Organic Chemistry

Chapter 5

Alcohols

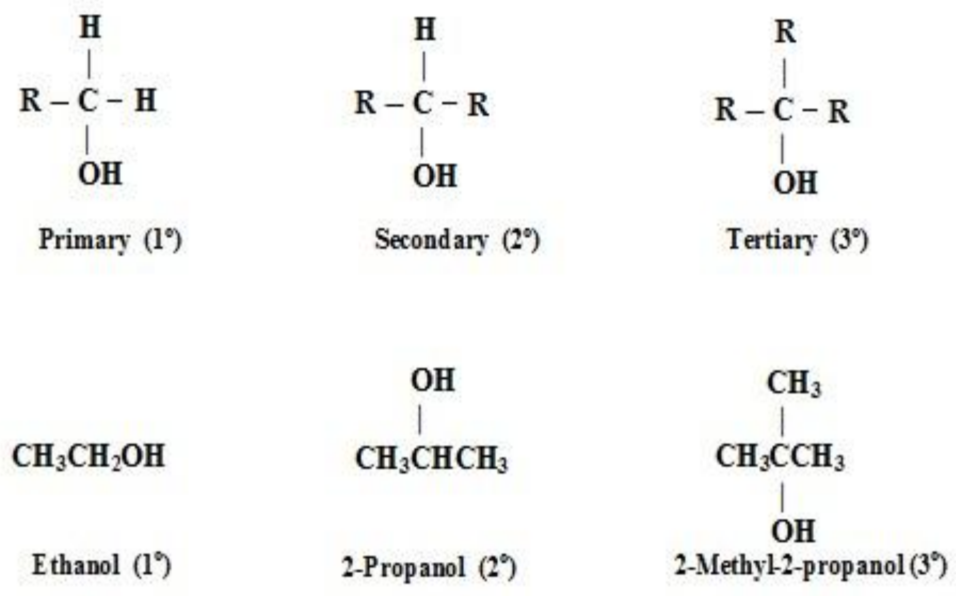
5.1 Introduction

All alcohols contain the hydroxyl group **(-OH)** attached to a saturated carbon. These have the general formula **R-OH**, where **R** is an alkyl or substituted alkyl group. The group may be primary, secondary, or tertiary; it may be open chain or cyclic; it may contain a double bond, a halogen atom, an aromatic ring, or additional hydroxyl group. The **-OH** group is the functional group, determines the properties characteristic of this family. Variations in structure of the **R** group may affect the rate at which the alcohol undergoes certain reactions, and even, in a few cases, may affect the kind of reaction.

Compound in which the hydroxyl group is attached directly to an aromatic ring are not alcohols; they are phenols.

5.2 Classification of alcohols

Alcohols other than methanol, are classified as, primary, secondary, or tertiary, depending on the number of carbons bonded to the carbon atom bearing the **–OH** group. If one carbon is bonded to this carbon atom, the alcohol is primary, if two carbons are bonded, it is secondary, and if three carbons are bonded, it is tertiary.



5.3 Nomenclature

Among the simple alcohols the common names are very commonly used. To write these names, simply put the name of its alkyl group and follow it by the word alcohol. For example; CH_3OH methyl alcohol.

The IUPAC rules for naming the alcohols are very similar to those for naming alkanes, and the following principle are followed:

1- The longest carbon chain that contains the hydroxyl group is considered the parent compound.

2-The **–e** ending of the name of this carbon chain is replaced **–ol**.

3- The location of the hydroxyl and any other groups are shown by the smallest possible numbers, with the position of the hydroxyl group having the highest priority.

