FirstHope Notes | B.Pharm Semester 5

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.

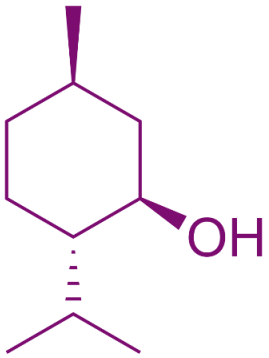
Various Terpenoids

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 (~3400 cm^{-1}), C-H stretching, and methyl groups.
- Nuclear Magnetic Resonance (NMR) Spectroscopy:
  - **^{1}H 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

1. Quantitative Analysis:

- **GC-FID (Flame Ionization Detector):** Quantifies menthol content in essential oils.
- **HPLC with UV Detection:** Measures menthol concentration in purified samples.

2. Quality Control:

- Ensuring purity through chromatographic profiles.
- Assessing physical properties like melting point.

Applications and Significance

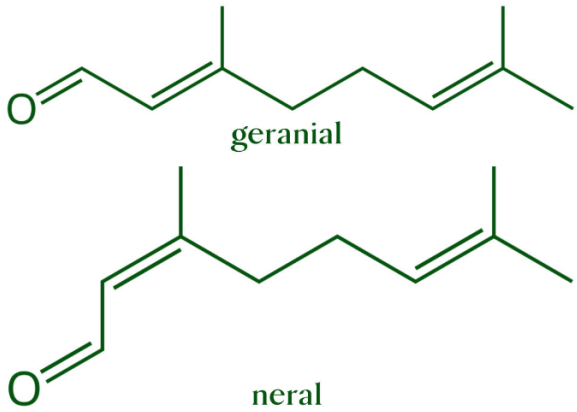
- Menthol is used in topical analgesics, cough and cold medications, oral hygiene products, and as a flavoring agent.
- Its cooling sensation is due to menthol's ability to activate the TRPM8 receptors in sensory neurons.

Citral

Source and Occurrence

Cymbopogon citratus

- Citral is a key component of lemongrass (Cymbopogon citratus) and lemon myrtle (Backhousia citriodora) essential oils.
- It exists in two isomeric forms: geranial (trans-citral) and neral (cis-citral).



Isolation

1. Extraction:

- **Steam Distillation:** Similar to menthol, citral is extracted via steam distillation of lemongrass leaves.
- **Solvent Extraction:** Alternatively, organic solvents like hexane or ethanol can be used to extract essential oils containing citral.

2. Separation:

- Post-distillation, the essential oil is separated from water.
- **Fractional Distillation:** To isolate citral from other components based on boiling points.

3. Purification:

- **Chromatography:** Utilizing techniques like column chromatography on silica gel to separate citral from other terpenoids.
- **Recrystallization:** Not typically applicable for citral as it is a liquid at room temperature, but distillation under reduced pressure can enhance purity.

Identification

1. Physical Properties:

- **Appearance:** Colorless liquid.
- **Boiling Point:** ~230°C.
- **Odor:** Strong lemon-like aroma.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Detects functional groups such as aldehyde (~1720 cm^{-1}) and C=C stretching (~1650 cm^{-1}).
- **^{1}H and ^{13}C NMR Spectroscopy:** Elucidate the molecular structure, confirming the presence of aldehyde and double bonds.
- **Mass Spectrometry:** Molecular ion peak at m/z 152.

3. Chromatographic Techniques:

- **GC:** Essential for separating citral isomers and confirming purity via retention times.
- **HPLC:** Used for quantitative analysis.

Analysis

1. Quantitative Analysis:

- **GC-FID:** Measures citral concentration in essential oils.
- **HPLC:** Provides precise quantification in purified samples.

2. Quality Control:

- Assessing purity through spectral data and chromatographic profiles.
- Ensuring absence of impurities or other isomers beyond acceptable limits.

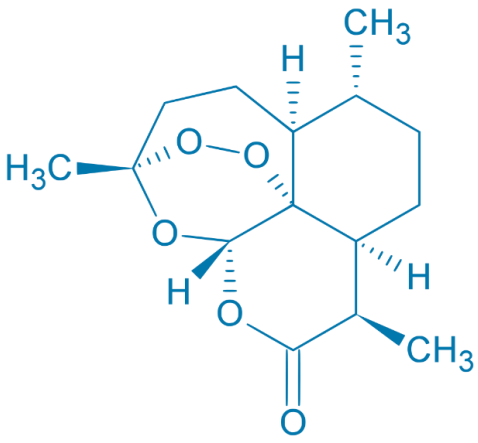
Applications and Significance

- Citral is widely used in the flavor and fragrance industry for its lemon scent.
- It also possesses antimicrobial and anti-inflammatory properties, making it valuable in cosmetics and medicinal formulations.

