

Synthesis and odor characteristics of some analogs of acyclic sesquiterpenoids

By Jozef Gora and Urszula Antczak
Institute of General Food Chemistry, Technical University, Lodz, Poland

Acyclic sesquiterpenoids (nerolidol, farnesol, α - and β -sinesal) reveal very interesting odor qualities as well as good blending and fixative properties. However, a lack of inexpensive natural sources for their production and the complex multistage methods needed for their synthesis from chemical raw materials limit their use in perfumery.^{1,2}

These are the reasons for our study of the syntheses of close analogs of acyclic sesquiterpenoids. Such materials might show similar odor qualities and could become interesting perfume products; the relatively simple methods of synthesis of the analogs result in lower prices.

Following these assumptions we have designed and accomplished, on a large laboratory scale, syntheses of several close analogs of acyclic sesquiterpenoids, some of which reveal very interesting odor qualities.

Syntheses of C₁₄ compounds (carried out as shown in figure 1), having structures of 2,6,10-trimethylundecane and of 2,2,5,9-tetramethyldecane, thus being similar to those of acyclic sesquiterpenoids, with various functional groups and different numbers and positions of double bonds, allowed us to discover some interesting relationships between chemical structure and odor.

Dihydroapofarnesal (3) (2,6,10-trimethyl-5,9-undecadien-1-al) was prepared by the Darzens method from geranylacetone (2) (a mixture of cis and trans isomers in a ratio of 40:60).³

The condensation of geranylacetone (2) and ethyl chloracetate in the presence of metallic sodium in toluene containing a 5% addition of tert-butanol resulted in ethyl ester of 2,6,10-trimethyl-1,2-epoxy-5,9-undecadien-carboxylic-1-acid, the yield being 75-80%.

The ester was hydrolyzed to alkylglycide acid and then decarboxylated to dihydroapofarnesal (3). The decarboxylation process was carried out by a new method developed by us. Alkylglycide acid was proportioned by a stream of superheated steam (190-200°C). This resulted in a yield of the aldehyde as high as 80%.⁴ The

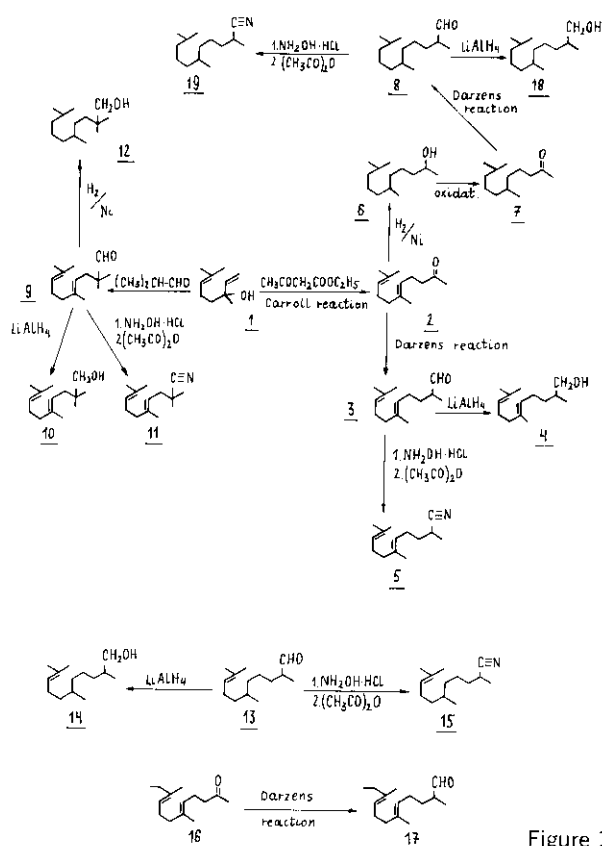


Figure 1

dihydroapofarnesal (3), obtained just like the initial geranylacetone, was a mixture of cis and trans isomers in the ratio of 40:60. The mixture was separated into the individual isomers by gas chromatography.⁴

By the same procedure as in the case of dihydroapofarnesal (3), starting with tetrahydrogeranylacetone (7) we prepared 2,6,10-trimethylundecan-1-al (8) and 2,6,10-trimethyl-5,9-dodecadien-1-al (17) from ethyl-

⁴Varian chromatograph, a 2 m column, 10% OV-101 celite filling, temperature 165 C, V_{N₂} = 28 cm³ min.

Acyclic sesquiterpenoids

geranylacetone (16) by the Darzens method. On the other hand, 2,2,5,9-tetramethyl-4,8-decadien-1-al (9) was prepared by the condensation of linalool (1) and isobutyl aldehyde in the presence of p-toluenesulphonic acid in a toluene system according to a modified method described by Voytkievich and coworkers.^{5,6} Aldehyde (9), so prepared, composed a mixture of cis and trans isomers in a ratio of 44:56.

