College of Medicine

Medical Chemistry

Lecture No. 3

Carboxylic acids alcohols, and ethers in Medical Chemistry

First stage

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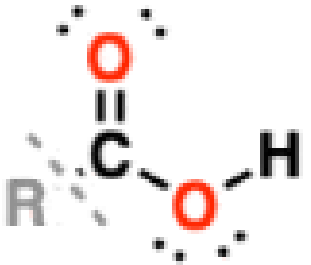
Carboxylic acids (-COOH), alcohols (-OH), and ethers (-O-) are important organic compounds in medical chemistry. They play essential roles in drug design, metabolism, and pharmaceutical formulations. Their unique structures and chemical properties make them important in drug formulation, metabolism, and treatment.

alcohol
(-hydroxy)

ether
(-alkoxy)



carboxylic
acid

1. Structure and Nomenclature

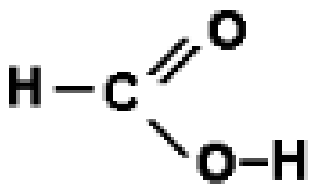
A. Carboxylic Acids (R-COOH)

Contain a carboxyl (-COOH) functional group, which includes a carbonyl (-C=O) and hydroxyl (-OH) group.

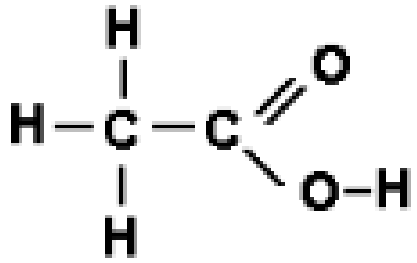
General formula: R-COOH

Naming: Replace -e of the parent alkane with -oic acid.

Example: Methanoic acid (Formic acid), Ethanoic acid (Acetic acid)



methanoic acid

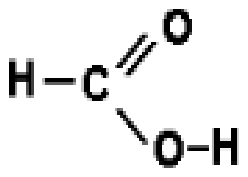


ethanoic acid

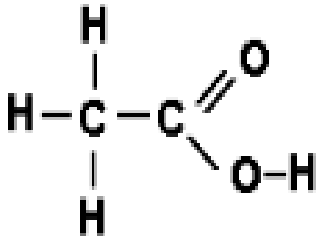
Classification of Carboxylic Acids:

Based on Carbon Chain:

Aliphatic: Methanoic acid, Ethanoic acid

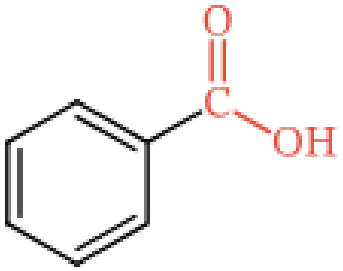


methanoic acid

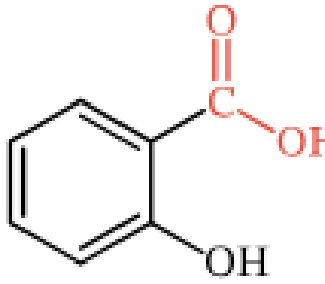


ethanoic acid

Aromatic: Benzoic acid, Salicylic acid



Benzoic acid

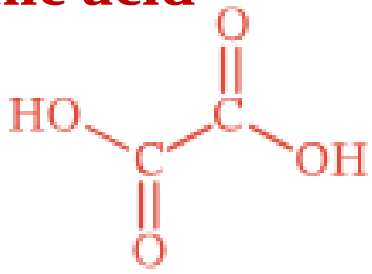


Salicylic acid

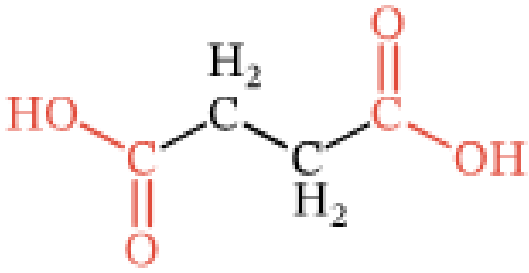
Based on Number of -COOH Groups:

Monocarboxylic acids: Formic acid, Acetic acid

Dicarboxylic acids: Oxalic acid, Succinic acid

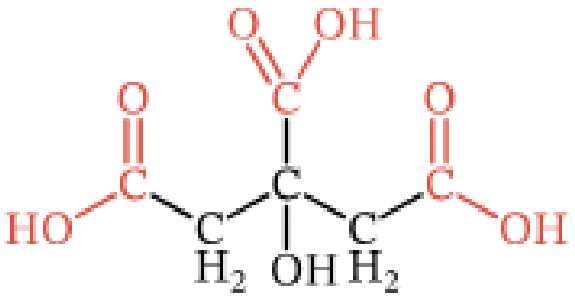


Oxalic acid



Succinic acid

Tricarboxylic acids



B. Alcohols (R-OH)

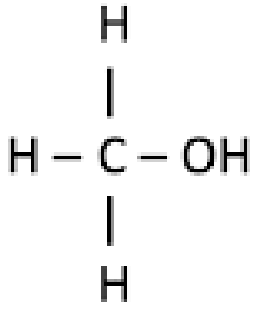
Contain a hydroxyl (-OH) functional group attached to a carbon atom.

General formula: R-OH

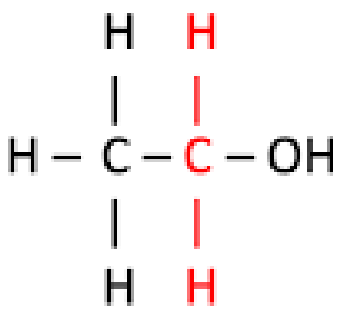
Naming: Replace -e of the parent alkane with -ol.

Example: Methanol, Ethanol

Methanol



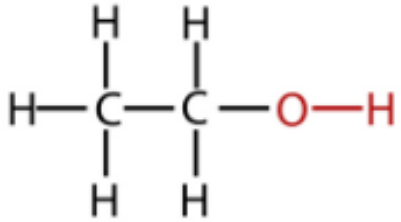
Ethanol



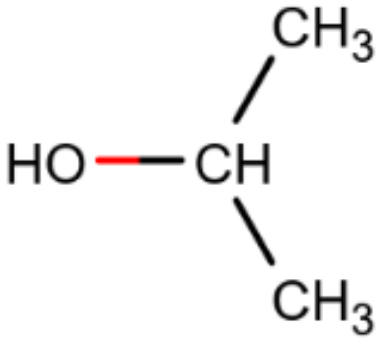
Classification of Alcohols:

Based on the Carbon Atom to which -OH is Attached:

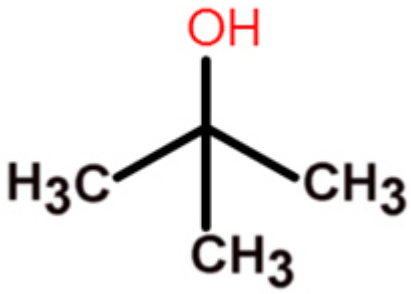
Primary alcohols (1°): **Ethanol, Methanol**



Secondary alcohols (2°): **Isopropanol**



Tertiary alcohols (3°): **Tert-butanol**



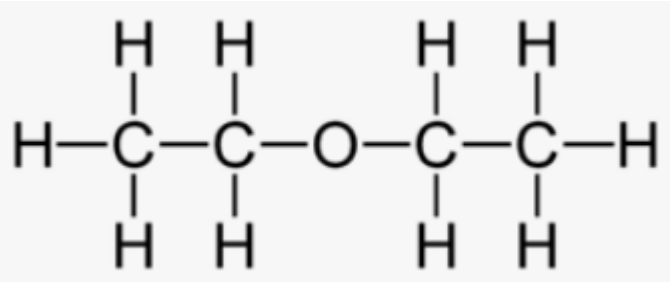
Ethers (-O-)

Contain an oxygen atom bonded to two carbon atoms (R-O-R').

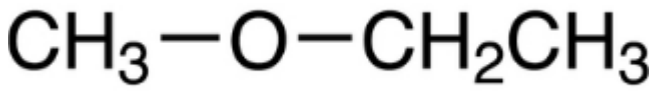
General formula: R-O-R’

Naming: Name the two alkyl groups followed by “ether”.

Example: Diethyl ether (C_2H_5-O-C_2H_5), Ethyl methyl ether



Diethyl ether



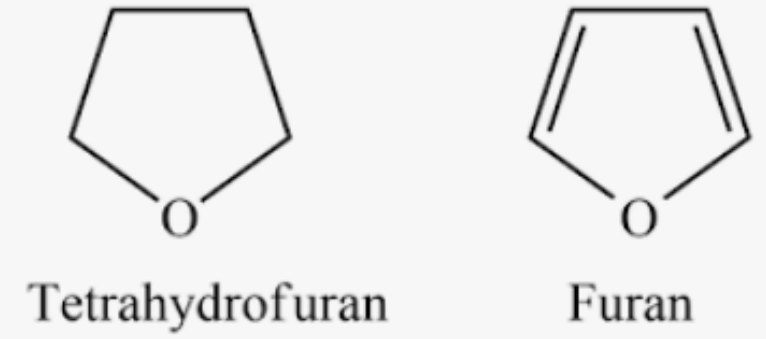
Ethyl methyl ether

Classification of Ethers:

Simple (Symmetric) Ethers: Same alkyl groups (e.g., Diethyl ether).