Artemisinin

Source and Occurrence

- Artemisinin is a sesquiterpene lactone containing a peroxide bridge, isolated from the sweet wormwood plant (Artemisia annua).
- It is renowned for its potent antimalarial properties.



Isolation

1. Extraction:

- **Solvent Extraction:** Dried and powdered Artemisia annua leaves are subjected to extraction using solvents like ethanol or dichloromethane.

2. Purification:

- **Liquid-Liquid Extraction:** Separates artemisinin from other components based on solubility differences.
- **Chromatography:**
  - **Column Chromatography:** Utilizing silica gel or reverse-phase columns to isolate artemisinin.
  - **High-Performance Liquid Chromatography (HPLC):** For higher purity levels.

3. Crystallization:

- Precipitation of artemisinin by altering solvent conditions, followed by filtration and drying.

Identification

1. Physical Properties:

- **Appearance:** White crystalline solid.
- **Melting Point:** Decomposes before melting.
- **Solubility:** Soluble in chloroform, ether, and other organic solvents; insoluble in water.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Detects functional groups, especially the characteristic peroxide bridge (~800 cm^{-1}).
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Confirms the presence of specific hydrogen environments.
  - **^{13}C NMR:** Provides detailed carbon framework information.
- **Mass Spectrometry:** Molecular ion peak at m/z 282.4.

3. Chromatographic Techniques:

- **HPLC:** Confirms purity and quantifies artemisinin content.
- **GC-MS:** Sometimes used but can cause decomposition due to high temperatures.

Analysis

1. Quantitative Analysis:

- **HPLC with UV Detection:** Standard method for quantifying artemisinin levels.
- **Spectrophotometry:** Less common due to specificity issues.

2. Quality Control:

- Ensuring the absence of impurities that could affect efficacy.
- Verifying structural integrity via spectroscopic data.

Applications and Significance

- Artemisinin is a cornerstone in antimalarial therapy, especially against Plasmodium falciparum.
- Its derivatives, such as artesunate and artemether, are critical in combination therapies to prevent resistance.

Glycosides

Glycosides

Definition

- Glycosides are compounds consisting of a sugar moiety (glycone) linked to a non-sugar aglycone via a glycosidic bond. Aglycones can be terpenoids, phenols, or alkaloids.

Structure and Classification

- **Based on aglycone:**
  - **Flavonoid Glycosides**: Flavonoid aglycone.
  - **Cardiac Glycosides**: Steroid or triterpenoid aglycones.
  - **Saponins**: Triterpenoid or steroid aglycones with soap-like properties.
  - **Cyanogenic Glycosides**: Release hydrogen cyanide upon hydrolysis.
- Additionally classified by sugar type (e.g., glucose, rhamnose) and glycosidic bond type.

Biosynthesis

- Formed by glycosyltransferase enzymes attaching sugar moieties to aglycones, altering solubility, stability, and bioactivity.

Occurrence in Nature

- Common in plants for defense, pigmentation, and storage. Also found in some animals and microorganisms.

Biological Activities and Uses

- **Pharmacological Effects**: E.g., cardiac glycosides like digoxin for heart conditions.
- **Defense Mechanisms**: Toxins or deterrents against pests.
- **Industrial Uses**: Natural colorants and antioxidants in food and cosmetics.

Examples

- **Rutin**: Flavonoid glycoside with antioxidant properties in various fruits and vegetables.
- **Glycyrrhetinic Acid**: Saponin glycoside from licorice root, used in flavorings and as an anti-inflammatory agent.

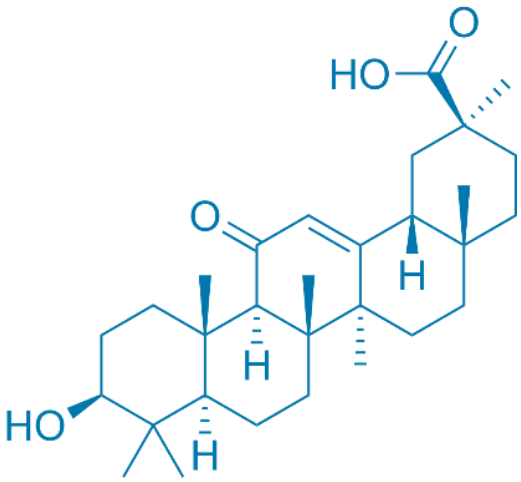
Various Glycosides

Glycyrrhetinic Acid

Source and Occurrence

- Glycyrrhetinic acid is derived from Glycyrrhiza glabra (licorice) root.
- It is the aglycone of glycyrrhizin, a triterpenoid saponin responsible for the sweet taste of licorice.

Glycyrrhiza glabra



Isolation

1. Extraction:

- **Alcoholic Extraction:** Dried licorice root is powdered and extracted with ethanol or methanol to obtain the glycosides.

2. Hydrolysis:

- **Acid Hydrolysis:** Glycyrrhizin is hydrolyzed under acidic conditions to yield glycyrrhetinic acid and glucose.

