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PHARMACEUTICAL ORGANIC CHEMISTRY – I

UNIT 3

TOPIC :

- **Alcohols***

  Qualitative tests, Structure and uses of Ethyl alcohol, Methyl alcohol,

  chlorobutanol, Cetosteryl alcohol, Benzyl alcohol, Glycerol, Propylene glycol

Alcohols

- Alcohols are organic compounds that contain one or more hydroxyl (–OH) groups attached to a saturated carbon atom (sp^3 hybridized). They are classified as:
- Primary (1°) alcohol: –OH is attached to a carbon which is attached to one other carbon
- Secondary (2°) alcohol: –OH is attached to a carbon which is attached to two other carbons
- Tertiary (3°) alcohol: –OH is attached to a carbon which is attached to three other carbons

Qualitative Tests for Alcohols

Qualitative tests are **chemical reactions** used to:

- Detect the presence of alcohols in a compound.
- Distinguish between primary, secondary, and tertiary alcohols.

1. Ceric Ammonium Nitrate (CAN) Test

→ This is a color reaction test used to detect the presence of the alcohol functional group (–OH).

Reagent:

- Ceric ammonium nitrate solution (bright yellow)

Procedure:

- Add 1 mL of ceric ammonium nitrate solution to 1 mL of alcohol.

Observation:

- The solution turns yellow to red, indicating the presence of an alcohol.

Inference:

- Primary and secondary alcohols give a red color.

- Tertiary alcohols may give no or faint color change.

2. Lucas Test

→ This test is used to distinguish between primary, secondary, and tertiary alcohols based on the rate of formation of alkyl halides.

Reagent:

- Lucas reagent = Conc. HCl + Anhydrous $ZnCl_2$

Procedure:

- Mix 1 mL of alcohol with 2 mL of Lucas reagent in a test tube and shake.

Observation:

Type of Alcohol	Time	Observation
Tertiary (3°)	< 30 sec	Cloudy appearance immediately
Secondary (2°)	5–10 min	Cloudiness appears slowly
Primary (1°)	> 30 min	No visible change at room temp

Inference:

- The cloudy layer is due to formation of insoluble alkyl chloride.

3. Victor Meyer's Test

→ A chemical test to distinguish primary, secondary, and tertiary alcohols through color reactions after several steps.

Procedure (Summary of Steps):

- Alcohol → Iodoalkane (with red phosphorus + iodine)
- Iodoalkane → Nitroalkane (with $AgNO_2$)
- Treat with HNO_2 and NaOH

Observation :

Type of Alcohol	Color
Primary (1°)	Red

Secondary (2°)	Blue
Tertiary (3°)	Colorless

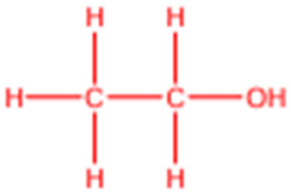
Ethyl Alcohol

→ IUPAC Name: Ethanol
→ Common Name: Ethyl Alcohol
→ Molecular Formula: C_2H_5OH or CH_3CH_2OH
→ Molecular Weight: 46.07 g/mol

Structure of Ethyl Alcohol

Ethyl alcohol contains:

- **A two-carbon chain (ethane backbone)**
- **A hydroxyl group (–OH)** attached to the terminal carbon.



Or condensed as:
$CH_3–CH_2–OH$

- It is a **primary alcohol**, since the –OH group is attached to a carbon bonded to **only one other carbon.**

Uses of Ethyl Alcohol

Pharmaceutical and Medical Uses

→ **Disinfectant & Antiseptic:**
- Used to disinfect skin, surgical instruments, and surfaces.
- Usually in 70% alcohol solution for maximum germicidal activity.

→ **Solvent:**
- Widely used as a solvent for drugs, tinctures, and extracts.
- Used in syrups, elixirs, and liniments.

→ **Preservative:**
- Prevents microbial growth in pharmaceutical preparations.

→ **Antidote for Methanol Poisoning:**
- Competitively inhibits alcohol dehydrogenase to prevent toxic methanol metabolism.

Industrial Uses

→ **Solvent in Chemical Industry:**
- Used for dissolving resins, dyes, oils, perfumes, and alkaloids.

→ **Fuel and Fuel Additive:**
- Used as biofuel or blended with petrol (gasohol) in internal combustion engines.

