

Emmolactone, a Bisnor-triterpene

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In continuation of earlier studies¹ of the extractives of *Emmenospermum alphonoides* F. Muell., a neutral compound {m.p. 255–256°, $[\alpha]_D + 123^\circ$ (chloroform)} was isolated from the bark. This compound, for which we propose the name emmolactone, analysed for $C_{28}H_{38}O_3$ with a molecular weight of 422 (mass spectrum). The three oxygen atoms are present as a hydroxyl and a γ -lactone [ν_{\max} 3280 and 1754 cm^{-1} (Nujol)]. Emmolactone gave an acetate, m.p. 247–248°, $[\alpha]_D + 34^\circ$ (chloroform). The hydroxyl group is secondary, as a lone proton on the same carbon atom could be identified by a downfield shift of a multiplet from δ (CHOH) 4.75 to δ (CHOAc) 5.65. The absence of a signal in the δ 4 region indicates that the lactone is tertiary.

In the n.m.r. spectrum of emmolactone a multiplet (1H) at about δ 5.90 indicated a trisubstituted double bond and doublets at δ 5.92 and δ 5.47 ($J_{AB} = 6.0$ c./sec.) showed the presence of a *cis*-disubstituted double bond as an AB system. Multiplets at δ 4.78 and δ 4.52 (2H) and a singlet at δ 1.76 (3H) indicated an isopropenyl group, and in agreement with this emmolactone had strong absorption at 1630 and 885 cm^{-1} (Nujol). In addition, four tertiary methyl groups were evident.

Hydrogenation of emmolactone [for which partial structure (I) is proposed] using a 5% rhodium/alumina catalyst caused reduction of the *cis*-disubstituted double bond and the isopropenyl group and, in agreement with the proposed allylic nature of the hydroxyl group, also effected hydrogenolysis to give the lactone $C_{28}H_{42}O_2$ (II) (ν_{\max} 1758 cm^{-1}) which still possessed a trisubstituted double bond [multiplet at δ 5.51 (1H)]. When a 10% palladium/carbon catalyst was used, hydrogenolysis of both the hydroxyl and lactone groups occurred, presumably by allylic hydrogenolysis of the intermediate (II), to give a carboxylic acid

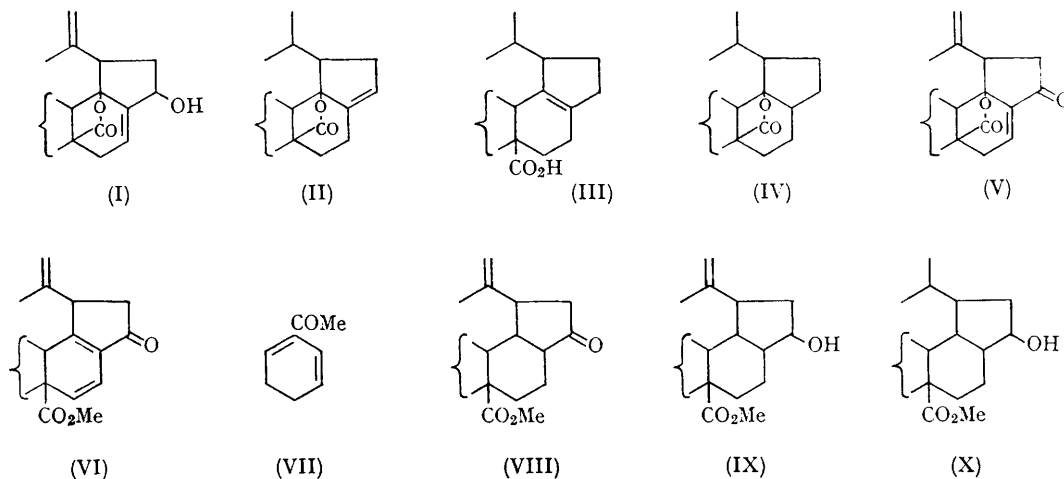
$C_{28}H_{44}O_2$ (characterised as its methyl ester) which has been assigned the partial structure (III). The ester possessed no olefinic protons but gave a colour with tetranitromethane indicating the presence of a tetrasubstituted double bond; cyclisation with hydrogen chloride in chloroform gave the saturated lactone (no colour with tetranitromethane) $C_{28}H_{44}O_2$ (IV) [ν_{\max} 1758 cm^{-1} (Nujol)], molecular weight 412 (mass spectrum) and establishes the pentacarbocyclic nature of emmolactone. In (II), (III), and (IV) the isopropenyl methyl signal was replaced by a *gem*-dimethyl doublet.

Oxidation of emmolactone with Jones' reagent gave the conjugated enone $C_{28}H_{36}O_3$ (V) (λ_{\max} 245 $m\mu$; ϵ , 7,000). A medium-intensity band at 1410 cm^{-1} indicated a methylene adjacent to a carbonyl in a five-membered ring; the trisubstituted double bond now gave a triplet ($J = 3.0$ c./sec.) centred at δ 6.79 (1H). Chromatography of (V) on alumina caused rearrangement to a conjugated dienone acid, which was characterised as its more stable methyl ester $C_{28}H_{38}O_3$ (VI), λ_{\max} 293 $m\mu$; ϵ , 3170 [*cf.* the ultraviolet absorption of (VII) which has a similar cross-conjugated dienone chromophore and has λ_{\max} 286 $m\mu$; ϵ , 2400].² In agreement with the proposed structure, the n.m.r. spectrum of (VI) indicates the introduction of the *cis*-disubstituted double bond (with no protons on the adjacent carbon atoms) by the appearance of doublets at δ 6.30 and δ 5.97 ($J_{AB} = 9.5$ c./sec.).

