Crystalline Chemical Components of *Fomes senex* and Structure of Senexdiolic acid and Related Compounds

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The isolation of four new terpenoid (one C_{30} and three C_{29}) compounds from the fungus *Fomes senex* and the elucidation of their structures are described. The C_{30} compound, senexdiolic acid, is shown to be 3β,22-dihydroxylanosta-8,24-dien-30-oic acid (Ia), senexonol is 22-hydroxy-31-norlanosta-8,24-dien-3-one (Il), senexdione is the corresponding nor-diketone (Io), and oxidosenexone is 22,25-epoxy-31-norlanost-8-en-3-one (IIe). These compounds have significance for the biosynthesis of sterols.

THE wood-rotting fungus *Fomes senex* has not been studied chemically. We have described the structure of new crystalline components of this fungus in a preliminary note,[1] and we now provide details of the isolation of the known and new compounds, and the elucidation of the structures of the latter.

The light petroleum extract of the fungus contained three new neutral compounds and two known triterpene acids, trametenolic acid B and pinicolic acid A. The subsequent ether extract contained a new acid which has been named senexdiolic acid.

Structure of Senexdiolic Acid (Ia).—The formula, $C_{30}H_{48}O_4$, the Liebermann–Burchard colour reaction, and the n.m.r. spectra of the derivatives showed that it was a tetracyclic triterpene. It contained one carboxy-group and two hydroxy-groups which could be easily acetylated, and oxidised with chromium trioxide to oxo-groups. The latter reaction was carried out on the methyl ester (Ib). The tetranitromethane test was positive.

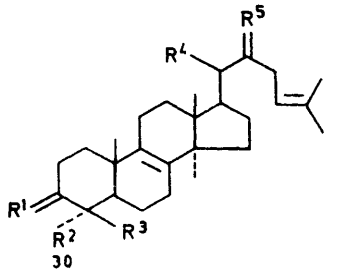
The 24,25-*double bond and* 22-*hydroxy-group*. The molecular formula showed the presence of two double bonds, and one was easily reducible under catalytic conditions, the other resistant. The location of the former at position 24,25 was deduced from the formation of acetone from ozonolysis of the diacetate (Ic) or on treating it with OsO_4–$NaIO_4$, and from the fragment (*a*) (*m*/*e* 69) in the mass spectrum of the ester (Ib).[2] The location of a hydroxy-group at C-22 was inferred from the signal for $-CO{\cdot}CH_2CH{=}C$ in the n.m.r. spectrum of the dioxo-ester (Ie) and from the fragment (*b*) (*m*/*e* 99) in the mass spectrum of (Ib). On heating with acid in alcoholic solution, senexdiolic acid was isomerised to a new compound in which the side chain hydroxy-group and double bond were no longer present. Similar treatment of 24,25-dihydrosenexdiolic acid produced no change. On the basis of its spectral properties and those of its derivatives the acid isomerisation product of senexdiolic acid may be assigned the epoxide structure (IIa).

The 3-*hydroxy-group and carboxy-group*. When the epoxy-acid (IIa) was oxidised with chromium trioxide, a neutral nor-ketone was obtained. Obviously the initial product is a β-keto-acid. It is shown later that the hydroxy-group in ring A of senexdiolic acid has the 3β-configuration and hence the nor-product from (IIa) may be represented as (IIe). The colour reactions and spectral properties were in agreement with this structure. From this it followed that the carboxy-group in (IIa) and (Ia) should be at C-30 or -31.

The i.r. spectra of the esters (Ib), (Ie), (IIb), and (IId) exhibited a strong absorption at *ca.* 1245 cm^{-1} which could be ascribed to an equatorial ester group.[3] Further, when the ester group in compound (Ib) was reduced with lithium aluminium hydride to the primary alcohol (If), and this was subsequently acetylated to give (Ig), the n.m.r. signal of the CH_2OAc protons appeared as an AB quartet centred at δ 3·81 p.p.m. (*J* 12 Hz), thus

[1] A. K. Batta and S. Rangaswami, *Current Sci.*, 1970, **39**, 416.
[2] G. Galli and S. Marconi, *Steroids*, 1967, **10**, 189.
[3] S. Bory and M. Fetizon, *Bull. Soc. chim. France*, 1964, 570.

showing that the CH_2OAc group was equatorial.[4] Thus the carboxy-group was identified as having come from C-30.