Mixed (Asymmetric) Ethers: Different alkyl groups (e.g., Methyl ethyl ether).

Cyclic Ethers: Oxygen within a ring structure (e.g., Furan, Tetrahydrofuran).



	ic Acids		
Polarity	Highly polar	Polar	Slightly polar
Boiling Point	Very high (due to hydrogen bonding)	High (due to hydrogen bonding)	Low (no hydrogen bonding)
Solubilit y in	Soluble (small	Soluble (small	Slightly soluble

Chemical Reactions:

1. Acidic Nature

Carboxylic acids donate protons (H^+), forming carboxylate ions.

Example: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

2. Esterification

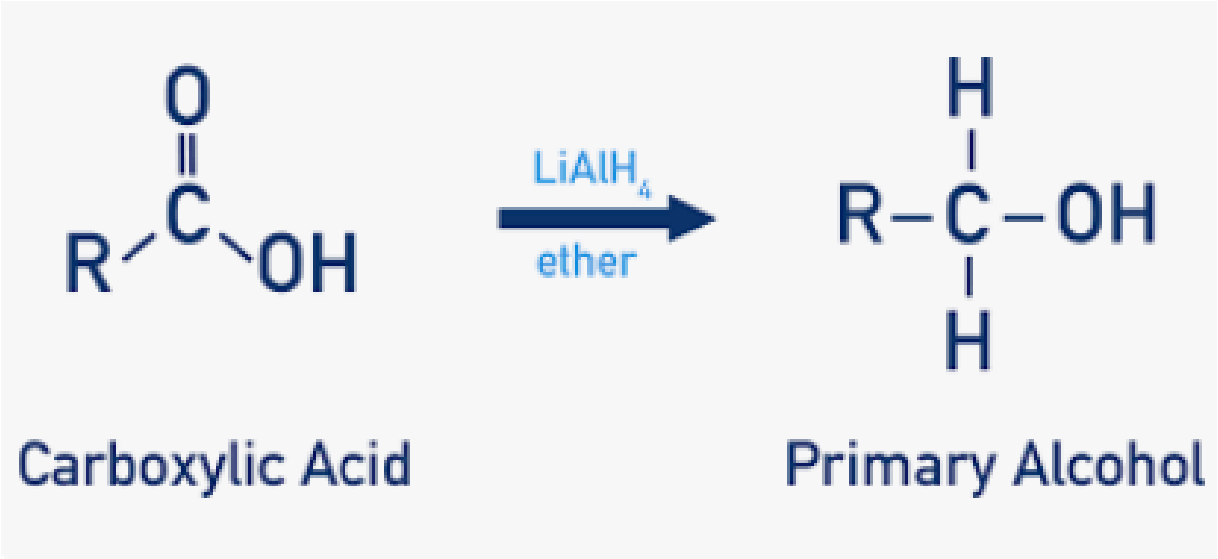
React with alcohols in the presence of an acid catalyst to form esters (important in pharmaceuticals).

Example: Acetic acid + Ethanol → Ethyl acetate + Water

3. **Reduction to Alcohols**

Can be reduced to primary alcohols using strong reducing agents like $LiAlH_4$ (Lithium aluminum hydride).

Example: $CH_3COOH + LiAlH_4 \rightarrow CH_3CH_2OH$



Chemical Reactions of alcohols:

1. Oxidation:

Primary alcohols → Aldehydes → Carboxylic acids

Secondary alcohols → Ketones

Example: Ethanol → Acetaldehyde → Acetic Acid

2. Esterification:

React with acids to form esters.

3. Dehydration:

Converts alcohols to alkenes using strong acids.