Hydrogenation of (VI) using palladium catalyst gave a mixture of compounds, the major product being the ketone (VIII), $C_{28}H_{44}O_3$ (λ_{\max} 293–295 $m\mu$; ϵ , 34), in which all the olefinic bonds had been reduced apart from that in the isopropenyl group; presumably the hydrogenation of the more substituted double bonds has been greatly facilitated

by their conjugation. The carbonyl absorptions of (VIII) (in chloroform) were at 1730 and 1715 cm^{-1} . Reduction of (VIII) with sodium borohydride gave the corresponding alcohol (IX) with absorption at 1710 cm^{-1} (chloroform) indicating once again the presence of the cyclopentanone ring. Further confirmation was obtained by hydrogenation (Adams' catalyst/acetic acid) of (VIII) to the fully saturated alcohol (X), $\text{C}_{29}\text{H}_{48}\text{O}_3$ (ν_{max} 3605 and 1709 cm^{-1}) followed by oxidation

cyclic system, particularly in view of the co-occurrence of betulic acid, ceanothic acid, and ceanothenic acid in *E. alphonoides* is that involving the fused system of two cyclopentane and three cyclohexane rings as in ceanothic and ceanothenic acids. The presence of an isolated double bond as an AB system similar to that in ring-A of ceanothenic acid, together with the above biogenetic considerations, leads us to propose structure (XII) for emmolactone, and this has been



of (X) with chromic acid to the corresponding ketone $\text{C}_{29}\text{H}_{46}\text{O}_3$ which had absorption at 1730 and 1712 cm^{-1} . The moiety (XI), containing a fused cyclopentane-cyclohexane system, satisfactorily accounts for the above observations concerning the environment and interactions of the hydroxyl group, the trisubstituted double bond, and the γ -lactone.

Conversion of emmolactone into compounds (V), (VI), (VIII), and (IX) caused considerable variations in the olefinic proton signals of the isopropenyl group, suggesting its close proximity to the respective reaction sites as in (I); this position is analogous to that occupied by the isopropenyl group in the lupeol class of triterpenes.

The presence of an isopropenyl group, a lactone group, and four tertiary methyl groups, leaves a maximum of twenty carbon atoms available for the pentacyclic system. The most probable

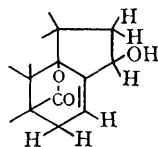
confirmed by relating emmolactone and ceanothenic acid.

Dimethyl dihydroceanothenate (XIII) was oxidized with mercuric acetate (*cf.* ref. 3) to give dimethyl dehydrodihydroceanothenate⁴ for which we now propose structure (XIV) in which the introduced double bond is tetrasubstituted. In agreement with this, the n.m.r. spectrum of (XIV) shows olefinic proton signals for only the two olefinic protons of the isopropenyl group.* In our hands, when (XIV) was subjected to lithium iodide halogenolysis, decarboxylation of the $\beta\gamma$ -unsaturated carboxyl group at C-17 occurred also, leading directly to the monocarboxylic acid (III) as the major product of the reactions; the identity of this acid was confirmed by preparation of its methyl ester and of the lactone (IV), each of which was identical with the corresponding compound prepared from emmolactone. This establishes the

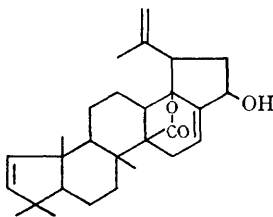
* This point has already been noted in the case of the mercuric acetate oxidation product of lupeol (ref. 5, p. 1873). We have also observed that mercuric acetate oxidation of dimethyl ceanothate introduces a tetrasubstituted double bond, and methyl betulate behaves similarly.⁶ This throws some doubt on the position allotted to the second carbonyl group (at C-14) in ceanothenic acid,⁴ but the structure of ceanothenic acid has since been conclusively shown to be that proposed by de Mayo and Starratt⁴ by converting melaleucic acid into tetrahydroceanothenic acid.⁷

structure of emmolactone as (XII), and delineates all stereochemical features with the exception of

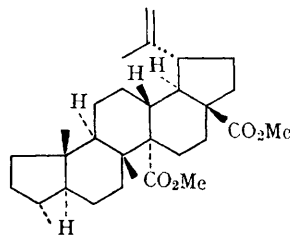
the configuration of the isopropenyl group and of the hydroxyl group. The possibility that the



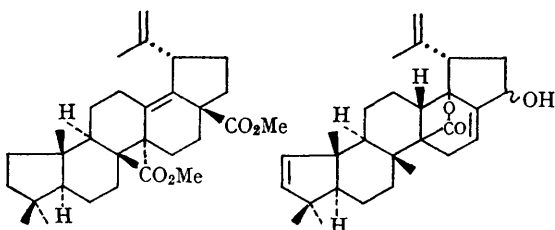
(XI)



(XII)



(XIII)



(XIV)

(XV)

isopropenyl group has been inverted during the mercuric acetate oxidation cannot be excluded, but on biogenetic grounds it is considered most likely that emmolactone possesses the normal (α -) configuration of the isopropenyl group of the lupane triterpenes and that emmolactone can be represented by structure (XV).

Infrared spectra were determined in carbon tetrachloride solution except where otherwise stated; n.m.r. spectra were determined in deuteriochloroform.

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³ J. M. Allison, W. Lawrie, J. McLean, and J. M. Beaton, *J. Chem. Soc.*, 1961, 5224.

⁴ P. de Mayo and A. N. Starratt, *Canad. J. Chem.*, 1962, **40**, 1632.

⁵ H. Budzikiewicz, J. I. Brauman, and C. Djerassi, *Tetrahedron*, 1965, **21**, 1855.

⁶ C. S. Chopra and (the late) D. E. White, *Tetrahedron*, in the press.

⁷ Personal communication, Professor P. Jefferies, University of Western Australia.