15. *The Triterpene Resinols and Related Acids. Part XV. The Dehydration of α-Amyrin and α-Amyradienol with Phosphoric Oxide:* l-α-*Amyradiene and* l-α-*Amyratriene.*

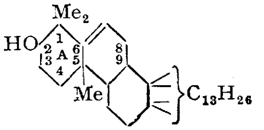
By E. S. Ewen, A. E. Gillam, and F. S. Spring.

l-α-Amyradiene obtained by dehydration of α-amyrin with phosphoric oxide contains a conjugated diene system. Dehydration of α-amyradienol with the same reagent yields l-α-*amyratriene*, which contains a conjugated triene system. The ethenoid linkage of α-amyrin must consequently be situated in the vicinity of the hydroxyl group.

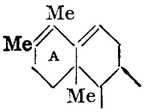
Three α-amyradienes have been described in the literature; dehydration of α-amyrin with phosphorus pentachloride gives *d*-α-amyradiene, m. p. 134°, $[\alpha]_D + 109°$ (Vesterberg and Westerlind, *Annalen*, 1922, **428**, 250; Vesterberg, *Ber.*, 1887, **20**, 1245), and dehydration of the triterpene alcohol with phosphoric oxide yields the isomeric *l*-α-amyradiene, m. p. 193—194°, $[\alpha]_D - 105°$ (Vesterberg, *Ber.*, 1891, **24**, 3835). The third α-amyradiene, m. p. 119—120°, $[\alpha]_D + 137°$, was obtained by Winterstein and Stein (*Annalen*, 1933, **502**, 223) by the thermal decomposition of α-amyrin benzoate. We have examined the ultra-violet absorption spectra of the three α-amyradienes and we find that, whereas the two *d*-isomers do not exhibit selective absorption of any appreciable intensity above 2200 A., the *l*-isomer exhibits intense selective absorption with a maximum at 2395 A. ($\varepsilon_{max.} = 15{,}000$), showing that the hydrocarbon contains a conjugated system of ethenoid linkages distributed between two rings and that the ethenoid linkage of α-amyrin is in close proximity to the hydroxyl group.

The simplest structural interpretation of this observation is that the ethylenic linkage of α-amyrin is located between C_6 and C_7 (I) in the hydropicene nuclear structure, and that *l*-α-amyradiene is represented by the partial formula (II). This relative location of the unsaturated centre and hydroxyl group in the α-amyrin group of triterpenes, which is attractive since it corresponds to that in the more abundantly occurring zoosterols and phytosterols, has been suggested by Simpson and Williams (J., 1938, 1712; Ruzicka and Wirz, *Helv. Chim. Acta*, 1939, **22**, 948; Simpson and Kon, J., 1941, 793). If the ethylenic linkage of α-amyrin is between C_6 and C_7, an angular methyl group cannot be attached to C_9, since the reversible transformation of α-amyrenonol (III) into α-amyradienol (V) requires the presence of a hydrogen at C_9 (Ewen and Spring, J., 1940, 1196). Furthermore, the mechanism used to explain the formation of 1 : 2 : 5 : 6-tetramethylnaphthalene and 1 : 5 : 6-trimethyl-β-naphthol from α-amyrin (Spring and Vickerstaff, J., 1937, 249; Brunner, Hofer, and Stein, *Monatsh.*, 1932, **61**, 293; 1933, **63**, 79) would not be valid.

A method of testing the partial formula (I) for α-amyrin is apparently afforded by α-amyrenonol, which will be represented by (III); under suitable reaction conditions, dehydration of α-amyrenonol would be expected to give an α-amyradienone (IV) containing a conjugated diene-one chromophore. Spring and Vickerstaff (*loc. cit.*) showed that dehydration of α-amyrenonol with phosphorus pentachloride gives a mixture of the two unsaturated ketones, α-amyradienone-I and α-amyradienone-II. We have examined the absorption spectra of these isomers; both exhibit maxima in the neighbourhood of 2500 A. ($\varepsilon_{\max.} \simeq 12{,}000$) closely approximating to that of α-amyrenonol, thus showing that dehydration of the latter by means of phosphorus pentachloride has not led to an increase in conjugation. Dehydration of α-amyrenonol with phosphoric oxide gives a mixture of α-amyradienone-II and an amorphous phosphorus-containing substance; the reagent which converts α-amyrin into the conjugated *l*-α-amyradiene has not led to an increase in conjugation in the case of α-amyrenonol.