(I)

a; $R^1 = \alpha$-OH, $R^2 = CO_2H$, $R^3 = R^4 = Me$, $R^5 = H,OH$

b; $R^1 = \alpha$-OH, $R^2 = CO_2Me$, $R^3 = R^4 = Me$, $R^5 = H,OH$

c; $R^1 = \alpha$-OAc, $R^2 = CO_2H$, $R^3 = R^4 = Me$, $R^5 = H,OAc$

d; $R^1 = \alpha$-OAc, $R^2 = CO_2Me$, $R^3 = R^4 = Me$, $R^5 = H,OAc$

e; $R^1 = R^5 = O$, $R^2 = CO_2Me$, $R^3 = R^4 = Me$

f; $R^1 = \alpha$-OH, $R^2 = CH_2OH$, $R^3 = R^4 = Me$, $R^5 = H,OH$

g; $R^1 = \alpha$-OAc, $R^2 = CH_2OAc$, $R^3 = R^4 = Me$, $R^5 = H,OAc$

h; $R^1 = \alpha$-OH, $R^2 = R^3 = Me$, $R^4 = CO_2H$, $R^5 = H_2$

i; $R^1 = \alpha$-OH, $R^2 = R^3 = Me$, $R^4 = CO_2Me$, $R^5 = H_2$

j; $R^1 = O$, $R^2 = R^3 = Me$, $R^4 = CO_2H$, $R^5 = H_2$

k; $R^1 = \alpha$-OH, $R^2 = R^3 = Me$, $R^4 = CH_2OH$, $R^5 = H_2$

l; $R^1 = O$, $R^2 = R^4 = Me$, $R^3 = H$, $R^5 = H,OH$

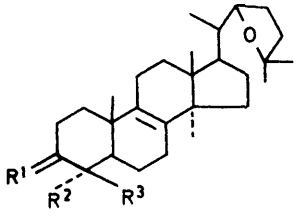
m; $R^1 = H_2$, $R^2 = R^4 = Me$, $R^3 = H$, $R^5 = H,OH$

n; $R^1 = \alpha$-OH, $R^2 = R^4 = Me$, $R^3 = H$, $R^5 = H,OH$

o; $R^1 = R^5 = O$, $R^2 = R^4 = Me$, $R^3 = H$

The 8,9-double bond. The double bond which resisted catalytic hydrogenation was shown by i.r. to be tetrasubstituted. Oxidation of (IIIb) with selenium dioxide gave a product which showed $\lambda_{max.}$ and log ε values characteristic of $\Delta^{7,9(11)}$lanostadiene compounds, and hence, the original double bond should be at position 8,9.

Correlation with lanostenol. The triol (IIIc) prepared from (If) was converted into the tritosylate (IIId) and this was reduced with lithium aluminium hydride. One of the products was identical with lanost-8-en-3β-ol (IIIe) which was prepared from trametenolic acid B (Ih) by converting it into lanost-8-ene-3,21-diol (IIIf) and treating its ditosylate (IIIg) with lithium aluminium hydride. This result correlated the new compound with a known member of the lanostane series, and established the location and stereochemistry of the hydroxy-group in ring A. Hence, senexdiolic acid is 3β,22-dihydroxylanosta-8,24-dien-30-oic acid (Ia). The configuration at C-22 is presently under study.



(II)

a; $R^1 = \alpha$-OH, $R^2 = CO_2H$, $R^3 = Me$

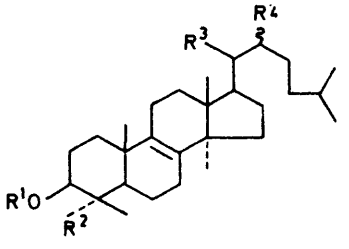
b; $R^1 = \alpha$-OH, $R^2 = CO_2Me$, $R^3 = Me$

c; $R^1 = \alpha$-OAc, $R^2 = CO_2H$, $R^3 = Me$

d; $R^1 = O$, $R^2 = CO_2Me$, $R^3 = Me$

e; $R^1 = O$, $R^2 = Me$, $R^3 = H$

Structure of the Neutral Compounds.—The nor-compound (IIe) obtained from (IIa) as described earlier, was identical with one of the neutral components of the light petroleum extract, named oxidosenexone. The same compound was formed by acid treatment of another neutral component which possessed a hydroxy- and an oxo-group, an easily reducible and a resistant double bond, and gave a positive Zimmermann colour test. This latter compound should, therefore, have the structure (II) and has been called senexonol. Mild CrO_3 oxidation of senexonol gave rise to the third neutral component which has two oxo-groups and two double bonds. It should therefore have the structure (Io) and has been called senexdione.



(III)