→ **Raw Material:**
- Used in the synthesis of esters, ethyl chloride, acetaldehyde, and other compounds.

Beverage Industry

→ **Alcoholic Beverages:**
- Main intoxicating ingredient in beer, wine, whisky, vodka, etc.
- Produced by fermentation of sugars using yeast.

Laboratory Uses

→ **Cleaning Agent:**
- Used to clean lab glassware, microscope lenses, etc.

→ **Reagent:**
- Used in organic reactions like esterification, dehydration, oxidation, etc.

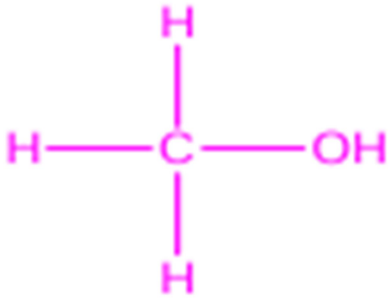
Methyl Alcohol

→ IUPAC Name: Methanol
→ Common Name: Methyl alcohol / Wood alcohol
→ Molecular Formula: CH_3OH
→ Molecular Weight: 32.04 g/mol

Structure of Methyl Alcohol

Methyl alcohol consists of:

- A **single carbon atom** (from methane)
- Bonded to **three hydrogen atoms** and **one hydroxyl group (–OH)**



Or simply:
CH_3–OH

- It is the **simplest primary alcohol,** as the –OH is attached to a carbon bonded to only hydrogen atoms.

Uses of Methyl Alcohol

Industrial Uses

→ **Solvent:**

- Used to dissolve oils, resins, dyes, inks, and adhesives.
- Acts as a solvent in varnishes, paint removers, and antifreeze.

→ **Fuel and Fuel Additive:**

- Used as an industrial fuel, and in blended fuels (e.g., methanol + petrol).
- Also used in race cars and camping stoves.

→ **Production of Chemicals:**

- Used in the manufacture of:
  - Formaldehyde
  - Acetic acid
  - Methyl chloride
  - Methyl esters
  - Methylated spirit (denatured alcohol)

Laboratory and Pharmaceutical Uses

→ **Laboratory Reagent:**

- Used as a solvent and cleaning agent for lab glassware and instruments.

→ **Disinfectant Base:**

- Used in surface sterilization, though less preferred than ethanol due to toxicity.

→ **Preservative:**

- Used to preserve biological specimens and as a fixative in histology.

Miscellaneous Uses

→ **Windshield Washer Fluids and Antifreeze:**

- Added to automotive products to prevent freezing in cold climates.

→ **Methylated Spirit:**

- Used as denatured alcohol (ethanol + methanol) to prevent human consumption.

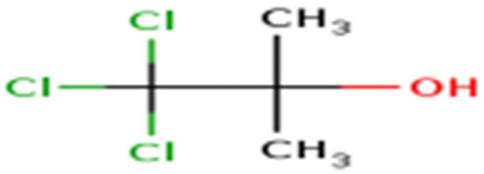
Chlorobutanol

→ IUPAC Name: 1,1,1-Trichloro-2-methyl-2-propanol
→ Common Name: Chlorobutanol
→ Molecular Formula: $C_4H_7Cl_3O$
→ Molecular Weight: 177.46 g/mol

Structure of Chlorobutanol

Chlorobutanol is a **halogenated tertiary alcohol**, derived from butanol, where:

- Three chlorine atoms are attached to the **same carbon atom** (trichloromethyl group)
- The hydroxyl group (–OH) is on a **tertiary carbon**



Uses of Chlorobutanol

Pharmaceutical Uses

→ **Preservative:**

- Used as a preservative in ophthalmic (eye drops), injectable, and oral pharmaceutical preparations.
- Effective against bacteria and fungi.

→ **Sedative and Hypnotic:**

- Exhibits mild sedative and hypnotic properties.
- Previously used in formulations for insomnia and anxiety, but largely replaced by safer alternatives.

→ **Local Anesthetic:**

- Has local anesthetic action (mild) and is used in topical preparations.

→ **Antimicrobial Agent:**

- Effective against Gram-positive and Gram-negative bacteria.