(I.)



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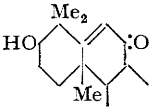

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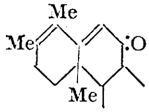

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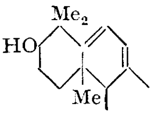
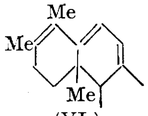
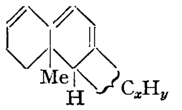


(V.)



(VI.)



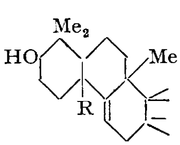
(VII*a*) $x = 16, y = 30$
(VII*b*) $x = 17, y = 30$

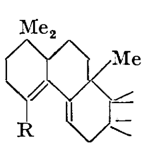
Treatment of α-amyrenonol with hydriodic acid–acetic acid mixture gives an α-*amyradienone*-III, m. p. 169°, which exhibits two absorption bands situated at 2600 A. ($\varepsilon_{\max.} = 12{,}000$) and 2920 A. ($\varepsilon_{\max.} = 11{,}000$). Although the intensity and location of these well-defined maxima are not modified by repeated crystallisation of the unsaturated ketone, we have not overlooked the possibility that the compound, m. p. 169°, may be a mixed crystal of the true α-amyradienone-III containing the chromophoric system in (IV) together with an isomer containing an isolated ethylenic linkage and an αβ-unsaturated keto-group. The former component would give rise to the absorption maximum at 2920 A. (Picard and Spring, J., 1941, 35) and the latter to the maximum in the neighbourhood of 2600 A. However, α-amyradienone-III could not be resolved by the chromatographic method using activated alumina. It is of interest that, when treated with hydriodic acid–acetic acid mixture, α-amyrin yields *l*-α-amyradiene.

Attention was next directed to the dehydration of α-amyradienol, which we have previously shown contains a conjugated system of ethylenic linkages in one ring (Spring and Vickerstaff, *loc. cit.*; Ewen, Spring, and Vickerstaff, J., 1939, 1303). If the partial formulæ (I) and (III) be assumed for α-amyrin and α-amyrenonol respectively, α-amyradienol will be (V). Treatment of the dienol with phosphorus pentachloride gives *dichloro*-α-*amyradiene*, m. p. 128—129°, which exhibits a maximum at 2800 A. ($\varepsilon_{\max.} = 11{,}800$). Treatment of dichloro-α-amyradiene with zinc dust and acetic acid gives *d*-α-*amyratriene*, m. p. 131—133°, $[\alpha]_D + 439°$, exhibiting an absorption maximum at 2810 A. ($\varepsilon_{\max.} = 11{,}000$). The absorption spectra of α-amyradienyl acetate (max. 2800 A., $\varepsilon_{\max.} = 11{,}500$), dichloro-α-amyradiene, and *d*-α-amyratriene are strikingly similar both in location of the maxima and in intensity of absorption, showing that the dehydration of α-amyradienol (to give *d*-α-amyratriene) has not led to an increase in conjugation, the introduced ethylenic linkage being isolated from the diene chromophore.

Dehydration of α-amyradienol with phosphoric oxide gives 1-α-*amyratriene*, m. p. 140—142°, $[\alpha]_D - 450°$, which exhibits an absorption maximum at 2950 A. ($\varepsilon_{\max.} = 33{,}000$). The absorption spectrum of this hydrocarbon establishes that its three ethylenic linkages are conjugated; in terms of the α-amyrin partial formula (I) the simplest representation of *l*-α-amyratriene is (VI). Neither *l*-α-amyradiene nor *l*-α-amyratriene reacts with maleic anhydride in boiling benzene solution. However, it is not possible, as yet, to define more closely the environment of the conjugated triene system in *l*-α-amyratriene. Although the ergostatetraene described by Windaus and Buchholz (*Ber.*, 1939, **72**, 598), which probably contains a conjugated triene system, exhibits a maximum at approximately 2900 A. ($\varepsilon_{\max.} = 35{,}000$) in very close agreement with that of *l*-α-amyratriene, and the cholestatriene formulated as (VII*a*) exhibits a maximum at 3020 A. (Eckhardt, *Ber.*, 1938, **71**, 461), dehydroergosterol, dehydrolumisterol (Heilbron, Moffet, and Spring, J., 1937, 413), and the ergostatetraene formulated as (VII*b*) (Heilbron, Kennedy, Spring, and Swain, J., 1938, 869) all exhibit maxima in the neighbourhood of 3200. The reason for this variation is almost certainly to be found in differences in the molecular environment of the triene system; formulations such as (VII) for cholestatriene and ergostatetraene are not rigidly established.