3. Purification:

- **Liquid-Liquid Extraction:** Using solvents like chloroform to separate glycyrrhetinic acid from aqueous phase.
- **Recrystallization:** Purifying the extracted acid by dissolving in suitable solvents and recrystallizing.

4. Chromatography:

- **Column Chromatography:** On silica gel to further purify glycyrrhetinic acid.

Identification

1. Physical Properties:

- **Appearance:** White crystalline powder.
- **Melting Point:** Approximately 295-297°C.
- **Solubility:** Soluble in organic solvents like ethanol and chloroform; sparingly soluble in water.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Identifies functional groups such as hydroxyl groups (~3400 cm^{-1}) and carbonyl groups (~1700 cm^{-1}).
- **NMR Spectroscopy:**
  - **^{1}H NMR and ^{13}C NMR:** Provide detailed structural information confirming the triterpenoid structure.
- **Mass Spectrometry:** Molecular ion peak at m/z 472 (as sodiated ion, [M+Na]^+).

3. Chromatographic Techniques:

- **HPLC:** Used for purity assessment.
- **Thin-Layer Chromatography (TLC):** For preliminary identification.

Analysis

1. Quantitative Analysis:

- **HPLC:** Precise quantification in licorice extracts.
- **Spectrophotometric Methods:** Utilized with appropriate standards.

2. Quality Control:

- Verifying purity through spectral data.
- Assessing absence of contaminants.

Applications and Significance

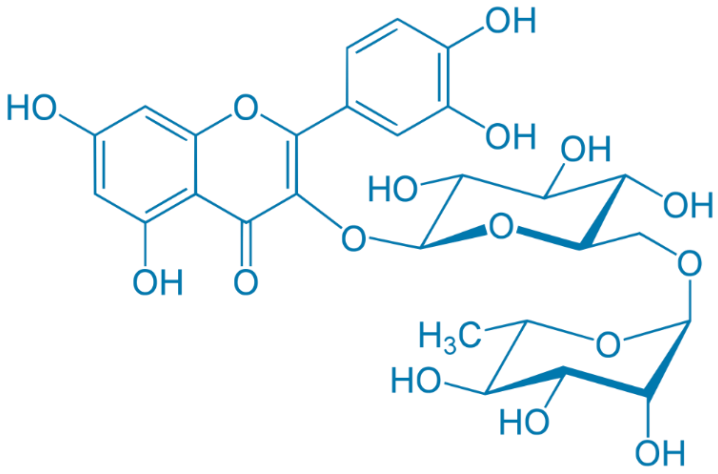
- Glycyrrhetinic acid exhibits anti-inflammatory, antiviral, and hepatoprotective activities.
- It is used in the treatment of chronic hepatitis and as a flavoring agent in food products.

Rutin

Source and Occurrence

Buckwheat

- Rutin is a flavonoid glycoside found in various plants, including Buckwheat (Fagopyrum esculentum), Citrus fruits, Apples, and Tea.
- It contributes to the yellow coloration in plants and has significant antioxidant properties.



Isolation

1. Extraction:

- **Ethanol or Methanol Extraction:** Dried plant material is powdered and extracted with alcohol to solubilize rutin.

2. Purification:

- **Liquid-Liquid Extraction:** Partitioning between solvents of different polarities to remove unwanted compounds.
- **Column Chromatography:** Typically using silica gel with a gradient of solvents (e.g., chloroform-methanol-water) to isolate rutin.

3. Crystallization:

- Rutin can be recrystallized from ethanol or methanol to enhance purity.

Identification

1. Physical Properties:

- **Appearance:** Yellow crystalline powder.
- **Melting Point:** Approximately 250°C (decomposes).
- **Solubility:** Soluble in water, methanol, and ethanol.

2. Spectroscopic Techniques:

- **UV-Visible Spectroscopy:** Shows characteristic absorption peaks due to the flavonoid structure.
- **IR Spectroscopy:** Identifies functional groups such as hydroxyl groups and glycosidic linkages.
- **NMR Spectroscopy:**

- **^{1}H NMR:** Reveals proton environments characteristic of the flavonoid skeleton and sugar moieties.
- **^{13}C NMR:** Confirms the carbon framework.

➢ **Mass Spectrometry:** Molecular ion peak at m/z 610 (as [M+H]^+).

3. Chromatographic Techniques:

➢ **HPLC:** Essential for purity assessment and quantification.

➢ **TLC:** Used for initial screening and identification.

Analysis

1. Quantitative Analysis:

➢ **HPLC with UV Detection:** Common method for rutin quantification in plant extracts.

➢ **Spectrophotometric Methods:** Using colorimetric assays with specific reagents.

2. Quality Control:

➢ Ensuring purity via HPLC profiles.

➢ Verifying structural integrity through NMR and MS data.

