Steroids. Part XXXI.[1] Attempted Modification of the 14α-Methyl Group in 4,4,14α-Trimethyl Steroids

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5α-Lanost-8-en-3β-yl acetate was converted by way of 3β-acetoxy-5α-lanost-8-en-7-one into 3β-acetoxy-7α-hydroxy-5α-lanost-8-ene, which as the 7α-nitrite did not undergo the Barton reaction, and which with lead tetra-acetate–iodine gave 3β-acetoxy-5α-lanosta-7,9(11)-diene. 3β-Acetoxy-5α-lanost-9(11)-en-7-one, when hydrogenated over platinum in ethyl acetate–perchloric acid gave only 3β-acetoxy-5α-lanosta-7,9(11)-diene, whilst use of sodium borohydride yielded mainly 3β-acetoxy-7β-hydroxy-5α-lanost-9(11)-ene. Reductive cleavage of the 7β,8β-epoxide of 3β-acetoxy-5α-lanosta-7,9(11)-diene also yielded a 7β-hydroxy-5α-lanost-9(11)-ene; the 7α,8α-epoxide of 3β-acetoxy-5α-lanosta-7,9(11)-diene could not be prepared.

RECENTLY we described [2] the modification and removal of the 14α-methyl group in 11-oxo-derivatives of 5α-lanostane. We also examined removal of the 14α-methyl group in the 5α-lanostane series in the absence of the 11-oxo-group, and now report these experiments.

5α-Lanost-8-en-3β-yl acetate (I) was converted into the Δ^{7}-isomer (II; R = Me),[3] which when treated with *m*-chloroperbenzoic acid gave the 7α,8α-epoxide (III). It was anticipated that the 7α,8α-epoxide (III) would be cleaved by lithium–ethylamine [4] to yield the required 7α-ol (IV; R = H) rather than the reported 8α-ol;[5] this has since been confirmed by Fried *et al.*[6] After Fried's communication describing the transformation of the 7α-ol (IV; R = H) with lead tetra-acetate into the 3β,32-diacetate (II; R = CH_2·OAc), and the accompanying paper by Barton *et al.*[7] describing the photolysis of the 7α-nitrite (IV; R = NO), convertible into the aldehyde (II; R = CHO) and the acid [8] (II; R = CO_2H), we discontinued this work, but record some other results in this series.

Several groups of workers [3,9] have reported the Δ^{8}-7-ketone (V) as a minor product during the oxidation of 5α-lanosten-8-en-3β-yl acetate (I) to the related Δ^{8}-7,11-diketone with chromium trioxide in acetic acid. If, however, the oxidation is carried out in chloroform–acetic acid,[10] considerable yields of the Δ^{8}-7-ketone (V) and, unexpectedly, of the isomeric $\Delta^{9(11)}$-7-ketone [11] (VI) are obtained. The compound (VI), purified by column chromatography and repeated recrystallisation, has been identified by its n.m.r. spectrum, which showed a signal for one vinyl proton at τ 4·6, and by its ready conversion into the conjugated ketone (V) by treatment with boron trifluoride.

The Δ^{8}-7-ketone (V) was unaffected by hydrogen–platinum oxide in ethyl acetate; use of these reagents in the presence of perchloric acid gave only 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H). Reduction of (V) with sodium borohydride in dioxan gave the Δ^{8}-7α-ol (VIII; R = H), the n.m.r. spectrum of which showed a signal for the quasi-equatorial 7β-proton at τ 5·8 (W_H 10 c./sec.),[12] and a considerable quantity of 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H). The allylic 7α-ol (VIII; R = H), which decomposed to give 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) during prolonged column chromatography, when treated with nitrosyl chloride–pyridine [13] gave the unstable 7α-nitrite (VIII; R = NO), $\nu_{max.}$ 1626 (N=O) and 756 (O–N=O) cm.$^{-1}$, the mass spectrum of which showed no parent peak at *m*/*e* 515 and a base peak at *m*/*e* 469 corresponding to the loss of O–N=O. The molecular geometry of the Δ^{8}-7α-nitrite (VIII; R = NO), as disclosed by a Dreiding model, indicated that proton abstraction from the axial 14α-methyl group would be unlikely since the distance (4 Å) between the 7α-nitrite group and the 14α-methyl group is greater than the maximum distance (2·8 Å) predicted by Heusler and Kalvoda [14] for photochemical proton abstraction from a neighbouring group. As predicted, no proton abstraction reaction occurred when the Δ^{8}-7α-nitrite (VIII; R = NO) was photolysed for long periods in toluene with a 125 w mercury lamp, although the nitrite was quantitatively converted into the parent alcohol (VIII; R = H). Similarly, treatment of the Δ^{8}-7α-ol (VIII; R = H) with lead tetra-acetate and iodine [15] did not lead to proton abstraction from the 14α-methyl group, and instead gave 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H).

