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# TERPENES XII. THE CONSTITUTIONS OF AROMADENDRENE, GLOBULOL, LEDOL AND VIRIDOFLOROL.

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CHEMICAL investigations aimed at structure elucidation of aromadendrene produced seven formulas. The last two proposals[1] (I and II) rest on these facts. Aromadendrene contains part structure IV, dehydrogenation gives guaiazulene (III), three rings are present, one of which is probably three membered. We now wish to propose IX as the complete expression for this sesquiterpene.

We have confirmed IV by base catalyzed deuterium exchange with X (2.9D introduced) and extended it to V by exchange with VI[1] (3.0D introduced). The presence of a $C_6 \longrightarrow C_{11}$ bond was then established. Acid isomerization of dihydroaromadendrene gave XI (I.R. bands at 885, 1640, 3330 $cm^{-1}$) which on dehydrogenation over palladium at 320° yielded zierazulene (XIV)[2] identified by visible spectrum, picrate m.p. 116-118°,

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[1] A. J. Birch and F. N. Lahey, Aust. J. Chem. 6, 379 (1953) and earlier literature cited.

[2] D. J. Collins, J. Chem. Soc. 531 (1959), whom we thank for a specimen.

trinitrobenzene adduct m.p. 119-123°, pure and mixed with an authentic sample.[2] Ozonization of XI yielded XII ($\nu$1692 $cm^{-1}$), 3.0D atoms introduced with NaOD/EtOD which had mass peaks at m/e 208 (parent), 165 and 43 ($CH_3CO$). The diketone XIII[3] exhibited peaks at m/e 208, 165 and 43, while the hexadeuterio diketone had peaks at m/e 214, 168 and 46 ($CD_3CO$). This shows that XII and XIII are $C_6$ substituted methylketones rather than cyclooctanones.[1] Enolization towards $C_6$ is sterically prohibited by the methyl group at $C_4$ and the situation is entirely analogous to that in maaliol.[4] Since the $C_6 \longrightarrow C_7$ and $C_7 \longrightarrow C_{11}$ bonds are retained in the dehydrogenation products III and XIV, the presence of a cyclopropane ring is established.

In agreement with recent findings of Šorm and coworkers[5] ozonization of aromadendrene $[\alpha]_D^{25}$ + 7° (ethanol) from Eucalyptus Nova Anglica has repeatedly yielded only apoaromadendrone (X). Contrary to previous views,[1,6] we believe the A/B rings to be trans-locked in this ketone for the following reasons. (a) Earlier work established the higher stability of the trans-isomer in the unsubstituted bicyclo-[5.3.0]-decane system[7-9] and there is no reason to assume that the substituents present in X should

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[3] W. Treibs and H. Barchet, Ann. **566**, 89 (1950).

[4] G. Büchi, M. Schach v. Wittenau and D. M. White, J. Amer. Chem. Soc. **81**, 1968 (1959).

[5] L. Dolejs, V. Herout, O. Motl, F. Šorm and M. Soucek, Chem. & Ind. 566 (1959).

[6] L. Dolejs, F. Sorm and M. Soucek, Chem. & Ind. 160 (1959).

[7] D. C. Ayres and R. A. Raphael, J. Chem. Soc. 1779 (1958).

[8] H. L. Goering, A. C. Olson and H. H. Esby, J. Amer. Chem. Soc. **78**, 5371 (1956).

[9] A. C. Cope and G. Holzman, J. Amer. Chem. Soc. **72**, 3062 (1950).

revert this order of stability. (b) In agreement with the molecular model, the catalytic reduction of XV, m.p. 43°, $\lambda_{max}^{EtOH}$ 248 mμ, ε6000; I.R. bands at 1670, 1605 (s) $cm^{-1}$, one vinyl hydrogen in the NMR spectrum, gave only the thermodynamically less stable α-apoaromadendrone[1] (VIII). The unsaturated ketone (XV) was readily available by bromination of X with N-bromosuccinimide followed by dehydrobromination with dimethylformamide in the presence of lithium chloride. Exposure of the ketoacid (VI) to strong alkali and treatment with hydroxylamine produced the original oximinoacid[1] which demonstrated that the large groups at $C_4$ and $C_5$ are trans. The optical rotatory dispersion curve (kindly measured by Prof. Carl Djerassi) of the cis-ketone (VIII) exhibited a single positive Cotton effect while the trans-ketone (X) had a negative curve. This relationship is in agreement with the Moffitt-Woodward octant rule[10] only if the two ketones have the absolute configurations implied in VIII and X. The configurations at the remaining centers $C_6$ and $C_7$ must be identical and the acid catalyzed ring cleavages [(cf.4)] already discussed strongly suggest the stereochemistry pictured in VII to XIII.