(VIII.)





(IX.)

The dehydration of α-amyrin and α-amyradienol to *l*-α-amyradiene and *l*-α-amyratriene, respectively, establishes a relatively close association of the hydroxyl and the ethylene linkage in the α-amyrin group of triterpenes. However, it is not established that the ethylenic linkage is situated between C_6 and C_7, an alternative partial formulation for α-amyrin and *l*-α-amyradiene being shown at (VIII) and (IX) respectively. It is hoped that a further examination of the degradation products described in this paper, and in particular of *l*-α-amyradiene, will define more closely the position of the unsaturated centre in the α-amyrin series.

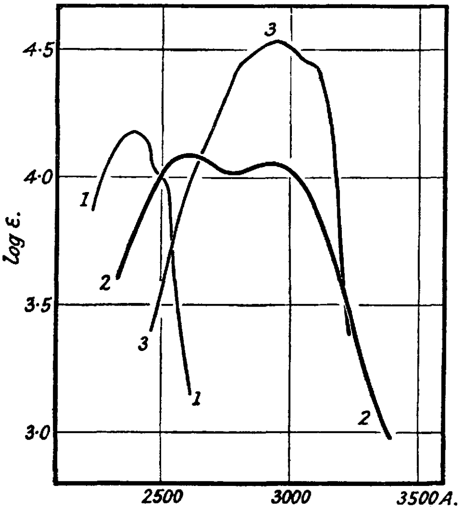
EXPERIMENTAL.

Specific rotations were measured in chloroform solution; m. p.'s are uncorrected.

α-Amyradiene.—(*a*) The hydrocarbon prepared as described by Vesterberg (*loc. cit.*) was obtained in prismatic needles, m. p. 193—194°, $[\alpha]_{\mathrm{D}}^{20^\circ}$ −101° (*l* = 1, *c* = 0·8). It gave a brown coloration with tetranitromethane in chloroform.

(*b*) A solution of α-amyrin (2 g.) in acetic acid (20 c.c.) was refluxed with hydriodic acid (*d* 1·7; 8 c.c.) for 4 hours. The cooled solution was diluted with water, and the mixture extracted with ether; the extract was washed successively with sodium thiosulphate solution and dilute hydrochloric acid. Removal of the solvent and crystallisation of the product from ether–alcohol gave *l*-α-amyradiene in prismatic needles, m. p. 193—194° either alone or when mixed with the specimen prepared by method (*a*); $[\alpha]_{\mathrm{D}}^{20^\circ}$ − 104° (*l* = 1, *c* = 1·5).

Absorption Spectra in Alcohol.



1. l-*α-Amyradiene.* 2. *α-Amyradienone*-III. 3. l-*α-Amyratriene.*

d-*α-Amyradiene.*—This was prepared by the method of Vesterberg and Westerlind (*loc. cit.*); it was obtained from ether–alcohol in needles, m. p. 134—135°, $[\alpha]_{\mathrm{D}}^{21^\circ}$ + 109° (*l* = 0·5, *c* = 0·7 in chloroform). *d*-α-Amyradiene was recovered unchanged after shaking with phosphoric oxide in benzene solution for 48 hours. α-Amyradienone-I was obtained by the method of Spring and Vickerstaff (*loc. cit.*); it separates from alcohol in needles, m. p. 197°. *Light absorption in alcohol:* Maximum at 2490 A., ε = 14,000.