Applications and Significance

- Rutin is known for its antioxidant, anti-inflammatory, and vasoprotective effects.
- It is used in dietary supplements, pharmaceuticals for chronic venous insufficiency, and as a bioflavonoid in various health products.

Alkaloids

Alkaloids

Definition

- Alkaloids are nitrogen-containing natural compounds, primarily derived from amino acids, known for diverse pharmacological activities and often bitter taste.

Structural Features

- Contain basic nitrogen atoms with complex ring and heterocyclic structures.

Classification

- Based on biosynthetic origin or structure:
    - **Pyridine/Piperidine**: e.g., Nicotine
    - **Indole**: e.g., Vincristine
    - **Quinoline/Quinolizidine**: e.g., Quinine
    - **Tropane**: e.g., Cocaine, Atropine
    - **Isoquinoline**: e.g., Morphine, Reserpine
    - **Purine**: e.g., Caffeine

Biosynthesis

- Derived from amino acids like ornithine, lysine, tyrosine, and tryptophan through complex enzymatic pathways.

Occurrence in Nature

- Primarily in plants (e.g., Solanaceae, Papaveraceae, Rubiaceae), also in some fungi and animals.

Biological Activities and Uses

- **Pharmaceuticals**: Medications such as analgesics (morphine), stimulants (caffeine), and anti-malarials (quinine).
- **Toxicity**: Serve as defense compounds.
- **Psychoactive Effects**: Affect the central nervous system (e.g., cocaine, LSD).

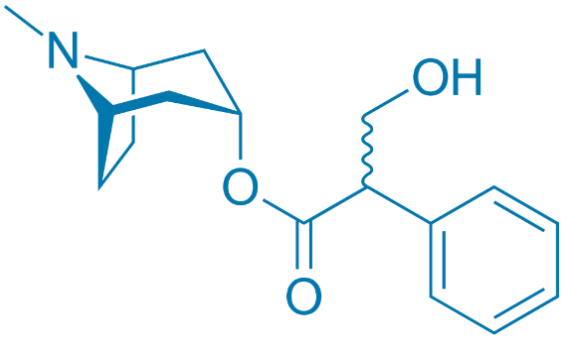
Examples

- **Caffeine**: Stimulant in coffee, tea, cacao.
- **Atropine**: Tropane alkaloid for nerve agent/pesticide poisoning.
- **Quinine**: Anti-malarial from cinchona bark.
- **Reserpine**: Isoquinoline alkaloid used to treat high blood pressure and psychotic disorders.

Various Alkaloids

Atropine

Source and Occurrence



Atropa belladonna

- Atropine is extracted from Atropa belladonna (deadly nightshade), Datura stramonium (jimsonweed), and other Solanaceae family members.
- It is a tropane alkaloid with potent antimuscarinic properties.

Isolation

1. **Extraction:**

Acid-Base Extraction:

- **Acidic Extraction:** Plant material is treated with an aqueous acid (e.g., HCl) to convert atropine into its water-soluble salt.
- **Basification:** The aqueous layer is basified with a strong base (e.g., NaOH) to free the atropine alkaloid, which is then extracted into an organic solvent like chloroform or ether.

2. **Purification:**

- **Recrystallization:** The extracted atropine can be recrystallized from solvents like ethanol or methanol.
- **Column Chromatography:** Utilizing silica gel columns with appropriate solvent systems to achieve high purity.

Identification

1. **Physical Properties:**

- **Appearance:** White crystalline powder.
- **Melting Point:** Approximately 214-216°C.
- **Solubility:** Soluble in water as its hydrobromide or hydrochloride salts; soluble in organic solvents in free base form.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Detects functional groups such as hydroxyl groups and ester linkages.
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Reveals signals corresponding to the tropane ring protons and methyl groups.
  - **^{13}C NMR:** Confirms the carbon skeleton of atropine.
- **Mass Spectrometry:** Molecular ion peak at m/z 289 (free base).

3. Chromatographic Techniques:

- **HPLC:** Used for purity assessment and quantification.
- **TLC:** Standard method for monitoring extraction and purification stages.

Analysis

1. Quantitative Analysis:

- **HPLC with UV Detection:** Primary method for determining atropine levels in samples.
- **Spectrophotometric Methods:** Using specific reagents for colorimetric assays.

2. Quality Control:

- Ensuring the absence of other tropane alkaloids like scopolamine and hyoscyamine.
- Verifying structural integrity via spectral data.