The Czech investigators have recently[5] demonstrated the existence of two diastereomeric aromadendrenes and they were able to correlate ledol[11] and viridoflorol[12] with alloaromadendrene $[\alpha]_D^{20}$ -21.6° for which

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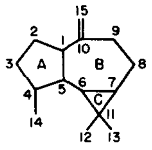
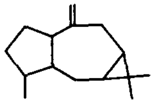
[10] R. B. Woodward, private communication.

[11] N. P. Kiryalov, Chem. Abstr. **49**, 5389 (1955) and earlier papers.

[12] R. O. Hellyer and H. H. G. McKern, J. Proc. R. Soc. N.S.W. **89**, 188 (1956).



I



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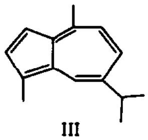

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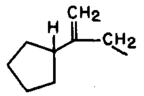

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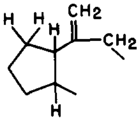
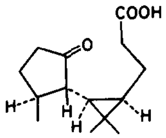
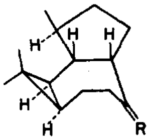


V

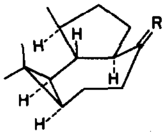


VI



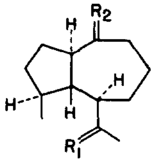
VII $R{=}CH_2$

VIII $R{=}O{=}$



IX $R{=}CH_2$

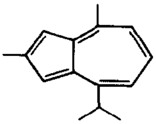
X $R{=}O{=}$



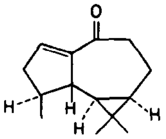
XI $R_1{=}CH_2$ ; $R_2 = {<}^{CH_3}_{H}$

XII $R_1{=}O{=}$ ; $R_2 = {<}^{CH_3}_{H}$

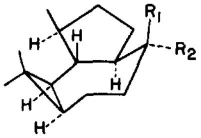
XIII $R_1{=}O{=}$ ; $R_2{=}O{=}$



XIV

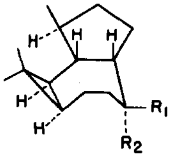


XV



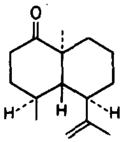
XVI $R_1{=}CH_3$ ; $R_2{=}OH$

XVII $R_1{=}OH$ ; $R_2{=}CH_3$



XVIII $R_1{=}CH_3$ ; $R_2{=}OH$

X!X $R_1{=}OH$ ; $R_2{=}CH_3$



XX

we wish to propose structure VII. Similarly, globulol[13] was obtained by partial synthesis from aromadendrene. We have independently reached the same conclusions in the following manner. Configurationally pure aromadendrene (IX) $[\alpha]_D^{25}$ +9° (EtOH) was prepared from apoaromadendrone (X) according to Wittig.[14] Epoxidation followed by reduction with lithium aluminum hydride gave globulol, m.p. 87°, $[\alpha]_D^{26}$ -43° ($CHCl_3$), phenylurethane, m.p. 144°, and a liquid tertiary alcohol $[\alpha]_D^{25}$ -34° (EtOH) possibly identical with palustrol.[15] Treatment of X with methyllithium gave only the liquid alcohol which shows[4] that this epimer has structure XVII while globulol is XVI. The configuration at $C_{10}$ of globulol is in agreement with its behaviour on rate controlled dehydration with thionyl chloride in pyridine which provided mainly the olefin containing an exocyclic double bond.[6] Further support for the configurations assigned was provided by the mass spectra of the two epimeric alcohols. The intensity of the molecular ion at m/e 222 was 0.19% of the total ion yield in globulol while it was 0.29% in the spectrum of the epimer which indicated that globulol (XVI) is the thermodynamically less stable isomer.[16] Treatment of α-apoaromadendrone (VIII) with methyllithium gave only ledol identical by m.p., mixed m.p., rotation and infrared spectrum with an authentic sample.[17] The mode

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[13] A. Blumann, A. R. H. Cole, K. J. L. Thierberg and D. E. White, Chem. & Ind. 1426 (1954).

[14] G. Wittig, Angew. Chem. **68**, 505 (1956).

[15] N. P. Kiryalov, J. Gen. Chem. U.S.S.R. **24**, 1257 (1954).

[16] K. Biemann and J. Seibl, J. Amer. Chem. Soc. in press.

[17] We are indebted to Drs. P. de Mayo and T. Bruun for a sample of ledol.

of formation[4] and its behaviour on dehydration[6] indicate structure XVIII for ledol and the unsaturated ketone[11] formed on acid catalyzed dehydration of ledglycol must be XX. A configurationally homogeneous sample of alloaromadendrene (VII) $[\alpha]_D^{26}$ -19° (EtOH) was prepared by a Wittig reaction[14] from α-apoaromadendrone (VIII). Epoxidation followed by hydride reduction yielded ledol (XVIII) and an isomeric tertiary alcohol which according to Dolejs *et al.*[5] is identical with viridoflorol to which we assign structure XIX.

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