It is known that a functional group has a great effect on the odor of a compound. In order to qualify the effect, starting with the above mentioned aldehydes (3 and 9) and adoxal (13)^b we prepared the corresponding alcohols and nitriles and evaluated their odor properties.

The alcohols. Dihydroapofarnesol (4), 2,6,10-trimethyl-9-undecen-1-ol (14) and 2,2,5,9-tetramethyl-4,8-decadien-1-ol (10) were prepared by the reduction of corresponding aldehydes with lithium aluminium hydride under standard conditions to a yield of 95%; 2,2,5,9-tetramethyldecan-1-ol (12) was prepared by the hydrogenation of aldehyde (9) in the presence of

nickel catalyst NiRCH 55/5,^c the yield being 95%.

The nitriles. 6,10-Dimethyl-2-cyano-5,9-undecadien (5), 6,10-dimethyl-2-cyano-9-undecen (15), and 2,5,9-trimethyl-2-cyano-4,8-decadien (11) were prepared from corresponding aldehydes via the aldoxime stage by the modified method of Pearson and Burton,⁷ using for the dehydration acetic anhydride with an addition of sodium acetate.⁸ The yield of nitriles was 70-75%.

The degree of purity of the compounds prepared was measured by TLC and GLC; their structures were determined by IR, NMR, and MS techniques.

The odor properties of the obtained products are summarized in Table I.

Considering the properties given in Table I, one may state that the odors of the compounds are different depending on their carbon skeleton, the number and position of double bonds, and the type of functional group.

Several C₁₄ derivatives of 2,6,10-trimethylundecane reveal different odor properties than those of 2,2,5,9-tetramethyldecane; particularly striking is the decline of the strong ozonic (ozone-like) note characteristic for aldehyde (3) and partly for nitrile (5) compared with aldehyde (9) and nitrile (11), which have milder, fresh floral-fruity odors.

The odor differences are less distinct between the corresponding alcohols (4 and 10). The former has a floral-woody lime-like odor, and its equivalent a lily of the valley-like floral odor with a rose note. The extension of the aldehyde (3) by a -CH₂ group (aldehyde 17) had no significant effect on the odor, weakening only the characteristic ozonic note.

In accordance with expectations the geometric isomers of aldehyde (3) reveal different odor properties. The characteristic intensive floral odor with an ozonic note is revealed only by trans-dihydroapofarnesol.⁹

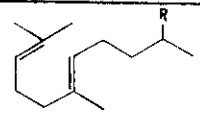
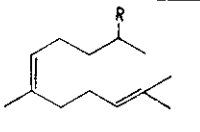
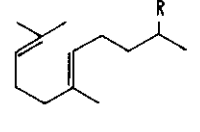
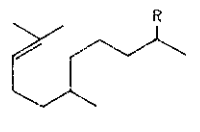
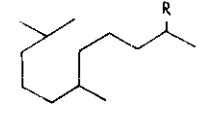
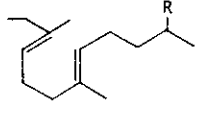
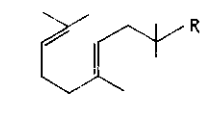
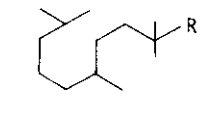
The number and position of double bonds is an important part of the odor properties of the examined compounds. Aldehyde (13), alcohol (14), and nitrile (15) each have one olefin bond less than aldehyde (3), alcohol (4), and nitrile (5), respectively. The first group of compounds (one olefin bond in a molecule) has odor properties of different floral notes than the second group of compounds, containing two olefin bonds in a molecule.

A complete hydrogenation of olefin bonds in the compounds under investigation has a disadvantageous effect on their odor properties. An