The molecular geometry of the $\Delta^{9(11)}$-7α-nitrite (IX;

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[1] Part XXX, C. W. Shoppee, and B. C. Newman, *J. Chem. Soc.* (*C*), 1968, 981.

[2] C. W. Shoppee, J. C. Coll, N. W. Hughes, and R. E. Lack, *Tetrahedron Letters*, 1965, 3249; C. W. Shoppee, N. W. Hughes, and R. E. Lack, *J. Chem. Soc.*, 1966, 2359.

[3] R. E. Marker, E. L. Wittle, and L. W. Mixon, *J. Amer. Chem. Soc.*, 1937, **59**, 1368.

[4] J. F. Fried, J. W. Brown, and M. Applebaum, *Tetrahedron Letters*, 1965, 849.

[5] A. S. Hallsworth and H. B. Henbest, *J. Chem. Soc.*, 1957, 4606.

[6] J. F. Fried, J. W. Brown, and L. Borkenhagen, *Tetrahedron Letters*, 1965, 2499.

[7] T. J. Bentley, J. F. McGhie, and D. H. R. Barton, *Tetrahedron Letters*, 1965, 2497.

[8] D. H. R. Barton, private communication.

[9] L. Ruzicka, E. Rey, and A. C. Muhr, *Helv. Chim. Acta*, 1944, **27**, 472; M. J. Birchenough and J. F. McGhie, *J. Chem. Soc.*, 1950, 1249; J. F. Cavalla and J. F. McGhie, *J. Chem. Soc.*, 1951, 744.

[10] C. S. Barnes, private communication.

[11] M. V. Mijović, W. Voser, H. Heusser, and O. Jeger, *Helv. Chim. Acta*, 1952, **35**, 964.

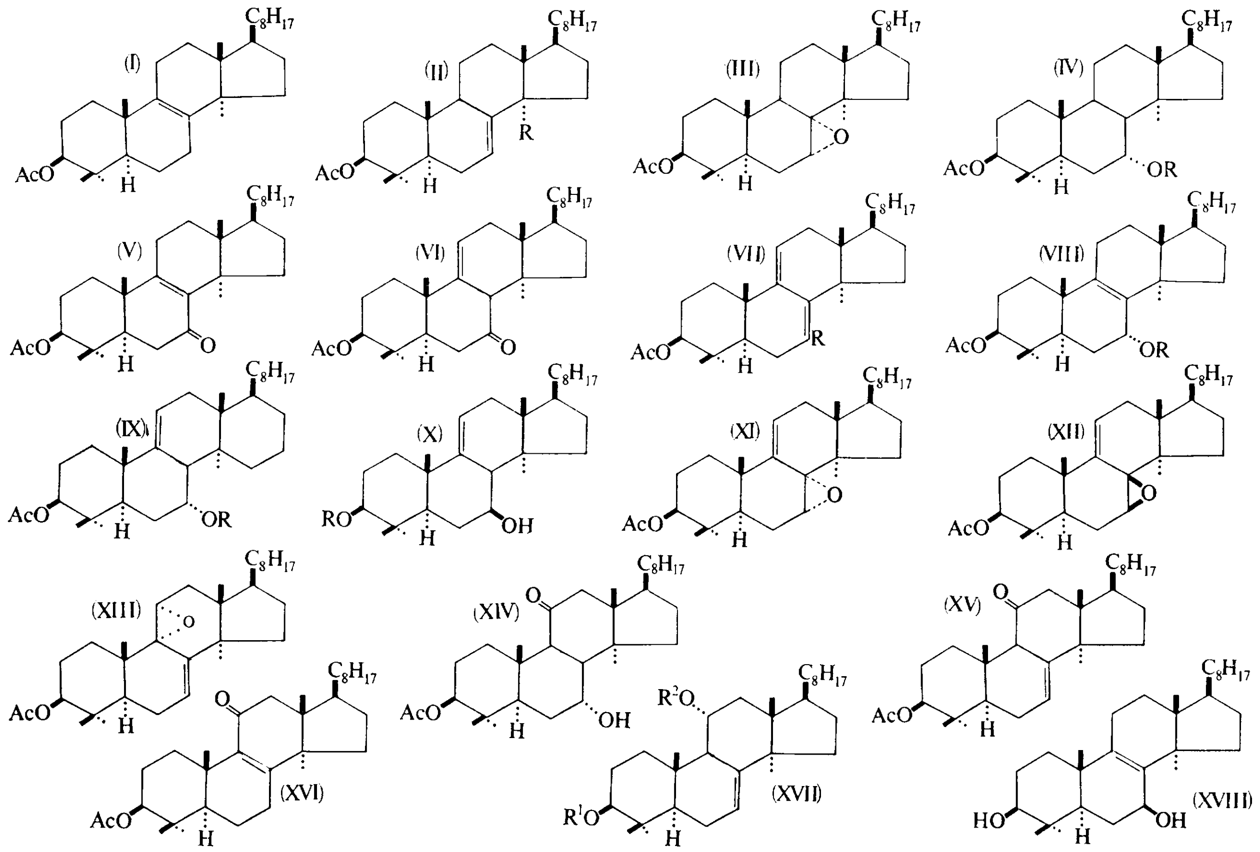
[12] A. Hassner and C. Heathcock, *J. Org. Chem.*, 1964, **29**, 1352.

