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THIOSTEROID—XXVIII

STEROIDAL TRANSANNULAR 2α,5α-EPISULPHIDE—2.[1] SYNTHESIS OF 17β-HYDROXY-3-OXO-5α-ANDROSTAN-2α,5-EPISULPHIDE AND ITS 19-NOR DERIVATIVE

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Abstract—17β-Hydroxy-3-oxo-5α-androstan-2α,5-episulphide and its 19-nor derivative were synthesized in a manner similar to that described in the preceding paper. In the course of the synthesis, the reaction of 3-oxo-2α,5α-episulphides with alkali was found to give rise to Cβ-S bond cleavage. In a model experiment with 3-oxo-5α-cholestan-2α,5-episulphide, 3-oxocholest-4-ene-2α-thiol was formed under nitrogen and bis 3-oxocholesta-1,4-dien-2-yl disulphide in the air.

THE preceding paper[1] reported the facile cyclization of 5α-cholest-2-ene-5-thiol with bromine or lead tetra-acetate, leading to 3β-*endo* substituted 5α-cholestan-2α,5-episulphide, a 7-thiabicyclo[2.2.1]heptane system. Interest in the synthesis of modified steroid hormones led us to investigate this reaction further. This paper deals with the synthesis of 17β-hydroxy-3-oxo-5α-androstan-2α,5-episulphide (**8b**) and its 19 nor derivative (**8e**) in addition to the cleavage reaction of the C_{β}-S bond in 3-oxo-5α-cholestan-2α,5-episulphide.

Key intermediates, **6a** and **6c**, containing 2-ene-5α-thiol moieties as their partial structure, were synthesized by methods similar to those described,[1, 2] starting with dehydroepiandrosterone and 19-norandrost-5-ene-3β,17β-diol 17-monoacetate.[3] The oxidation of these compounds with *m*-chloroperbenzoic acid gave a mixture of 5α,6α- and 5β,6β-epoxides, (**1a**) and (**1b**), which were treated with perchloric acid in aqueous dioxan to yield the corresponding 3β,5α,6β-triols, (**2a** and **2b**), respectively, as sole products. The partial tosylation of **2a** and **2b** with 1·1 molar equivalent of tosyl chloride in pyridine, followed successively by dehydration with collidine and acetylation in the presence of acid catalyst, furnished the corresponding 2-ene-5α,6β-diol diacetates, (**3b** and **3d**), respectively, in good yield. Although heating 5α-cholest-2-ene-5,6β-diol diacetate with potassium hydroxide in isopropanol gave 5β-cholest-2-en-5,6β-epoxide[2] in 72% yield, the same treatment of 5,6β-diacetoxy-5α-androst-2-en-17-one (**3b**) afforded undesirable results, the yield of the expected 5,6β-epoxy-5β-androst-2-en-17-one (**4a**) being only 30·2%, while the hydrolysis product, 5,6β-dihydroxy-5α-androst-2-en-17-one (**3a**), was produced in 53·2% yield. The same treatment of 19-nor-5α-androst-2-ene-5,6β,17β-triol triacetate (**3d**) resulted mainly in hydrolysis of the acetoxyl groups, affording 19-nor-5α-androst-2-ene-5,6β,17β-triol. By replacement of the reagent with a more bulky base, potassium t-butoxide in t-butanol, in the above reaction, the desired 5β,6β-epoxide (**4b**) was successfully prepared from **3d**, and subsequent acetylation with acetic anhydride and pyridine furnished the

crystalline 17-acetate (**4c**) in 80% overall yield. When these 2-en-5β,6β-epoxides (**4a** and **4c**) were treated with thiocyanic acid in ether,[4] the corresponding 5α-thiocyanato-6β-ols, (**5a** and **5b**) were obtained, mesylation of which, followed by reduction with LAH gave 17β-hydroxy-5α-androst-2-ene-5-thiol (**6a**) and its 19-nor derivative (**6c**), respectively, in good yield. In order to introduce the 3-oxo-17-ol function into the compounds later, it was considered necessary to protect the 17-OH group with a suitable acyl group at this stage. Thus, the compounds, **6a** and **6c**, were treated with 1·2 molar equivalents of benzoyl chloride in pyridine to afford the corresponding 17-monobenzoates (**6b** and **6d**), respectively, in high yield.

The treatment of **6b** and **6d** with lead tetraacetate in boiling cyclohexane furnished 3β-acetoxyl-17β-benzoyloxy-5α-androstan-2α,5-episulphide (**7b**) and its 19-nor derivative (**7d**) in 76·5% and 87% yield, respectively. In the latter case, the solvent in the reaction was replaced with a mixture of cyclohexane and benzene, because the substrate (**6d**) has poor solubility in cyclohexane alone. The structures of **7b** and **7d** were supported by their NMR spectra, exhibiting one proton triplet (J = 3·5 Hz)[1] assigned to the bridge head proton. The partial hydrolysis of **7b** and **7d** were achieved by treatment with potassium hydrogen carbonate in aqueous methanol. Thus, 3,17-diol 17-monobenzoates, (**7c** and **7e**), were obtained in high yield. An alternative method for the preparation of **7c** was carried out in the following way. Bromination of 17β-benzoyloxy-5α-androst-2-ene-5-thiol (**6b**) with 1 molar equivalent of bromine in carbon tetrachloride gave the 3β-bromo-2α,5α-episulphide (**7a**) in 95% yield, the NMR spectrum of which indicates an *endo* configuration of the bromine.[1] The substitution reaction of **7a** with potassium acetate in boiling DMF resulted in formation of the 3β-ol (**7c**) and its acetate (**7b**).[1] When the mixture was treated, without purification, with potassium hydrogen carbonate in aqueous methanol, **7c** was obtained in 93·2% yield from **7a**. Oppenauer oxidation of **7c** and **7e** furnished the corresponding 3-oxo-2α,5α-episulphides, (**8a** and **8d**). In this stage, we encountered difficulty in the hydrolysis of the benzoyloxy groups at C_{17}, because of instability of the 3-oxo-2α,5α-episulphide moieties to base. For example, heating **8a** with potassium carbonate in aqueous methanol gave a complex mixture, the IR spectrum of which shows many absorption bands due to a hydroxyl, benzoyloxy, thiol, and an α,β-unsaturated ketone, indicating C_β—S bond cleavage.

