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A BF_3-Et_2O CATALYZED REARRANGEMENT OF 3α, 4α-EPOXYSHIONANE

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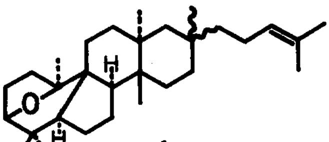
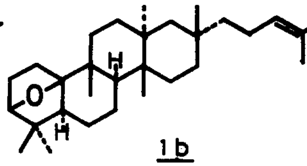
Structural study of baccharis oxide (1a), a new triterpene oxide, has been reported by Norwegian workers.[1] Structure elucidation of 1a was based on its BF_3-catalyzed rearrangement into bacchar-12-en-3β-ol (9).[1] The configuration of the side chain was left undetermined ; this was later shown to be α.[2] Our interests in close biogenetic relationship between baccharis oxide and shionone (2),[3] coupled with those in their backbone rearrangements, led us to undertake a BF_3-Et_2O catalyzed rearrangement of 3α, 4α-epoxyshionane (4). Recent revision of the structure of baccharis oxide to 1b by X-ray study[4] prompted us to report our chemical findings in a preliminary form.

Epoxidation of shion-3-ene (3)[5] with m-chloroperbenzoic acid in benzene gave a mixture (ca. 7:3) of α- and β-epoxides (4 and 5),[6] which was separated on silica gel column chromatography. Treatment of the α-epoxide (4), $C_{30}H_{52}O$, M^+ 428, m.p. 140-141°, with BF_3-Et_2O in dry benzene until a complete disappearance of the starting material (TLC, within 10 min) gave two major spots[7] (TLC) due to alcoholic products. Oxidation of the more polar alcoholic fraction (containing 6 and 12) with CrO_3 in pyridine followed by chromatography over SiO_2 gave two isomeric ketones.

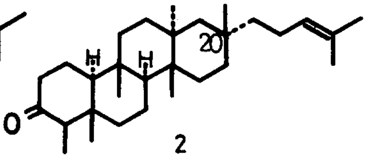
The more polar ketone, $C_{30}H_{50}O$, M^+ 426, m.p. 102-102.5°, $\nu_{C=O}$ 1710 cm^{-1}, was found to be bacchar-12-en-3-one (7) by the following evidences. The PMR spectrum shows, in addition to an olefinic proton at δ 5.27 ppm, signal patterns (δ 2.4-2.6 ppm) due to CH_2 adjacent to C=O group similar to those of 4,4,10-trimethyl triterpene 3-ones (β-amyrone and lupenone). The CD data of 7 ($[\theta]_{290}$ + 2600, $[\theta]_{325}$ - 90 ; in MeOH) are almost the same as those of dipterocarpol (8).[8] This suggests that the A/B/C ring junctures of these compounds are in close stereochemical relationship. On treatment with $NaBH_4$ 7 was converted into an alcohol (9), $C_{30}H_{52}O$, M^+ 428, m.p.



1a



1b



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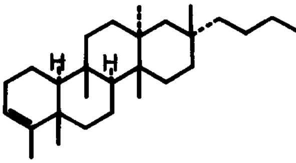

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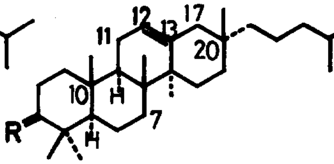
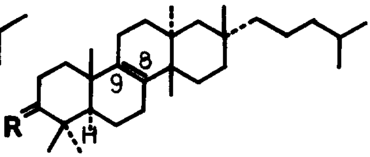
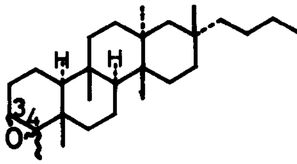


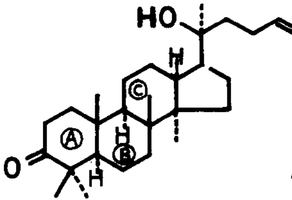
6 R = α-OH, β-H
7 R = O
9 R = β-OH, α-H
10 R = β-OAc, α-H
19 R = H, H



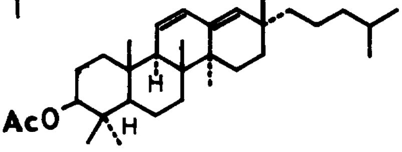
12 R = α-OH, β-H
13 R = O
14 R = β-OH, α-H
15 R = β-OAc, α-H
20 R = H, H



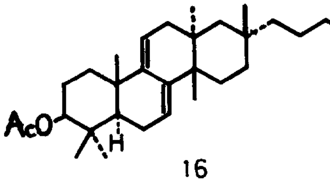
4 3α,4α-epoxide, 4β-CH$_3$
5 3β,4β-epoxide 4α-CH$_3$