[13] D. H. R. Barton, J. M. Beaton, L. E. Geller, and M. M. Pechet, *J. Amer. Chem. Soc.*, 1961, **83**, 4076.

[14] K. Heusler and J. Kalvoda, *Angew. Chem. Internat. Edn.*, 1964, **3**, 525.

[15] K. Heusler, J. Kalvoda, P. Wieland, G. Anner, and A. Wettstein, *Helv. Chim. Acta*, 1962, **45**, 2575.

R = NO), as disclosed by a Dreiding model, appears suitable for proton abstraction from the axial 14α-methyl group. The synthesis of the $\Delta^{9(11)}$-7α-ol (IX; R = H) was therefore investigated. Reduction of the $\Delta^{9(11)}$-7-ketone (VI) with sodium borohydride in dioxan gave mainly the equatorial $\Delta^{9(11)}$-7β-ol (X), the n.m.r. spectrum of which contained a signal for the axial 7α-proton at τ 6·3 (W_H 27 c./sec.); the approach of the reagent is thus more retarded by the steric requirements of the two β-orientated methyl groups at C-10 and C-13 than by the steric influence of the closer single α-orientated methyl group at C-14. The $\Delta^{9(11)}$-7-ketone was unchanged by attempted hydrogenation with platinum oxide in ethyl acetate; in the presence of perchloric acid the sole product was 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H). The $\Delta^{7,9(11)}$-enol acetate (VII; R = OAc),[11] when treated with hydrogen–platinum oxide in ethyl acetate or with sodium borohydride in dioxan, methods successfully employed in the conversion of cholesta-3,5-dien-3-yl acetate into cholest-5-en-3β-yl acetate,[16] furnished mainly unchanged material, whilst use of hydrogen–platinum oxide in the presence of perchloric acid gave largely 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H).



An alternative approach to the $\Delta^{9(11)}$-7α-ol (IX; R = H) appeared to involve cleavage of the $\Delta^{9(11)}$-7α,8α epoxide (XI), derivable from 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H). Routes leading to the last-named compound were therefore examined. Treatment of 5α-lanost-8-en-3β-yl acetate (I) with *N*-bromosuccinimide gave an inseparable mixture of starting material and 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) in almost equal proportions, as disclosed in the n.m.r. spectrum by the integral of the 7- and 11-vinyl proton signals (τ 4·6) which together equal one proton, and by the two signals for the C(18)-methyl protons at τ 9·30 and 9·45, which were of almost equal intensity and together equal to three protons. Oxidation of 5α-lanost-7-ene-3β-yl acetate[3] (II; R = Me) with selenium dioxide[17] gave a reasonable yield of 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H), the n.m.r. spectrum of which showed a two-proton multiplet signal at τ 4·6 (vinyl 7-H and 11-H), and a signal for three protons at τ 9·45 [C(18)-Me], and the u.v. spectrum of which exhibited the characteristic absorption bands at 237 244, and 257 mμ.[18] It has been reported[11] that the action of mono-perphthalic acid on 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) gave a $\Delta^{9(11)}$-7,8-epoxide (m.p. 184°) since on treatment with boron trifluoride the latter yielded the Δ^{8}-7-ketone (V). However, 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) when treated with *m*-chloroperbenzoic acid (1 mol.) gave two

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[16] W. S. Johnson, private communication.

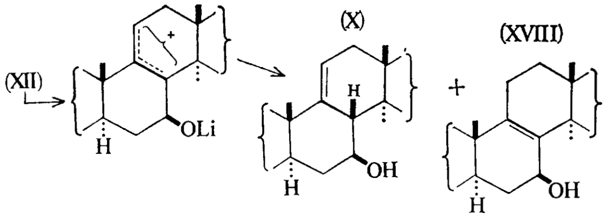
[17] L. J. Bellamy and C. Dorée, *J. Chem. Soc.*, 1941, 176.