Applications and Significance

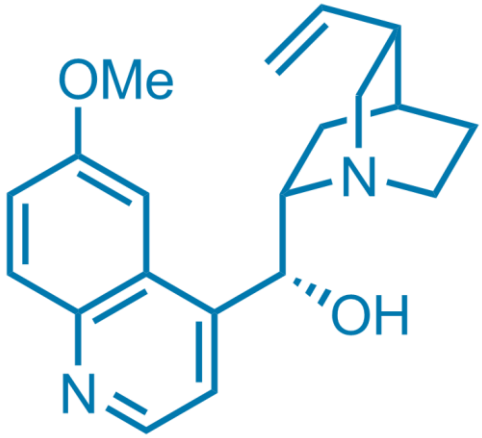
- Atropine is utilized as an antimuscarinic agent to treat bradycardia, as a mydriatic agent in ophthalmology, and as an antidote for organophosphate poisoning.
- Its ability to cross the blood-brain barrier makes it significant in both therapeutic and toxicological contexts.

Quinine

Source and Occurrence

- Quinine is obtained from the bark of the cinchona tree (Cinchona officinalis, Cinchona bark).
- It is a bitter alkaloid with antimalarial properties.

cinchona tree



Isolation

1. Extraction:

- **Bark Processing:** The bark is dried and powdered.
- **Alkaloid Extraction:** Mixed with an acidic aqueous solution (e.g., dilute HCl) to convert quinine into its water-soluble salt.

2. Purification:

- **Liquid-Liquid Extraction:** Basify the solution with NaOH to free the quinine base, which is then extracted into an organic solvent like ether or chloroform.
- **Crystallization:** Quinine is crystallized from the organic phase by adding a non-solvent (e.g., ethanol).

3. Chromatography:

- **Column Chromatography:** Further purification using silica gel columns and appropriate solvent systems.

Identification

1. Physical Properties:

- **Appearance:** White crystalline solid.
- **Melting Point:** Approximately 176-180°C.
- **Solubility:** Soluble in alcohol, ether, and slightly soluble in water.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Identifies functional groups such as quinoline ring and hydroxyl groups.
- **NMR Spectroscopy:**

- **^{1}H NMR:** Characteristic signals from the quinoline moiety and ethyl side chain.
- **^{13}C NMR:** Confirms the quinoline ring structure.

➢ **Mass Spectrometry:** Molecular ion peak at m/z 324 (free base).

3. Chromatographic Techniques:

➢ **HPLC:** For purity assessment and quantification.

➢ **TLC:** Used during extraction and purification stages.

Analysis

1. Quantitative Analysis:

➢ **HPLC with UV Detection:** Standard method for quinine quantification, especially in pharmaceutical formulations.

➢ **Spectrophotometric Methods:** Utilizing specific detection wavelengths.

2. Quality Control:

➢ Ensuring the absence of other cinchona alkaloids like quinidine.

➢ Confirming structural integrity through spectroscopic data.

Applications and Significance

- Quinine is historically significant as the first effective treatment for malaria.
- It is also used in tonic water and serves as a precursor for synthesizing other antimalarial drugs.
- Its bitter taste has led to widespread use in beverages and flavorings.

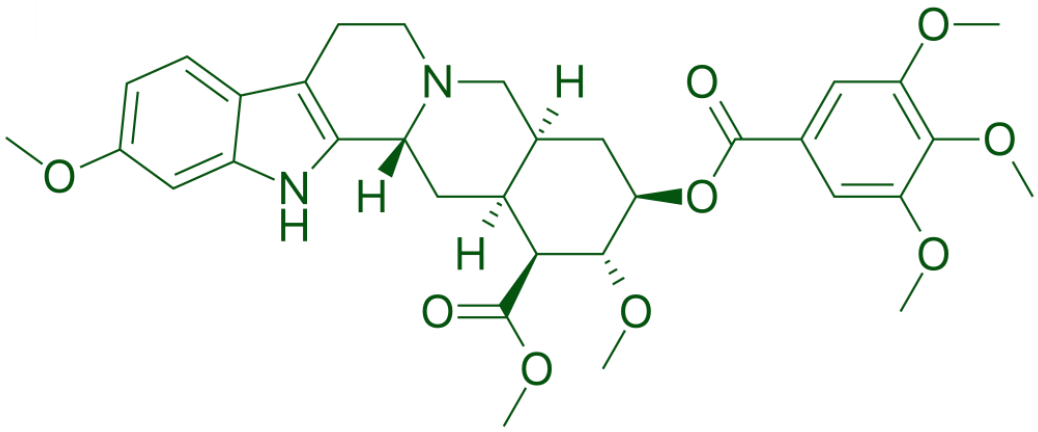
Reserpine

Source and Occurrence

Rauwolfia serpentina

- Reserpine is extracted from the roots of Rauwolfia serpentina (Indian snakeroot) and Rauwolfia vomitoria.

- It is an indole alkaloid with antihypertensive and antipsychotic properties.



Isolation

1. Extraction:

- **Alcoholic Extraction:** Dried and powdered Rauwolfia roots are extracted with ethanol or methanol to obtain the alkaloids.

2. Purification:

Acid-Base Extraction:

- The extract is acidified to convert reserpine into its water-soluble salt.
- Basification liberates the free base, which is then extracted with an organic solvent like chloroform.

