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A NEW C20 α,β-UNSATURATED ALDEHYDE (3,7,13-TRIMETHYL-10-ISOPROPYL-2,6,11,13-TETRADECATETRAEN-1-AL) (I) FROM TOBACCO

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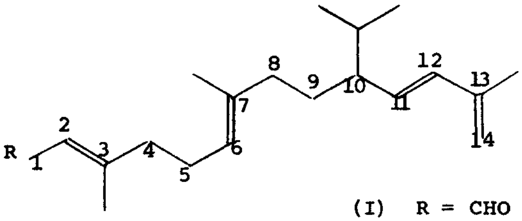
Recently, two precursors of solanone (VI) were isolated from cured tobacco (2) and it was suggested that these anomalous terpenoid compounds were derived by an oxidative cleavage of a duvatriene diol. We wish to report the occurrence in tobacco flowers of a new C20 α,β-unsaturated aldehyde which may also be derived from a similar macrocyclic precursor.

The compound, for which we propose the structure (I), was isolated from freshly picked tobacco flowers by cold (0°C) benzene extraction followed by chromatography on silica gel and alumina. The purified compound (3) is unstable, decomposing slowly even under nitrogen at 0°C.

Compound (I) $C_{20}H_{32}O$ (4) showed the following infrared absorption bands (γ_{max} CCl_4); 2750 and 1678 cm^{-1} (α,β-unsaturated aldehyde), 3064, 1774, and 884 cm^{-1} (disubstituted terminal methylene), 967 cm^{-1} (*trans*-disubstituted double bond) 1632 and 1608 cm^{-1} (conjugated double bonds). The presence of a second chromophore, apart from the α,β-unsaturated aldehyde, was shown by the intensity of the ultraviolet maximum (λ_{max}= 233 mμ, ε_o= 3.66 x 10^4) (5). The N.M.R. signal (6) for the aldehydic proton at δ 9.96 was a doublet (J=7.5 c/s) indicating the presence of an α-proton. The olefin region of the spectrum contained absorptions which integrated for six protons; δ 6.08 (doublet, J=15.8 c/s, 1H), δ 5.85 (doublet, J=7.5 c/s, 1H), δ 5.38 (dbl. doublets, J=15.8 and 8.2 c/s, 1H), δ 5.08 (multiplet, 1H) and δ 4.86 (singlet, 2H). Two superimposed doublets centred at δ 0.85 (6H) indicated the presence of an isopropyl group with non-equivalent methyls. Only three other methyl signals were observed: δ 1.60 (3H), δ 1.82 (3H), both showing weak allylic splitting ($J < 1.0$ c/s) and δ 2.17 (singlet, 3H).

The signals centred at δ 6.08 and δ5.38 are due to the two protons of a <u>trans</u>-disubstituted double bond. The occurrence of the δ 6.08 proton as a doublet (J=15.8 c/s) and the δ 5.38 proton as a doublet of doublets (J=15.8 c/s and 8.2 c/s) show that the double bond is flanked by a fully substituted carbon and a methine carbon. The deshielding of these protons place the double bond in a conjugated diene system.

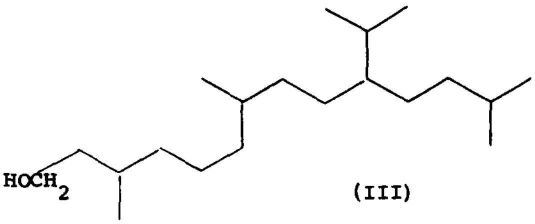
Comparison of the N.M.R. of (I) with that of the corresponding allylic alcohol (II), produced by sodium borohydride reduction, indicates the nature of the conjugated aldehyde substituents. The replacement of the one proton doublet at