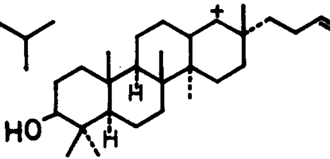
8



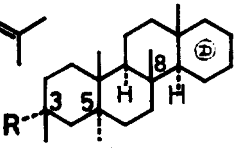
11



16



17



18

143.5-144°, with an equatorial OH group (PMR in CDCl$_3$: $\underline{H}$-C-OH, δ 3.27 ppm, quartet, $\underline{J}$ = 5 and 8 Hz). Oxidation of the acetate (10), m.p. 177-178°, with SeO$_2$ in AcOH gave bacchara-11,13(17)-dien-3β-yl acetate (11),[9] $C_{32}H_{52}O_2$, M^+ 468 ; ν_{max}^{nujol} 1735, 1280 and 875 cm^{-1}; λ_{max}^{EtOH} 250 nm (ε 12500), 241 (19400) and 234 (17400) ; PMR in CDCl$_3$: AB part of ABX-system at δ_A 5.52 and δ_B 5.92 ppm with J_{AB} = 9 Hz, a broad singlet at δ 5.23 ppm. Physical constants of 9, 10 and 11 are in good agreement with those of published data[1,10] of the corresponding baccharane derivatives.

The 8-ene structure (13) was suggested for the less polar ketone by the evidences shown below. The ketone (13), m.p. 174.5-177.5°, $\nu_{C=O}$ 1710 cm^{-1}, shows no signal due to olefinic proton in its PMR spectrum (in $CDCl_3$). Reduction of 13 with $NaBH_4$ afforded an alcohol (14), m.p. 135-136°, which on acetylation gave an acetate (15). Oxidation of 15 with SeO_2 in AcOH gave a diene-acetate (16), which exhibits UV absorptions$[\lambda_{max}^{EtOH}$ 249 nm (ε 6000), 238 (10800) and 231 (10000)$]$ characteristic of 7,9(11)-diene.11)

The formation of alcohols (6 and 12)12) from the α-epoxide (4) by BF_3-catalyzed rearrangement was thus shown. These findings confirm the "baccharane skeleton" including stereochemistry at C-20 2,4,9) and show that baccharis oxide (1b) and shionone (2) belong to the same biogenetic family1) having the common precursor ion (17).

Present result is of interest when it is considered as a complete backbone rearrangement of perhydrochrysene skeleton. From various studies on steroids, terpenoids and suitable model compounds, requirements for backbone rearrangements could be summarized as follows : 13,14,15) a) an anti-coplanar disposition of migrating groups favors a facile rearrangement, b) the molecule should have an intramolecular strain inherent to its carbon framework, c) it should have a group at which a carbonium ion can be generated, d) final products are thermodynamically stable ones among different skeletons under consideration,14) though kinetically controlled products from intermediate carbonium ions were isolated in many cases,15) e) product ratio depends on various factors such as reaction medium, modes of formation of cationic species, and so on.16) As to D-homo-steroids (perhydrochrysene skeleton), Kirk et al.17) reported a backbone rearrangement involving all possible cationic intermediates which gave rise to racemized 8-ene under a forced condition, while Khuong-Huu et al.18) reported a local migration when no stabilizing function such as C=O exists at the another end of the molecule. In our case, three methyl groups and a side chain incorporated at 8β, 5α, 3β and 3α positions on D-homosteroid (cf. backbone structures of 18 and 4 are the same) enhanced the conformational energy by additional 1, 3-diaxial methyl-methyl interactions which induced sequential 1,2-methyl and hydrogen shifts giving rise to bacchar-12-en-3α-ol (6). As a first approximation, bacchar-12-ene (19) seems to be less stable than the 8-ene (20), because the former contains three successive diaxial methyl groups while the latter does two independent pairs of diaxial interactions.19) If this is the case, present result could be well accounted for by a kinetically controlled complete backbone rearrangement in perhydrochrysene skeleton.

Further studies on the other reaction products and their thermal properties are under way.

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5. Y. Tanahashi, T. Takahashi, F. Patil and G. Ourisson, *Bull. Soc. Chim. France* **1964**, 584.
6. Configurations of the epoxide ring in **4** and **5**, deduced from their mode of formation and from examination of their rearrangement products, were firmly established by paramagnetic induced shifts experiments using Eu(fod)$_3$-d$_{27}$.
7. Each of two major spots was found to be a mixture of two alcohols by PMR using shift reagents.
8. P. Witz, H. Herrmann, J.-M. Lehn and G. Ourisson, *Bull. Soc. Chim. France* **1963**, 1101.
9. Nomenclature following biogenetic standpoint was applied.
10. The authors wish to thank Professor T. Bruun for a generous gift of **11** together with spectral data of **9**, **10** and **11**.
11. The IR and UV spectra of **16** are not identical with those of the 3β-acetoxy-1(10), 5-diene obtained by oxidation of the 3β-acetoxy-5(10)-ene. [Y. Tanahashi, Y. Moriyama, T. Takahashi, F. Patil, J.-F. Biellmann and G. Ourisson, *Bull. Soc. Chim. France* **1966**, 1670]
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15. For ex. see D. J. Dunham, R. G. Lawton, *J. Amer. Chem. Soc.* **93**, 2075 (1971).
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