7. ALCOHOLS, PHENOLS, ETHERS

(R–OH) (Ar–OH) (R–O–R')

STUDY NOTES

1. Alcohols & Phenols; Ethers:

i) Common name : • Alcohol (Aliphatic hydroxy compounds)
• Phenols (–OH directly attached to an aromatic ring.)
• Ether (Oxygen is bonded to two alkyl/aryl groups.)

ii) IUPAC name : • Alkanol (Alcohols) • Phenols • Alkoxyalkanes (Ethers)

iii) General Formula : • Alcohol: R-OH (or) C_nH_{2n+1} –OH ;
• Ether: R–O–R'

iv) Alcohols Ex : • CH_3OH (Methyl alcohol), C_2H_5OH (Ethyl alcohol)

Phenols Ex : • C_6H_5OH (Phenol), $CH_3–C_6H_4OH$ (Cresol)

Ethers Ex : • $CH_3–O–CH_3$ (Simple ether), $CH_3–O–C_2H_5$ (Mixed ether)

I) ALCOHOLS & PHENOLS

2. Classification of Alcohols :

2.1. Alcohols are compounds containing **hydroxyl group (–OH)** attached to carbon.

Based on number of –OH groups:

i) Monohydric alcohols → one –OH. **Ex:** ethanol - CH_3CH_2OH

ii)Dihydric alcohols → two –OH. **Ex:** ethylene glycol - $OH–CH_2–CH_2–OH$

iii)Trihydric alcohols → three –OH **Ex:** glycerol $OH–CH_2–CH(OH)–CH_2–OH$

iv)Polyhydric alcohols → more than three –OH

Based on type of carbon bonded to –OH:

1) Compounds containing SP^3 C–OH bond:

i) Aliphatic alcohols → –OH on saturated carbon. **Ex:** ethanol - CH_3CH_2OH

ii)Allylic alcohols →–OH attached to carbon next to C=C **Ex:** $CH_2=CH–CH_2–OH$

iii)Benzylic alcohols → –OH attached to carbon next to benzene ring. **Ex:** $C_6H_5–CH_2OH$

2) Compounds containing SP^2 C–OH bond

Enols → –OH attached directly to double bonded carbon. **Ex:** phenol - 

2.2 . Classification of Phenols:

i) Monohydric phenols→ one –OH. **Ex:**Phenol, Cresol (o-, m-, p- forms), Nitrophenol

ii)Dihydric phenols→two –OH. **Ex:**Catechol (ortho), Resorcinol (meta), Hydroquinone (para)

iii)Trihydric phenols →three –OH. **Ex:**Pyrogallol, Phloroglucinol

3. IUPAC Nomenclature:

Prefix + root word + i suffix + 1° suffix + 2° suffix

(a) Alcohols:

i) Replace "-e" of alkane with **-ol**

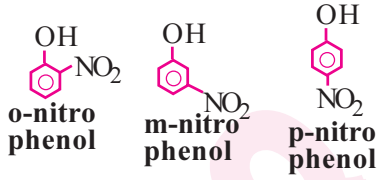
ii) In the number chain give –OH the lowest position

iii)**Ex:** ethanol, propan-2-ol

(b) Phenols:

i) IUPAC Name: Derivatives of **phenol**

ii)Substituents indicated by **o-, m-, p-** positions. **Ex:**



o-nitro phenol **m-nitro phenol** **p-nitro phenol**

(c) Ethers:

i)IUPAC Name: **alkoxyalkanes** **Ex:** methoxyethane

4. Nature of the Functional Group OH:

i) In O–H bond Oxygen is **sp^3 hybridised**

ii) O–H is bent structure due to lone pairs

iii) **O–H bond is polar** → hydrogen bonding

iv) **Cleavage of O–H bond:** Breaking the C–O bond between C in R and O in O–H.

5.1 Preparation of Alcohols:

i) From Alkenes: Hydration of alkenes (acid catalysed)

ii) From Carbonyl Compounds:

(a) Reduction of aldehydes and ketones:

• Aldehydes → primary alcohols

• Ketones → secondary alcohols

(b) Reduction of carboxylic acids and esters: Gives primary alcohols

iii) From Grignard Reagents: React with carbonyl compounds→ alcohols

5.2 Preparation of Phenols:

i) From haloarenes

ii) From benzenesulphonic acid

iii) From diazonium salts

iv) From cumene (industrial method)

6. Physical Properties of Alcohols :

i) Boiling Points: High due to **hydrogen bonding**

ii) Solubility: • Lower alcohols are soluble in water. •Solubility decreases with chain length.

7. Chemical Reactions:

a) Cleavage of O–H bond:

1. Acidity of alcohols and phenols:

(i) Reaction with metals: Alcohol + Na → alkoxide + H_2

(ii) Acidity of alcohols: Weak acids

(iii) Acidity of phenols: More acidic due to **resonance stabilization**

2. Esterification: Alcohol + Carboxylic acid → ester + water

(b) Cleavage of C–O bond in alcohols:

i) Reaction with hydrogen halides: Alcohol → alkyl halide

$R–OH + HX \rightarrow R–X + H_2O$

ii) Reaction with phosphorus halides (PX_3 or PX_5) (X= Cl, Br, I): Forms alkyl halides

iii) Dehydration: Forms alkenes (acid + heat)

Mechanism: E_1 or E_2 depending on alcohol type (C-O cleavage can occur via SN^1 or SN^2 mechanism depending on the structure of alcohol.)

iv) Oxidation:

• Primary (1° Alcohol) → aldehyde→ acid • Secondary (2° Alcohol) → ketone

• Tertiary (3° Alcohol)→ resistant to oxidation

(c) Reactions of Phenols:

i) Electrophilic substitution/ Nucleophilic attack: –OH activates benzene ring

a) Nitration → nitrophenol **b) Halogenation** → halophenol

ii) Kolbe's Reaction: Formation of salicylic acid

iii) Reimer-Tiemann Reaction: Formation of salicylaldehyde

iv) Reaction with zinc dust: Phenol → benzene

v) Oxidation: Forms quinones

II) ETHERS

8. 1 Preparation of Ethers:

i) Dehydration of alcohols at 413 K gives ether

ii) Williamson Ether Synthesis: Alkoxide + alkyl halide give ether

8. 2 Physical Properties: Lower boiling point than alcohols, slightly soluble in water

8.3 Chemical Reactions:

i) Cleavage of C–O bond: With HI or HBr → alcohol + alkyl halide

ii) Electrophilic substitution: Occurs in aromatic ethers

9. Uses of Alcohols:

i) Methanol (CH_3OH) : Prepared from CO + H_2, **Uses:** fuel, solvent

ii) Ethanol (C_2H_5OH): Prepared by fermentation **Uses:** beverages, fuel, antiseptic

iii Glycerol (Glycerin): Cosmetics, soaps, medicines.

Quick Revision Points

- **Alcohol →R–OH;** • **Phenol → Ar–OH** • **Ether→R–O–R**
- Phenol > Alcohol (acidity);
- Alcohol → Oxidation, dehydration, substitution;
- Phenol → Ortho/para directing • Ether → Least reactive
- Alcohols show **hydrogen bonding→ high boiling point**
- Phenols are **more acidic than alcohols**
- Grignard reagents are important for alcohol preparation
- Williamson synthesis is best for ethers •Phenol shows **electrophilic substitution easily**