- **Recrystallization:** Reserpine is recrystallized from chloroform or ethanol to enhance purity.

3. Chromatography:

- **Column Chromatography:** Using silica gel and appropriate eluent systems to purify reserpine.

Identification

1. Physical Properties:

- **Appearance:** Yellowish crystalline powder.
- **Melting Point:** Approximately 190°C.
- **Solubility:** Soluble in alcohol, chloroform; insoluble in water.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Identifies functional groups such as indole ring and ester functionalities.
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Reveals proton environments specific to the indole moiety and side chains.

- ^{13}**C NMR:** Confirms the carbon framework of reserpine.

➢ **Mass Spectrometry:** Molecular ion peak at m/z 608 (free base).

3. Chromatographic Techniques:

➢ **HPLC:** For assessing purity and quantification.

➢ **TLC:** Monitoring extraction and purification stages.

Analysis

1. Quantitative Analysis:

➢ **HPLC with UV Detection:** Primary method for reserpine quantification.

➢ **Spectrophotometric Methods:** Using specific wavelengths corresponding to reserpine's absorbance.

2. Quality Control:

➢ Ensuring the absence of other indole alkaloids like ajmalicine.

➢ Verification via spectral data.

Applications and Significance

- Reserpine is used as an antihypertensive agent by depleting catecholamines and serotonin from nerve terminals.
- It was also employed in psychiatric treatments for its antipsychotic effects, although its use has declined due to side effects.

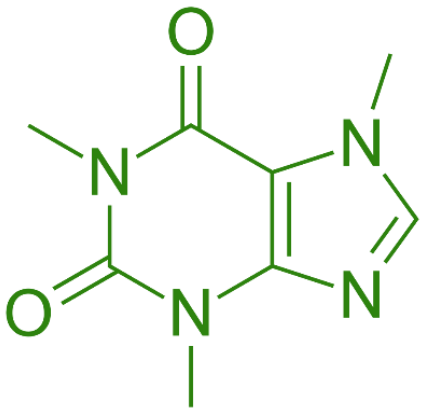
Caffeine

Source and Occurrence

Camellia sinensis

- Caffeine is a purine alkaloid found in Coffee beans (Coffea spp.), Tea leaves (Camellia sinensis), Cacao beans (Theobroma cacao), and Kola nuts (Cola spp.).

- It is a central nervous system stimulant.



Isolation

1. Extraction:

- **Solvent Extraction:** Ground coffee beans or tea leaves are extracted with water or organic solvents like dichloromethane or ethyl acetate.

2. Purification:

- **Liquid-Liquid Extraction:** Using solvents of different polarities to separate caffeine from other components.
- **Crystallization:** Caffeine can be crystallized from hot water as it is highly soluble when heated.

3. Chromatography:

- **Column Chromatography:** Using silica gel with appropriate eluent systems (e.g., chloroform-methanol).
- **HPLC:** For higher purity requirements.

Identification

1. Physical Properties:

- **Appearance:** White crystalline powder.
- **Melting Point:** Approximately 238°C.
- **Solubility:** Highly soluble in water, methanol, and chloroform.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Identifies functional groups like carbonyl and amine groups.
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Provides information on methyl groups and other proton environments.
  - **^{13}C NMR:** Confirms the carbon skeleton of caffeine.
- **Mass Spectrometry:** Molecular ion peak at m/z 194 (free base).

3. Chromatographic Techniques:

- **HPLC:** Essential for purity assessment and quantification.
- **GC-MS:** Possible but may require derivatization due to caffeine's thermal stability.

Analysis

1. Quantitative Analysis:

- **HPLC with UV Detection:** Standard method for caffeine determination in beverages and pharmaceuticals.
- **Spectrophotometric Methods:** Using specific absorbance peaks for caffeine.

2. Quality Control:

- Ensuring high purity for pharmaceutical applications.
- Verifying absence of related xanthine alkaloids like theobromine and theophylline.

Applications and Significance

- Caffeine is widely consumed for its stimulant effects, enhancing alertness and reducing fatigue.
- It is also used in headache remedies, weight loss supplements, and as an additive in various food and beverage products.

Resins

Resins

Definition

- Resins are viscous, solid or semi-solid mixtures of organic compounds, mainly terpenoids and derivatives, exuded by plants (especially conifers) and some insects for protection and structural purposes.

Composition

- **Diterpenes/Triterpenes**: Backbone structures.
- **Phenolic Compounds**: Provide rigidity and reactivity.
- **Other Compounds**: Essential oils, alcohols, acids.

Sources

- **Plant Resins**: E.g., pine resin, frankincense.
- **Insect Resins**: E.g., lac insect exudates.

Extraction and Processing

- Harvested by tapping plants (e.g., incising tree bark).
- Processed to remove impurities, producing products like turpentine and rosin.