[18] C. Dorée, J. F. McGhie, and F. Kurzer, *J. Chem. Soc.*, 1949, 570.

isomeric epoxides, a $\Delta^{9(11)}$-7β,8β-epoxide (m.p. 177°) (XII) and a Δ^{7}-9α,11α-epoxide (m.p. 187°) (XIII), which when treated with boron trifluoride gave respectively the Δ^{8}-7-ketone (VI) and a mixture of Δ^{7}-11-ketone (XV) and Δ^{8}-11-ketone (XVI) (as shown by i.r. spectroscopy). The n.m.r. spectrum (deuteriopyridine) of each epoxide contained signals for one vinyl proton at τ 4·3, for the 3α-proton at τ 5·4 and for one proton on the carbon atom connected to the epoxide group at τ 6·9 (W_H 8 c./sec.), but a study of Dreiding models of the two sets of epimeric epoxides indicated that neither the configurations of the 7α,8α-epoxide and the 7β,8β-epoxide pair, nor those of the 9α,11α-epoxide and 9β,11β-epoxide pair, can be determined by reference to the width of the signal in the n.m.r. spectrum as is usual for alcohols.[12]

Reduction of the epoxides (XII) and (XIII) with lithium–ethylamine in the presence of t-butyl alcohol gave respectively the $\Delta^{9(11)}$-3β,7β-diol (X; R = H) and the Δ^{7}-3β,11α-diol (XVII; $R^1 = R^2 = H$). The $\Delta^{9(11)}$-3β,7β-diol (X; R = H) was also prepared by basic hydrolysis of 3β-acetoxy-5α-lanost-9(11)-en-7β-ol (X; R = Ac). The Δ^{7}-3β,11α-diol (XVII; $R^1 = R^2 = H$) was also obtained by the action of lithium–ethylamine in t-butyl alcohol on the thionyl chloride–pyridine dehydration product from 3β-acetoxy-7α-hydroxy-5α-lanostan-11-one (XIV),[2] and formed a diacetate (XVII; $R^1 = R^2 =$ Ac) with acetic anhydride–pyridine at 20°, which indicated that an equatorial 11α-hydroxy-group was present, since an 11β-hydroxy-group is unaffected under these conditions.[11,19] The n.m.r. spectrum of each crude diol contained a signal for the 3α-proton at τ 6·8, a broad signal for an axial proton on the carbon atom bearing the oxygen atom at τ 6·3 (W_H 25 c./sec.), and a signal for a vinyl proton, (2/3H integral) at τ 4·7. The fact that the signals for the vinyl 11-proton in the diol (X; R = H) and for the vinyl 7-proton in the diol (XVII; $R^1 = R^2 = H$) integrated for only 2/3H suggests that these major products are accompanied respectively by the diol (XVIII) and by 5α-lanost-8-ene-3β,11α-diol.

The reactions [(XII) ⟶ (X; R = H)] and [(XIII) ⟶ (XVII; $R^1 = R^2 = H$)] appear to be examples of equatorial fission of an epoxide,[20] and to explain these occurrences we suggest participation of the double bond.[21]



As neither the 3β,7β-diol (X; R = H), nor the 3β,11α-diol (XVII; $R^1 = R^2 = H$) had the geometry required for hydrogen abstraction at C-32 this approach was not further investigated.

EXPERIMENTAL

For general experimental directions see *J. Chem. Soc.*, 1959, 345. M.p.s were determined with a Kofler hot-stage apparatus. U.v. absorption spectra (solutions in ethanol) and i.r. absorption spectra (solutions in carbon tetrachloride) were measured with Perkin-Elmer 4000A and 221 spectrophotometers, respectively. N.m.r. spectra were measured with Varian A60 or HA100 instruments with deuteriochloroform as solvent and tetramethylsilane as internal reference. Column chromatography was performed with alumina (Spence type H, activity II) or silica gel (Davison, 100—200 mesh). T.l.c. was carried out with silica plates in ether–benzene (1 : 10), and the plates developed with sulphuric acid. Mass spectral determinations were performed with an MS9 double-focus mass spectrometer.

3β-*Acetoxy*-5α-*lanost*-7-*ene* (II; R = Me).—3β-Acetoxy-5α-lanost-8-ene (I) (30 g.) in chloroform (150 ml.) at 0° was treated with a stream of dry hydrogen chloride for 2 hr. and left at 20° for 14 hr. The n.m.r. spectrum of an aliquot (1 ml.), worked up in the usual way, indicated 63% conversion into the 7-ene (II; R = Me) as shown by the ratio of the 7-vinyl proton signal (τ 4·8) to the 3α-proton signal (τ 5·47). Unchanged 8-ene was oxidized to the 7,11-diketone, according to the method of Marker *et al.*,[3] and the product was recystallised twice from ethyl acetate–methanol (1 : 1) to give 3β-acetoxy-5α-lanost-7-ene (9 g.), m.p. 146—147° (lit.,[2] 149°) τ 4·8 (7-H), 9·08 (32-Me), 9·35 (13β-Me), and 9·19 (10β-Me).

