

The Prévost Reaction with 5 α -Androst-2-ene

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Treatment of 5 α -androst-2-ene with silver benzoate and iodine gives, as major products, the diaxial and diequatorial esters 5 α -androstane-2 β ,3 α -diol dibenzoate and 5 α -androstane-2 α ,3 β -diol dibenzoate, and the iodo-diester, 1 α -iodo-5 α -androstane-2 β ,3 β -diol dibenzoate. A mechanism for the Prévost reaction involving two regioisomeric iodo-benzoates has been established by the preparation and solvolysis of the intermediate iodo-benzoates.

The four epimeric 5 α -androstane-2,3-diols have been prepared.

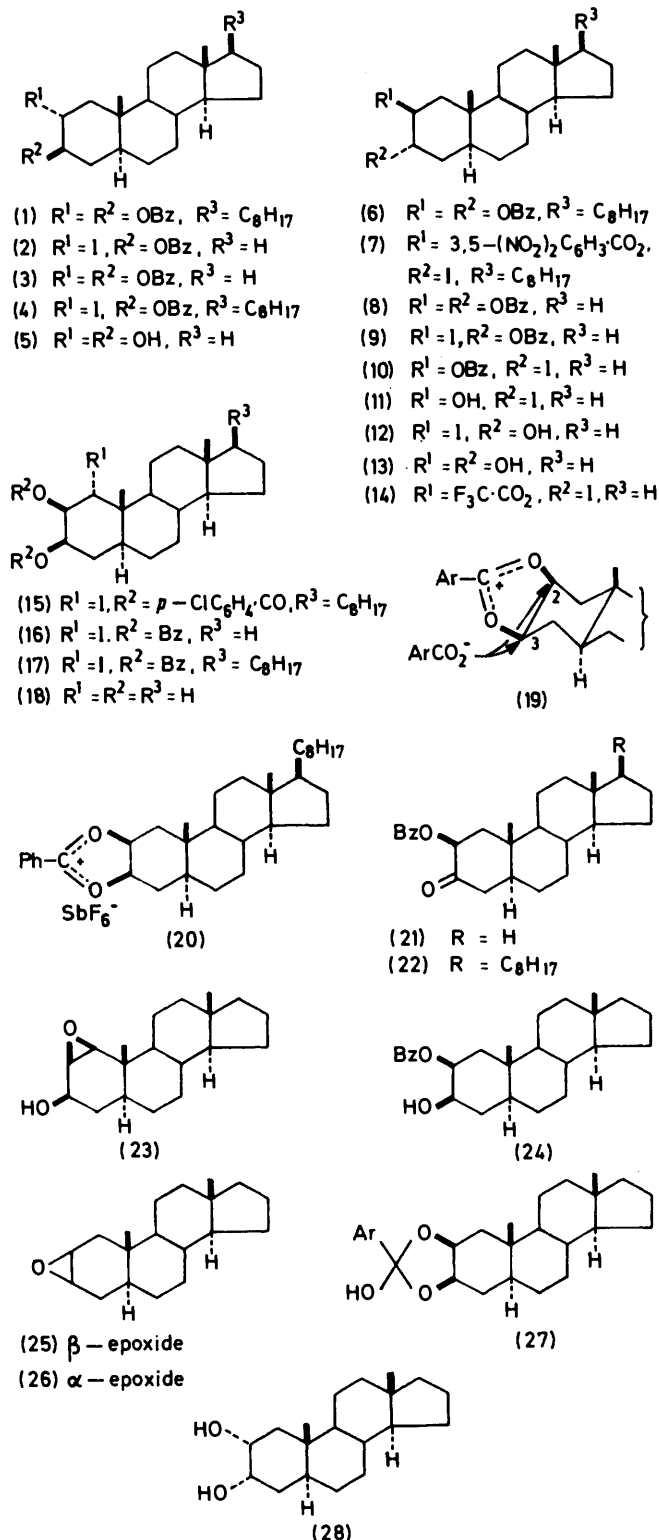
DURING the preparation of steroidal vicinal diols by the action of silver benzoate and iodine in a Prévost reaction with 5 α -cholest-2-ene, Meakins *et al.*¹ obtained the diequatorial ester (1) in addition to the expected diaxial ester (6). Depending on the nature of the silver salt, the iodo-ester (7) (with silver 3,5-dinitrobenzoate) or the iodo-diester (15) (with silver *p*-chlorobenzoate) was also obtained. Meakins *et al.* showed that the diequatorial esters did not arise by rearrangement of diaxial compounds, and therefore suggested that a common intermediate, *viz.* the 1,3-dioxolan-2-ylum ion (19) was undergoing competitive reactions at positions 2 and 3 as indicated. The formation of appreciable amounts of diequatorial esters and thus a reduced preference for diaxial opening of the dioxolan-2-ylum ion was rational-

