion is to administer ethanol. Alcohol dehydrogenase has a higher affinity for ethanol, thus preventing methanol from binding and acting as a substrate . Any remaining methanol will then have time to be excreted through the kidneys. Remaining formaldehyde will be converted to formic acid and excreted.

Toxicity

(multifunctional alcohols)

Ethylene glycol is toxic compound, its tioxicity is due to an oxidation product. Liver enzyme oxidase ethylene glycol to oxalic acid.

$$HOCH_2CH_2OH \xrightarrow[\text{dehydrogenase enzymes}]{\text{Liver enzyme}} HOOCCOOH$$

Oxalic acid crystallized as calcium salt (CaC_2O_4) in the kidney leading to renal damage, which might lead to kidney failure and death.

Propylene glycol is non toxic, and can be used as solvent for drugs, it can be oxidized by liver enzyme to pyruvic acid which is an intermediate in carbohydrate metabolism in the body.

$$CH_3CH(OH)CH_2OH \xrightarrow[\text{dehydrogenase enzymes}]{\text{Liver enzyme}} CH_3COCOOH$$