3β-*Acetoxy*-7α,8α-*epoxy*-5α-*lanostane* (III).—The 7-ene (II; R = Me) (1 g.) in chloroform (10 ml.) was treated with *m*-chloroperbenzoic acid (1 g.) in chloroform (20 ml.) at 0° for 20 hr. The product, which showed one main spot on t.l.c., was worked up to give the 7α,8α-epoxide (III) (565 mg.), m.p. 148—149° (from methanol containing a trace of pyridine) (lit.,[4] m.p. 156—157°), τ 6·5, W_H 9 c./sec. (7β-H) (Found: C, 78·9; H, 10·8. Calc. for $C_{32}H_{54}O_3$: C, 78·9; H, 11·2%).

Oxidation of 3β-*Acetoxy*-5α-*lanost*-8-*ene* (I).—3β-Acetoxy-5α-lanost-8-ene (40 g.) in chloroform (135 ml.) and acetic acid (200 ml.) was treated dropwise, with stirring, with a solution of chromium trioxide (40 g.) in water (20 ml.) at 25—30°. The mixture was diluted with water (400 ml.) and extracted with chloroform to give a crude product, which was chromatographed on silica (1500 g.) in hexane. Elution with ether–hexane (1 : 9) gave unchanged 8-ene (2·5 g.), m.p. and mixed m.p. 117°. Elution with ether–hexane (1 : 6) gave 3β-acetoxy-5α-lanost-9(11)-en-7-one (VI) (6 g.), m.p. 149—151° (from ethyl acetate) (lit.,[11] m.p. 153—154°), no selective u.v. absorption *ca.* 240 mμ, $\nu_{max.}$ 1706 cm.$^{-1}$, τ 4·6 (11-H) (Found: C, 79·4; H, 11·0. Calc. for $C_{32}H_{52}O_3$: C, 79·3; H, 10·8%). Further elution with the same eluant gave material (7·5 g.) shown by t.l.c. to contain at least three compounds, and finally 3β-acetoxy-5α-lanost-8-en-7-one, m.p. 147° (lit.,[11] 149—150°), $\lambda_{max.}$ 255 mμ (log ε 4·0), $\nu_{max.}$ 1738 and 1669 cm.$^{-1}$ The 9(11)-en-7-one (VI) in benzene, when treated with boron trifluoride etherate according to the method of Mijović *et al.*,[11] gave 3β-acetoxy-5α-lanost-8-en-7-one (V).

Reduction of 3β-*Acetoxy*-5α-*lanost*-8-*en*-7-*one* (V).—(a) *With hydrogen–platinum.* 3β-Acetoxy-5α-lanost-8-en-7-one

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[19] W. Voser, M. Montavon, H. H. Gunthard, O. Jeger, and L. Ruzicka, *Helv. Chim. Acta*, 1950, **33**, 1893.

[20] D. H. R. Barton, D. A. Lewis, and J. F. McGhie, *J. Chem. Soc.*, 1957, 2907.

[21] C. W. Shoppee and G. H. R. Summers, *J. Chem. Soc.*, 1952, 3361.

(200 mg.) in ethyl acetate (50 ml.) was shaken in hydrogen with platinum oxide (100 mg.) and a trace of perchloric acid until hydrogen absorption ceased. After the usual work-up, the residue was chromatographed on silica in pentane to give a mixture of 3β-acetoxy-5α-lanost-8-ene (I) and 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H), identical with the product obtained by similar reduction of the 9(11)-en-7-one (VI).

(b) *With sodium borohydride.* 3β-Acetoxy-5α-lanost-8-en-7-one (2 g.) in aqueous dioxan (50 ml.) was treated with sodium borohydride (100 mg.) in dioxan (20 ml.) at 20° for 24 hr. The usual work-up gave a crude product which was chromatographed on silica (200 g.) in hexane. Elution with ether–hexane (1 : 19) gave 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) (250 mg.), identified by comparison with an authentic sample. Further elution with ether–hexane (1 : 9) gave unchanged 8-en-7-one (V) (700 mg.); elution with ether gave 3β-*acetoxy*-5α-*lanost*-8-*en*-7α-*ol* (VIII) (500 mg.), m.p. 169—170°, $\nu_{max.}$ 3585 cm.$^{-1}$, τ 5·4 (3α-H) and 5·8 (W_H 10 c./sec., 7β-H) (Found: C, 78·3; H, 11·1. $C_{32}H_{54}O_3$ requires C, 78·9; H, 11·2%).