We, therefore, studied the reaction of 3-oxo-5α-cholestan-2α,5-episulphide (**10**) with alkali as the model experiment. Heating **10** with 1% methanolic potassium hydroxide under a stream of nitrogen, followed by acetylation gave 2α-acetylthiocholest-4-en-3-one (**11b**) in 45% yield as the sole crystalline product. The structure of **11b** was supported by the UV (λ_{max} 233 and 253 mμ) and NMR spectra. The latter provides a quartet (J = 14·3 and 5·5 Hz) at 5·56 τ due to an axial proton on the carbon bearing the acetylthio moiety as well as a broad singlet at 4·18 τ assigned to the vinyl proton at C_4. These data are also in good agreement with those for 2α-acetylthio-testosterone acetate reported by Krämer *et al.*[5] However, treatment of the ketone (**10**) with potassium carbonate in boiling aqueous dioxan and methanol in the air resulted in the formation of an unexpected product. After purification by preparative TLC, the major product, obtained in 54% yield, was characterized as bis(3-oxo-cholesta-1,4-dien-2-yl) disulphide (**12**) from the following data. Determination of the mol wt by means of an osmometer gave the value of 841 (Calc. 827) and the IR as well as the UV spectrum indicates the presence of a cross conjugated homoannular dienone. Furthermore, the

Chart 1

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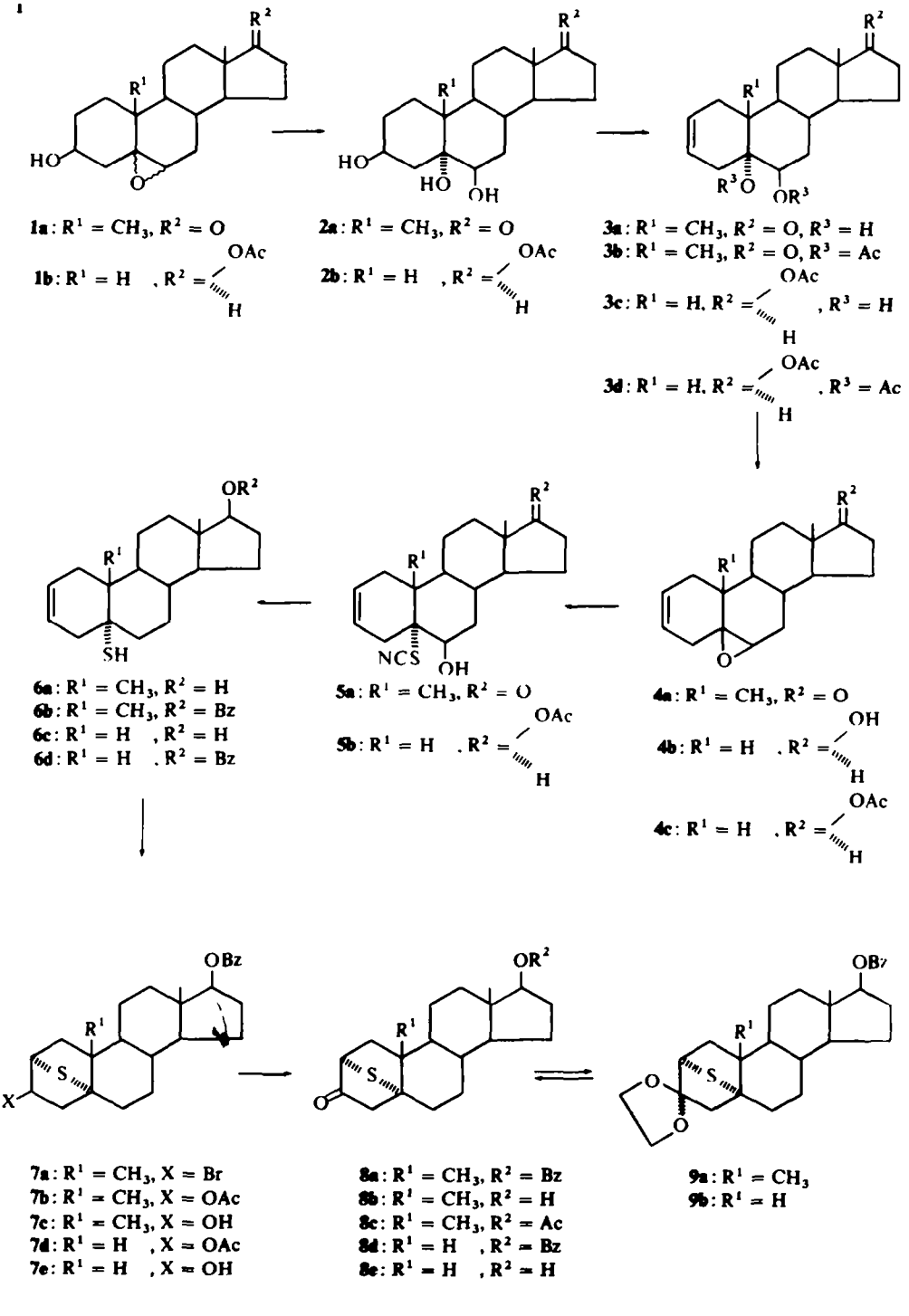

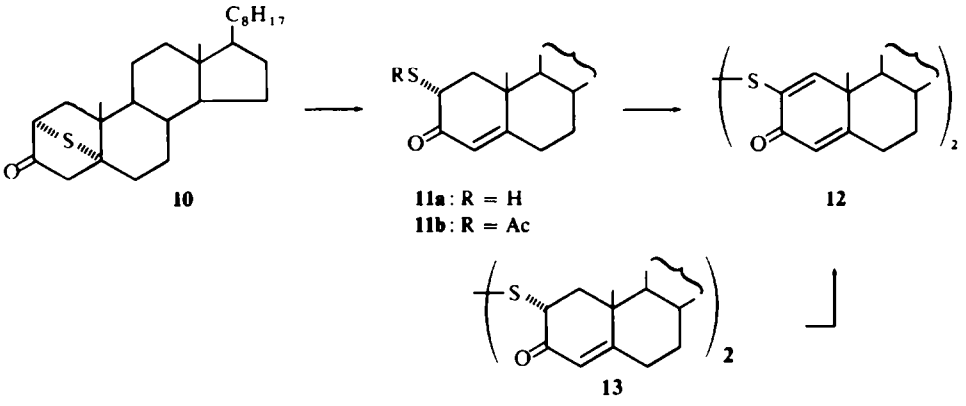

NMR spectrum reveals two vinyl proton signals at 3·89 and 3·03 τ, being devoid of a proton signal on the carbon bearing the sulphur substituent. It is interesting to note that the disulphide (**12**) was also obtained in lower yield on reaction of bis(3-oxo-cholest-4-en-2α-yl) disulphide[6] (**13**) under similar conditions. But the reaction required prolongation of the reaction time. It seems likely that the unexpected reaction proceeds through the disulphide (**13**) by a mechanism involving heterolytic cleavage of the disulphide linkage with the enolate anion, followed by air-oxidation of the thione formed *via* the fully conjugated enol form, as shown in the following Chart. In the reaction of the enone disulphide (**13**), the observed lowering of the yields of **12**

Chart 2

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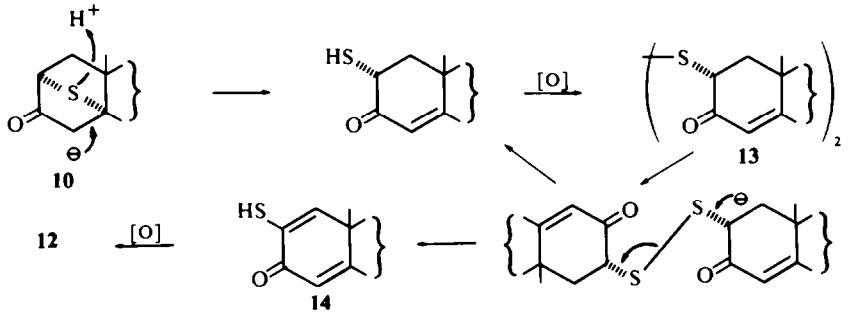

and the requirement of prolonged reaction time might be ascribed to the heterogeneity of the reaction mixture owing to the low solubility of **13** in the solvent.