ized by the suggestion that the reactions had small and therefore similar activation energies. Meakins and his co-workers noted that their results conflicted with the strong preference for diaxial opening of compound (20) by bromide ion,² and suggested that increasing the size of the attacking ion (to PhCO₂⁻) would enhance the tendency for equatorial approach at position 2. However, a model of the intermediate (19) in which ring A adopts a skew-boat conformation to accommodate a nearly planar dioxolanylium ring indicates that there should be no steric preference for attack at either C-2 or C-3. In the light of recent work by Mangoni and his

¹ P. S. Ellington, D. G. Hey, and G. D. Meakins, *J. Chem. Soc. (C)*, 1966, 1327.

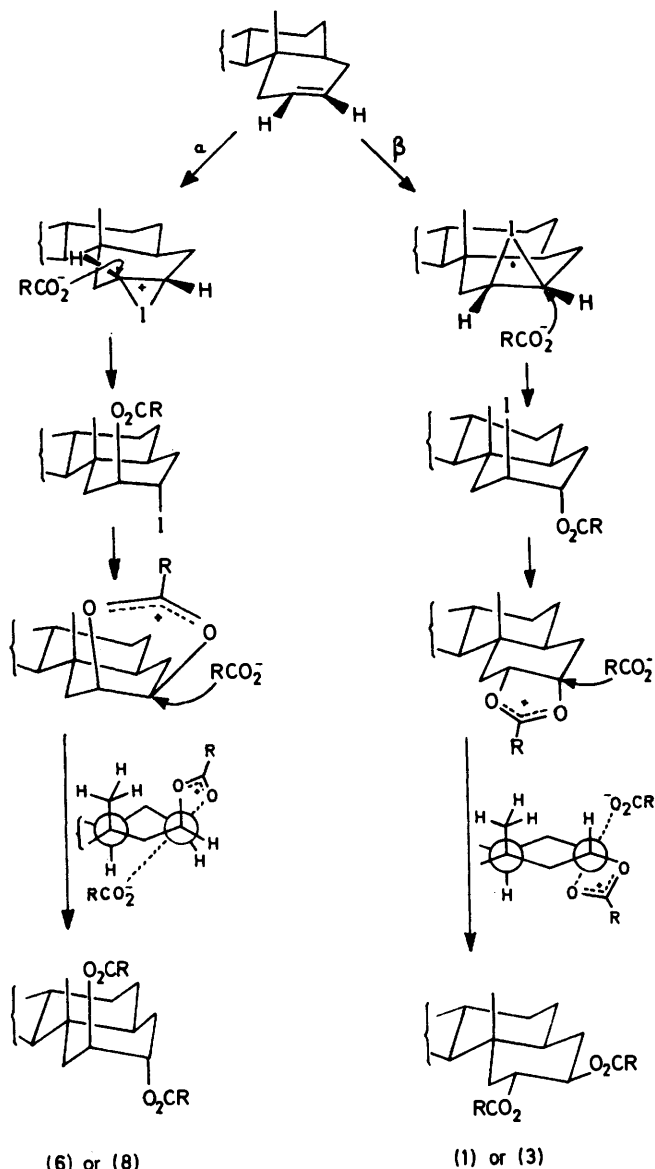
² J. F. King and A. D. Allbutt, *Chem. Comm.*, 1966, 14.

co-workers³ and ourselves,⁴ the formation of both diaxial and diequatorial esters can be explained more



the dibenzoate (6) being formed as the major product as a result of the steric preference for formation of an α -iodonium ion.

