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SYNTHESIS OF TAGETENONES AND THEIR OCCURRENCE IN OIL OF *TAGETES MINUTA*

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Abstract—*Cis*- and *trans*-ocimenones were identified as constituents of oil of *Tagetes minuta* L and their structures verified by synthesis.

INTRODUCTION

DIHYDROTAGETONE (I), *cis*-tagetone (II) and *trans*-tagetone (III) have been identified as carbonyl components in the oil of *Tagetes glandulifera* Shrank.[1,2] The stereochemistry of tagetone was established through synthesis of both the *cis*- and *trans*-tagetone[2,3] and by analysis of the NMR spectra of the stereoisomers.[3,4] Boehm, Thaller and Whiting[2] also noted that the oil of *T. minuta* L.* showed the presence of both components (II) and (III), but that these two substances were not the major products. Two peaks, having about twice the GLC retention time of ketones (II) and (III) and also showing similar degree of separation and relative size, were also present. We have identified these latter products as *cis*- and *trans*-ocimenones (IV) and (V).[5]

(I) (II) R = iBu (III) R = iBu (IV) R = Me_2C CH— (V) R = Me_2C.CH—

$$Me_2C\ CH\ COCl\ CH_2{\cdot}CMe\ CH\ CH_2 \xrightarrow[\text{acid}]{\text{Lewis}} \begin{array}{c} Me_2C\ CH\ CO\ CH_2\ CMe\ CH\ CH_2Cl\ \ (VI) \\ \downarrow \\ (IV) + (V) \end{array}$$

RESULTS

Cis-β-Ocimene, ketone (I) and the *cis*-, *trans*-mixture of (II) and (III) were readily isolated by preparative GLC and identified by NMR and m.s. methods. Due to the instability of the *cis*- and *trans*-ketones (IV) and (V) their mixture was best isolated by reversed phase partition chromatography. The NMR spectrum of the mixture showed close resemblance to the NMR spectra of ketones containing the 2-methylprop-1-enyl[6] and 2-methyl-

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* For further information on the identity of *T. glandulifera* Shrank and *T. minuta* L see Ref. 2. According to the Botanical Research Institute (Pretoria) and the Royal Botanic Gardens (Kew), these two names are synonyms.

† In part

[1] T. G H JONES and F. B SMITH, *J Chem. Soc.* **127**, 2530 (1925), **129**, 2767 (1926); and T. G. H. JONES, *Proc. R. Soc Queensland* **45**, 45 (1934).

[2] E E BOEHM, V. THALLER and M C WHITING, *J. Chem Soc.* 2535 (1963).

[3] P. TEISSEIRE and B CORBIER, presented at the IVth International Congress on Essential Oils, Tbilissi, September 1968.

[4] E O BISHOP and J. I. MUSHER, *Mol. Phys.* **6**, 621 (1963)

[5] The name tagetenones has been proposed for the $C_{10}H_{14}O$ ketones of the dehydrotagetone series (ocimenone, myrcenone and others) isolated from *Lippia asperfolia* cf. Y. R. NAVES, *Helv. chim Acta* **31**, 29 (1948).

[6] e g. NMR Spectra Catalog, Varian Associates, Palo Alto, California, 1962 and 1963, Spectrum No. 114

buta-1,3-dienyl groups.[3, 4] Similarly the mass spectrum of the mixture of ketones showed the molecular ion at *m/e* 150 and the four ions at *m/e* 55, 67, 83, and 95, which are best explained by α-splitting.

The ketones (IV) and (V) could be synthesized by condensation of senecioyl chloride with isoprene in the presence of a variety of Lewis acids. Best results were obtained with antimony trichloride. The NMR spectrum and GLC analysis of the synthesized ocimenones were consistent with the fact that a 1:9 mixture of isomers (IV) and (V) was obtained. Evidence for the partial formation of the unstable intermediate (VI) (GLC and m.s.) was obtained.

It should also be mentioned that oil from *T. minuta* at different stages of maturity, showed differences in the relative concentrations of the ketones (I)–(V). The oil from young plants (before the flowering stage) gave the ocimenones (IV) and (V) in 20% yield (GLC and reversed phase partition chromatography). However, GLC analysis (column B; see Experimental) of the oil obtained from plants at the stage of seed shedding gave the following: *cis*-β-ocimene (41%), dihydrotagetone (13·5%), tagetones (9%) and ocimenones (26·5%) together with minor unidentified components. These results are at variance with previously published analysis for the oil of *T. minuta.*[7]

EXPERIMENTAL

Analytical GLC was carried out with a PYE 105-Model 15 instrument on either column (A) (8 ft × $\frac{3}{16}$ in. glass column packed with 10% FFAP on 60–80 mesh Chromosorb W AW-DMCS) or column (B) (15 ft × $\frac{3}{16}$ in. glass column packed with 10% PEGS on 60–80 mesh Chromosorb W AW-DMCS). Preparative GLC was carried out on a 30 ft × $\frac{3}{8}$ in. glass column packed with 15% FFAP on 60–80 mesh Chromosorb A AW-DMCS