CH_3OH

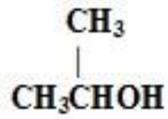
Methanol (Methyl alcohol)

CH_3CH_2OH

Ethanol (Ethyl alcohol)

$CH_3CH_2CH_2OH$

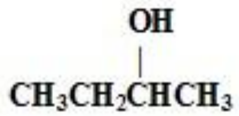
1-Propanol



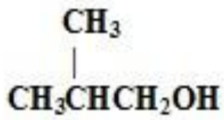
2-Propanol (Isopropyl alcohol)

$CH_3CH_2CH_2CH_2OH$

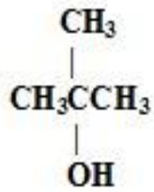
1- Butanol



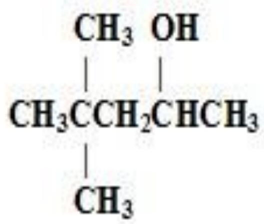
2-Butanol (*sec*-Butyl alcohol)



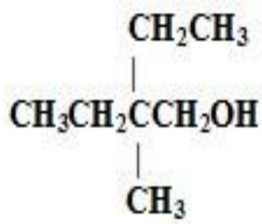
2-Methyl-1-propanol
(Isobutyl alcohol)



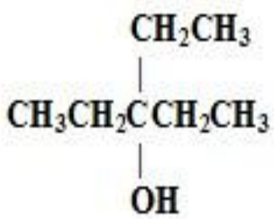
2-Methyl-2-propanol
(*tert*-Butyl alcohol)



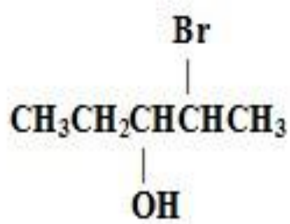
4,4-Dimethyl-2-pentanol



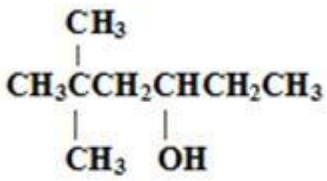
2-Ethyl-2-methyl-1-butanol



3-Ethyl-3-pentanol



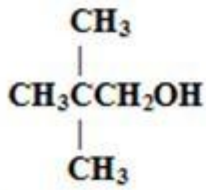
2-Bromo-3-pentanol



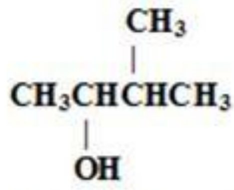
5,5-Dimethyl-3-hexanol

$ClCH_2CH_2OH$

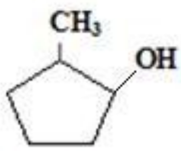
2-Chloroethanol



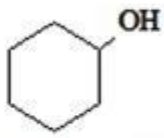
2,2-Dimethyl-1-propanol



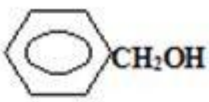
3-Methyl-2-butanol



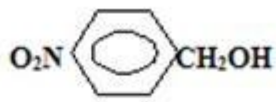
2-Methylcyclopentanol



Cyclohexanol

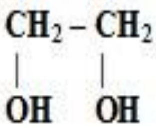


(Benzyl alcohol)

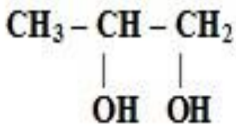


(*p*-Nitrobenzyl alcohol)

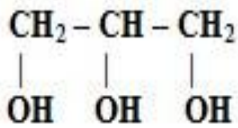
In the IUPAC system, a compound containing two hydroxyl groups is named as a diol, one containing three hydroxyl groups is named as a triol, and so on.



1,2-Ethanediol
(Ethylene glycol)

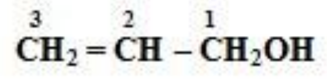


1,2-Propanediol
(Propylene glycol)

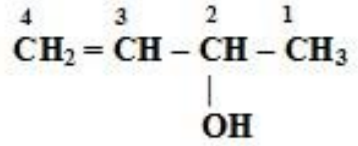


1,2,3-Propanetriol
(Glycerol, Glycerin)

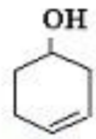
An alcohol containing a double bond is named as an alkenol, with number to indicate the position of the double bond and the hydroxyl group.



2-Propen-1-ol



3-Buten-2-ol



4-Cyclohexenol

5.4 Physical Properties of Alcohols

Alcohol molecules are polar, because the **–OH** group is highly polar. To show this, only compare boiling of ethane for example (formula weight 30 , b.p. –89), with methyl alcohol (formula weight 32 , b.p. 65).