In order to examine the possibility of α - and β -iodonium ion formation we have carried out Prévost reactions with 5 α -androst-2-ene, in which the absence of the cholestane side chain simplifies n.m.r. investigation of the products. Meakins *et al.* found that a molar ratio of 1 : 2 : 4 of 5 α -cholest-2-ene to iodine to silver salt was



SCHEME 1

suitable for almost complete reaction of the alkene and for minimizing the unwanted Hunsdiecker reaction. They also established that when the mixture was heated under reflux in benzene, a reaction time of 1 h was

³ M. Adinolfi, M. Parrilli, G. Barone, and L. Mangoni, *Gazzetta*, 1975, **105**, 1021, and papers cited therein.

⁴ R. C. Cambie, R. C. Hayward, J. L. Roberts, and P. S. Rutledge, *J.C.S. Perkin I*, 1974, 1120; see also A. Bowers, E. Denot, and R. Becerra, *J. Amer. Chem. Soc.*, 1960, **82**, 4007.

reasonably in terms of initial formation of both α - and β -iodonium ions (Scheme 1). Diaxial opening of each intermediate would lead to the observed products,

adequate; after that the amount of steroidal carboxylates did not increase but products formed by alternative reactions accumulated. In the present work, 5 α -androst-2-ene was treated with silver benzoate and iodine in refluxing benzene for 40 min to give, consistently, five products. In order of decreasing R_F value these were identified from microanalytical, mass spectral, ^1H n.m.r., and i.r. characteristics and by comparison with the products from 5 α -cholest-2-ene, as the diequatorial iodo-ester 2 α -iodo-5 α -androstan-3 β -yl benzoate (2) (6%), the diequatorial dibenzoate 5 α -androstan-2 α ,3 β -diol dibenzoate (3) (21%), the iodo-diester 1 α -iodo-5 α -androstan-2 β ,3 β -diol dibenzoate (16) (12%), the diaxial dibenzoate 5 α -androstan-2 β ,3 α -diol dibenzoate (8) (46%), and the oxo-benzoate 2 β -benzoyloxy-5 α -androstan-3-one (21) (6%). The structure of the iodo-ester (2) was confirmed by reduction with lithium aluminium hydride to 5 α -androstan-3 β -ol,⁵ and that of the iodo-dibenzoate (16) by conversion with ethanolic potassium hydroxide into 1 β ,2 β -epoxy-5 α -androstan-3 β -ol (23). Assignment of the oxo-group of the oxo-benzoate (21) to the 3-position and the benzoate group to the 2 β -position followed from (i) the smooth positive Cotton effect,⁶ (ii) a comparison of the downfield doublet of doublets at δ 5.18 (J_{ae} 7, J_{an} 12 Hz) * in the ^1H n.m.r. spectrum with the corresponding signals of six isomeric α -acetoxycholestanones,⁷ and (iii) the similarity of the 10-methyl signal (δ 1.13) to that of the diaxial dibenzoate (8) (δ 1.09) [*cf.* δ 1.07 for (3)].

When the Prévost reaction was conducted at lower temperature (20 °C) for a longer time (3 days), only three products were obtained, *viz.* the diequatorial iodo-benzoate (2), the iodo-dibenzoate (16), and the diaxial dibenzoate (8). Reactions were also carried out in other solvents in order to examine solvent effects on the product distribution (Table I). The major product

TABLE I
Effects of solvent on product distribution

Solvent	Products (%)						
	(9)	(2)	(3)	(16)	(8)	(21)	(24)
PhH		10		33	51		
Et ₂ O		7		9	19		55
CH ₂ Cl ₂	21	3	9	6	12		40
CHCl ₃		5	10		10	13	47
CCl ₄		9		24	60		

* All reactions were carried out at 20 °C for 3 days.

obtained with diethyl ether, dichloromethane, or chloroform was identified as 5 α -androstan-2 β ,3 β -diol 2-benzoate (24) from its spectral parameters. An additional product obtained with dichloromethane as solvent

* Application of the Karplus equation gives C-1-C-2 dihedral angles which are readily accommodated if ring-A adopts a twist-boat conformation, this apparently being favoured over a chair form as a result of 1,3-diaxial interaction of the 2 β -benzoate group with the 10-methyl group in the latter case.