The following modification finally led to a successful accomplishment of the hydrolysis of the benzoyloxy group at C_{17} in the 3-oxo compounds, **8a** and **8d**. The ketalization of **8a** and **8d** with 2-methyl-2-ethyl-1,3-dioxolane[7] in the presence of acid catalyst at room temperature proceeded smoothly, affording the corresponding ethylene ketals, (**9a** and **9b**). These ketals were subjected to LAH reduction, followed by acid hydrolysis of the ketal moieties, furnishing 17β-hydroxy-3-oxo-5α-androstan-2α,5-episulphide (**8b**) and its 19-nor derivative (**8e**), respectively, in high overall yield. Studies on the biological activities of these compounds are now in progress.

EXPERIMENTAL

All m.ps were measured on a Kofler hot-stage apparatus and are uncorrected. Optical rotations were determined in 1% EtOH—$CHCl_3$ with a Perkin–Elmer Polarimeter, type 141. Unless otherwise stated, UV spectra were recorded in 95% EtOH with a Hitachi EPS-2 spectrophotometer and IR spectra in Nujol mulls by use of a Koken DS-201B spectrophotometer. NMR spectra were taken on $CDCl_3$ solns with a Varian A-60 spectrometer, TMS serving as internal standard. For preparative TLC, silica gel G (E. Merck Co.) was used as an adsorbent.

Androstane series

3β,5,6β-*Trihydroxy-5α-androstan-17-one* (**2a**). To a soln of 50 g dehydroepiandrosterone in 550 ml CH_2Cl_2 was added 41·8 g *m*-chloroperbenzoic acid at room temp over 30 min. The resulting soln was stirred for 30 min at room temp, poured into iced Na_2CO_3 aq and extracted with CH_2Cl_2. Removal of the solvent afforded 53 g (quantitative) **1a** as an amorphous solid. This material was dissolved in 400 ml dioxan, and to the soln was added 140 ml 10% $HClO_4$ at room temp. The slightly turbid mixture was stirred for 2·5 hr at the same temp and poured into ice water. The deposited crystals were collected by filtration, washed with water and dried under reduced press to give 46·1 g (82·5%) **2a** as colourless crystals, m.p. 300–302° (reported m.p. 295–298°),[8] ν_{max} 3460, 3380 (OH), 1725 (C=O), 1205, 1075, 1045, 1030, 1005, 870 cm^{-1}.

5,6β-*Diacetoxy-5α-androst-2-en-17-one* (**3b**). The oxotriol **2a** (46·1 g, 0·143 M) was treated with 30 g (0·158 M) *p*-toluenesulphonyl chloride in 500 ml pyridine for 2 days at room temp. The mixture was poured into ice water and extracted with CH_2Cl_2. The CH_2Cl_2 soln was washed successively with 10% HCl, 10% Na_2CO_3 aq and water and dried over Na_2SO_4. Evaporation of the solvent gave 70·5 g of the 3-monotosylate as an oily material; $\nu_{max}^{CHCl_3}$ 3470 (OH), 1730 (C=O), 1597, 1170, 925 (OTs) cm^{-1}. A soln of this tosylate, which was not purified, in a mixture of 100 ml collidine and 100 ml xylene was heated under reflux for 2·8 hr, and poured into ice water. The ethereal extract was worked up in the usual way affording 40·25 g **3a** as a crystalline residue; ν_{max} 3550, 3460 (OH), 3040 (Δ^2), 1728 (C=O), 1210, 1075, 1050, 1022, 865 cm^{-1}. To a soln of **3a** in 500 ml AcOH were added 150 ml Ac_2O and 2 g *p*-toluenesulphonic acid successively. The mixture was allowed to stand overnight at room temp. Work-up in the usual way afforded 51·6 g oily product, which was crystallized from ether-petroleum ether giving 33·9 g (50·5%) **3b** as colourless crystals. Recrystallization from MeOH gave the pure sample of **3b**, m.p. 167–169°, $[\alpha]_D^{22}$ + 5·4 ± 0·5° (*c* = 0·996). ν_{max} 3026, 1658 (Δ^2), 1739, 1733, 1256, 1241, 1234, 1211 (C=O, OAc), 1024, 931, 820, 638 cm^{-1}; NMR: τ 9·10 (s, 3, 13-Me), 8·91 (s, 3, 10-Me), 8·05, 7·92 (each s, 6, OAc), 4·45 (br. t, 2, *J* = 4·0 Hz; 2-H, 3-H), 4·06 (m, 1, Wh/2 = 6 Hz, 6α-H). (Found: C, 71·38; H, 8·33. $C_{23}H_{32}O_5$ requires: C, 71·11; H, 8·30%).

5,6β-*Epoxy-5β-androst-2-en-17-one* (**4a**). To a soln of 29·6 g **3b** in 70 ml i-PrOH, was added a soln of 30 g KOH in 230 ml i-PrOH. The resulting mixture was heated under reflux for 1 hr and poured into ice water. The CH_2Cl_2 extract was worked up in the usual way to afford 22·2 g oily material. Crystallization from ether gave 12·35 g (53·2%) **3a** as colourless crystals. The mother liquor was evaporated leaving 9·8 g residue, which was chromatographed over 250 g standardized Al_2O_3 (Grade II). Elution with petroleum ether–benzene (1:1) and concentration of the fraction afforded 6·60 g (30·2%) **4a** as colourless crystals. Recrystallization from acetone-hexane gave 6·34 g pure sample, m.p. 114–116°, $[\alpha]_D^{23}$ +75·6 ±1·2° (*c* = 0·974); ν_{max} 3034 (Δ^2), 1741 (C=O), 1066, 1055, 1029, 1015, 945, 897, 869, 760, 726, 690, 655 cm^{-1}; NMR: τ 9·15 (s, 3, 13-Me), 8·99 (s, 3, 10-Me), 6·92 (d, 1, *J* = 2·5 Hz,[9] 6α-H), 4·22 (m, 2, W h/2 = 4·0 Hz; 2-H, 3-H). (Found: C, 79·45; H, 9·18. $C_{19}H_{26}O_2$ requires: C, 79·48; H, 9·15%).

6β-*Hydroxy-5-thiocyanato-5α-androst-2-en-17-one* (**5a**). To a soln of 11·76 g **4a** in 50 ml ether was added 150 ml HSCN-ether-soln, prepared from 58·5 g KSCN as described, at room temp. Within 10 min, colourless crystals were deposited gradually in the mixture. After being allowed to stand at room temp for 2 hr, the mixture was diluted with CH_2Cl_2. The soln was washed with 10% Na_2CO_3 aq and water, and dried (Na_2SO_4). Removal of the solvent afforded the crude product, which was crystallized from ether-petroleum ether giving 10·17 g (71·6%) **5a** as colourless crystals. Recrystallization from acetone-n-hexane afforded the pure sample, m.p. 172·5–173°, $[\alpha]_D^{24}$ +21·5 ±0·6° (*c* = 1·018), ν_{max} 3490 (OH), 3020 (Δ^2), 2140 (SCN), 1728 (C=O), 747, 727, 664 cm^{-1}; NMR: τ 9·11 (s, 3, 13-Me), 8·75 (s, 3, 10-Me), 5·79 (m, 1, W h/2 = 7·5 Hz, 6α-H), 4·23 (m, 2, W h/2 = 4·0 Hz, 2-H, 3-H). (Found: C, 69·80; H, 7·97; N, 4·15; S, 9·23. $C_{20}H_{27}NO_2S$ requires: C, 69·52; H, 7·88; N, 4·05; S, 9·28%).

