PENTACYCLIC TRITERPENOID BACKBONE REARRANGEMENT: CONSTITUTION OF BREIN

Sir:

Dehydration of α -amyrin (Ia) under various conditions gives a product, "l- α -amyradiene" in which the double bonds are conjugated and heteroannular, and whose structure has been shown¹ to be (IIa). We believe that this remarkable molecular rearrangement, referred to as a backbone rearrangement,² in addition to its intrinsic mechanistic interest, affords a useful and widelyapplicable method³ for structure elucidation in the ursane and oleanane groups of triterpenoids. As an example, we now wish to report its utilization in establishing the structure of brein, a pentacyclic triterpenoid first isolated⁴ in 1851 as a constituent of Manila elemi resin.

Significant structural work due to Morice and Simpson⁵ and Büchi, Jeger and Ruzicka⁶ culminated in brein being represented as urs-12-ene- 3α , 21 (or 22)-diol.⁷ Our re-investigation shows that brein is urs-12-ene- 3β , 16 β -diol (Ib).

The earlier assignment of the unusual 3α -hydroxyl configuration has been questioned⁸ on the basis of molecular rotation differences. Direct chemical evidence on the 3-configuration was adduced. Partial acetylation of brein gives the diol monoacetate (Id), which on chromic acid oxidation yields breinonol-B acetate (Ic, m.p. 210–212°, $[\alpha]_{\rm D}$ + 47°), alternatively obtained by catalytic hydrogenation of breindione (Ig) and acetylation. In our hands, Wolff-Kishner reduction of (Ic) gave α -amyrin (Ia) in high yield, thus establishing that brein has a 3β -hydroxyl group.

Subjection of the key intermediate, breinonol-B (Ie, m.p. 226–227°, $[\alpha]_{\rm D}$ + 87°) to the backbone rearrangement by treatment with phosphorus pentoxide in benzene gave a product (IIb), which we were unable to obtain crystalline, but which was characterized by its ultraviolet absorption spectrum ($\lambda^{\rm EtOH}$ 240 m μ , ϵ 4900 and 293 m μ , ϵ 9100), characteristic of a *heteroannular conjugated dienone*,⁹ and not a conjugated diene. This indicated the location of the ketone group in breinonol-B and consequently the second hydroxyl group in brein, at C-16.

Additional support for this conclusion was provided by this series of experiments which also established the configuration of the C-16 hydroxyl group. Reduction of breindione (Ig) with sodium

(1) M. B. E. Fayez, J. Grigor, F. S. Spring and R. Stevenson, J. Chem. Soc., 3378 (1955).

(2) G. Brownlie, F. S. Spring, R. Stevenson and W. S. Strachan, Chem. and Ind., 1156 (1955).

(3) (a) G. G. Allan, F. S. Spring, R. Stevenson and W. S. Strachan, J. Chem. Soc., 3371 (1955); (b) G. G. Allan, M. B. E. Fayez, F. S. Spring and R. Stevenson, *ibid.*, 456 (1956).

(4) S. Baup, Jahresbericht für Chemie, 528 (1851).

(5) I. M. Morice and J. C. E. Simpson, (a) J. Chem. Soc., 795 (1940);
 (b) 198 (1942).

(6) G. Büchi, O. Jeger and L. Ruzicka, (a) Helv. Chim. Acta, 29, 442 (1946); (b) 31, 139 (1948).

(7) For a review of the evidence, see J. Simonsen and W. C. J. Ross, "The Terpenes," Vol. IV, Cambridge University Press, New York, N. Y., pp. 148-155.

(8) W. Klyne and W. M. Stokes, J. Chem. Soc., 1979 (1954).

(9) For the spectrum of 3α -hydroxy-12-ketochola-7,9(11)-dienic acid, which has an identical chromophore, see H. Heusser, K. Eichenberger, P. Kurath, H. R. Dallenbach and O. Jeger, *Helv. Chim. Acta*, **34**, 2106 (1951).



borohydride and then acetylation gives a diol monoacetate ($C_{32}H_{52}O_3$, $[\alpha]_{\rm p}$ + 47°, m.p. 202– 205°) which differs from (Id) but which gives (Ic) on oxidation and must therefore be the 16-epimer (If) of brein. Since the 16-hydroxyl group of brein is acetylated under conditions in which (If) is resistant, it has the equatorial conformation. Brein consequently is represented as urs-12-ene-3 β ,16 β diol. Dehydration of (If) and 3 β -acetoxyurs-12en-15-ol¹⁰ with phosphorus oxychloride in pyridine gives, in low yield in each case, the same product, ursa-12,15-dien-3 β -yl acetate ($C_{32}H_{50}O_2$, m.p. 228– 229°, $[\alpha]_{\rm p}$ + 40°).

Satisfactory analyses have been obtained for all new crystalline compounds.

(10) W. Laird, F. S. Spring and R. Stevenson, 1960, in press.

(11) Department of Chemistry, Brandeis University, Waltham, Mass.

CHEMISTRY DEPARTMENTWILLIAM LAIRDROYAL COLLEGE OF SCIENCE & TECHNOLOGYF. S. SPRINGGLASGOW, SCOTLANDROBERT STEVENSON¹¹

RECEIVED MAY 14, 1960

ON THE THERMAL AND RADIATION-INDUCED CHAIN REACTION BETWEEN METHANE AND ETHYLENE

Sir:

Previous publications from this laboratory have emphasized the use of nuclear radiation as a convenient initiator, and, therefore, a powerful tool for elucidating the mechanism of ordinary hydrocarbon free radical chain reactions.¹⁻⁴ Provided it can be shown that the radiation-induced reaction is free radical in nature, one has available a new probe with which reactions can be initiated

(1) P. J. Lucchesi, D. L. Baeder and J. P. Longwell, Proc. Fifth

World Petroleum Congress, New York, N. Y., June, 1959.
(2) P. J. Lucchesi and C. E. Heath, THIS JOURNAL, 81, 4770 (1959).

(3) W. Bartok and P. J. Lucchesi, *ibid.*, **81**, 5918 (1959).
(4) P. J. Lucchesi, B. L. Tarmy, R. B. Long, D. L. Baeder and J. P

Longwell, Ind. Eng. Chem., 50, 879 (1958).