a; $R^1 = Ac$, $R^2 = CO_2H$, $R^3 = Me$, $R^4 = OAc$

b; $R^1 = Ac$, $R^2 = CO_2Me$, $R^3 = Me$, $R^4 = OAc$

c; $R^1 = H$, $R^2 = CH_2OH$, $R^3 = Me$, $R^4 = OH$

d; $R^1 = Ts$, $R^2 = CH_2OTs$, $R^3 = Me$, $R^4 = OTs$

e; $R^1 = R^4 = H$, $R^2 = R^3 = Me$

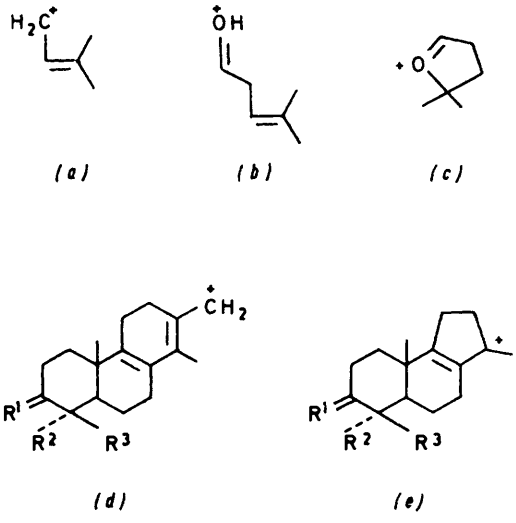
f; $R^1 = R^4 = H$, $R^2 = Me$, $R^3 = CH_2OH$

g; $R^1 = Ts$, $R^2 = Me$, $R^3 = CH_2OTs$, $R^4 = H$

Mass spectral fragmentations of the four new compounds were fully consistent with the structures assigned to them. Two diagnostically useful fragments (*a*) and

[4] A. Gaudemer, J. Polonsky, and E. Henkert, *Bull. Soc. chim. France*, 1964, 407.

(*b*) derivable from the side chain have already been referred to. Fragment (*a*) was observed in the case of (Ib), (Ic), (Il), and acetyl-(Im). Fragment (*b*) was observed in the case of (Ib) and (Il), and fragment (*c*) in the case of (IIe). The entire side chain also fragmented; the ion corresponding to (side chain — H_2O) (*m/e* 109)



was observed in the case of (Ib) and (Il), and the fragment corresponding to (side chain — AcOH) (*m/e* 109) was observed in the case of (Ic) and acetyl-(Im). The principal fragments from the ring system are those corresponding to (*d*) and (*e*) [see spectrum of (Il), acetyl-(Im), and (IIe)]. In the case of the 3-hydroxy-compound (Ib), only the anhydro(Δ^2)-fragments were recorded, while in the case of the 3-acetoxy-compound (Ic), besides (*d*) and (*e*), the Δ^2-fragments formed by loss of AcOH were also recorded.

The nor-compounds (Il), (Io), and (IIe) were unaffected by refluxing with alcoholic potassium hydroxide. According to Djerassi *et al.*[5] this indicates that the 4-methyl group has the stable equatorial configuration.

Recent studies on the biological demethylation of 4,4-dimethyl-sterols [6-8] have shown that of the two 4-methyl groups in the starting compound, the 4α-methyl group is eliminated first, the 4α-hydroxymethyl compound constituting an intermediate stage, and the residual 4β-methyl group is then epimerised to 4α- in the resulting compound. It is interesting to note that in senexdiolic acid the 4α-methyl group is oxygenated, and in the nor-compounds senexonol, senexdione, and oxidosenexone the orientation of the 4-methyl group is α. The isolation of the four new compounds together from the same natural source is therefore of significance for the biosynthesis of sterols.

[5] C. Djerassi, G. W. Krakower, A. J. Lemin, L. H. Liu, J. S. Mills, and R. Villotti, *J. Amer. Chem. Soc.*, 1958, **80**, 6284.

[6] K. B. Sharples, T. E. Snyder, T. A. Spencer, K. K. Maheshwari, G. Guhn, and R. B. Clayton, *J. Amer. Chem. Soc.*, 1968, **90**, 6874; K. B. Sharples, T. E. Snyder, T. A. Spencer, K. K. Maheshwari, J. A. Nelson, and R. B. Clayton, *ibid.*, 1969, **91**, 3394.

EXPERIMENTAL

M.p.s were taken on a Kofler block. Rotations were taken in chloroform unless otherwise stated. I.r. spectra were recorded on a Perkin-Elmer Infracord-137 spectrometer in KBr unless otherwise stated. N.m.r. spectra were taken in deuteriochloroform on a 60 MHz instrument with Me_4Si as internal reference. Acetates were prepared by reaction with acetic anhydride–pyridine at room temperature for 48 h. Methyl esters were prepared by using diazomethane. All the substances described gave Liebermann–Burchard and tetranitromethane colour reactions. For known compounds, only the molecular formulae are stated; these compounds all gave satisfactory values for C and H on elemental analysis.

The materials used in this investigation were collected from Dehra Dun at the foot of the Himalayas. The coarsely powdered fungus (3 kg) was extracted with light petroleum and then with ether.