^bGivaudan

^cHoechst

Table I. Odor characteristics of prepared analogs of acyclic sesquiterpenoids

No	R \longrightarrow	- CHO	- CH ₂ OH	- C \equiv N
1	2	3	4	5
1	 cis + trans	3 tenacious, sweet, floral odor, nasturtium-like with ozonic note less floral than farnesal C ₁₄ H ₂₄ O, M.w. 208,35	4 floral-woody odor flower of the lime-like, reminiscent of certain notes from Muguet, similar to the farnesol C ₁₄ H ₂₆ O, M.w. 210,36	5 green-floral odor rose and nasturtium like with weak ozonic note C ₁₄ H ₂₃ N, M.w. 205,35
2	 cis	3 cis fruity-floral odor, very sweet, qualmish, no similar to the farnesal C ₁₄ H ₂₄ O, M.w. 208,35	-	-
3	 trans	3 trans intensive, floral odor nasturtium-like with ozonic note no similar to the farnesal C ₁₄ H ₂₄ O, M.w. 208,35	-	-
4	 cis	13 agreeably, sweet, rosy-floral with ozonic note C ₁₄ H ₂₆ O M.w. 210,36	14 intensive, sweet, floral-balsamic reminiscent of certain notes of farnesol C ₁₄ H ₂₈ O M.w. 212,38	15 agreeably floral odor of lily of the valley C ₁₄ H ₂₅ N M.w. 207,34
5	 cis	8 weak, floral light fatty, no similar to the tetrahydrofarnesal C ₁₄ H ₂₈ O M.w. 212,38	18 weak, floral odor of lily of the valley, light fatty C ₁₄ H ₃₀ O M.w. 214,37	19 weak, green-floral C ₁₄ H ₂₇ N M.w. 209,36
6	 trans	17 very tenacious, fresh green odor nasturtium like with weak ozonic note, no similar to the farnesal C ₁₅ H ₂₆ O M.w. 222,37	-	-
7	 cis + trans	9 intensive, agreeably green-floral C ₁₄ H ₂₄ O M.w. 208,35	10 intensive, fresh agreeably, floral odor rose abd of lily of valley C ₁₄ H ₂₆ O M.w. 210,36	11 sweet- fruity-floral odor peach and melon-like C ₁₄ H ₂₃ N M.w. 205,35
8	 cis	-	12 weak odor, camphor-like C ₁₄ H ₃₀ O M.w. 214,37	-

Acyclic sesquiterpenoids

example of this is aldehyde (8) which has a weak floral-fatty odor, unlike aldehydes (3) and (13) revealing fresh floral odors.

Similarly, the saturated alcohol (12) has an insignificant, weak camphor-like odor with a mildewy note, contrasting with the agreeable floral odor of the unsaturated alcohol (10).

Different functional groups have distinct effects on the odor of the compounds under investigation. The reduction of an aldehyde group to hydroxymethylene ($-CHO \rightarrow -CH_2OH$) makes the odor much weaker, causes a decline of the characteristic fresh green (or ozone-like) note and the appearance of a milder, sweet floral odor. The modification of the aldehyde group to the nitrile ($-CHO \rightarrow -C \equiv N$) also changes the nature of the odor, making it more fruity, which is particularly seen when comparing the odors of aldehyde (9) and nitrile (11).

In summary, it could be stated that the crucial factors affecting the odor of the compounds under investigation are the carbon chain structures and type of functional groups. These observations confirm Beets' thesis that "the profile of a molecule with an easily accessible functional group is responsible for the odor type. The nature of the functional group is relatively unimportant as long as it guarantees a sufficient affinity."⁹ Moreover, it is necessary to emphasize that the analogs of the sesquiterpenoid alcohols C_{14} revealed sesquiterpenoid alcohol-famesol-like odor but on the contrary the odor of corresponding aldehydes is completely different. The characteristic feature of the C_{14} aldehydes is the very intensive, sharp, fresh green odor with a specific ozone-like note, which is not demonstrated by the sesquiterpenoid aldehyde.

Some of these compounds have very interesting odor properties. They could find practical use in the perfumery industry.

References

1. H. R. Ansari and A. J. Curtis, *J. Soc. Cosm. Chem.* **25**, 203 (1974)
2. P. Z. Bedoukian, *Perfumery and Flavoring Synthetics*, New York (1967)
3. J. Kulesza and J. Gora, *Riechstoffe, Aromen, Körperpflegemittel* **19**, 156 (1969)
4. J. Kulesza, J. Gora, U. Antczak, and W. Brud, *Polish Pat.* 85 803 (1977)
5. S. A. Voytkievich, J. J. Gushtchina, and T. A. Rudolff, *Maslozirowaya Promyshlenost* **1974** (11) 28
6. S. A. Voytkievich, J. J. Gushtchina, and T. A. Rudolff, *Pat. SU* 355147 (1972)
7. D. E. Pearson and J. D. Burton, *J. Org. Chem.* **19**, 960 (1954)
8. J. Gora and B. Stefanska, *TSPK Pollena* **20** (2), 58 (1976)
9. M. G. Beets, *J. Amer. Perfum.* **76**, (6), 54 (1961)
10. J. Gora and U. Antczak, *Synthesis and olfactive properties of some derivatives of 2,6-dimethylundecane*, VI International Congress of Essential Oils, San Francisco, USA 1974
11. S. Arctander, *Perfume and Flavor Chemicals*, New York 1969