Industrial and Cosmetic Uses

→ **Cosmetics and Toiletries:**

- Sometimes used as a preservative in cosmetics like creams and lotions.

→ **Veterinary Medicine:**

- Used in veterinary ophthalmic solutions as a preservative and antiseptic.

Cetostearyl Alcohol

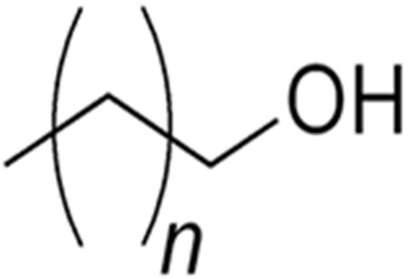
→ Other Names:
- Ceto-Stearyl Alcohol
- C16–C18 Fatty Alcohol Mixture
- Cetanol and Stearyl Alcohol mixture

→ Molecular Formula: Mixture of $C_{16}H_{34}O$ (Cetyl alcohol) and $C_{18}H_{38}O$ (Stearyl alcohol)

→ Molecular Weight: Varies with ratio; average ~250–270 g/mol

Structure of Cetostearyl Alcohol

Cetostearyl alcohol is **not a single compound**, but a **mixture** of two high molecular weight fatty alcohols:



Uses of Cetostearyl Alcohol

Pharmaceutical Uses

→ **Emulsifying Agent:**

- Used in ointments and creams as a non-ionic emulsifier.
- Helps stabilize oil-in-water (O/W) and water-in-oil (W/O) emulsions.

→ **Consistency Agent (Stiffening Agent):**

- Provides body, texture, and stability to semi-solid formulations like ointments, lotions, and pastes.

→ **Solvent Base:**

- Used in topical drug formulations as a base or carrier.

→ **Skin Protectant:**

- Mild emollient action; protects skin from dryness and irritation.

Cosmetic Uses

→ **Thickening Agent in Creams and Lotions:**

- Adds rich texture to moisturizers, hair conditioners, and body creams.

→ **Emollient:**

- Softens and smoothens skin by forming a moisture-retaining barrier.

→ **Opacifier:**

- Makes products look white and creamy by scattering light.

Industrial Uses

→ **Lubricants and Polishes:**

- Used in wax formulations for lubricants, polishes, and coatings.

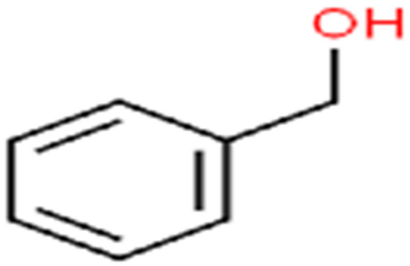
Benzyl alcohol

→ IUPAC Name: Phenylmethanol
→ Common Name: Benzyl Alcohol
→ Molecular Formula: $C_6H_5CH_2OH$
→ Molecular Weight: 108.14 g/mol

Structure of Benzyl Alcohol

Benzyl alcohol consists of:

- A **benzene ring (C_6H_5–)**
- Attached to a **–CH_2OH** group (hydroxymethyl group)



Uses of Benzyl Alcohol

Pharmaceutical Uses

→ **Preservative in Injectable Solutions:**

- Used as a bacteriostatic preservative in multi-dose vials of injectables.

→ **Solvent for Active Pharmaceutical Ingredients (APIs):**

- Helps dissolve poorly water-soluble drugs in parenteral and topical preparations.

→ **Local Anesthetic:**

- Has mild local anesthetic action—used in topical pain-relief products.

→ **Component in Ointments and Lotions:**

- Used as a co-solvent and antimicrobial agent in skin preparations.

Cosmetic and Personal Care Uses

→ **Fragrance Fixative:**

- Used in perfumes and cosmetics to stabilize and fix fragrance.

→ **Solvent in Lotions and Creams:**

- Helps dissolve fragrance ingredients and actives in cosmetic formulations.

→ **Hair Products:**

- Included in shampoos and conditioners for fragrance and solvent properties.

Industrial Uses

→ **Paints and Coatings:**

- Used as a solvent in inks, lacquers, and coatings.

→ **Photographic Developers:**

- Acts as a component in photographic chemicals.