3β-*Acetoxy*-5α-*lanost*-8-*en*-7α-*yl Nitrite* (VIII; R = NO).—The 8-en-7α-ol (VIII; R = H) (100 mg.) in pyridine (10 ml.) at 0° was treated with a stream of nitrosyl chloride according to the method of Barton *et al.*[13] Water (100 ml.) was added and the suspension was left overnight to allow coagulation and the product was filtered to give the *nitrite* (VIII; R = NO) (90 mg.), $\nu_{max.}$ 1626 (N=O) and 756 (O–N) cm.$^{-1}$, mass spectrum: no parent peak (515), base peak (469) corresponding to loss of NO_2. Attempted crystallisation from various solvents led to decomposition to 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H); this substance was also isolated after attempted purification by preparative t.l.c. on silica.

Photolysis of 3β-*Acetoxy*-5α-*lanost*-8-*en*-7α-*yl Nitrite* (VIII; R = NO).—The nitrite (VIII; R = NO) (90 mg.) in toluene (50 ml.) under nitrogen was irradiated in a Pyrex tube with a 125 w lamp (in a cooling jacket) immersed directly in the solution for 20 min. to give the 8-en-7α-ol (VIII; R = H) (75 mg.), identical with an authentic sample. This conversion appeared to be photochemical, since a sample of the 8-en-7α-yl nitrite (VIII; R = NO) was stable in dry toluene for 2 days.

Action of Lead Tetra-acetate and Iodine on 3β-*Acetoxy*-5α-*lanost*-8-*en*-7α-*ol* (VIII; R = H).—Lead tetra-acetate (2 g.) and calcium carbonate (1 g.) were heated at 80° for 10 min. in cyclohexane (25 ml.); iodine (500 mg.) and the 8-en-7α-ol (VIII; R = H) (100 mg.) were added, and the mixture was heated under reflux during irradiation with a 500 w tungsten lamp. After 2½ hr. the cooled mixture was filtered, and the filtrate was washed with 10% sodium thiosulphate solution (40 ml.) and with water. Removal of the solvent left 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H), identical with an authentic sample.

Reduction of 3β-*Acetoxy*-5α-*lanost*-9(11)-*en*-7-*one* (VI).—(a) *With hydrogen and platinum.* 3β-Acetoxy-5α-lanost-9(11)-en-7-one (VI) (200 mg.), in ethyl acetate (50 ml.) containing a trace of perchloric acid, was shaken in hydrogen with platinum oxide (100 mg.) until hydrogen uptake ceased. The usual work-up gave a mixture (m.p. 145°), of 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) and the 8-ene (I). The former was identified by its characteristic u.v. absorption spectrum[11] ($\lambda_{max.}$ 236, 244, and 252 mμ); the n.m.r. spectrum showed the product to be a mixture. The signal at τ 4·5 (7-H, 11-H) was of low intensity, and the expected signal at τ 9·45 [13β-Me in (VIII)] was accompanied by another signal at τ 9·30 [13β-Me in (I)].

(b) *With sodium borohydride.* The $\Delta^{9(11)}$-ene-7-one (VI) (250 mg.) in dioxan (30 ml.) was treated with sodium borohydride at 20° for 48 hr. The product was worked up in the usual way to give 3β-*acetoxy*-5α-*lanost*-9(11)-*en*-7β-*ol* (X; R = Ac), m.p. 143—145° (from acetic acid), $\nu_{max.}$ 3612 cm.$^{-1}$, τ 4·7 (11-H) and 6·3 (W_H 27 c./sec., 7α-H) (Found: C, 76·45; H, 11·1. $C_{32}H_{54}O_3,H_2O$ requires C, 76·5; H, 11·2%).

3β-*Acetoxy*-5α-*lanost*-9(11)-*ene*-7α-*ol* (IX; R = H).—Attempted reduction of the enol acetate (VII; R = OAc)[11] in dioxan with sodium borohydride for 48 hr. at 20°, or by hydrogenation with platinum oxide in ethyl acetate, gave only unchanged material. In the presence of perchloric acid hydrogenation yielded mainly 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H).

Preparation of 3β-*Acetoxy*-5α-*lanosta*-7,9(11)-*diene* (VII; R = H).—(a) *With* N-*bromosuccinimide on* 3β-*acetoxy*-5α-*lanost*-8-*ene* (I). 3β-Acetoxy-5α-lanost-8-ene (5 g., 1 mol.) in anhydrous carbon tetrachloride (60 ml.) was heated under reflux with *N*-bromosuccinimide (2 g., 0·9 mol.) for 2 hr. Succinimide was filtered off and the carbon tetrachloride solution was washed with 3N-sodium hydroxide and with water. The solvent was removed and the residue, dissolved in hexane, was filtered through an alumina column (40 g.) to give a mixture of 3β-acetoxy-5α-lanost-8-ene (I) and 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H) (1·65 g.), m.p. 148—150° (from acetone), $\lambda_{max.}$ 236, 244, and 252 mμ (log ε 3·79, 3·86, and 3·72) [lit.,[18] $\lambda_{max.}$ 237, 244, and 251 mμ (log ε 4·17, 4·23, and 4·04)], τ 4·6 (7-H and 11-H; integral 1H), and a split signal at τ 9·25 and 9·45 (13β-Me, combined integral 3H).