Chemical Reactions for Ethers:

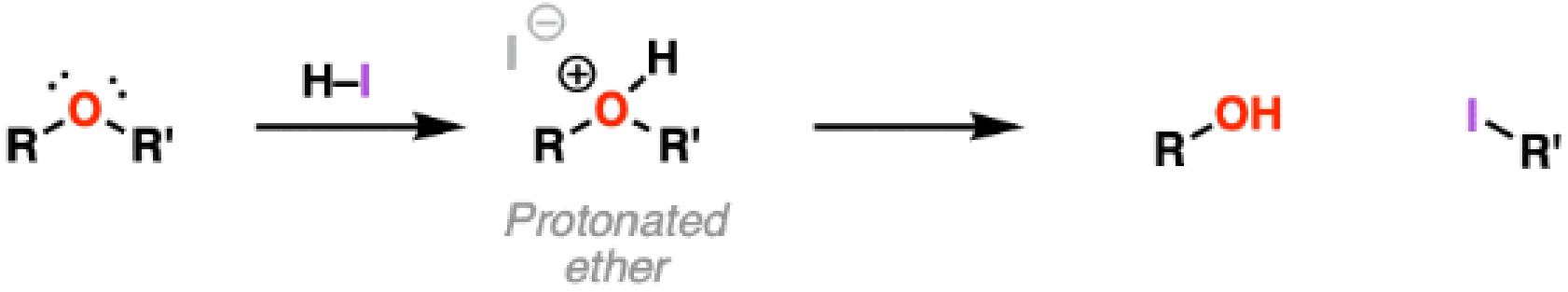
1. Formation of Ethers (Williamson Ether Synthesis)

Alkoxide + Alkyl Halide → Ether

Example: $C_2H_5ONa + C_2H_5Br \rightarrow C_2H_5\text{-}O\text{-}C_2H_5 + NaBr$

2. Acidic Cleavage of Ethers

Reacts with strong acids (HI, HBr) to form alcohols and alkyl halides.



3. Role in Medicinal Chemistry

Carboxylic Acids in Medicine:

Fatty Acids: Essential for cell membranes and energy production.

Lactic Acid: Plays a role in muscle metabolism and fermentation

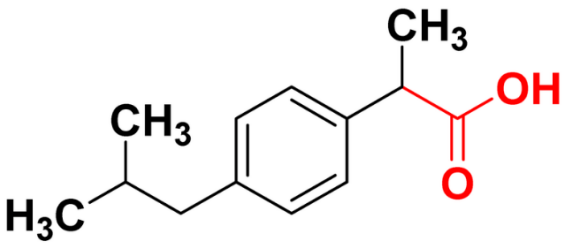
Ibuprofen: Anti-inflammatory drug.

Aspirin (Acetylsalicylic acid): Used as an anti-inflammatory and pain reliever.

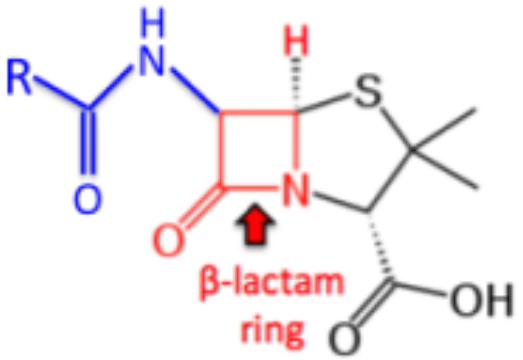
Penicillin: Contains a carboxyl group essential for its antibiotic activity

Acetylsalicylic acid

$C_9H_8O_4$



Ibuprofen



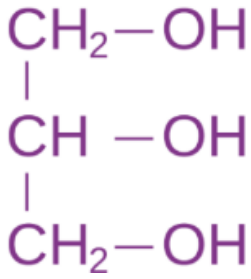
penicillins

Alcohols in Medicine:

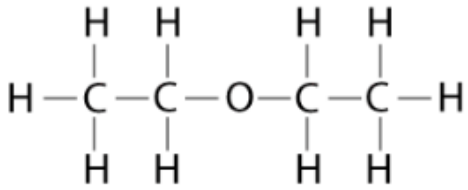
Ethanol: Used as a disinfected and solvent.

Methanol: Toxic, but used in chemical synthesis.

Glycerol: Used in pharmaceutical formulations and skin care.

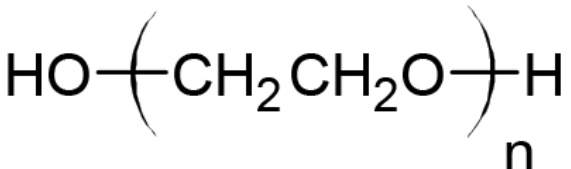


Ethers in Medicine:



Diethyl Ether: Used as an anesthetic.

Codeine: Contains (a sleep-inducing and analgesic drug derived from morphine) an ether functional group.



Polyethylene Glycol (PEG): Used in drug formulations for solubility enhancement.