† Coincidental support for this pathway arises from the work of Mangoni *et al.*,⁹ who found that treatment of an α -orientated 1,3-dioxolan-2-ylidonium ion, which would arise in the present case from opening of a β -iodonium ion (Scheme 1), with silver benzoate gave the diequatorial dibenzoate (1) in 77% yield with only 6% of the diaxial dibenzoate (6).

was formulated as 2 β -iodo-5 α -androstan-3 α -yl benzoate (9), and this structure was subsequently confirmed by synthesis (see later).

In order to obtain evidence for the formation of both α - and β -iodonium ions, independent syntheses of the iodo-benzoates (9) and (10) were carried out. If solvolysis of the iodo-ester (10) with silver benzoate was to lead to both diaxial and diequatorial dibenzoates then a mechanism involving both diaxial and diequatorial opening of a β -dioxolan-2-ylidonium ion⁸ would be supported. In this case only an α -iodonium ion need be postulated. If, however, solvolysis of the iodo-benzoate (10) gave none of the diequatorial dibenzoate (3) then a further pathway (Scheme 1) involving diaxial opening of an α -dioxolan-2-ylidonium ion and by implication of a β -iodonium ion would be necessary in order to explain formation of the dibenzoate (3) as a product of the Prévost reaction. Likewise, if solvolysis of the iodo-benzoate (9) gave the dibenzoate (3) but not the dibenzoate (8), a pathway involving diaxial openings of an α -iodonium and a β -dioxolan-2-ylidonium ion would be indicated in order to explain formation of the dibenzoate (8) in the Prévost reaction.†

For the preparation of 3 α -iodo-5 α -androstan-2 β -yl benzoate (10), 5 α -androst-2-ene was treated with a mixture of iodine, potassium iodate, and sulphuric acid¹⁰ at 20 °C for 20 h. Chromatography of the product gave unchanged alkene (4%), the diaxial iodohydrin (11) (52%), a mixture of the iodohydrins (11) and (12) (3%), and the 2 β ,3 α -diol (13) (22%). When the reaction was carried out for 72 h the diol (13) was the only product. The diol must arise by diaxial opening of the 2 β ,3 β -epoxide (25), which was itself observed as a product before chromatography, when the reaction was carried out for 15 h. Gurst and Djerassi¹¹ have noted that the epoxide (25) is sensitive to chromatography, being readily opened to the diol (13). The epoxide (25) must arise from a slow transformation of the iodohydrin (11),¹² but it is interesting that this reaction takes place in an acidic medium rather than a basic medium¹³ which is normally required for epoxide formation from halohydrins. Since the iodohydrin (12) was obtained in much lower yield than the iodohydrin (11), it appears that the addition of 'hypoiodous acid' to 5 α -androst-2-ene occurs stereoselectively, an α -

⁵ L. Mamlok and J. Jacques, *Bull. Soc. chim. France*, 1960, 484.

⁶ C. Djerassi, 'Optical Rotatory Dispersion,' McGraw-Hill, New York, 1960, p. 42.

⁷ K. L. Williamson and W. S. Johnson, *J. Amer. Chem. Soc.*, 1961, **83**, 4623.

⁸ J. F. King and A. D. Allbutt, *Canad. J. Chem.*, 1970, **48**, 1754; A. Balsamo, P. Crotti, B. Macchia, and F. Macchia, *Tetrahedron*, 1973, **29**, 199.

⁹ R. Caputo, L. Mangoni, and L. Previtiera, *Steroids*, 1975, **25**, 619.

¹⁰ J. W. Cornforth and D. T. Green, *J. Chem. Soc. (C)*, 1970, 846.

¹¹ J. E. Gurst and C. Djerassi, *J. Amer. Chem. Soc.*, 1964, **86**, 5542.

¹² M. Parrilli, G. Barone, M. Adinolfi, and L. Mangoni, *Tetrahedron Letters*, 1976, 207.