17β-*Hydroxy-5α-androst-2-ene-5-thiol* (**6a**). The foregoing **5a** (10·17 g) was treated with 11·0 g methanesulphonyl chloride in 100 ml pyridine overnight at room temp. Usual work-up gave 12·3 g of the mesylate as an amorphous solid; $\nu_{max}^{CHCl_3}$ 3040 (Δ^2), 2180 (SCN), 1740 (C=O), 1170, 1010, 995 (OMs) cm^{-1}.

To a stirred suspension of 6·7 g LAH in 200 ml of a mixture of dry THF and ether (1:1) a soln of the

mesylate (12·3 g) in 200 ml of the solvent was added dropwise at room temp. The mixture was heated under reflux, with stirring, for 3 hr and worked up in the usual way. The crude product (8·0 g) was chromatographed over 250 g Florisil. The eluates with petroleum ether-benzene (1:1) afforded a solid, which was recrystallized from CH_2Cl_2-MeOH to give 7·23 g (80·4%) **6a** as colourless crystals, m.p. 192–194°, $[\alpha]_D^{24}$ +3·2 ±0·4° (*c* = 1·027), ν_{max} 3263, 1064 (OH), 3018, 1650 (Δ^2), 1022, 633 cm^{-1}; NMR: τ 9·27 (s, 3, 13-Me), 9·10 (s, 3, 10-Me), 6·34 (m, 1, W h/2 = 17·0 Hz, 17α-H), 4·37 (m, 2, W h/2 = 4·0 Hz, 2-H, 3-H). (Found: C, 74·84; H, 9·94; S, 10·34. $C_{19}H_{30}OS$ requires: C, 74·45; H, 9·87; S, 10·46%).

17β-*Benzoyloxy*-5α-*androst*-2-*ene*-5-*thiol* (**6b**). The enethiol **6a** (5·96 g) was treated with 3·29 g Ph·COCl in 30 ml pyridine at 0° overnight. Usual work-up and recrystallization from CH_2Cl_2-acetone afforded 7·1 g (89·0%) **6b**, m.p. 180–182°, $[\alpha]_D^{23}$ +44·5 ±0·9° (*c* = 0·933), ν_{max} 3018, 655 (Δ^2), 1713, 1602, 1577, 1281, 1116, 720 (BzO), cm^{-1}; NMR: τ 9·07 (s, 6, 13-Me, 10-Me), 5·13 (dd, 1, *J* = 8·5, 7·0 Hz; 17α-H), 4·35 (m, 2, W h/2 = 4·0 Hz, 2-H, 3-H), *ca* 2·50 (m, 3, Ph-H), *ca* 1·95 (m, 2, Ph-H). (Found: C, 76·04; H, 8·09; S, 8·07. $C_{26}H_{34}O_2S$ requires: C, 76·05; H, 8·35; S, 7·81%).

In another run, when the benzoylation was carried out at room temp, the product showed 2 spots on TLC (cyclohexane-AcOEt = 5:1) and was separated into each component by preparative TLC. The more mobile fraction gave **6b** as the major product. The less mobile fraction afforded a small amount of the 5,17-dibenzoate, which on recrystallization from CH_2Cl_2-MeOH gave the pure sample, m.p. 200–202°, $[\alpha]_D^{23}$ +38·9 ±0·8° (*c* = 1·003), ν_{max} 3060, 3040, 1594, 1580, 710 (Ph), 1712, 1295, 1280 (BzO), 1640, 1195, 1167 (BzS), 905 cm^{-1}. (Found: C, 76·91; H, 7·44; S, 6·25. $C_{33}H_{38}O_3S$ requires: C, 77·00; H, 7·44; S, 6·23%).

3β-*Bromo*-17β-*benzoyloxy*-5α-*androstan*-2α,5-*episulphide* (**7a**). To a soln of 5·36 g (13·1 mM) **6b** in 100 ml CCl_4, a soln of 2·20 g (13·8 mM) Br_2 in 20 ml CCl_4 was added dropwise at room temp over 10 min. The resulting soln was stirred for 20 min and concentrated to dryness under reduced press. Crystallization from ether-petroleum ether afforded 6·05 g (94·7%) of **7a** as colourless crystals. Recrystallization from acetone gave the pure sample, m.p. 180–182°, $[\alpha]_D^{24}$ +65·8 ±1·1° (*c* = 1·007), ν_{max} 1722, 1602, 1586, 1295, 1278, 1115, 715 (BzO), 684, 658 cm^{-1}; NMR: τ 9·06 (s, 3, 13-Me), 8·89 (s, 3, 10-Me), 6·38 (t, 1, *J* = 4·0 Hz, 2β-H), 5·40 (m, 1, W h/2 = 15·0 Hz, 3α-H), 5·15 (t, 1, *J* = 7·5 Hz, 17α-H), *ca* 2·53 (m, 3, Ph-H), *ca* 1·97 (m, 2, Ph-H). (Found: C, 63·98; H, 6·96; Br, 16·60; S, 6·70. $C_{26}H_{33}O_2BrS$ requires: C, 63·79; H, 6·80; Br, 16·32; S, 6·55%).

3β,17β-*Dihydroxy*-5α-*androstan*-2α,5-*episulphide* 3-*acetate* 17-*benzoate* (**7b**). A mixture of 340 mg (0·767 mM) $Pb(OAc)_4$ and 130 mg (1·30 mM) $CaCO_3$ in 6 ml cyclohexane was heated under reflux, with stirring, for 30 min. To the boiled mixture, a soln of 103 mg (0·252 mM) **6b** in 2 ml cyclohexane was added dropwise under reflux.

The resulting mixture was refluxed with stirring for 5 min. After the excess of $Pb(OAc)_4$ and $CaCO_3$ had been filtered off, the filtrate was evaporated to dryness under reduced press. Preparative TLC, using cyclohexane-AcOEt (3:1) as developing solvent, afforded 90 mg (76·5%) **7b** as colourless crystals. Recrystallization from acetone-n-hexane gave the pure sample, m.p. 202–204°, $[\alpha]_D^{23}$ +34·1 ±0·6° (*c* = 1·000), ν_{max} 1729, 1245, 1016 (AcO), 1713, 1600, 1583, 1295, 1285, 1119, 720 (BzO) cm^{-1}; NMR: τ 9·04 (s, 3, 13-Me), 8·94 (s, 3, 10-Me), 7·96 (s, 3, OAc), 6·33 (m, 1, W h/2 = 9·0 Hz, 2β-H), 5·13 (dd, 1, *J* = 9·0, 7·0 Hz, 17α-H), 4·78 (dt, 1, *J* = 4·0, 8·0 Hz, 3α-H), *ca* 2·50 (m, 3, Ph-H), *ca* 1·95 (m, 2, Ph-H). (Found: C, 71·93; H, 7·64; S, 7·00. $C_{28}H_{36}O_4S$ requires: C, 71·64; H, 7·74; S, 6·84%).

