Alcohols
1 - Nomenclature, Properties and Applications

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Alcohol Functional Group

Alcohol has one organic group R (alkyl, aryl, or vinyl) and an H, bonded to the same oxygen atom, R–O–H.

Alcohols resemble water as they have an OH group and oxygen is single bonded, so it is sp^3 hybridized thus the bond angle on oxygen is 109^o.

Alcohols are the most common functional group found in natural products. Their synthetic value is quite high as they can be made from several functional groups and can be converted to many other functional groups.

They have many applications in our lives.

Thiols (R–S–H) are sulfur analogues of alcohols.

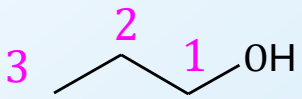
Nomenclature

Smaller alcohols have common or general names as well as IUPAC names.

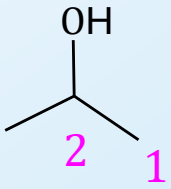
- The OH group gets priority over alkenes, alkynes, alkyl groups and halides.
- Find the parent chain to give the OH group the lowest possible number.
- Change the suffix -e to -ol. (e.g. methane to methanol)

Common names: Uses the alkyl group as first name and functional group as the second name, e.g., methyl alcohol and ethyl alcohol. Common names can only be used for a few small alcohols or the more commonly occurring alcohols. Below I have given the general names in itallics.

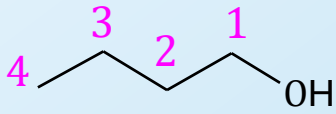
CH_3OH *methyl alcohol*/ methanol
C_2H_5OH *ethyl alcohol*/ ethanol



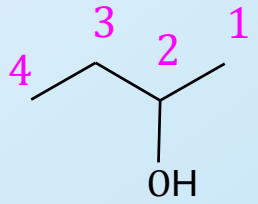
propyl alcohol
Propan-1-ol



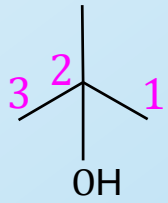
isopropyl alcohol
Propan-2-ol



butyl alcohol
Butan-1-ol



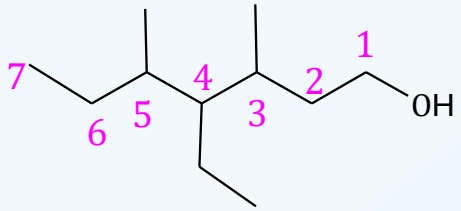
secbutyl alcohol
Butan-2-ol



t-butyl alcohol
2-methylropan-2-ol

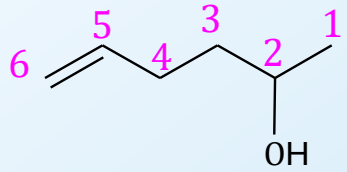
Nomenclature – Substituents and Diols

- Any halogen or alkyl substituents will get lower priority than alcohols.



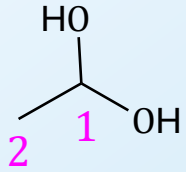
4-ethyl-3,5-dimethylheptan-1-ol

- Unsaturated alcohols Number the chain to give OH the lower number; end the name with "ol" because alcohols get priority over alkenes in nomenclature.

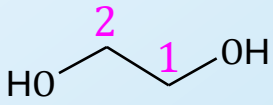


hex-5-ene-2-ol

- Two or more alcohols: Glycols are when alcohol groups are adjacent to each other.

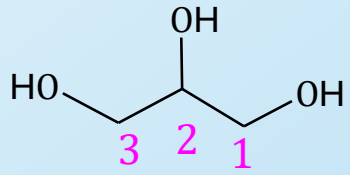


1,1-ethanediol



1,2-ethanediol

ethlylene glycol

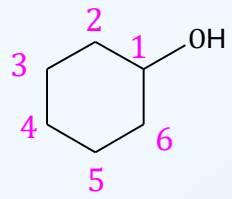


1,2,3-propanetriol

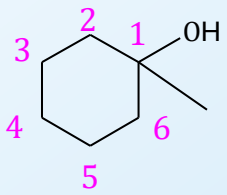
propylene glycol

Nomenclature – Cyclic alcohols

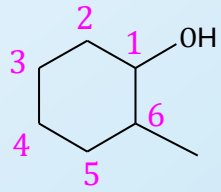
- Cyclic Alcohols – Start numbering from where OH group is. Don't number the OH carbon unless there is another substituent on it. It is understood that OH carbon is numbered 1.



cyclohexanol

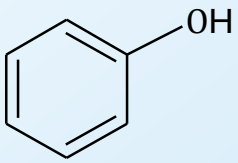


1-methylcyclohexanol



2-methylcyclohexanol

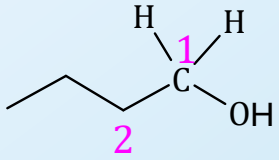
- Benzene with alcohol group, are named phenol.



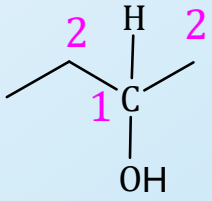
Nomenclature – 1º, 2º, 3º

Just like halides are classified as 1º, 2º and 3º, alcohols are classified the same way. The structures below show the carbon "1" as the one with alcohol and carbon "2" as the carbon attached to the carbon attached to the carbon with alcohol.

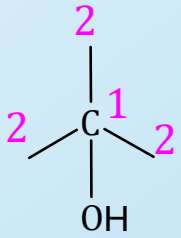
- Methyl (C has 3 H's).
- Primary (1º) - C has two H's, one alkyl group.



