

Terpenoids

Terpenoids

Definition

- Terpenoids, or isoprenoids, are a diverse class of naturally occurring organic compounds derived from five-carbon isoprene units.
- They undergo modifications like oxidation and rearrangement, resulting in varied structures and functions.

Structure and Classification

- Based on isoprene units:
 - **Monoterpenoids:** C_{10} (2 units)
 - **Sesquiterpenoids:** C_{15} (3 units)
 - **Diterpenoids:** C_{20} (4 units)
 - **Triterpenoids:** C_{30} (6 units)
 - **Tetraterpenoids:** C_{40} (8 units)
 - **Polyterpenoids:** $>C_{40}$

Biosynthesis

- Produced via:
 - **Mevalonate Pathway:** In cytosol of eukaryotes and some prokaryotes.
 - **MEP Pathway:** In plastids of plants and most bacteria.
- Both pathways generate isopentenyl pyrophosphate (IPP) and dimethylallyl pyrophosphate (DMAPP).

Occurrence in Nature

- Widely found in plants, contributing to aromas, flavors, and colors. Also present in animals, fungi, and some bacteria.
- Common sources include essential oils, resins, and waxes.

Biological Activities and Uses

- **Ecological Roles:** Defense against herbivores/pathogens; attract pollinators.
- **Pharmaceuticals:** Medicinal properties like anti-inflammatory and anticancer (e.g., paclitaxel, artemisinin).
- **Industrial Applications:** Fragrances, flavorings, solvents, and synthetic material precursors.

Examples

- **Menthol:** Monoterpenoid in mint oils, provides cooling sensation.
- **Citral:** Monoterpenoid with a strong lemon scent, used in fragrances and flavorings.
- **Artemisinin:** Sesquiterpenoid with potent anti-malarial properties.

Various Terpenoids

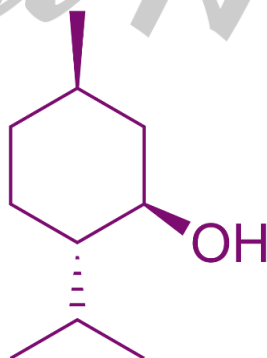
Menthol

Source and Occurrence



peppermint plant

- Menthol is predominantly found in the essential oils of the peppermint plant (**Mentha × piperita**), but it is also present in other mint species such as spearmint (**Mentha spicata**).



- It is widely used in pharmaceuticals, cosmetics, and food industries for its cooling sensation and minty flavor.

Isolation

1. Extraction:

Steam Distillation:

- The primary method for extracting menthol involves steam distillation of peppermint leaves.
- The plant material is subjected to steam, which vaporizes the volatile compounds, including menthol.
- **Procedure:**

- A. Fresh peppermint leaves are harvested and subjected to steam under controlled conditions.
- B. The steam carries the volatile oils into a condenser, where they are cooled and condensed back into liquid form.
- C. The resulting mixture separates into an aqueous phase and an oil phase due to immiscibility.

2. Separation:

- The oil phase, containing menthol and other terpenoids, is collected. Menthol may constitute about 30-40% of peppermint oil.

3. Purification:

- **Crystallization:** Menthol can be purified by fractional crystallization. The crude menthol is dissolved in a suitable solvent (e.g., ethanol) and cooled to allow menthol crystals to form.
- **Recrystallization:** Further purification is achieved by recrystallizing the menthol crystals to remove impurities.

Identification

1. Physical Properties:

- **Appearance:** Pure menthol appears as colorless crystals.
- **Melting Point:** Approximately 42-44°C.
- **Odor:** Characteristic minty aroma.

2. Spectroscopic Techniques:

- **Infrared (IR) Spectroscopy:** Identifies functional groups.
- Menthol shows characteristic peaks for hydroxyl groups ($\sim 3400\text{ cm}^{-1}$), C-H stretching, and methyl groups.
- Nuclear Magnetic Resonance (NMR) Spectroscopy:
 - **^1H NMR:** Provides information on the hydrogen environment, confirming the presence of isopropyl groups and hydroxyl groups.
 - **^{13}C NMR:** Identifies carbon skeleton.
- **Mass Spectrometry (MS):** Confirms molecular weight (152.23 g/mol) and fragmentation pattern.

3. Chromatographic Techniques:

- **Gas Chromatography (GC):** Used to confirm purity and identify menthol by retention time compared to standards.
- **High-Performance Liquid Chromatography (HPLC):** Further analytical confirmation.

Analysis



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