Force of attraction between alcohol molecules obviously must be greater than between molecules of alkanes. Hydrogen bonding accounts for this.

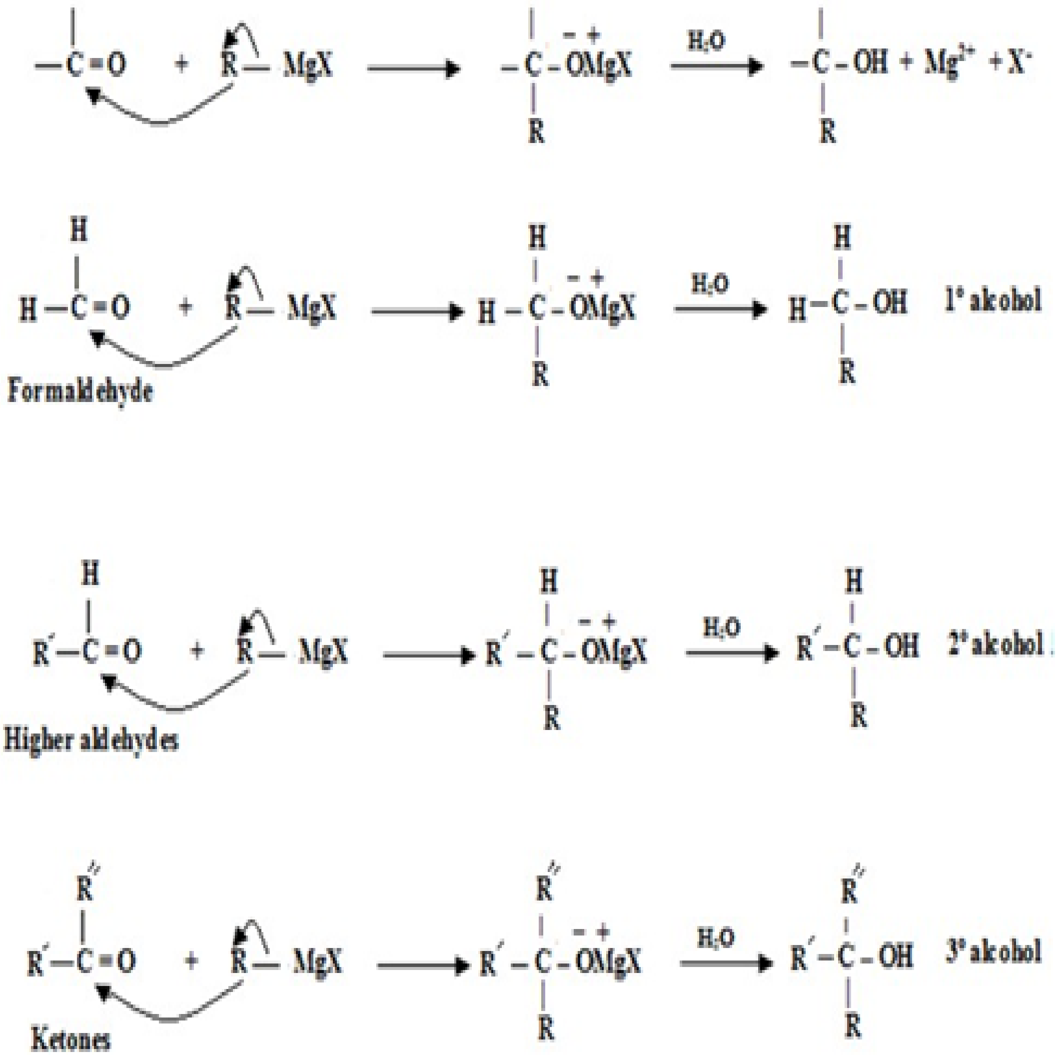
The presence of an alcohol group sharply increases the tendency to dissolve in water. Methane, for example, is insoluble in water, but methyl alcohol is completely soluble, because of the hydrogen bonding with water as illustrated:

O ——— H-----------------O——————— H

5.5 Preparation of Alcohols:

1- Grignard reaction

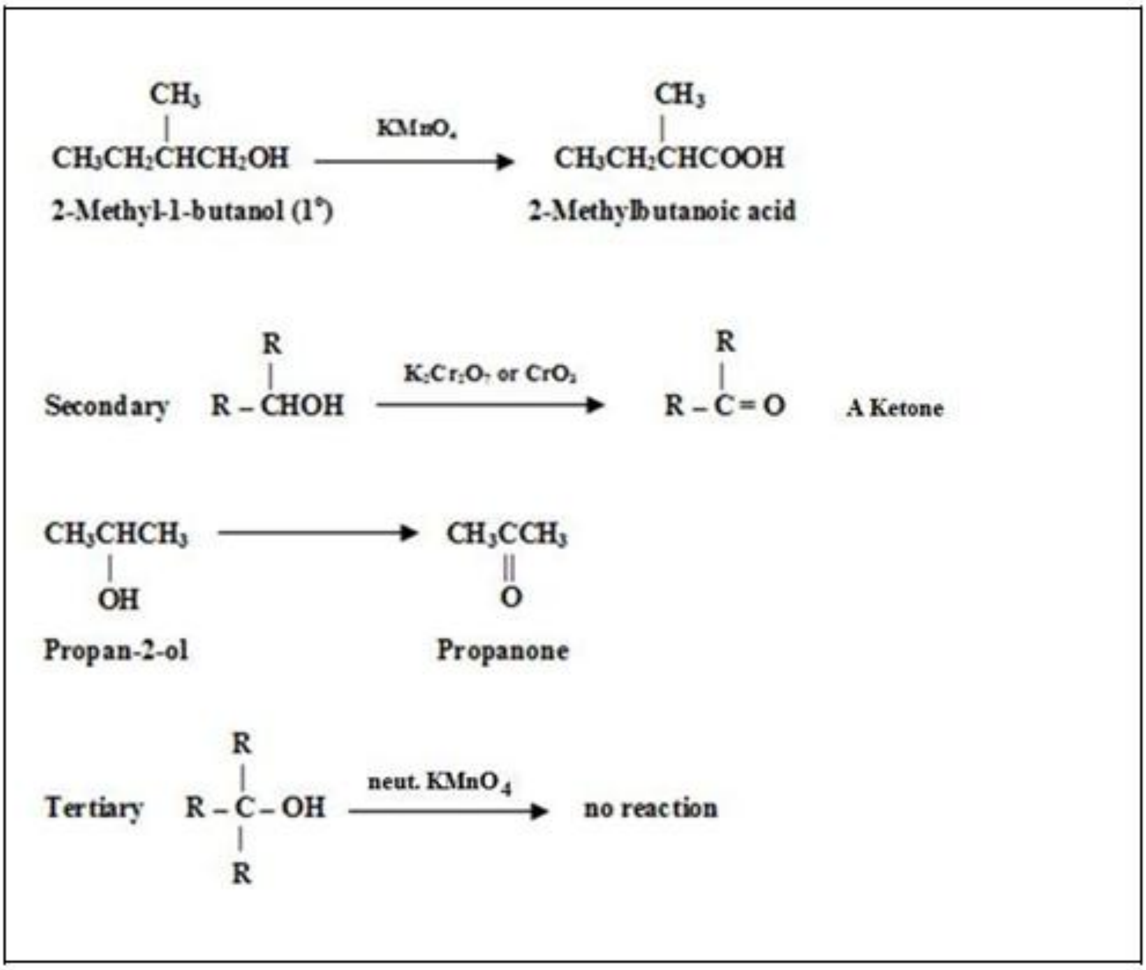
One of the most important uses of the Grignard reagent lies in its reaction with aldehydes and ketones. The product is the magnesium salt of the weakly acidic alcohol and is easily converted into alcohol itself by the addition of the stronger acid, water.