α-Amyradienone-II.—A solution of α-amyrenonol (5 g.) in ether (30 c.c.) was shaken for 24 hours with phosphoric oxide (2 g.). The solution was washed with water and dried (sodium sulphate), and the residue obtained after removal of the solvent extracted with hot acetone. The insoluble fraction separated from ethyl acetate as an amorphous powder, m. p. 205—209°. This substance contained phosphorus which could not be removed either by attempted crystallisation or by filtration through a column of alumina. Repeated crystallisation of the acetone-soluble fraction from alcohol gave α-amyradienone-II in needles, m. p. 162—163°. When prepared by the dehydration of α-amyrenonol with phosphorus pentachloride, α-amyradienone-II was obtained in needles, m. p. 160—161°, undepressed by the specimen described above. It gave a yellow coloration with tetranitromethane (Found: C, 85·4; H, 11·1. Calc. for $C_{30}H_{46}O$: C, 85·25; H, 11·0%). *Light absorption in alcohol:* Maximum at 2520 A., ε = 13,000.

α-Amyradienone-III.—A mixture of α-amyrenonol (5 g.), glacial acetic acid (50 c.c.), and hydriodic acid (*d* 1·7; 15 c.c.) was refluxed for 8 hours. The cold solution was diluted with water and extracted with ether; the extract was washed with sodium thiosulphate, dilute hydrochloric acid, and water. Removal of the ether and repeated crystallisation of the residue from methyl alcohol gave *α-amyradienone*-III as laminæ, m. p. 179°, $[\alpha]_{\mathrm{D}}^{20^\circ}$ + 170° (*l* = 1, *c* = 2·3 in chloroform). It gave a yellow coloration with tetranitromethane in chloroform (Found: C, 85·2; H, 10·9. $C_{30}H_{46}O$ requires C, 85·25; H, 11·0%).

α-Dichloroamyradiene.—α-Amyradienol (Ewen, Spring, and Vickerstaff, *loc. cit.*) (m. p. 159—160°; 1·9 g.) in light petroleum (b. p. 60—80°; 50 c.c.) was shaken with phosphorus pentachloride (0·93 g.). When the evolution of hydrogen chloride had diminished (1 hour) the mixture was heated under reflux for 2 minutes, cooled, and washed with warm water. Removal of the solvent from the dried (sodium sulphate) solution and three crystallisations of the residue from alcohol gave *α-dichloroamyradiene* in needles, m. p. 128—129°, $[\alpha]_{\mathrm{D}}^{21^\circ}$ +407° (*l* = 0·5, *c* = 0·5 in chloroform) (Found: C, 75·4; H, 9·4. $C_{30}H_{46}Cl_2$ requires C, 75·4; H, 9·7%).

d-*α-Amyratriene.*—A solution of α-dichloroamyradiene (0·5 g.) in acetic acid (5 c.c.) was heated, under reflux, with zinc dust (0·2 g.) for 4 hours. The hot liquid was filtered and diluted with water. The solid separating was collected, washed with water, and dried. Two crystallisations from absolute alcohol gave d-*α-amyratriene* in long silky needles, m. p. 131—133°, $[\alpha]_{\mathrm{D}}$ +439° (*l* = 1, *c* = 1·6) (Found: C, 88·4; H, 11·5. $C_{30}H_{46}$ requires C, 88·6; H, 11·4%). *d*-α-Amyratriene gave an intense brown coloration with tetranitromethane in chloroform.

l-*α-Amyratriene.*—A solution of α-amyradienol (1 g.) in dry benzene (30 c.c.) was shaken for 24 hours with phosphoric oxide (1·5 g.). The mixture was washed with warm water, and the filtered solution evaporated to dryness. Four crystallisations of the residue from alcohol gave l-*α-amyratriene* in needles, m. p. 140—142°. The hydrocarbon gave a red-brown coloration with tetranitromethane in chloroform, which was considerably more intense than that produced by α-amyradienol, $[\alpha]_{\mathrm{D}}^{20^\circ}$ − 450° (*l* = 1, *c* = 0·8) (Found: C, 88·6; H, 11·7. $C_{30}H_{46}$ requires C, 88·6; H, 11·4%).

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