

Brief outline of occurrence, distribution, isolation, identification tests, therapeutic activity and pharmaceutical application of terpenoid

- The terpenoids, also known as isoprenoids, are a large and diverse class of naturally occurring organic chemicals derived from the 5-carbon compound isoprene, and the isoprene polymers called terpenes. While sometimes used interchangeably with "terpenes", terpenoids contain additional functional groups, usually containing oxygen. Terpenoids are the largest class of plant secondary metabolites, representing about 60% of known natural products.
- Many terpenoids have substantial pharmacological bioactivity and are therefore of interest to medicinal chemists.
- Plant terpenoids are used for their aromatic qualities and play a role in traditional herbal remedies.
- Terpenoids contribute to the scent of eucalyptus, the flavors of cinnamon, cloves, and ginger, the yellow color in sunflowers, and the red color in tomatoes.
- Well-known terpenoids include citral, menthol, camphor, salvinorin A in the plant *Salvia divinorum*, the cannabinoids found in cannabis, and ginkgolide and bilobalide found in *Ginkgo biloba*. The provitamin beta carotene is a terpene derivative called a carotenoid.
- The steroids and sterols in animals are biologically produced from terpenoid precursors. Sometimes terpenoids are added to proteins, e.g., to enhance their attachment to the cell membrane; this is known as isoprenylation.
- Terpenoids play a role in plant defense as prophylaxis against pathogens and attractants for the predators of herbivores.
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- There are many different classes of naturally occurring compounds. Terpenoids also form a group of naturally occurring compounds majority of which occur in plants, a few of them have also been obtained from other sources. Terpenoids are volatile substances which give plants and flowers their fragrance. They occur widely in the leaves and fruits of higher plants, conifers, citrus and eucalyptus.
- The term 'terpene' was given to the compounds isolated from turpentine, a volatile liquid isolated from pine trees. The simpler mono and sesqui terpenes are chief constituent of the essential oils obtained from sap and tissues of certain plants and trees. The di and tri terpenoids are not steam volatile. They are obtained from plant and tree gums and resins. Tetraterpenoids form a separate group of compounds called Carotenoids.
- The term 'terpene' was originally employed to describe a mixture of isomeric hydrocarbons of the molecular formula $C_{10}H_{16}$ occurring in the essential oils obtained from sap and tissue of plants, and trees. But there is a tendency to use more general term terpenoids which include hydrocarbons and their Oxygenated derivatives. However the term terpene is being used these days by some authors to represent terpenoids.

- By the modern definition: "Terpenoids are the hydrocarbons of plant origin of the general formula $(C_5H_8)_n$ as well as their oxygenated, hydrogenated and dehydrogenated derivatives".

Classification

Terpenoids are modified terpenes wherein methyl groups have been moved or removed, or oxygen atoms added. Some authors use the term "terpene" more broadly, to include the terpenoids. Just like terpenes, the terpenoids can be classified according to the number of isoprene units that comprise the parent terpene:

Terpenoids	Analogue terpenes	Number of isoprene units	Number of carbon atoms	General formula	Examples ^[7]
Hemiterpenoids	Isoprene	1	5	C_5H_8	DMAPP, isopentenyl pyrophosphate, isoprenol, isovaleramide, isovaleric acid, HMBPP, prenol
Monoterpenoids	Monoterpenes	2	10	$C_{10}H_{16}$	Bornyl acetate, camphor, carvone, citral, citronellal, citronellol, geraniol, eucalyptol, hinokitiol, iridoids, linalool, menthol, thymol
Sesquiterpenoids	Sesquiterpenes	3	15	$C_{15}H_{24}$	Farnesol, geosmin, humulone
Diterpenoids	Diterpenes	4	20	$C_{20}H_{32}$	Abietic acid, ginkgolides, paclitaxel, retinol, salvinorin A, sclareol, steviol
Sesterterpenoids	Sesterterpenes	5	25	$C_{25}H_{40}$	Andrastin A, manoalide
Triterpenoids	Triterpenes	6	30	$C_{30}H_{48}$	Amyrin, betulinic acid, limonoids, oleanolic acid, sterols, squalene, ursolic acid
Tetraterpenoids	Tetraterpenes	8	40	$C_{40}H_{64}$	Carotenoids
Polyterpenoid	Polyterpenes	>8	>40	$(C_5H_8)_n$	Gutta-percha, natural rubber

Terpenoids can also be classified according to the type and number of cyclic structures they contain: linear, acyclic, monocyclic, bicyclic, tricyclic, tetracyclic, pentacyclic, or macrocyclic. The Salkowski test can be used to identify the presence of terpenoids.

Salkowski's test, also known simply as **Salkowski test**, is a qualitative chemical test, that is used in chemistry and biochemistry for detecting a presence of cholesterol and other sterols. This biochemical method got its name after German biochemist Ernst Leopold Salkowski, who is known for development of multiple new chemical tests, that are used for detection of different kinds of molecules (besides cholesterol and other sterols also for creatinine, carbon monoxide, glucose and indoles. A solution that has tested positive on the Salkowski's test becomes red and gets yellow glow.

For Salkowski test's procedure one needs a sample, that is to be tested for sterols, as well as chloroform and concentrated sulfuric acid that represent Salkowski's reagent. Usually the solution of chloroform and the sample is prepared first and later treated with concentrated sulfuric (VI) acid. After that the whole solution needs to be shaken well.

A solution that has tested positive on this qualitative chemical test exhibits two distinct layers in a test tube; the upper layer (chloroform) gets blueish red to violet colour, while the layer of sulfuric acid becomes yellow to green, with greenish glow being visible. If a sample does not contain any cholesterol or other sterols the tested solution remains unchanged and retains its original colour.

Isolation of mono and sesquiterpenoids

Both mono and sesquiterpenoids have common source i.e essential oils. Their isolation is carried out in two steps:

i) Isolation of essential oils from plant parts

ii) Separation of Terpenoids from essential oils

i) Isolation of essential oils from plant parts: The plants having essential oils generally have the highest concentration at some particular time. Therefore better yield of essential oil plant material have to be collected at this particular time. e.g. From jasmine at sunset. there are four methods of extractions of oils.

a) Expression method

b) Steam distillation method

c) Extraction by means of volatile solvents

d) Adsorption in purified fats

Steam distillation is most widely used method. In this method macerated plant material is steam distilled to get essential oils into the distillate form these are extracted by using pure organic volatile solvents. If compound decomposes during steam distillation, it may be extracted with petrol at 50°C. After extraction solvent is removed under reduced pressure.

ii) Separation of Terpenoids from essential oil: A number of terpenoids are present in essential oil obtained from the extraction. Definite physical and chemical methods can be used for the separation of terpenoids. They are separated by fractional distillation. The terpenoid hydrocarbons distill over first followed by the oxygenated derivatives.

More recently different chromatographic techniques have been used both for isolation and separation of terpenoids.

1. Most of the terpenoids are colourless, fragrant liquids which are lighter than water and volatile with steam. A few of them are solids e.g. camphor. All are soluble in organic solvent and usually insoluble in water. Most of them are optically active.

2. They are open chain or cyclic unsaturated compounds having one or more double bonds. Consequently they undergo addition reaction with hydrogen, halogen, acids, etc. A number of addition products have antiseptic properties.

3. They undergo polymerization and dehydrogenation.

4. They are easily oxidized nearly by all the oxidizing agents. On thermal decomposition, most of the terpenoids yields isoprene as one of the product.