Pinicolic Acid A (Ij) *and Tramentenolic Acid* B (Ih).—The light petroleum extract (20 g) was separated into acidic and non-acidic fractions and the former were chromatographed over silica gel (60 g). Chloroform eluted pinicolic acid A (Ij) (0·9 g), $C_{30}H_{46}O_3$, m.p. 205—207°, $[\alpha]_D$ +66·0°; methyl ester $C_{31}H_{48}O_3$, m.p. 120—121°, $[\alpha]_D$ +68·0°. Chloroform–methanol (49 : 1) eluted trametelonic acid B (Ih) (1·7 g), $C_{30}H_{48}O_3$, m.p. 258—261°, $[\alpha]_D$ +40·2°; methyl ester (Ii), $C_{31}H_{50}O_3$, m.p. 129—130°, $[\alpha]_D$ +48°; acetate, $C_{32}H_{50}O_4$, m.p. 239—242°, $[\alpha]_D$ +44·1°; methyl ester acetate, $C_{33}H_{52}O_4$, m.p. 145—146°, $[\alpha]_D$ +63·0°. The acid of m.p. 258—261° was converted into the acid of m.p. 205—207° described above by Oppenauer oxidation and the reverse transformation was achieved by the action of $NaBH_4$. The product of catalytic reduction (24,25-dihydro-derivative) of the ester acetate of (Ih) gave on SeO_2 oxidation the 7,9(11)-diene, m.p. 144—146°, $\lambda_{max.}$ (EtOH) 236, 243, and 252 nm (log ε 4·16, 4·26, and 4·13).

Isolation of Senexonol (Il), *Senexdione* (Io), *and Oxidosenexone* (IIe).—The non-acidic fraction (14·5 g) of the light petroleum extract was chromatographed over neutral alumina (300 g). The initial light petroleum–benzene (17 : 3) eluates on crystallisation from chloroform–methanol yielded oxidosenexone (IIe) as plates (0·06 g). The later eluates on repeated crystallisation from methanol yielded senexdione (Io) (0·02 g) as needles. Subsequent eluates, with light petroleum–benzene (3 : 1) on repeated crystallisation from methanol gave needles of senexonol (Il) (0·2 g).

Senexdiolic Acid (Ia).—The ether extract (4·8 g) consisted largely of acidic components which were separated from the neutral matter and chromatographed over silica gel (150 g). Chloroform–methanol (49 : 1) eluted small amounts of trametenolic acid B. Elution with chloroform–methanol (47 : 3) yielded *senexdiolic acid* (3β,22-*dihydroxylanosta*-8,24-*dien*-30-*oic acid*) (Ia) (2·1 g), which crystallised from chloroform–methanol as needles, m.p. 273—276°, $[\alpha]_D$ +74·4° (*c* 0·86, $CHCl_3$–MeOH 1 : 1) (Found: C, 76·4; H, 9·8. $C_{30}H_{48}O_4$ requires C, 76·3; H, 10·2%); $\nu_{max.}$ 3570, 1700, 1660, 1256, 1027, and 810 cm^{-1}; *methyl ester* (Ib), m.p. 199—201°, $[\alpha]_D$ +69·6° (*c* 1·72) (Found: C, 76·2; H, 10·4. $C_{31}H_{50}O_4$ requires C, 76·5; H, 10·3%); $\nu_{max.}$ 3600, 1730, 1254, 1245, 1045, 1035, and 856 cm^{-1}; δ 5·08 (1H, m, $CH_2CH{=}C$), 3·68 (3H, s, CO_2Me), 1·71, 1·63 (6H, 2 s,

[7] E. L. Ghisalberti, N. J. DeSouza, H. H. Rees, L. J. Goad, and T. W. Goodwin, *Chem. Comm.*, 1969, 1403.

[8] F. F. Knapp and H. J. Nicholas, *Chem. Comm.*, 1970, 399.

C=CMe$_2$), and 1·12—0·70 (15H, 4 s, 5 × Me), *m/e* 486 (M^+, 12%), 471 (6), 453 (6), 341 (M^+ — side chain — H_2O, 7), 299 [fragment (*d*) — H_2O, 3], 273 [fragment (*e*) — H_2O, 4], 109 (side chain — H_2O, 23), 99 [fragment (*b*), 47], and 69 [fragment (*a*), 100]; *acetate* (Ic) of the parent acid, m.p. 224—226°, $[\alpha]_D$ +77·1° (*c* 0·70) (Found: C, 73·1; H, 9·8. $C_{34}H_{52}O_6$ requires C, 73·4; H, 9·4%), *m/e* 556 (M^+, 3%), 496 (9), 481 (34), 421 (11), 387 (M^+ — side chain, 7), 345 [fragment (*d*), 6], 327 (M^+ — side chain — AcOH, 11), 319 [fragment (*e*), 6], 285 [fragment (*d*) — AcOH, 7], 259 [fragment (*e*) — AcOH, 8], 109 (side chain — AcOH, 91), 69 [fragment (*a*), 80], and 43 (100); *acetate* (Id) of the methyl ester, m.p. 163—164°, $[\alpha]_D$ +47·6° (*c* 1·10) (Found: C, 73·4; H, 9·6. $C_{35}H_{54}O_6$ requires C, 73·7; H, 9·5%); δ 5·08 (1H, m, CH_2CH=C), 3·67 (3H, s, CO_2Me), 2·0, 1·97 (6H, 2 s, 2 × OAc), 1·67, 1·63 (6H, 2 s, C=CMe$_2$), and 1·22—0·75 (15H, 4 s, 5 × Me).