(b) *With selenium dioxide on* 3β-*acetoxy*-5α-*lanost*-7-*ene* (II; R = Me).—3β-Acetoxy-5α-lanost-7-ene (1 g., 0·5 mol.) in acetic acid (30 ml.) was treated with an excess of selenium dioxide (1 g.) as a saturated aqueous suspension and heated under reflux for 4 hr. The boiling solution was filtered to remove selenium and cooled. The crystals were filtered off and dissolved in hexane, and the solution was filtered through an alumina column (20 g.). The product had m.p. 169—171° (from methanol), $\lambda_{max.}$ 237, 244, and 252 mμ, (log ε 4·19, 4·27, and 4·08), τ 4·6 (7-H and 11-H, integral 2H) and 9·45 (13β-Me, integral 3H).

Epoxidation of 3β-*Acetoxy*-5α-*lanosta*-7,9(11)-diene (VII; R = H).—3β-Acetoxy-5α-lanosta-7, 9(11)-diene (VII; R = H) (200 mg.) was treated with *m*-chloroperbenzoic acid (95 mg., 1 mol.) in chloroform (20 ml.) at 0° for 20 hr. The product, isolated in the usual way, was chromatographed on neutralized reactivated alumina[22] in hexane. Elution with hexane gave starting material (60 mg.), m.p. and mixed m.p. 169°. Further elution with hexane and with ether–hexane (1 : 49) gave two monoepoxides, separated by preparative t.l.c. on silica in ether–hexane (1 : 49). The less polar compound was 3β-*acetoxy*-7β,8β-*epoxy*-5α-*lanost*-9(11)-*ene* (XII) (54 mg.), m.p. 177—178° (from ether) [Found: *M* (mass spectrometry), 484·390. $C_{32}H_{52}O_3$ requires *M*, 484·3916]; the mass spectrum showed the parent peak (100%), and peaks at *M* − 15 (90%) and *M* − 60 (50%); n.m.r. spectrum: τ 4·3 (11-H), 5·4 (3α-H), and 6·9 [W_H 8 c./sec., for one proton (7α-H) on carbon attached to oxygen]. The more polar compound was 3β-*acetoxy*-9α,11α-*epoxy*-5α-*lanost*-7-*ene* (XIII) (69 mg.), m.p.

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[22] T. Reichstein and C. W. Shoppee, *Discuss. Faraday Soc.*, 1949, 305.

187—188° (from ether) [Found: M (mass spectrometry), 484·390. $C_{32}H_{52}O_3$ requires M, 484·3916]; the mass spectrum showed the parent peak (100%), and peaks at $M - 29$ (90%) and $M - 141$ (60%); n.m.r. spectrum: τ 4·3 (7-H), 5·4 (3α-H), and 6·9 [W_H 8 c./sec., for one proton (11α-H) on carbon attached to oxygen].

Rearrangement of Epoxides (XII) *and* (XIII) *with Boron Trifluoride.*—(*a*) The $\Delta^{9(11)}$-7β,8β-epoxide (XII) (5 mg.) in benzene (5 ml.) at 20° was treated with boron trifluoride etherate (5 drops) for 5 min.; the mixture was diluted with water and extracted with ether, and the product was purified by preparative t.l.c. on silica to give 3β-acetoxy-5α-lanost-8-en-7-one (V), m.p. and mixed m.p. 145—146°, $\nu_{max.}$ 1738 (OAc), 1655 (Δ^8-C(7)O), and 1585 cm.$^{-1}$, identical in the fingerprint region with the spectrum of an authentic sample.

(*b*) The Δ^7-9α,11α-epoxide (XIII) (5 mg.) in benzene (5 ml.) at 20° was treated with boron trifluoride etherate for 5 min. The mixture was diluted with water and worked up as before to yield a mixture of 3β-acetoxy-5α-lanost-8-en-11-one (XVI), $\nu_{max.}$ (Nujol) 1735 (OAc) and 1670 (Δ^8-C(11)O) cm.$^{-1}$, and 3β-acetoxy-5α-lanost-7-en-11-one (XV), $\nu_{max.}$ (Nujol) 1735 (OAc) and 1715 (11-CO) cm.$^{-1}$. After equilibration of the mixture with boron trifluoride etherate in benzene at 20° for 24 hr., the conjugated Δ^8-11-ketone (XVI), m.p. 126°, $\nu_{max.}$ 1735 and 1660 cm.$^{-1}$, was obtained.