→ **Plasticizers and Epoxy Resins:**

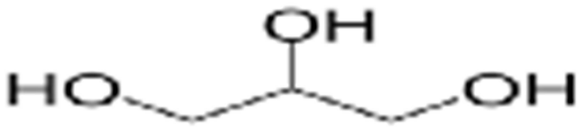
- Used as a solvent or additive in plastic manufacturing.

Glycerol

→ IUPAC Name: Propane-1,2,3-triol
→ Common Name: Glycerol or Glycerin
→ Molecular Formula: $C_3H_8O_3$
→ Molecular Weight: 92.09 g/mol

Structure of Glycerol

Glycerol is a **triol,** meaning it contains **three hydroxyl (–OH) groups**, one on each carbon of a propane chain.



Uses of Glycerol

Pharmaceutical Uses

→ **Humectant:**
- Retains moisture in creams, ointments, suppositories, and oral formulations.

→ **Solvent:**
- Used to dissolve drugs that are not water-soluble (e.g., tinctures, elixirs).

→ **Laxative:**
- Glycerin suppositories or enemas act as mild hyperosmotic laxatives.

→ **Emollient:**
- Soothes and softens dry or irritated skin.

→ **Preservative:**

- Inhibits microbial growth by reducing water activity in oral and topical preparations.

→ **Vehicle in Syrups:**

- Non-toxic and sweet-tasting, used as a vehicle or sweetening agent.

Cosmetic and Personal Care Uses

→ **Skin Care Products:**

- Common in moisturizers, lotions, creams as it hydrates and protects skin.

→ **Hair Care Products:**

- Used in shampoos, conditioners, and serums to prevent dryness and improve texture.

Food Industry

→ **Sweetener and Humectant:**

- Used in low-fat foods, icing, candies, and soft drinks.

→ **Food Preservative:**

- Helps extend shelf life by preventing microbial growth.

Industrial Uses

→ **Explosives Manufacture:**

- Used to prepare nitroglycerin, a key component in dynamite.

→ **Antifreeze and Lubricant:**

- Used in coolants, brake fluids, and plasticizers.

→ **Printing and Paint Industry:**

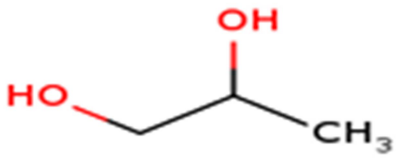
- Acts as a solvent and plasticizer in inks and paints.

Propylene Glycol

→ IUPAC Name: Propane-1,2-diol
→ Common Name: Propylene Glycol
→ Molecular Formula: $C_3H_8O_2$
→ Molecular Weight: 76.09 g/mol

Structure of Propylene Glycol

Propylene glycol is a **dihydric alcohol** (diol), meaning it contains **two hydroxyl (–OH) groups** on adjacent carbon atoms in a three-carbon propane backbone.



Uses of Propylene Glycol

Pharmaceutical Uses

→ **Solvent:**
- Used as a solvent and co-solvent for oral, injectable, and topical formulations.

→ **Humectant:**
- Retains moisture in ointments, creams, and lotions to prevent drying.

→ **Preservative Enhancer:**
- Enhances antimicrobial preservative activity in liquid dosage forms.

→ **Plasticizer in Suppositories:**
- Improves consistency and softening behavior of glycerogelatin bases.

→ **Excipient in Tablets:**
- Acts as a wetting agent and stabilizer.

Cosmetic and Personal Care Uses

→ **Moisturizer:**
- Used in skin creams, lotions, shampoos, and makeup products for its hydrating property.

→ **Solvent for Fragrances and Dyes:**
- Helps dissolve colors, perfumes, and active ingredients.

→ **Non-irritant Base:**
- Used in baby products and sensitive-skin formulations due to its mildness.

Food and Beverage Uses

→ **Food Additive (E1520):**
- Used as a carrier solvent for flavors, colors, and preservatives.

→ **Humectant and Stabilizer:**
- Keeps food products moist and shelf-stable, especially in baked goods and icings.

Industrial Uses

→ **Antifreeze and Coolants:**
- Used in non-toxic antifreeze formulations (e.g., in HVAC systems and RVs).

→ **De-icing Fluids:**
- Main component in aircraft de-icing and anti-icing solutions.

→ **Plasticizer and Hydraulic Fluids:**
- Used in brake fluids, printing inks, and hydraulic systems.