New Aroma Chemicals: Thujone Alternatives

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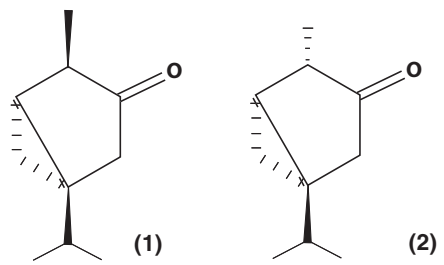
Perfumers often use the descriptor "thujone" to describe a particular note in fragrances. However, the odor of thujone itself seems to be inseparable from the character of the essential oils in which it is found. This article will examine the uses of thujone and thujone-containing materials in perfumery, and describe some synthetic materials — old and new— that are intended to provide this note.

Chemical Structure

Thujone is a monoterpenoid ketone that exists in two major forms —α (**1**) and β (**2**)— as illustrated in Figure 1.

Figure 1. α-Thujone ((-)-thujone) (1) and β-thujone ((+)-isothujone) (2)



Both isomers are widely distributed in nature, and are generally found together. Thujones are particularly prevalent in species of *Artemisia*, most famously in *Artemisia absinthium*, from which wormwood oil is derived. The use of wormwood oil in the French liquor absinthe gave rise to many cases of poisoning, and as a consequence absinthe was banned in 1915. The attractiveness of absinthe to its devotees lay in the double intoxication effect: the alcohol acted as a sedative, and the thujone contained in the wormwood oil reportedly produced excitement and auditory and visual hallucinations. This became popular with many famous creative individuals, including de Maupassant, Rimbaud, Verlaine and Tolouse-Lautrec, but the effect on unstable personalities — as in the case of Vincent Van Gogh — led to tragic consequences.[1]

A partial list of the major sources of thujone is presented in Table 1.

Other oils that may contain minor amounts of thujone include various species of thyme, sage, hyssop, marjoram, juniper, tagette, basil, myrtle, millefeuille and rosemary. The use of thujone in food additives has been banned or restricted in many jurisdictions, but it is difficult to exclude it completely, given its widespread distribution in nature. At present, there appear to be no restrictions on the use of thujone in perfumery.

Arctander describes the odor of thujone as "powerful and penetrating, warm-harbaceous, minty-camphora-

Table 1. Some major sources of thujone

Essential oil	Botanical name	α-Thujone (percent)	β-Thujone (percent)	Reference
cedarleaf (Thuja)	*Thuja occidentalis*[2]	31.0-47.0	8-11	3
dalmation sage	*Salvia officinalis*	18.0-43.0	3.0-8.5	4
armoise	*Artemisia vulgaris*	35.0	5.0	5
wormwood	*Artemisia absinthium*	0.5-1.2	17.0-42.0	6
tansy (thujone chemotype[7])	*Tanacetum vulgare*	<1.0	68.0-75.0	8

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ceous."[9] This description probably refers to thujone from a natural source, such as cedarleaf oil, and the evaluation of such a material is undoubtedly influenced by the source from which it is derived. When the perfumer thinks of thujone, his odor memory probably summons the impressions of cedarleaf, sage, and armoise oils, which have certain odor characteristics in common. Most perfumers with whom this author has consulted would concur that the thujone or thujonic impression refers broadly to an odor type in which the descriptors "herbaceous", "minty", "camphoraceous", "green", "warm", "fresh" and""spicy" are all featured to some degree. The use of the term "thujone-like" in perfumery must therefore be understood to mean an impression created by an interwoven complex of related notes, rather than a single distinct note.

Synthetic Alternatives to Thujone

Although pure thujone as such is not an article of commerce, the thujonic essential oils listed in Table 1 are well appreciated and widely used in perfumery. Nonetheless, it is often desirable to find a synthetic substitute for a natural material for reasons of aesthetics, price, performance, toxicology or availability. In order to supplement the natural oils, a number of synthetic thujone-like materials have been developed over the years; some of these have become items of commerce. The synthetics may be categorized into three general structural classes: cycloalkanones, oxaspiroundecanes and bicycloheptanes.

Cycloalkanones: Several cyclic ketones with nine or 10 carbons have been shown to have thujonic odor; these molecules are similar to thujone in molecular weight and formula. A recent addition to this class is structure **3**, a relative of Pineone (Givaudan) (**4**) (Figure 2).