Methyl Senexdionate (Ie).—The ester (Ib) (100 mg) in acetone (50 ml) was treated with Jones reagent [containing CrO_3 (100 mg)], kept for 1 h, then poured into water and the product purified by passing through neutral alumina. *Methyl senexdionate* (*methyl* 3,22-*dioxolanosta*-8,24-*dien*-30-*oate*) (Ie) crystallised from methanol as needles (0·07 g), m.p. 155—156°, $[\alpha]_D$ +42·9° (*c* 1·63) (Found: C, 76·8; H, 9·8. $C_{31}H_{46}O_4$ requires C, 77·2; H, 9·5%), $\nu_{max.}$ 1740, 1705, 1244, and 796 cm^{-1}; δ 5·32 (1H, t, CH_2CH=C), 3·73 (3H, s, CO_2Me), 3·13 (2H, d, *J* 7 Hz, CO·CH_2CH=C), 1·76, 1·65 (6H, 2 s, C=CMe$_2$), and 1·37—0·73 (15H, 5 s, 5 × Me).

Dihydrosenexdiolic Acid Acetate (IIIa).—The acetate (Ic) of the acid was hydrogenated with 10% Pd–C as catalyst. 3,22-*Diacetoxylanost*-8-*en*-30-*oic acid* (IIIa) crystallised from methanol as needles, m.p. 205—207°, $[\alpha]_D$ +76·7° (*c* 0·85) (Found: C, 73·2; H, 9·8. $C_{34}H_{54}O_6$ requires C, 73·1; H, 9·7%); $\nu_{max.}$ 1750, 1740, 1710, 1266, and 1235 cm^{-1}; δ 5·28—4·68br (2H, 2 signals, 3- and 22-H), 2·01, 1·97 (6H, 2 s, 2 × OAc), and 1·24—0·67 (21H, 6 s, 7 × Me). Its methyl ester (IIIb) crystallised from methanol as needles, m.p. 171—173°, $[\alpha]_D$ +50·7° (*c* 0·81).

Oxidation of (IIIb) *with Selenium Dioxide*.—The ester (IIIb) (20 mg) in acetic acid (1·5 ml) was refluxed with selenium dioxide (20 mg) for 6 h. Selenium was filtered off, solvent removed under reduced pressure, and the residue chromatographed over neutral alumina. Benzene eluted a solid (14 mg) which crystallised from methanol as needles, m.p. 168—170°, $[\alpha]_D$ +59·2° (*c* 0·49), $\lambda_{max.}$ (EtOH) 236 (log ε 4·13), 243 (4·16), and 252 nm (4·11), $\nu_{max.}$ 1748, 1250, and 807 cm^{-1}.

Formation of Oxidosenexolic Acid (IIa) *from Senexdiolic Acid* (Ia).—A solution of (Ia) (100 mg) in methanol (50 ml) was refluxed with conc. HCl (1·5 ml) for 1·5 h. Methanol was removed under reduced pressure with intermittent addition of water. The precipitated solid was crystallised from chloroform–methanol as needles of 22,25-*epoxy*-3-*hydroxylanost*-8-*en*-30-*oic acid* (IIa) (85 mg), m.p. >310°, $[\alpha]_D$ +56·1° (*c* 0·87, C_5H_5N) (Found: C, 76·3; H, 10·0. $C_{30}H_{48}O_4$ requires C, 76·3; H, 10·2%); $\nu_{max.}$ 3500, 1710, 1230, 1125, 1030, and 882 cm^{-1}; *acetate* (IIc), m.p. 285—287°, $[\alpha]_D$ +60·2° (*c* 0·81) (Found: C, 74·9; H, 10·0. $C_{32}H_{50}O_5$ requires C, 74·7; H, 9·7%); *methyl ester* (IIb), m.p. 223—225°, $[\alpha]_D$ +54·3° (*c* 0·91) (Found: C, 76·6; H, 10·2. $C_{31}H_{50}O_4$ requires C, 76·5; H, 10·3%); $\nu_{max.}$ 3636, 1730, 1255, 1242, 1135, 1100, and 1047 cm^{-1}.

Methyl Oxidosenexonate (IId).—The ester (IIb) in acetone was oxidised with Jones reagent; the product after purification gave *methyl* 22,25-*epoxy*-3-*oxolanost*-8-*en*-30-*oate* (IId) as needles (from methanol), m.p. 225—227°, $[\alpha]_D$ +64·9° (*c* 0·87) (Found: C, 76·9; H, 9·8. $C_{31}H_{48}O_4$ requires C, 76·9; H, 9·9%); $\nu_{max.}$ 1740, 1710, 1250, 1125, 1050, and 880 cm^{-1}; δ 4·07 (1H, m, 22-H), 3·73 (3H, s, CO_2Me), 1·72, 1·67 (4H, m, 23- and 24-H$_2$), 1·38, 1·26, 1·23 (9H, 3 s, *Me*–C–CO_2Me and C–O–C*Me*$_2$), and 1·14—0·73 (12H, 4 s, 4 × Me). The Zimmermann colour reaction was positive. The keto-ester (IId) in methanol was reduced with sodium borohydride at room temperature for 0·5 h. The crystallised product, m.p. 222—224°, was identical with the hydroxy-ester (IIb) described above (mixed m.p. and t.l.c.).