Condensation of Isoprene and Senecioylchloride

Isoprene (62 ml) and senecioyl chloride (16 6 g) were mixed with $SbCl_3$ (3 g) and stirred for 9 hr at 20°. Petroleum (75 ml) was added to the reaction mixture and the solution decanted from the dark insoluble residue (10 g). This process was repeated a further three times The combined extracts were washed with water until no further precipitate was formed, and dried ($MgSO_4$). Evaporation of the solvent at low temperature yielded an orange coloured liquid (25·6 g) which was further purified by a 36-tube counter-current distribution (phase capacity 50 ml) in petroleum–90% MeOH (1·1) at 25°. Tubes 7–24 (max. concentration at tube 15) contained the products (IV) and (V) The contents of the tubes were diluted with water and the petroleum layer separated, dried and the solvent evaporated to yield crude ketones (IV) and (V) (11·2 g), which was further purified by reversed phase partition chromatography on a column (120 cm, ϕ 2 cm) packed with Chromosorb P AW-DMCS (150 g) impregnated with petroleum (b p. 60–80°, 135 ml) in aq. MeOH (60%, v/v). The crude ketones (5 g) in petroleum (b p. 60–80°; 9 ml) and more Chromosorb (10 g) were thoroughly mixed and aq. MeOH (60%, v/v) added. After degassing, the slurry was poured on top of the column Elution was effected by gradually increasing the MeOH concentration to 90%. The fractions containing the ketones (IV) and (V) were combined, diluted with water and extracted with petroleum. The petroleum extracts were washed, dried, the petroleum evaporated *in vacuo* and the residue distilled to yield the ketones (IV) and (V), b p. 45° (air bath)/0 2 mm Hg; λ_{max} 288 nm (ϵ 27,300) in ether; ν_{max} (film) 1668s, 1620s, 1590s, 1452s, 1390m, 1365w, 1223m, 1115s, 1042s, 992w, 920m, 882m, 759m cm^{-1}; *m/e* 150(77), 135(100), 107(58), 95(43), 91(55), 83(51), 67(58), 55(60), 41(83), 39(80), τ[8] 8 12 ($3H_a$; $J_{ad} \simeq 1$), 7 83 ($3H_b$; $J_{bd} \simeq 1$), 7·76 ($3H_g$; $J_{eg} \simeq 1$), 4 66 ($1H_j$; J_{hj} 10), 4 44 ($1H_i$; J_{hi} 17), *ca* 3 94 (H_d and H_e), 3 62 (H_h) (Found: C, 79 9, H, 9·2. $C_{10}H_{14}O$ required: C, 80·0; H, 9·4%)

GLC (column A) showed the product to be 90% *trans*- and 10% *cis*-ocimenone, in agreement with the NMR analysis

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[7] K. L Handa, M. M. Chopra and M C. Nigam, *Perfumery. Essent. Oil Record* **54**, 372 (1963).

[8] For convenience the numbering used, corresponds to that shown in structure (I) NMR spectra were determined in deuterochloroform

Identification of the Components in the Oil of Tagetes minuta *L.*

The oil was isolated by steam distillation, dried ($MgSO_4$) and filtered. The following products were isolated by preparative GLC:

(i) *Cis*-β-Ocimene M^+ 136. The NMR absorptions were identical to previously published values.[9]

(ii) Dihydrotagetone τ^{3}9 10($3H_a + 3H_b$; $J_{a\text{ or }b,c}$ 6), 9 00 ($3H_g$, J_{fg} 6), 8·20–7 00 (6 H), 5·13 ($1H_j$, J_{hj} 9 5), 5·07 ($1H_i$, J_{hi} 17, J_{ij} 1 9, J_{fi} *ca.* 1), 4 27 ($1H_h$, J_{fh} 6); *m/e* 154(5), 97(23), 85(100), 69(36), 57(64), 55(27), 43(13) and 41(27).

(iii) *Cis*- and *trans*-Tagetone. The NMR absorptions were identical to published values.[3,4] *m/e* 152(10), 151(4), 137(8), 110(6), 109(20), 95(100), 67(62), 65(14), 44(41), and 41(60)

Cis- *and* trans-*Ocimenones*

Due to their instability, these compounds could not be isolated by preparative GLC, but were obtained in 20% yield (*cis–trans* ratio 3 2) from the oil of young plants by reversed phase partition chromatography as described above.

Based on the known NMR spectrum of *trans*-ocimenone, it was possible to determine the τ-values of the *cis*-isomer from the NMR spectrum of the mixture. These were as follows· τ8 03 (H_g, J_{eg} 1·2), 2 23 (H_h, J_{hi} 17·5, J_{hj} 10 5). (Found· C, 79 4; H, 9 3%)

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[9] G. Ohloff, J Seibl and E. Sz. Kovats, *Ann.* **675**, 83 (1964); C. W. L. Bevan, D. E. U. Ekong and J. I. Okogun, *J. Chem. Soc.* 1063 (1968)