3β,17β-*Dihydroxy*-5α-*androstan*-2α,5-*episulphide* 17-*monobenzoate* (**7c**). A stirred mixture of 6·05 g of **7a** and 4·85 g KOAc in 90 ml DMF was heated at 135° for 2 hr and poured into ice water. The deposited solid was collected by filtration, washed with water and dried, yielding 5·80 g mixture of **7b** and **7c**. This was dissolved in 70 ml THF and a soln of 5·0 g $KHCO_3$ in 50 ml aqueous MeOH (50%) was added. The resulting mixture was further refluxed for 4 hr and allowed to stand overnight at room temp. Work-up in the usual way afforded 5·75 g solid, which on recrystallization from CH_2Cl_2-MeOH gave 4·9 g (93·2%) **7c** as colourless crystals, m.p. 148–150°, $[\alpha]_D^{23}$ +28·9 ±0·7° (*c* = 0·992), ν_{max} 3553, 3243 (OH), 1715, 1702, 1603, 1584, 1293, 1285, 1118, 713 (BzO) cm^{-1}; NMR: τ 9·06 (s, 3, 13-Me), 8·89 (s, 3, 10-Me), 6·62 (t, 1, *J* = 3·8 Hz, 2β-H), 5·47 (m, 1, W h/2 = 16 Hz, 3α-H), 5·15 (t, 1, *J* = 7·5 Hz, 17α-H), *ca* 2·53 (m, 3, Ph-H), *ca* 1·97 (m, 2, Ph-H). (Found: C, 73·31; H, 8·09; S, 7·58. $C_{26}H_{34}O_3S$ requires: C, 73·20; H, 8·03; S, 7·52%).

Treatment of **7c** with Ac_2O-pyridine overnight at room temp afforded **7b** in quantitative yield.

17β-*Benzoyloxy*-3-*oxo*-5α-*androstan*-2α,5-*episulphide* (**8a**). A soln of 4·33 g (10·2 mM) **7c** and 25 ml cyclohexanone in 125 ml dry toluene was heated and 25 ml toluene was distilled off. To the remaining soln a soln 2·45 g (12·0 mM) Al(i-PrO)$_3$ in 60 ml dry toluene was added dropwise for 30 min under distillation of the toluene and the i-PrOH formed (100 ml of distilate). After addition of aqueous Rochelle salt, the mixture was subjected to steam-distillation for 1·5 hr. The CH_2Cl_2 extract gave 4·2 g crude product, which was purified by chromatography over 100 g of standardized Al_2O_3 (Grade II). The eluate with petroleum

ether-benzene (2:1) gave a small amount of oil. The eluate with petroleum ether-benzene (1:1) afforded 3·882 g solid, which on recrystallization from CH_2Cl_2-acetone afforded 3·768 g (87·5%) **8a** as colourless crystals, m.p. 200–201°, $[\alpha]_D^{23}$ −139·5 ±1·9° (*c* = 0·951), ν_{max} 1735 (C=O), 1712, 1602, 1584, 1313, 1295, 1285, 1124, 723 (BzO) cm^{-1}; NMR: τ 9·05 (s, 3, 13-Me), 8·96 (s, 3, 10-Me), 8·34, 7·86 (AB part of ABX, $|J_{1\alpha:1\beta}|$ = 14·0 Hz, $J_{2\beta:1\alpha}$ = 4·5 Hz, 1β-H, 1α-H), 7·54, 7·33 (AB type q, |*J*| = 18·5 Hz, 4α-H, 4β-H), 6·38 (d, 1, *J* = 4·2 Hz, 2β-H), 5·12 (dd, 1, *J* = 7·0, 9·0 Hz, 17α-H), *ca* 2·53 (m, 3, Ph-H), *ca* 1·97 (m, 2, Ph-H). (Found: C, 73·68; H, 7·62; S, 7·76. $C_{26}H_{32}O_3S$ requires: C, 73·55; H, 7·60; S, 7·55%).

17β-*Benzoyloxy*-3-*ethylenedioxy*-5α-*androstan*-2α,5-*episulphide* (**9a**). A mixture of 3·252 g **8a**, 330 mg *p*-toluenesulphonic acid and 10·4 g 2-methyl-2-ethyl-1,3-dioxolane[7] in 20 ml dry benzene was allowed to stand overnight at room temp and poured into 10% Na_2CO_3 aq. The CH_2Cl_2 extract gave 3·61 g solid, which on recrystallization from acetone-hexane afforded 3·551 g (98·8%) **9a** as colourless crystals, m.p. 171–173°, 182–183°, $[\alpha]_D^{23}$ +12·8 ±1·0° (*c* = 0·517), ν_{max} 3070, 1714, 1603, 1586, 1321, 1275, 1172, 717 (BzO), 1108, 1089 (ketal) cm^{-1}; NMR: τ 9·05 (s, 3, 13-Me), 8·92 (s, 3, 10-Me), 7·92, 7·64 (AB type q, |*J*| = 13·5 Hz, 4α-H, 4β-H), 6·71 (m, 1, W h/2 = 7·0 Hz, 2β-H), 6·08 (br. s, 4, ketal-H), 5·17 (t, 1, *J* = 7·8 Hz, 17α-H), *ca* 2·53 (m, 3, Ph-H), *ca* 1·97 (m, 2, Ph-H). (Found: C, 71·72; H, 7·80; S, 7·00. $C_{28}H_{36}O_4S$ requires: C, 71·76; H, 7·74; S, 6·84%).

17β-*Hydroxy*-3-*oxo*-5α-*androstan*-2α,5-*episulphide* (**8b**). To a cooled suspension of 575 mg (15·1 mM) LAH in 40 ml dry ether a soln of 3·4 g (7·25 mM) **9a** in 40 ml dry THF was added dropwise. The mixture was stirred at 0° for 1·5 hr and worked up in the usual way to afford 3·0 g product. A mixture of product in 30 ml acetone and 10·6 ml 10% $HClO_4$ was allowed to stand overnight at room temp and poured into ice water. The CH_2Cl_2 extract gave 2·5 g crude material, which was submitted to chromatography over 50 g Florisil. The eluate with petroleum ether-benzene (1:1) gave a small amount of oil. The eluates with benzene, benzene-CH_2Cl_2 (1:1) and CH_2Cl_2 were combined and concentration afforded 2·368 g solid. Recrystallization of the solid from acetone-n-hexane afforded 2·175 g (91·2%) **8b** as colourless crystals, m.p. 174–175°, $[\alpha]_D^{23}$ −233·6 ±2·7° (*c* = 1·008), ν_{max} 3435 (OH), 1732 (C=O) cm^{-1}, λ_{max}^{MeOH} 227, 262, 300 mμ (ε 1027, 160, 357); NMR: τ 9·23 (s, 3, 13-Me), 8·97 (s, 3, 10-Me), 8·32, 7·87 (AB part of ABX $|J_{1\alpha:1\beta}|$ = 14·0 Hz, $J_{1\beta:2\beta}$ = 1·2 Hz, $J_{1\alpha:2\beta}$ = 5·0 Hz, 1β-H, 1α-H), 7·57, 7·33 (AB type q, *J* = 18·5 Hz, 4α-H, 4β-H), 6·38 (d, 1, 2β-H), 6·35 (m, 1, 17α-H). (Found: C, 71·04; H, 8·80; S, 9·94. $C_{19}H_{28}O_2S$ requires: C, 71·20; H, 8·81; S, 10·01%). This compound was treated with Ac_2O-pyridine overnight at room temp to give **8c**, which on recrystallization from acetone-n-hexane afforded the pure sample, m.p. 185-187°, $[\alpha]_D^{23}$ −203·7 ±4·6° (*c* = 0·533), ν_{max} 1742 (C=O), 1726, 1250, 1048, 1027 (AcO) cm^{-1}. (Found: C, 69·67; H, 8·40; S, 8·98. $C_{21}H_{30}O_3S$ requires: C, 69·57; H, 8·34; S, 8·84%).