The odors of materials **5** and **6** also fit the thujone mold, suggesting that some thujone character is retained even when the carbonyl is displaced to a side chain (Figure 3).[12] Ketone **5**, known as Herbac (IFF) or Artemone (Givaudan), was first patented in 1969, and is still favored by some perfumers for its powerful herbal-woody scent, and its ability to enhance cedarleaf and thujone notes, especially in fresh-lavender compositions.[13]

It is noteworthy that the monocyclic ester **7** (Figure 4), a floral-rosy material of the damascone type, also has a distinctly thujonic-absinthe aspect.[14]

Oxaspiroundecanes: Ketones and esters tend to be unstable in basic and chlorine bleach media. An alternative is provided by spiro-acetals, such as Spirodecane (IFF) or Heridone (Dragoco) (**8**), which are desirable for their herbal thujone character and stability in chlorine bleach (Figure 5).[15] The closely related Thymoxane (IFF) (**9**) has a fresh thyme odor and is reported to combine well with sage and armoise notes (Figure 5).[16] Another material in this structural class is Oxaspirane (IFF) (**10**), which possesse an herbal-minty odor that moves in the direction of cedarleaf and lavandaceoustypes (Figure 5).[17]

Figure 2. Thujonic type (3): reminiscent of the typical odor of cedarleaf and hyssop[10]; structure (4): warm, herbaceous, minty, camphoraceous notes normally found in cedarleaf oil[11]

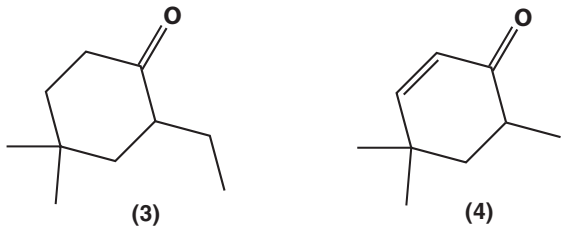


Figure 3. Two odor materials that fit the thujone mold

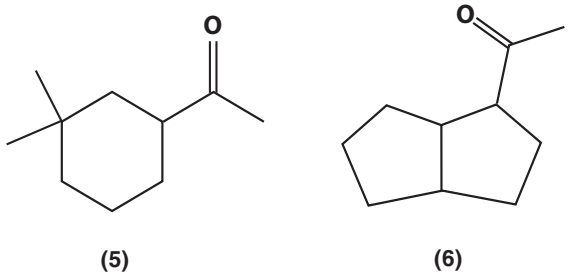


Figure 4. A floral-rosy monocyclic ester of the damascone type that possesses a thujonic-absinthe aspect

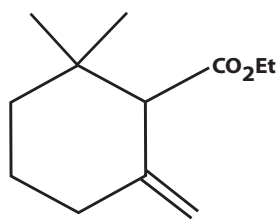
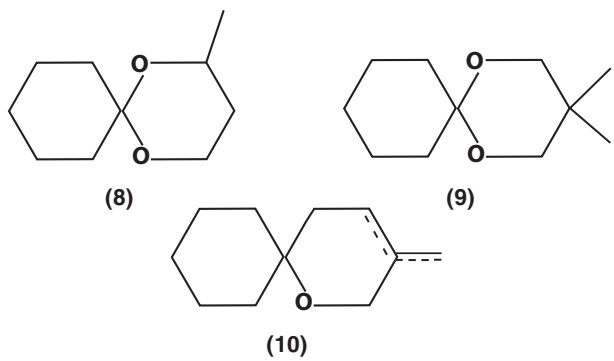


Figure 5. Oxaspiroundecanes Heridone (Dragoco) (8), Thymosane (IFF) (9) and Oxaspirance (IFF) (10)



Two recent patents independently disclosed an oxaspirodecane structure **11** with a minty sage odor type (Figure 6).[18] It is interesting to note the relationship to the

Figure 6. Oxaspirodecanse structure (11), monocyclic Anthoxan (Henkel) (12) and acetal

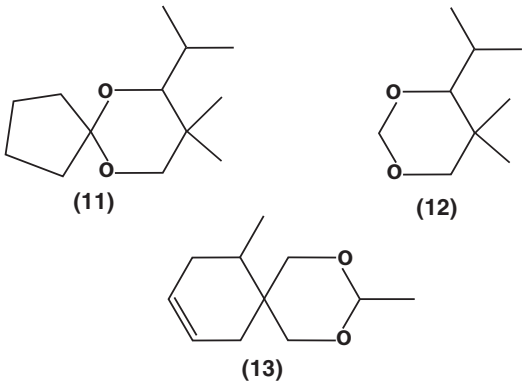
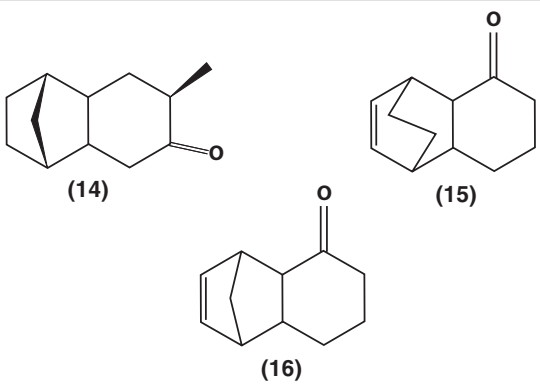