(I) R = CHO
(II) R = CH_2OH

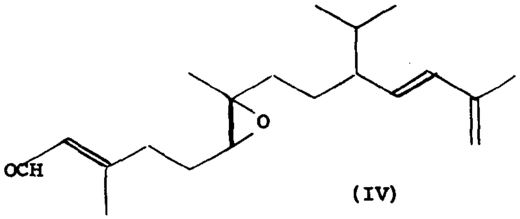
δ 5.85 (J=7.5 c/s) in (I) by a triplet at δ 5.48 (J=7.5 c/s) in (II) shows that the α-proton giving rise to this signal is split by only the aldehydic proton, thus indicating two β-alkyl groups in good agreement with a λ_{max} of 233 mμ. The shift of a methyl signal from δ 2.17 in (I) to δ 1.68 (triplet, allylic coupling, J=1.0 c/s, 3H) in (II) is due to the presence of a β-methyl substituent. The ultraviolet absorption in (II) (λ_{max}= 233 mμ, ϵ_0 =1.66 x 10^4) must be due to the conjugated diene and confirms its presence in (I).

Hydrogenation (PtO_2 in 95% EtOH) of (I) gave a saturated alcohol (III) (γ_{max} 3285 and 1085 cm^{-1}), mass spectrum molecular weight = 298 (m/e=297, loss of H), indicating a molecular formula of $C_{20}H_{42}O$. Compound (I) is therefore acyclic and



(III)

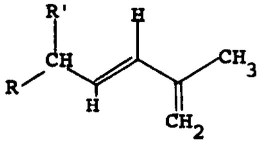
contains five double bond equivalents. This shows that (I) contains, in addition to the α,β-unsaturated aldehyde and conjugated diene, an isolated double bond.



(IV)

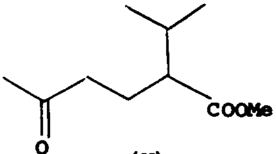
Treatment of (I) with a 10% molar excess of perbenzoic acid yielded a monoepoxide (IV). Preferential epoxidation of the isolated double bond had evidently occurred as the U.V. absorption (λ_{max}=233 mμ, ϵ_0=3.89 x 10^4) revealed that both chromophores were intact. The only obvious changes in the N.M.R. of (IV) compared with that of (I) are the disappearance of one olefinic proton signal (δ 5.08, multiplet) and the shift of a methyl signal from δ 1.60 to δ 1.24. The isolated double bond is therefore trisubstituted with one of its substituents a methyl group. The I.R. spectrum (IV) confirms the presence of the conjugated aldehyde (1682 cm^{-1}) and both the <u>trans</u>-disubstituted double bond (971 cm^{-1}) and the terminal disubstituted methylene (887 cm^{-1}) showing that these two bonds are in conjugation.

The chemical shift of the remaining unassigned methyl signal in (I) (δ 1.82) places the methyl group on an olefinic carbon. The carbon atom adjacent to the conjugated terminal methylene is the only such carbon whose substituents have not already been assigned. Placement of the remaining methyl group here allows the conjugated diene system to be drawn thus:-



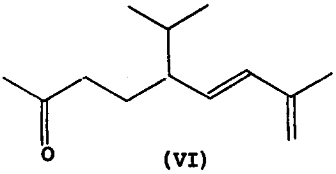
Oxidation of (I) with permanganate-metaperiodate (7) gave only one major acid, isolated and purified as its methyl ester and identified as methyl-5-keto-2-isopropyl hexanoate (V) by comparison (identical I.R. and N.M.R., G.L.C. retention time on two columns, and M.P., mixed M.P. and I.R. spectra of the semicarbazones) with an authentic sample prepared by ozonolysis of piperitone followed by an oxidative work up and methylation (8).

The isolation of this compound is compatible with the structure (I) assigned to the unsaturated aldehyde.



(V)

The N.M.R. spectrum of solanone (VI) (9) provides a useful model for the conjugated diene system of (I). Apart from the signals due to the trisubstituted double bond protons in (I), i.e. on C2 and C6, the spectra from δ 4.7 to δ 6.3 are superimposable.