- Secondary (2º) - C has one H, two alkyl groups.



- Tertiary (3º) - C has no H,, all are alkyl groups.



Physical Properties

1) Boiling point and melting points: High boiling points due to hydrogen bonding between molecules. Alcohols will have higher boiling points than the corresponding alkanes.

   As the number of alcohol groups increase i.e. diols and triols will have higher boiling points than one alcohol group compounds, with the same number of carbons.

2) Solubility in water: Small alcohols are miscible in water, but solubility decreases as the size of the alkyl group increases. Solubility will also increase as the number of alcohol groups increase in number. Triols > diols> mono alcohols.

3) Odor – most alcohols have a sweet smell.

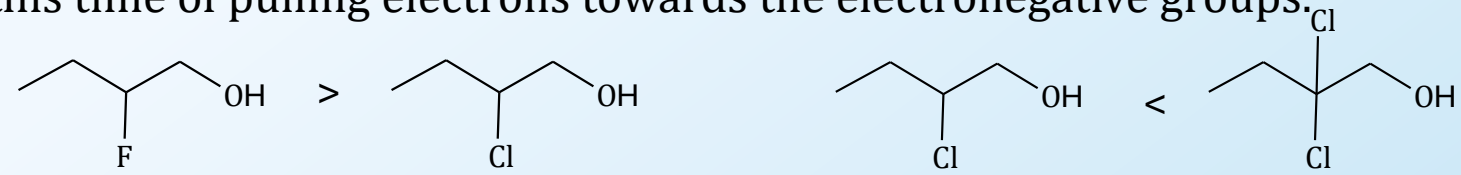
Acidity of Alcohols

The pK_a range of alcohols is 15.5-18.0 like water (15.7). And like water they can be amphoteric i.e., react with both acids and bases.

- Acidity decreases as alkyl group increases, due to electron donating inductive effect of the alkyl groups.

$$CH_3OH > CH_3CH_2OH > CH_3CH_2CH_2OH$$

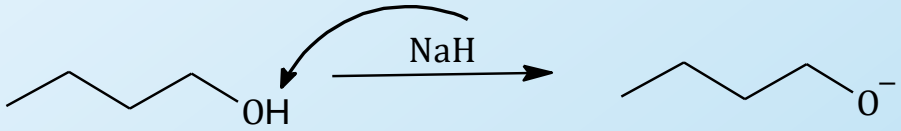
- Halogens near alcohol groups will increase the acidity, again inductive effect but this time of pulling electrons towards the electronegative groups.



- Reaction with bases and sodium results in formation of alkoxides. This is similar to making nucleophiles in S_N1 and S_N2 reactions. Alcohols give alkoxides with bases. Reaction of methanol with sodium metal gives methoxide.

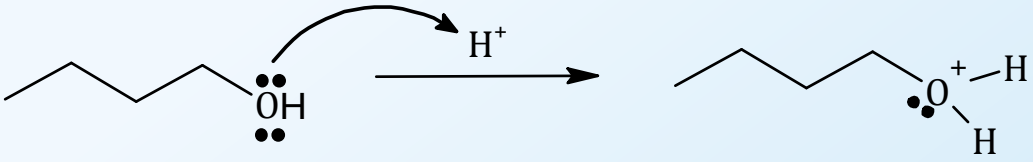
$$CH_3OH + Na \longrightarrow CH_3O^-Na^+$$

Less acidic alcohols will react with more reactive potassium. Some other bases (other than alkali metals), that can be used are NaH, $NaNH_2$.

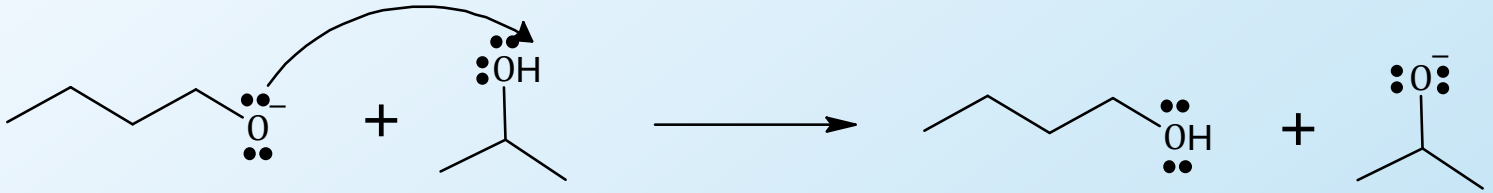


Basicity of Alcohols

Alcohols are weak Brønsted bases. They can react with acids to become protonated to give oxonium ions, ROH_2^+ .



The alkoxides can react with other alcohols which will behave like acids.



Applications of Alcohols

Methanol

- Also called “Wood alcohol” is a common industrial solvent. It used as a fuel at Indianapolis 500.
- It can be toxic; it’s consumption leads to blindness.

Ethanol

This is formed by fermentation of sugar and starches in grains. Distillation produces “hard” liquors. It forms an azeotrope with water and is always 95% ethanol.

- The denatured alcohol, ethanol is used as solvent. Denatured means 100% ethanol.
- Ethanol is also commonly used as fuel, Gasohol which is10% ethanol in gasoline.

Other Alcohols of Interest

- Isopropyl alcohol – disinfectant.
- Ethylene Glycol – antifreeze.
- Glycerol – used as medication.
- Sugar – all carbohydrates have alcohol groups.

Key Concepts

- Nomenclature
- Primary, secondary and tertiary alcohols
- Physical properties
- Acidity and basicity of alcohols
- Alkoxides