Figure 7. Plicatone (Firmenich) (14) and two related molecules (15 and 16)



monocyclic Anthoxan (Henkel) (**12**), which has an herbal-camphoraceous odor (Figure 6).[19] Acetal **13** also has a green, thujone fragrance, reportedly suitable for rosemary lavandin bases (Figure 6).

Bicycloheptanes and related structures: In order to increase substantivity, chemists frequently search for molecules of higher molecular weight that preserve the basic odor type. A notable example is Plicatone (Firmenich) (**14**), which is increasingly used in personal products, particularly masculine fragrances. Two related molecules from the literature, shown in Figure 7, support the structural context for this material. Plicatone (**14**) possesses "an aromatic odor with a strong thujonic connotation. It has a very natural, slightly camphoraceous and herbaceous fragrance, which is reminiscent of the odor of myrtle and cedarleaf."[21] Molecule **15** possesses an aromatic and fruity note with a green undernote. The material is reminiscent of the odor of myrtle and artemisia, with a thujonic side.[22] Molecule **16** is reminiscent of wormwood or liatris.[23]

It appears that a ketone group is not necessary for thujone character in this series, as evidenced by the epoxide **17**, which has a strong, fresh, herb-like smell reminiscent of cedarleaf oil and clary sage oil, and the aldehyde **18**, described as having a strong, green-aldehydic, wormwood-like note (Figure 8).[24,25] Two examples from the older literature, **19** and **20**, which have sweet, woody, thujone-like odors, indicate that the third ring is not required, either (Figure 9).[26,27]

Figure 8. Epoxide 17 and aldehyde 18

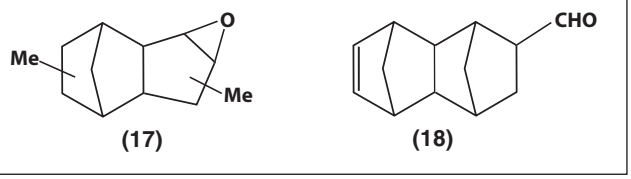


Figure 9. Molecules 19 and 20 possess a sweet, woody, thujone-like odor without the presence of a third ring

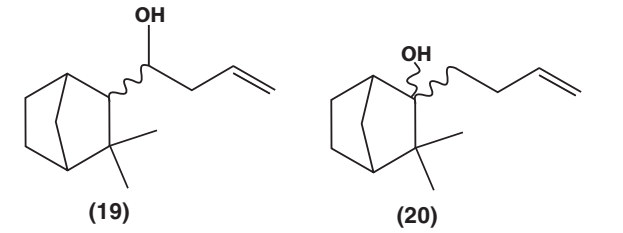
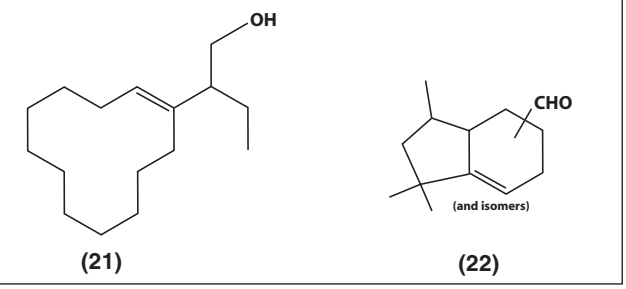


Figure 10. Cyclododecane derivative 21 (woody-amber) and bicyclic aldehyde 22 (woody-camphoraceous)



Miscellaneous structures: Finally, several materials that cannot be easily categorized, yet still fit the thujonic type, are reported in patent literature. Typically, these materials emphasize a particular aspect of the thujone complex; for example, the cyclododecane derivative **21** leans to the woody-amber side, whereas the bicyclic aldehyde **22** highlights the woody-camphoraceous theme.[28,29]

Conclusion

The thujonic note is quite multifaceted, and can be used to add freshness, lift and warmth to a broad range of fragrance types. With the array of natural and synthetic materials now available, the use of this attractive and versatile note can be expected to grow in all fragrance media.

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