¹³ C. Djerassi, 'Steroid Reactions; An Outline for Organic Chemists,' Holden-Day, San Francisco, 1963, p. 606.

addition of iodine occurring *via* the sterically favoured α -iodonium ion. Treatment of the iodohydrin (11) with methanolic potassium carbonate gave a mixture of the 2 β ,3 β -epoxide (25) (56%) and the diol (13) (25%), while benzoylation gave the desired iodobenzoate (10) in near quantitative yield. In addition to signals due to five aryl protons, the ^1H n.m.r. spectrum of the latter showed two narrow one-proton multiplets at δ 4.70 ($W_{1/2}$ 6 Hz) and 5.50 ($W_{1/2}$ 7 Hz), corresponding to equatorial protons geminal to iodine and benzoate groups, respectively. The magnitude of the downfield shift of the 10-methyl signal (0.29 p.p.m.) was also indicative of a 2 β -benzoate group, and its presence was confirmed when reduction of the iodobenzoate with lithium aluminium hydride afforded 5 α -androstan-2 β -ol.¹¹

Treatment of the iodobenzoate (10) with silver benzoate in undried benzene gave the diaxial dibenzoate (8) (45%) and the hydroxy-benzoate (24) (55%), whereas treatment of the iodo-benzoate (10) with iodine and silver benzoate under the earlier Prévost reaction conditions gave the dibenzoate (8) (55%) and the iodo-dibenzoate (16) (39%); no trace of the diequatorial dibenzoate (3) was formed in either reaction. The diequatorial iodobenzoate (2) obtained earlier from the Prévost reaction was unchanged after attempted solvolysis with silver benzoate in dry benzene at 20 °C for 3 days.

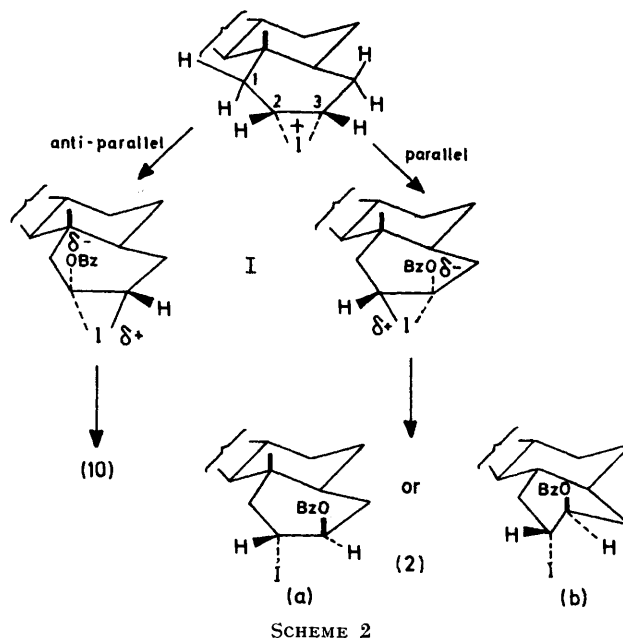
For the preparation of 2 β -iodo-5 α -androstan-3 α -yl benzoate (9), 5 α -andro-2-ene was converted (96% yield) into the 2 α ,3 α -epoxide (26) with *m*-chloroperbenzoic acid. The stereochemical assignment of the epoxide was in accord with the pattern for the C-2 and C-3 proton signals in the ^1H n.m.r. spectrum¹⁴ and the absence of a downfield shift of the 10-methyl signal (relative to 5 α -andro-2-ene¹⁵) which indicated the lack of a 2 β -substituent. Opening of the epoxide with sodium iodide, sodium acetate, and acetic acid gave the diaxial iodohydrin (12) as the major product (72%). The iodohydrin showed a two-proton multiplet at δ 4.42 in the ^1H n.m.r. spectrum with $W_{1/2}$ 10 Hz, indicating that the substituents at C-2 and C-3 must both be axial. Also, the magnitude of the downfield shift of the 10-methyl signal (δ 1.13) (relative to 5 α -andro-2-ene, δ 0.79¹⁵) was in accord with that (*ca.* 0.4 p.p.m.) recorded by Hassner¹⁶ for a 2 β -iodo-substituent. The compound was light-sensitive and susceptible to decomposition so that a satisfactory elemental analysis was not obtained. Also, in keeping with our experience of iodohydrins, no molecular ion was observed during high resolution mass spectrometry at either 70 or 12 eV, although ions at m/e 369.105 2 ($M^{+} - \text{CH}_3 - \text{H}_2\text{O}$) and 275.235 6 ($M^{+} - \text{I}$) were observed. However, benzoylation afforded the iodo-benzoate (9) obtained earlier. Solvolysis of the product with silver benzoate in dry benzene afforded the dibenzoate (3) in 73% yield.