19-Norandrostane Series

19-*Nor*-5α-*androstane*-3β,5,6β,17β-*tetraol* 17-*monoacetate* (**2b**). To a soln of 40 g of 19-norandrost-5-ene-3β,17β-diol 17-monoacetate[3] in 300 ml CH_2Cl_2 was added a soln of 30·7 g *m*-chloroperbenzoic acid in 450 ml CH_2Cl_2 at room temp over 30 min. After being stirred for an additional 30 min, the mixture was worked up in the usual way, affording 40·4 g (96%) **1b** as a colourless solid. To a soln of 40·4 g **1b** in 300 ml dioxan was added 110 ml 5% $HClO_4$ at room temp over 30 min. The resulting mixture was stirred for 15 min, poured into ice water, neutralized with KOH aq, and extracted with $CHCl_3$. The crystals, deposited during concentration of the extract, were collected by filtration and washed with CH_2Cl_2, affording 31·0 g (73·7%) **2b** as colourless crystals, m.p. 264–266·5°, ν_{max} 3470, 3270 (OH), 1720, 1268 (OAc), 1025 cm^{-1}; NMR (in d_5-pyridine): τ 9·13 (s, 3, 13-Me), 7·98 (s, 3, AcO), 6·0 (br. m, 1, 6β-OH), 5·92 (m, 1, W h/2 = 6·0 Hz, 6α-H), 5·0–5·6 (br. m, 2, 3α-H, 17α-H), 4·95 (br. s, 2, OH).

19-*Nor*-5α-*androst*-2-*ene*-5,6β,17β-*triol* 17-*monoacetate* (**3c**). The foregoing **2b** (14·3 g) was treated with 11·6 g *p*-toluenesulphonyl chloride in 70 ml pyridine at room temp overnight. Usual work-up afforded 17·9 g 3-monotosylate as an amorphous solid. This was heated at 175° for 10 min in 90 ml collidine. The mixture was poured into iced 10% HCl. The deposited solid was collected by filtration, washed with water and dried, yielding 9·6 g solid. Recrystallization from $CHCl_3$ gave 8·2 g (60·6%) **3c** as colourless crystals, m.p. 270–272°, $[\alpha]_D^{25}$ +21·8 ±1·7° (*c* = 0·358), ν_{max} 3510, 3400 (OH), 3030, 1664 (Δ^2), 1717, 1260 (OAc), 1036, 1020, 875 cm^{-1}; NMR (in d_5-pyridine): τ 9·14 (s, 3, 13-Me), 7·97 (s, 3, AcO), 5·90 (m, 1, W h/2 = 9·0 Hz, 6α-H), 5·25 (m, 1, 17α-H), 5·13 (br. s, 1, 5α-OH), 4·17 (m, 2, W h/2 = 5·0 Hz, 2-H, 3-H), 4·02 (d, 1, *J* = 5·0 Hz, 6β-OH). (Found: C, 70·68; H, 9·19. $C_{20}H_{30}O_4 \cdot 1/3\ H_2O$ requires: C, 70·56; H, 9·08%).

19-*Nor*-5α-*androst*-2-*ene*-5,6β,17β-*triol triacetate* (**3d**). A mixture of 5·8 g of **3c**, 150 mg *p*-toluenesulphonic acid, 50 ml Ac_2O and 150 ml AcOH was stirred at room temp overnight. As the reaction proceeded, **3c** gradually dissolved. The resulting soln was poured into ice water and the deposited solid was collected by

filtration, washed with water and dried. Recrystallization from n-pentane afforded 7·1 g **3d** as colourless crystals, m.p. 161–163°, $[\alpha]_D^{26}$ −27·2 ±0·6° (*c* = 1·113), ν_{max} 3035, 1668 (Δ^2), 1741, 1731, 1251, 1220, 1048, 1023 (OAc) cm^{-1}; NMR: τ 9·17 (s, 3, 13-Me), 8·03, 7·97, 7·93 (each s, 9, AcO), 5·38 (dd, 1, *J* = 9·0, 7·0 Hz, 17α-H), 4·45 (m, 2, W h/2 = 7·5 Hz, 2-H, 3-H), 4·17 (m, 1, W h/2 = 5·5 Hz, 6α-H). (Found: C, 68·77; H, 8·13. $C_{24}H_{34}O_6$ requires: C, 68·87; H, 8·19%).

17β-*Acetoxy*-19-*nor*-5β-*androst*-2-*en*-5.6β-*epoxide* (**4c**). A mixture of 7·1 g **3d** and 15 g t-BuOK in 210 ml t-BuOH was heated under reflux for 40 min and concentrated to dryness under reduced press. The residual oil was dissolved in benzene-petroleum ether (3:2) and filtered to remove excess t-BuOK. The filtrate was passed through a short column packed with 70 g Al_2O_3. Elution with the same solvent afforded 4·2 g **4b** as a colourless oil; $\nu_{max}^{CS_2}$ 3560, 3440, 1050 (OH), 3029 (Δ^2), 904, 773 cm^{-1}; NMR: τ 9·27 (s, 3, 13-Me), 7·02 (d, 1, *J* = 2·5 Hz,[9] 6α-H), 6·39 (dd, 1, *J* = 8·5, 7·5 Hz, 17α-H), 4·11 (m, 2, W h/2 = 6·0 Hz, 2-H, 3-H). Acetylation of 4·2 g **4b** with 4 ml Ac_2O in 10 ml pyridine at room temp overnight and recrystallization of the product from n-pentane gave 4·3 g (80·1%) **4c** as colourless crystals, m.p. 114–115°, $[\alpha]_D^{26}$ +30·6 ±1·2° (*c* = 0·578), ν_{max} 3040 (Δ^2), 1732, 1255, 1245, 1045, 1035 (AcO), 905, 770 cm^{-1}; NMR: τ 9·22 (s, 3, 13-Me), 7·98 (s, 3, AcO), 6·98 (d, 1, *J* = 2·5 Hz,[9] 6α-H), 5·38 (dd, 1, *J* = 8·0, 7·0 Hz, 17α-H), 4·08 (m, 2, W h/2 = 6·0 Hz, 2-H, 3-H). (Found: C, 75·98; H, 8·60. $C_{20}H_{28}O_3$ requires: C, 75·90; H, 8·92%).