Reduction of the Methyl Ester (IIb).—Reduction with $LiAlH_4$ was carried out in tetrahydrofuran (THF). The product, 22,25-epoxylanost-8-ene-3,30-diol, after chromatographic purification, crystallised from chloroform–methanol as *needles*, m.p. >300°; $[\alpha]_D$ +54·3° (*c* 0·603) (Found: C, 78·6; H, 11·2. $C_{30}H_{50}O_3$ requires C, 78·6; H, 11·5%); $\nu_{max.}$ 3550 and 1050 cm^{-1}. The acetonide (TsOH method, room temperature, 1 h), after chromatographic purification, crystallised from methanol as *needles*, m.p. 264—266°, $[\alpha]_D$ +50·2° (*c* 0·612) (Found: C, 78·9; H, 11·1. $C_{33}H_{54}O_3$ requires C, 79·5; H, 10·8%); $\nu_{max.}$ 1152, 1125, 1105, 1041, and 866 cm^{-1}.

Conversion of Oxidosenexolic Acid (IIa) *into Oxidosenexone* (IIe).—The acid (IIa) (40 mg) in acetone (20 ml) was oxidised with Jones reagent [containing CrO_3 (40 mg)]. The product after purification by passing through alumina, crystallised from chloroform–methanol as plates of (IIe), m.p. 220—222°, identical with naturally occurring oxidosenexone (mixed m.p., t.l.c., i.r.). The same product was obtained when the keto-ester (IId) was refluxed with 5% ethanolic KOH for 1 h, acidified with conc. HCl and further refluxed for 5 min.

Lanost-8-*en*-3β-*ol* (IIIe) *from Senexdiolic Acid* (Ia).—Methyl senexdiolate (Ib) (100 mg) in dry THF (25 ml) was refluxed with lithium aluminium hydride (100 mg) for 6 h. Work-up of the product and crystallisation from methanol yielded *lanosta*-8,24-*diene*-3,22,30-*triol* (If) (60 mg), m.p. 209—212°, $[\alpha]_D$ +64·9° (*c* 0·82, $CHCl_3$–MeOH 1 : 1) (Found: C, 78·2; H, 11·2. $C_{30}H_{50}O_3$ requires C, 78·6; H, 10·9%); $\nu_{max.}$ (Nujol) 3570, 1055, and 816 cm^{-1}; *acetate* (Ig), m.p. 163—165°, $[\alpha]_D$ +57·9° (*c* 0·91) (Found: C, 74·4; H, 9·7. $C_{36}H_{56}O_6$ requires C, 74·0; H, 9·6%); $\nu_{max.}$ 1750, 1250, and 825 cm^{-1}; δ 5·08 (1H, m, CH_2CH=C), 5·0—4·5br (2H, 3- and 22-*H*), 4·06—3·56 (2H, q, *J* 12 Hz, –CH_2OAc), 2·02, 2·0 (9H, 2 s, 3 × OAc), 1·63, 1·60 (6H, 2 s, C=CMe$_2$), and 1·03—0·68 (15H, 5 × Me); *acetonide* of (If) (TsOH method), m.p. 196—198°, $[\alpha]_D$ +48·6° (*c* 0·516) (Found: C, 79·5; H, 11·1. $C_{33}H_{54}O_3$ requires C, 79·5; H, 10·8%); $\nu_{max.}$ 3620, 1172, 1155, 1105, 1055, 1038, and 862 cm^{-1}. On copper pyrolysis, (If) gave formaldehyde (identified by colour reaction with chromotropic acid).

The triol (If) was hydrogenated over 10% Pd–C and yielded *lanost*-8-*ene*-3,22,30-*triol* (IIIc), m.p. 213—215°, $[\alpha]_D$ +66·3° (*c* 0·60, $CHCl_3$–MeOH 1 : 1) (Found: C, 78·2; H, 11·0. $C_{30}H_{52}O_3$ requires C, 78·3; H, 11·3%); $\nu_{max.}$ 3509, 1047, and 1027 cm^{-1}.