Uses

1. **Industrial Applications:**
   - Varnishes and lacquers
   - Adhesives (rosin)
   - Incense and fragrances (frankincense, myrrh)
2. **Pharmaceuticals and Medicine:**
   - Traditional antimicrobial and anti-inflammatory remedies
   - Modern drug formulations
3. **Art and Craft:**
   - Artists' varnishes for paintings
   - Rosin for string instrument bows

Biological Roles

- **Defense Mechanism**: Deters herbivores; inhibits fungi and bacteria.
- **Wound Healing**: Seals damaged areas to prevent infection.

Examples

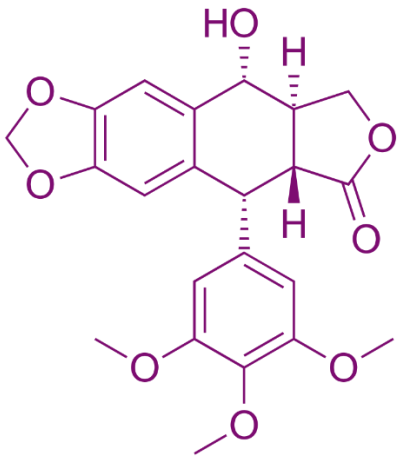
- **Podophyllotoxin**: Lignan resin from the mayapple plant, used as a precursor for anti-cancer drugs.
- **Curcumin**: Polyphenolic compound from turmeric, used for its anti-inflammatory and antioxidant properties.

Various Resins

Podophyllotoxin

Source and Occurrence

- Podophyllotoxin is extracted from the roots and rhizomes of Podophyllum species (e.g., Podophyllum peltatum—Mayapple).
- It is a lignan with antiviral and anticancer properties.



Isolation

1. **Extraction:**
   - **Ethanolic or Methanolic Extraction:** Dried Podophyllum roots are powdered and extracted with ethanol or methanol to obtain the resinous extract.

2. Purification:

- **Liquid-Liquid Extraction:** Utilizing solvents like chloroform or ether to partition podophyllotoxin.
- **Recrystallization:** Podophyllotoxin is recrystallized from methanol or ethanol to enhance purity.

3. Chromatography:

- **Column Chromatography:** Using silica gel with solvent systems (e.g., hexane-ethyl acetate) to purify podophyllotoxin.

Identification

1. Physical Properties:

- **Appearance:** White crystalline solid.
- **Melting Point:** Approximately 215°C.
- **Solubility:** Soluble in chloroform, ethanol, and other organic solvents; insoluble in water.

2. Spectroscopic Techniques:

- **IR Spectroscopy:** Identifies functional groups like hydroxyl and methoxy groups.
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Shows characteristic signals from aromatic protons and methylene groups.
  - **^{13}C NMR:** Confirms the lignan structure.
- **Mass Spectrometry:** Molecular ion peak at m/z 368 (free base).

3. Chromatographic Techniques:

- **HPLC:** For purity assessment and quantification.
- **TLC:** Monitoring extraction and purification stages.

Analysis

1. Quantitative Analysis:

- **HPLC with UV Detection:** Standard method for podophyllotoxin quantification.
- **Spectrophotometric Methods:** Utilizing specific absorbance peaks.

2. Quality Control:

- Ensuring high purity for therapeutic applications.
- Verifying structural integrity through spectral data.

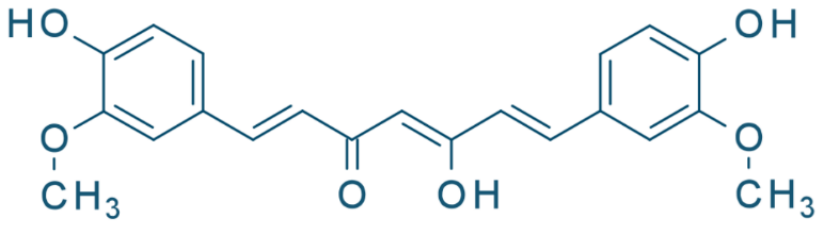
Applications and Significance

- Podophyllotoxin is a precursor for the synthesis of anticancer drugs like etoposide and teniposide.
- It exhibits antiviral properties, particularly against HPV (human papillomavirus), making it valuable in treating warts and certain cancers.

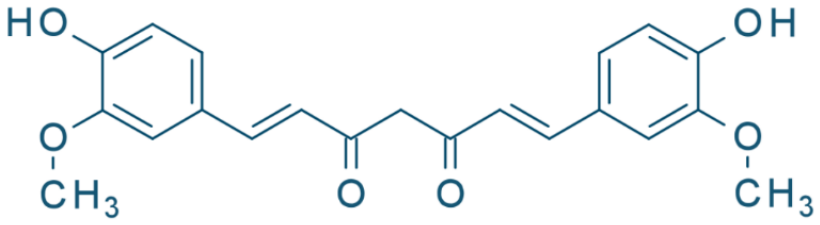
Curcumin

Source and Occurrence

- Curcumin is the principal curcuminoid found in Turmeric (Curcuma longa), a member of the ginger family.
- It is responsible for turmeric's bright yellow color and has extensive applications in food, cosmetics, and pharmaceuticals due to its anti-inflammatory and antioxidant properties.