Dehydration of 3β-*Acetoxy*-7α-*hydroxy*-5α-*lanostan*-11-*one* (XIV).—The 7α-hydroxy-11-ketone (XIV) (20 mg.) in pyridine (5 ml.) was treated with thionyl chloride (0·5 ml.) at 0° for 5 min. The product was poured on ice, and extracted with ether to yield a mixture of the Δ^7-11-ketone (XV) and the Δ^8-11-ketone (XVI), $\nu_{max.}$ (Nujol) 1735, 1715, and 1670 cm.$^{-1}$, which when equilibrated with boron trifluoride etherate in benzene at 20° for 24 hr. gave the Δ^8-11-ketone (XVI), m.p. 126° (lit.,[11] m.p. 130—132°), $\nu_{max.}$ 1735 and 1660 cm.$^{-1}$, fingerprint region identical with the spectrum of the sample prepared from the epoxide (XIII) by treatment with boron trifluoride etherate.

Reductive Cleavage of Epoxides (XII) and (XIII) *with Lithium–Ethylamine–t-Butyl Alcohol.*—(*a*) The $\Delta^{9(11)}$-7β,8β-epoxide (XII) (50 mg.) in ethylamine (15 ml.) containing t-butyl alcohol (5 drops) was treated at 0° with lithium, and the mixture was set aside at 0° until a blue colouration persisted. Ethylamine was evaporated off, ether was added, and the solution was filtered to remove any lithium. After the usual work-up, the product was chromatographed on silica in ether–hexane (1 : 9) to remove any non-polar compounds, and preparative t.l.c. of the polar fractions on silica in methanol–chloroform–ether (1 : 9·5 : 9·5) gave the $\Delta^{9(11)}$-3β,7β-diol (X; R = H), m.p. 212—214° (from ether) (lit.,[23] 213—214°), $\nu_{max.}$ (Nujol) 3350 cm.$^{-1}$, τ 4·7 (11-H), 6·25 (W_H 27 c./sec., 7α-H), and 6·7 (3α-H) all unchanged by deuterium exchange, and 9·34 (13β-Me). Hydrolysis of 3β-acetoxy-5α-lanost-9(11)-en-7β-ol (X; R = Ac) (50 mg.) with methanolic potassium hydroxide under reflux for 1 hr., followed by the usual isolation procedure, gave the $\Delta^{9(11)}$-3β,7β-diol (X; R = H), m.p. and mixed m.p. 213—214° (from ether), $\nu_{max.}$ (Nujol) 3350 cm.$^{-1}$, τ 4·7 (11-H), 6·25 (W_H 27 c./sec., 7α-H), and 6·7 (3α-H), all unaltered after deuterium exchange, and 9·34 (13β-Me).

(*b*) The Δ^7-9α,11α-epoxide (XIII) (50 mg.) in ethylamine (15 ml.) containing t-butyl alcohol (5 drops) was treated with lithium at 0° as in (*a*), and the product was isolated similarly. Preparative t.l.c. of the polar fractions in methanol–chloroform–ether (1 : 9·5 : 9·5) gave 5α-*lanost*-7-*ene*-3β,11α-*diol* (XVII; $R^1 = R^2 = H$), m.p. 197—199° (from acetonitrile), $\nu_{max.}$ (Nujol) 3325 cm.$^{-1}$, τ 4·75 (7-H), 6·1 (W_H 36 c./sec., 11β-H), 6·7 (3α-H), and 9·38 (13β-Me) [Found: M (mass spectrometry), 444·397. $C_{30}H_{52}O_2$ requires M, 444·3967]. The diacetate (XVII; $R^1 = R^2 = Ac$), prepared by use of acetic anhydride–pyridine at 20°, did not crystallise; the oil had $\nu_{max.}$ 1740 cm.$^{-1}$ (OAc), with no selective absorption in the u.v. at λ 236, 244, or 252 mμ (cf. ref. 18), and its mass spectrum showed no parent peak at m/e 528, but a peak at $M - 60$ (100%), probably corresponding to loss of the 11α-acetoxy-group to give 3β-acetoxy-5α-lanosta-7,9(11)-diene (VII; R = H). Reduction of 3β-acetoxy-5α-lanost-7-en-11-one (XV) (50 mg.) with lithium in ethylamine–t-butyl alcohol as in (*a*), followed by preparative t.l.c. of the product on silica in methanol–chloroform–ether (1 : 9·5 : 9·5) gave the Δ^7-3β-11α-diol (XVII; $R^1 = R^2 = H$), m.p. and mixed m.p. 197—198°, $\nu_{max.}$ (Nujol) 3325 cm.$^{-1}$, τ 4·75 (7-H), 6·1 (W_H 35 c./sec., 11β-H), 6·7 (3α-H), and 9·38 (13β-Me).

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