5-*Thiocyanato*-19-*nor*-5α-*androst*-2-*ene*-6β,17β-*diol* 17-*monoacetate* (**5b**). To a cold soln of 3·9 g of **4c** in 20 ml ether was added 50 ml of HSCN-ether soln prepared from 20 g KSCN.[4] After stirring at 0° for 1 hr, the mixture was washed with 10% Na_2CO_3 aq and water, and dried over Na_2SO_4. Removal of the solvent left 4·6 g solid. Recrystallization from ether-n-hexane afforded 2·8 g (60·5%) **5b** as colourless crystals, m.p. 172–174°, $[\alpha]_D^{26}$ −15·6 ±1·0° (*c* = 0·577), ν_{max} 3453 (OH), 3040, 1665 (Δ^2), 2143 (SCN), 1715, 1272, 1260, 1250, 1035 (OAc) cm^{-1}; NMR: τ 9·17 (s, 3, 13-Me), 7·97 (s, 3, AcO), 5·90 (m, 1, W h/2 = 8·5 Hz, 6α-H), 5·36 (dd, 1, *J* = 8·5, 7·5 Hz, 17α-H), 4·28 (m, 2, W h/2 = 5·5 Hz, 2-H, 3-H). (Found: C, 67·28; H, 7·01; N, 3·62; S, 8·68. $C_{21}H_{29}NO_3S$ requires: C, 67·17; H, 7·05; N, 3·73; S, 8·54%).

17β-*Hydroxy*-19-*nor*-5α-*androst*-2-*ene*-5-*thiol* (**6c**). The thiocyanatohydrin **5b** (2·8 g) was treated with 3 ml methanesulphonyl chloride in 20 ml pyridine overnight at room temp. Usual work-up gave 3·2 g mesylate as an amorphous solid, ν_{max} 3030 (Δ^2), 2160 (SCN), 1733, 1245, 1035 (AcO), 1325, 1120 (MsO), 800 cm^{-1}. To a stirred suspension of LAH (1·0 g) in 10 ml dry THF, a soln of 3·2 g of the mesylate in 30 ml dry THF at room temp was added dropwise during 20 min. The mixture was stirred for an additional 1 hr and worked up in the usual way, affording 2·6 g solid. Recrystallization from MeOH gave 1·33 g (61%) **6c** as colourless crystals, m.p. 155·5–156·5°, $[\alpha]_D^{25}$ +20·5 ±0·6° (*c* = 1·061), ν_{max} 3685, 3255, 1070, 1038, 1025 (OH), 3026, 1656 (Δ^2), 2573 (SH), 1204, 1140, 988, 910, 858, 783, 660 cm^{-1}; NMR: τ 9·26 (s, 3, 13-Me), 8·42 (s, 1, 17-OH), 6·35 (dd, 1, *J* = 8·0, 7·5 Hz, 17α-H), 4·37 (m, 2, W h/2 = 3·0 Hz, 2-H, 3-H). (Found: C, 73·72; H, 9·83; S, 10·98. $C_{18}H_{28}OS$ requires: C, 73·91; H, 9·65; S, 10·96%).

17β-*Benzoyloxy*-19-*nor*-5α-*androst*-2-*ene*-5-*thiol* (**6d**). To a cold soln of 2·75 g of **6c** in 30 ml pyridine was added 2·5 ml benzoyl chloride. The resulting mixture was stirred for 10 min at 0°, and poured into ice water. The deposited solid was collected by filtration, washed with water and dried. Recrystallization from ether gave 3·0 g (80·5%) **6d**, as colourless crystals, m.p. 217·5–218°, $[\alpha]_D^{26}$ +53·7 ±0·8° (*c* = 1·120), ν_{max} 3020, 1655, 666 (Δ^2), 2570 (SH), 1713, 1603, 1583, 1491, 1278, 1118, 718 (BzO) cm^{-1}; NMR: τ 9·09 (s, 3, 13-Me), 5·17 (m, 1, 17α-H), 4·42 (m, 2, W h/2 = 4·0 Hz, 2-H, 3-H), *ca* 2·65 (m, 3, Ph-H), *ca* 2·05 (m, 2, Ph-H). (Found: C, 75·94; H, 8·21; S, 8·01. $C_{25}H_{32}O_2S$ requires: C, 75·71; H, 8·13; S, 8·09%).

3β,17β-*Dihydroxy*-19-*nor*-5α-*androstan*-2α,5-*episulphide* 3-*acetate* 17-*benzoate* (**7d**). A stirred mixture of 12·0 g (27·1 mM) $Pb(OAc)_4$ and 4·0 g (40·0 mM) $CaCO_3$ in 100 ml cyclohexane was heated under reflux for 1 hr. To the boiling mixture, a soln of 3·0 g (7·57 mM) **6d** in 60 ml benzene was added dropwise with continuous heating and stirring. After the solid had been filtered off, the filtrate was worked up as described. The product (3·3 g) was recrystallized from ether-MeOH affording 3·0 g (87%) **7d** as colourless crystals, m.p. 127–128°, $[\alpha]_D^{25}$ +43·3 ±1·4° (*c* = 0·589), ν_{max} 1747, 1242, 1024 (AcO), 1722, 1603, 1585, 1490, 1294, 1274, 1119, 713 (BzO) cm^{-1}; NMR (in CCl_4): τ 9·06 (s, 3, 13-Me), 8·06 (s, 3, AcO), 6·35 (t, 1, *J* = 3·5 Hz, 2β-H), 4·80–5·30 (br. m, 2, 3α-H, 17α-H), *ca* 2·60 (m, 3, Ph-H), *ca* 2·05 (m, 2, Ph-H). (Found: C, 71·30; H, 7·50; S, 6·89. $C_{27}H_{34}O_2S$ requires: C, 71·33; H, 7·54; S, 7·05%).

3β,17β-*Dihydroxy*-19-*nor*-5α-*androstan*-2α,5-*episulphide* 17-*monobenzoate* (**7e**). A soln of 3·0 g **7d** and 2·0 g $KHCO_3$ in a mixture of 30 ml THF and 20 ml 90% MeOH was heated under reflux for 3 hr. After cooling, the mixture was diluted with ether and worked up in the usual way. Recrystallization from acetone-MeOH-n-hexane afforded 2·35 g (90·0%) **7e** as colourless crystals, m.p. 264–267°, $[\alpha]_D^{25}$ +49·3 ±1·5° (*c* = 0·601), ν_{max} 3370, 1028 (OH), 1720, 1603, 1583, 1490, 1280, 1120, 710 (BzO) cm^{-1}; NMR (in CCl_4): τ 9·05 (s, 3, 13-Me), 6·65 (t, 1, *J* = 3·5 Hz, 2β-H), 5·60 (m, 1, W h/2 = 17·5 Hz, 3α-H), 5·18 (m, 1, W h/2 = 16

Hz, 17α-H), *ca* 2·60 (m, 3, Ph-H), *ca* 2·05 (m, 2, Ph-H). (Found: C, 71·37; H, 7·80; S, 7·32. $C_{25}H_{32}O_3S \cdot 1/2\ CH_3OH$ requires: C, 71·46; H, 7·99; S, 7·48%).