Enol form



Keto form

Turmeric (Curcuma longa)

Isolation

1. **Extraction:**
   - **Solvent Extraction:** Dried turmeric rhizomes are powdered and extracted with ethanol, methanol, or acetone to obtain curcumin.

2. Purification:

- **Liquid-Liquid Extraction:** Partitioning between solvents of different polarities to isolate curcumin.
- **Recrystallization:** Curcumin is recrystallized from solvents like acetone or ethanol to achieve high purity.

3. Chromatography:

- **Column Chromatography:** Utilizing silica gel with solvent systems (e.g., hexane-ethyl acetate) to purify curcumin.
- **High-Performance Liquid Chromatography (HPLC):** For final purification steps.

Identification

1. Physical Properties:

- **Appearance:** Bright yellow crystalline powder.
- **Melting Point:** Approximately 183°C.
- **Solubility:** Soluble in organic solvents like ethanol, acetone, and dimethyl sulfoxide (DMSO); sparingly soluble in water.

2. Spectroscopic Techniques:

- **UV-Visible Spectroscopy:** Strong absorbance around 420 nm due to conjugated double bonds.
- **IR Spectroscopy:** Identifies functional groups such as hydroxyl and methoxy groups.
- **NMR Spectroscopy:**
  - **^{1}H NMR:** Reveals signals from aromatic protons, methoxy groups, and aliphatic chains.
  - **^{13}C NMR:** Confirms the structure of curcumin.
- **Mass Spectrometry:** Molecular ion peak at m/z 368 (free base).

3. Chromatographic Techniques:

- **HPLC:** Essential for purity assessment and quantification.
- **TLC:** Used for monitoring extraction and purification stages.

Analysis

1. Quantitative Analysis:

- **HPLC with UV Detection:** Primary method for curcumin quantification in turmeric and formulations.
- **Spectrophotometric Methods:** Utilizing specific absorbance characteristics.

2. Quality Control:

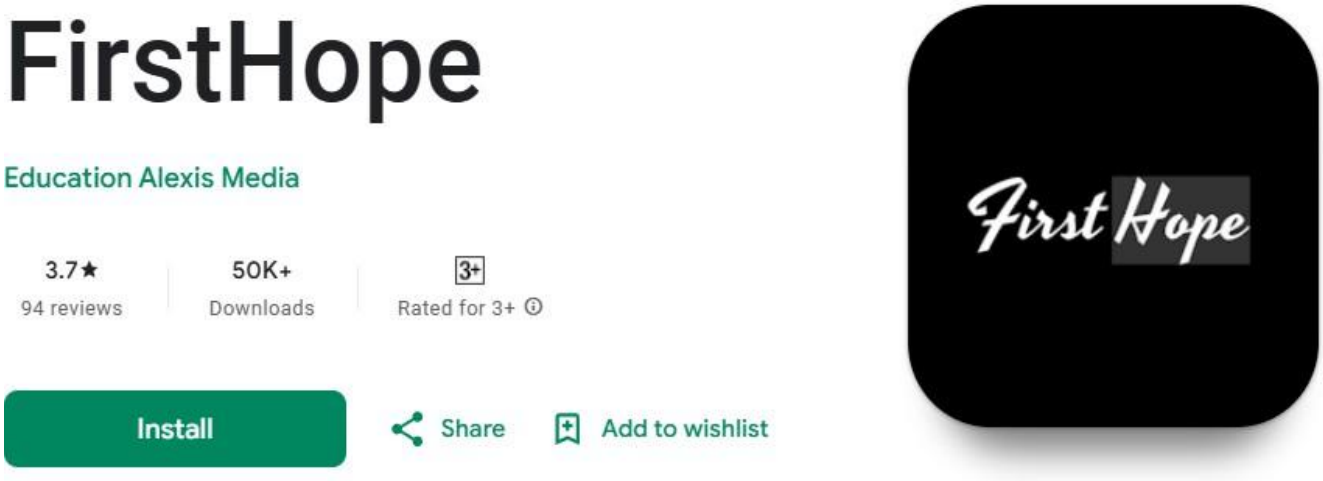
- Ensuring high purity through HPLC profiles.
- Confirming structural integrity via spectral data.

Applications and Significance

- Curcumin is extensively used as a dietary supplement, food coloring agent, and in traditional medicine.
- It exhibits anti-inflammatory, antioxidant, anticancer, and neuroprotective activities, making it a subject of intense biomedical research.

First Hope

Easy Short Notes Designed to Help You Score Better



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