The triol (IIIc) (150 mg) in dry pyridine (3 ml) was treated with tosyl chloride (300 mg) and left at room temperature for 48 h. The reaction product isolated in the usual way was chromatographed over neutral alumina. Benzene eluted the *tritosylate* (IIId) as a solid (150 mg) which crystallised from chloroform–methanol as silky needles, m.p. 224—225°, $[\alpha]_D$ +59·1° (*c* 0·47) (Found: C,

66·6; H, 7·3. $C_{51}H_{70}S_3O_9$ requires C, 66·4; H, 7·6%); $\nu_{max.}$ 1190 and 1172 cm^{-1}.

The tritosylate (IIId) (120 mg) in THF (50 ml) was refluxed with lithium aluminium hydride (200 mg) for 6 h. The product (60 mg) was chromatographed over neutral alumina (6 g). Benzene eluted a fraction (30 mg) which gave lanost-8-en-3β-ol (IIIe) as feathery needles (20 mg) (from chloroform–methanol), m.p. 140—142°, $[\alpha]_D$ +59·4° (*c* 0·91) (Found: C, 83·8; H, 12·2. Calc. for $C_{30}H_{52}O$: C, 84·0; H, 12·2%); acetate, m.p. 117—118°, $[\alpha]_D$ +57·0° (*c* 0·80) (Found: C, 81·3; H, 11·4. $C_{32}H_{54}O_2$ requires C, 81·6; H, 11·6%); each was identical (mixed m.p., t.l.c., i.r.) with the corresponding product obtained from trametenolic acid B as described below.

Lanost-8-en-3β-ol (IIIe) *from Trametenolic Acid* B (Ih).—Methyl trametenolate (Ii) (100 mg) in dry THF (25 ml) was refluxed with lithium aluminium hydride (100 mg) for 6 h. The diol (Ik) crystallised from chloroform–methanol as needles, $C_{30}H_{50}O_2$, m.p. 194—197°, $[\alpha]_D$ +52·6° (*c* 0·71) (lit.,[9] 189—192°, $[\alpha]_D$ +57°); acetate, $C_{34}H_{54}O_4$, m.p. 121—122°, $[\alpha]_D$ +59·2° (*c* 0·85).

The diol (Ik) was hydrogenated over 10% Pd–C; lanost-8-ene-3,21-diol (IIIf) crystallised from chloroform–methanol as plates, $C_{30}H_{52}O_2$, m.p. 187—189°, $[\alpha]_D$ +53·5° (*c* 0·92). The dihydro-diol (IIIf) was tosylated (tosyl chloride–pyridine, room temperature 36 h). The *ditosylate* (IIIg) crystallised from chloroform–methanol as needles, m.p. 173—175°, $[\alpha]_D$ +34·6° (*c* 1·13) (Found: C, 70·2; H, 9·0. $C_{44}H_{64}S_2O_6$ requires C, 70·0; H, 8·8%); $\nu_{max.}$ 1190 and 1175 cm^{-1}.

The ditosylate (IIIg) (100 mg) in dry THF (30 ml) was refluxed with lithium aluminium hydride (200 mg) for 3 h. The product (50 mg) was chromatographed over neutral alumina (5 g). The benzene eluates on crystallisation from chloroform–methanol yielded lanost-8-en-3β-ol (IIIe), m.p. 141—142°, $[\alpha]_D$ +58·3° (*c* 0·92) (Found: C, 83·7; H, 12·0. Calc. for $C_{30}H_{52}O$: C, 84·0; H, 12·2%) (lit.,[9] m.p. 144—145°, $[\alpha]_D$ +61·0°); acetate, $C_{32}H_{54}O_2$, m.p. 117—118°, $[\alpha]_D$ +57·6° (*c* 0·87) (lit.,[9] m.p. 119—120°, $[\alpha]_D$ +60·0°).

Senexonol (Il).—22-*Hydroxy*-31-*norlanosta*-8,24-*dien*-3-*one* (Il) had m.p. 117—118°, $[\alpha]_D$ +78·0° (*c* 0·82) (Found: C, 81·4; H, 10·9. $C_{29}H_{46}O_2$ requires C, 81·7; H, 10·8%); positive Zimmermann colour reaction; $\nu_{max.}$ (Nujol) 3640, 1712, 1055, and 780 cm^{-1}; *m/e* 426 (M^+, 57%), 411 (12) 393 (12), 341 (88), 323 (11), 299 (M^+ — side chain, 16), 257 [fragment (*d*), 21], 243 (16), 231 [fragment (*e*), 32], 109 (side chain — H_2O, 33), 99 [fragment (*b*), 81], and 69 [fragment (*a*), 100]. Ozonolysis or treatment with OsO_4–$NaIO_4$ of (Il) yielded acetone, identified as the dinitrophenylhydrazone. The acetate of (Il) gave *rods* from methanol, m.p. 134—135°, $[\alpha]_D$ +69·0° (*c* 0·913) (Found: C, 79·3; H, 10·4. $C_{31}H_{48}O_3$ requires C, 79·5; H, 10·4%); δ 5·3—4·7br (2H, m, 24- and 22-H), 1·95 (3H, OAc), 1·7, 1·64 (6H, C=CMe_2), and 1·18—0·73 (15H, 5 × Me).