17β-*Benzoyloxy-3-oxo-19-nor-5α-androstan-2α,5-episulphide* (**8d**). A mixture of 200 mg **7e**, 100 mg $Al(i\text{-}PrO)_3$, and 1 ml cyclohexanone in 5 ml dry toluene was refluxed for 45 min. After work-up in the usual way, recrystallization from CH_2Cl_2-acetone gave 170 mg (85·0%) **8d** as colourless crystals, m.p. 234–236°, $\nu_{max}^{CHCl_3}$ 1743 (C=O), 1715, 1603, 1585, 1125 (BzO), 1072, 1025 cm^{-1}; NMR: τ 9·03 (s, 3, 13-Me), 7·88, 7·49 (AB type q, 2, $|J|$ = 17·0 Hz, 4α-H, 4β-H), 6·30 (d, 1, J = 4·0 Hz, 2β-H), 5·10 (dd, 1, J = 7·0, 8·0 Hz, 17α-H), *ca* 2·50 (m, 3, Ph-H), *ca* 1·93 (m, 2, Ph-H). (Found: C, 73·03; H, 7·15; S, 7·55. $C_{25}H_{30}O_3S$ requires: C, 73·12; H, 7·37; S, 7·81%).

17β-*Benzoyloxy-3-ethylenedioxy-19-nor-5α-androstan-2α,5-episulphide* (**9b**). A soln of 90 mg **8d**, 20 mg *p*-toluenesulphonic acid and 0·8 ml 2-methyl-2-ethyl-1,3-dioxolane in 1 ml dry benzene was allowed to stand at room temp for 2 days. After usual work-up, recrystallization from acetone-n-pentane afforded 85 mg (85·3%) **9b** as colourless crystals, m.p. 204–205°, $\nu_{max}^{CHCl_3}$ 1715, 1603, 1585, 1283 (BzO), 1120, 1095 (ketal), 1025, 1015, 995, 970, 950 cm^{-1}. (Found: C, 71·61; H, 7·49; S, 7·40. $C_{27}H_{34}O_4S$ requires: C, 71·33; H, 7·54; S, 7·05%).

17β-*Hydroxy-3-oxo-19-nor-5α-androstan-2α,5-episulphide* (**8e**). The foregoing **9b** (85 mg) was reduced with 20 mg LAH in a mixture of 1 ml each dry THF and ether at 0° for 1 hr. The product (60 mg), ($\nu_{max}^{CHCl_3}$ 3580, 3480 (OH), 1105, 1070 (ketal), 1045, 1015, 950 cm^{-1}), was treated with 0·1 ml of 70% $HClO_4$ in 3 ml acetone overnight at room temp. After usual work-up, recrystallization from cyclohexane-acetone afforded 40 mg (69·7%) **8e** as colourless crystals, m.p. 208–209°, $\nu_{max}^{CHCl_3}$ 3590 (OH), 1740 (C=O) cm^{-1}; λ_{max}^{EtOH} 200·3 mμ (ε 2119), 226 (1387), 262 (215), 303·5 (417); NMR: τ 9·22 (s, 3, 13-Me), 7·88, 7·50 (AB type q, $|J|$ = 17·5 Hz, 4α-H, 4β-H), 6·15–6·45 (br. m, 2, 2β-H, 17α-H). (Found: C, 70·63; H, 8·51; S, 10·78. $C_{18}H_{26}O_2S$ requires: C, 70·55; H, 8·55; S, 10·46%).

The Reaction of 3-oxo-5α-cholestan-2α,5-episulphide with base

2α-*Acetylthiocholest-4-en-3-one* (**11b**). A mixture of 200 mg **10** and 200 mg KOH in 12 ml MeOH was heated at 70° for 1·5 hr under N_2 and poured into ice water. The CH_2Cl_2 extract was worked up in the usual way to afford 180 mg amorphous solid. Acetylation of this solid with 1 ml Ac_2O and 2 ml pyridine at room temp overnight gave 210 mg product as an oil. Purification was carried out by preparative TLC (cyclohexane-AcOEt = 3:1). Recrystallization of the fraction corresponding to the major spot, from ether-MeOH afforded 98 mg (45%) **11b** as colourless crystals, m.p. 78–79°, $[\alpha]_D^{23}$ −71·6 ±2·5° (c = 0·451), $\nu_{max}^{CHCl_3}$ 1691, 1116 (SAc), 1673, 1621 (4-en-3-one) cm^{-1}, λ_{max}^{dioxan} 233 mμ (ε 18700), CD (in dioxan): $[\theta]_{321}$ −6000, $[\theta]_{240}$ −43280, $[\theta]_{215}$ +53520; NMR: τ 9·30 (s, 3, 13-Me), 8·66 (s, 3, 10-Me), 7·62 (s, 3, —SAc), 5·56 (dd, 1, J = 14·3, 5·5 Hz, 2β-H), 4·18 (br. s, 1, 4-H). (Found: C, 75·96; H, 10·12; S, 6·99. $C_{29}H_{46}O_2S$ requires: C, 75·93; H, 10·11; S, 6·99%).

Bis 3-oxocholest-1,4-dien-2-yl disulphide (**12**)

(a) A mixture of 500 mg **10** and 500 mg K_2CO_3 in a mixture of 13 ml dioxan, 6 ml MeOH and 2 ml water was heated under reflux for 3 hr. After removal of the solvent under reduced press, water and CH_2Cl_2 were added to the mixture. The CH_2Cl_2 extract gave 492 mg residue, which was submitted to preparative TLC (cyclohexane-AcOEt = 4:1). The more mobile fraction yielded 58 mg (11·6%) starting **10**. The less mobile fraction gave a solid, which on recrystallization from ether-MeOH afforded 269 mg (54·1%) **12** as colourless crystals, m.p. 192–193°, $[\alpha]_D^{24}$ +299·4 ±6·6° (c = 0·517), $\nu_{max}^{CHCl_3}$ 1647, 1623, 1601 (1,4-dien-3-one) cm^{-1}, $\lambda_{max}^{isooctane}$ 235 mμ (ε 20110), 253 (18840), 297 (2830), CD (in dioxan); $[\theta]_{352}$ −8180, $[\theta]_{262}$ +76070; NMR: τ 9·30 (s, 3, 13-Me), 8·81 (s, 3, 10-Me), 3·89 (s, 1, 4-H), 3·03 (s, 1, 1-H), M.W. Found: 841, $C_{54}H_{82}O_2S_2$ requires: 827·328. (Found: C, 78·51; H, 9·95; S, 7·84. $C_{54}H_{82}O_2S_2$ requires: C, 78·39; H, 9·99; S, 7·75%).

(b) Compound **13**[6] (20 mg) was refluxed in 8 ml MeOH-H_2O (3:1) containing 20 mg Na_2CO_3 for 2 days. Work-up as described above afforded 5 mg **12**, m.p. 192–193°, identified by mixed m.p. and comparison of IR spectrum.

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