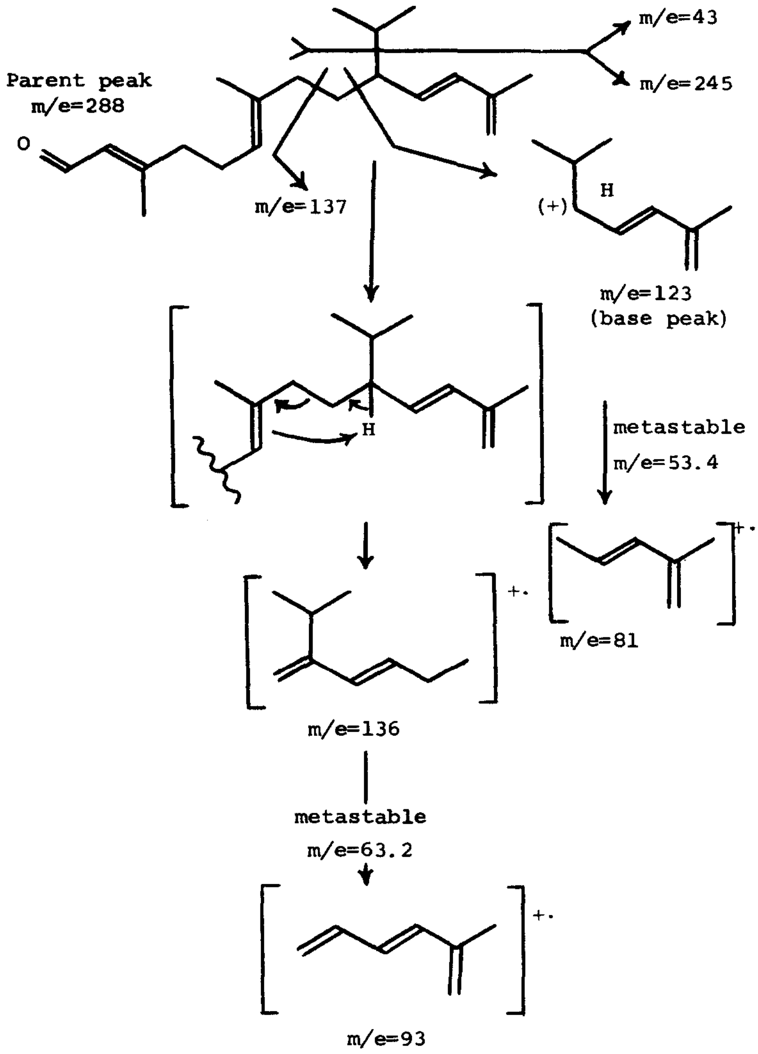


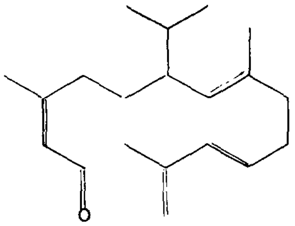
(VI)

This thus excludes an alternative structure (VII) whose _trans_-disubstituted double bond is adjacent to a methylene which would have split the olefinic δ 5.38 proton into a doublet of triplets whereas its occurrence as a doublet of doublets has been explained above as due to the disubstituted double bond being flanked by a methine group as in (I).

The major peaks in the mass spectrum of (I) can readily be accommodated by the structure shown (Fig. 1).

FIG. I. Major fragments from mass spectrum of compound (I)





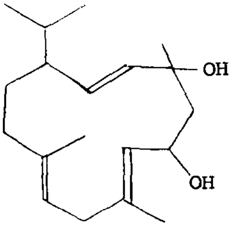
(VII)

The Stereochemistry of (I) and the Duvatriene diols

The geometry at C2 (in structure I) is uncertain, but the C6 double bond is assigned the trans configuration, i.e. as shown, by applying Bates' method (10) to the N.M.R. data. The C7 methyl group appears at δ 1.60 in (I) (11); Bates' values for trans (methyl substituted) double bonds of δ 1.59 (c.f. δ 1.66 for cis) may be applied particularly where such a group is isolated by two methylenes on each side.

We have converted β-4,8,13-duvatriene-1,3-diol (VIII) into the aldehyde (I) by the action of p-toluenesulphonic acid, thus confirming the structure of the aldehyde. This interconversion proves that the double bond at C7 in the duvatriene diol is trans and not cis as was previously suggested (12).

The all trans stereochemistry of the double bond in this macrocycle is compatible with the proposed biosynthesis from geranyl geraniol.



(VIII)

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