24,25-*Dihydrosenexonol*.—This was prepared by the catalytic reduction of senexonol over 10% Pd–C and crystallised from methanol as *needles*, m.p. 80—82°, $[\alpha]_D$ +75·0° (*c* 0·56) (Found: C, 80·9; H, 11·6. $C_{29}H_{48}O_2$ requires C, 81·3; H, 11·3%); *acetate*, m.p. 155—157°, $[\alpha]_D$ +66·7° (*c* 0·675) (Found: C, 78·8; H, 10·3. $C_{31}H_{50}O_3$ requires C, 79·1; H, 10·6%). On SeO_2 oxidation in AcOH, it gave the 7,9(11)-diene, m.p. 144—147°; $\lambda_{max.}$ (EtOH) 236, 243, and 252 nm (log ε 4·08, 4·12, and 4·02).

3-*Deoxosenexonol* (Im).—31-*Norlanosta*-8,24-*dien*-22-*ol* (Im), $C_{29}H_{48}O$ prepared by Wolff–Kishner reduction of senexonol, crystallised from methanol as plates, m.p. 79—80°, $[\alpha]_D$ +53·8° (*c* 0·86). It did not give the Zimmermann colour test, and the carbonyl absorption in the region 1710 cm^{-1} was absent; δ 1·7, 1·62 (6H, C=CMe_2), and 0·91—0·72 (15H, 5 × Me); *acetate*, plates from methanol, m.p. 106—107°, $[\alpha]_D$ +52·4° (*c* 0·68) (Found: C, 81·8; H, 10·8. $C_{31}H_{50}O_2$ requires C, 81·9; H, 11·0%); *m/e* 454 (M^+, 22%), 394 (10), 379 (75), 297 (22), 283 (13), 269 (8), 255 (5), 243 [fragment (*d*), 11], 229 (7), 217 [fragment (*e*), 11], 203 (9), 187 (6), 175 (10), 159 (11), 145 (11), 133 (9), 119 (12), 109 (side chain — AcOH, 51), and 69 [fragment (*a*), 58].

Senex-3,22-*diol* (In).—Senexonol (Il) in methanol was reduced with sodium borohydride at room temperature for 1 h. The product, purified by preparative t.l.c., crystallised from methanol giving 31-*norlanosta*-8,24-*diene*-3,22-*diol* (In) as plates, m.p. 148—150°, $[\alpha]_D$ +64·2° (*c* 0·84) (Found: C, 80·9; H, 11·1. $C_{29}H_{48}O_2$ requires C, 81·3; H, 11·2%).

Natural Senexdione (Io).—31-*Norlanosta*-8,24-*diene*-3,22-*dione* (Io) had m.p. 108—110°, $[\alpha]_D$ +57·1° (*c* 0·77) (Found: C, 81·9; H, 10·3. $C_{29}H_{44}O_2$ requires C, 82·1; H, 10·3%); $\nu_{max.}$ 1712, 845, and 780 cm^{-1}; δ 5·5—5·1br (1H, m, 24-H), 3·1 (2H, d, *J* 7 Hz, 23-H_2), 1·75, 1·60 (6H, C=CMe_2), and 1·25—0·73 (15H, 5 s, 5 × Me); positive Zimmermann colour reaction.

Semi-synthetic Senexdione (Io).—Senexonol (Il) was oxidised with Jones reagent at 0° for 0·5 h. The product isolated in the usual manner and purified by chromatography crystallised from methanol as needles, m.p. 107—109°, and was identical with natural senexdione (mixed m.p., t.l.c., and i.r.).

Natural Oxidosenexone (IIe).—22,25-*Epoxy*-31-*norlanost*-8-*en*-3-*one* (IIe) had m.p. 223—225°, $[\alpha]_D$ +54·8° (*c* 1·14) (Found: C, 81·4; H, 10·8. $C_{29}H_{46}O_2$ requires C, 81·7; H, 10·8%); $\nu_{max.}$ 1712, 1160, 1135, 1045, 990, and 885 cm^{-1}; δ 4·02 (1H, m, 22-H), 1·67, 1·62 (4H, 2 m, 23- and 24-H_2), 1·22, 1·20 (6H, 2 s, C–O–CMe_2), and 1·16—0·73 (15H, 5 s, 5 × Me); *m/e* 426 (M^+, 5%), 411 (3), 257 [fragment (*d*), 2], 231 [fragment (*e*), 2], and 99 [fragment (*c*), 100]; positive Zimmermann reaction.

Semi-synthetic Oxidosenexone (IIe).—Senexonol (Il) was refluxed with methanolic HCl (1%) for 1 h. The product crystallised from methanol as needles, m.p. 223—224° and was identical with natural oxidosenexone (mixed m.p., t.l.c., i.r.). Under the same experimental conditions, 24,25-dihydrosenexonol (described earlier) was recovered unchanged.

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