5.6 Reactions of Alcohols

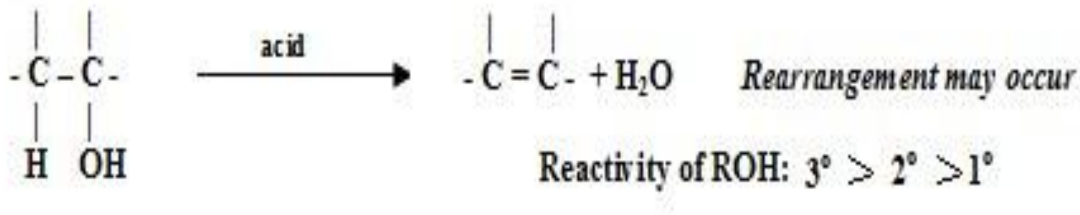
Alcohols are saturated compounds containing the functional group –OH. They can undergo nucleophilic substitution reactions, in which the hydroxyl group is displaced by other groups, or they can undergo elimination reactions, involving the loss of the elements of water when reacted with a dehydrating agent. Primary and secondary alcohols also undergo oxidation and the hydroxyl group shows acidic properties when treated with reactive metals.

1- Oxidation:



2- Dehydration:

As alcohols contain the hydroxyl group –OH, they may undergo the elimination of the elements of water. Concentrated sulphuric acid has a very strong affinity for water and behaves as a dehydrating agent towards alcohols. When heated with sulphuric acid, alcohols can be dehydrated to alkenes.

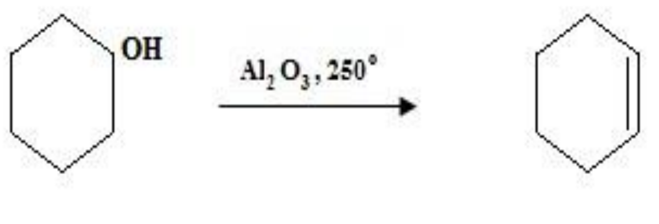


$$CH_3CH_2OH \xrightarrow[170\,^{\circ}C]{95\%\ H_2SO_4} CH_2=CH_2 + H_2O$$

Ethanol → Ethene

$$CH_3CH_2CH_2CH_2OH \xrightarrow[140\,^{\circ}C]{75\%\ H_2SO_4} CH_3CH=CHCH_3 + CH_3CH_2CH=CH_2$$

n-Butyl alcohol → 2-Butene (Chief product) + 1-Butene



Cyclohexanol → Cyclohexene

4- Ester formation

Alcohols react with acids to form esters.

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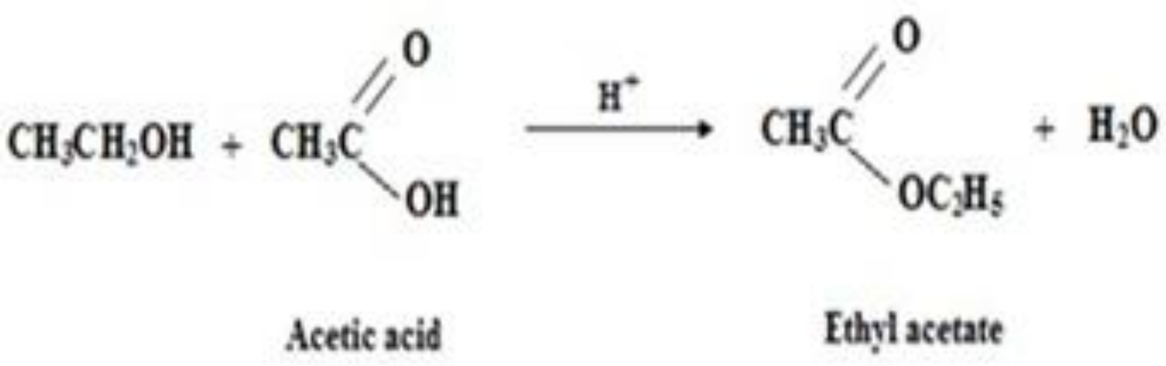

With best Wishes