¹⁴ K. Tori, T. Komeno, and T. Nakagawa, *J. Org. Chem.*, 1964, **29**, 1136.

¹⁵ K. Tori and T. Komeno, *Tetrahedron*, 1965, **21**, 309.

¹⁶ F. W. Fowler, A. Hassner, and L. A. Levy, *J. Amer. Chem. Soc.*, 1967, **89**, 2077.

Although the above results clearly favour the formation and diaxial opening of both α - and β -iodonium ions in the Prévost reaction with 5 α -andro-2-ene, opening of the α -iodonium ion led to two regioisomeric iodo-benzoates, *viz.* (2) and (10). However, their formation can be rationalized in terms of possible conformations during nucleophilic attack on the α -iodonium ion (Scheme 2).¹⁷ Attack by the anion at C-2 in the usual 'anti-parallel'¹⁸ mode would lead directly to the diaxial derivative (10), whereas 'parallel' attack at C-3 would give the less favoured skew conformation (a) [or



boat conformation (b)¹⁹]. Either conformation can then give the more stable chair form of (2) in which the substituents are still *trans* but now equatorial.

The presence of the hydroxy-benzoate (24) as a product of the Prévost reaction can be explained if moisture is present in the reaction mixture. Hydrolysis of the 1,3-dioxolan-2-ylum ion (19) could give the hemioorthoester (27), which then rearranges to the hydroxy-benzoate (24). The oxo-benzoate (21) probably arises from this latter product since it has been shown that alcohols are readily oxidized by acyl hypoiodites.²⁰ The iodo-dibenzoate (16) arises by abstraction of the 1 α -proton from the β -dioxolan-2-ylum ion (19) followed by a normal Prévost reaction at the 1,2-double bond of an allylic benzoate in the manner already outlined by Meakins *et al.* for the iodo-bis-*p*-chlorobenzoate (15).¹ Direct evidence in support of this pathway arises from

¹⁷ J. Valls and E. Toromanoff, *Bull. Soc. chim. France*, 1961, 758.

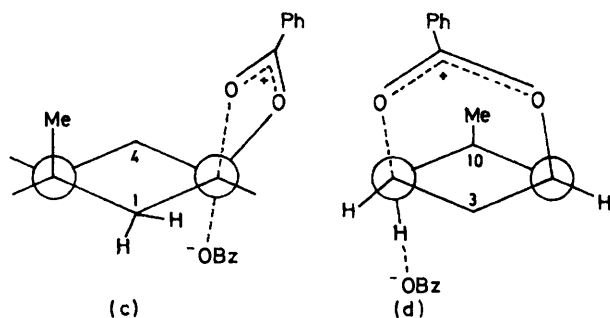
¹⁸ D. N. Kirk and M. P. Hartshorn, 'Steroid Reaction Mechanisms,' Elsevier, Amsterdam, 1968, p. 97.

¹⁹ A. Hassner and C. Heathcock, *J. Org. Chem.*, 1965, **30**, 1748.

²⁰ T. R. Beebe, B. A. Barnes, K. A. Bender, A. D. Halbert, R. D. Miller, M. L. Ramsay, and M. W. Ridenour, *J. Org. Chem.*, 1975, **40**, 1992.

the isolation of the iodo-dibenzoate (16) from the solvolysis of the iodo-benzoate (10) during the present study (*cf.* ref. 4).

As noted earlier, solvolysis of 3 α -iodo-5 α -androstan-2 β -yl benzoate (10) with silver benzoate in the presence of iodine gave both the diaxial dibenzoate (8) and the iodo-dibenzoate (16) but no diequatorial diester (3). It appears therefore that it is more favourable for the benzoate anion to abstract the 1 α -proton from the cation (19) than it is for the anion to attack the C-2 position from a 'parallel' [to C(1)-H α] or quasiequatorial direction. King and Allbutt²¹ have suggested that the preferred conformation of a free 1,3-dioxolan-2-ylum ion is a flat or nearly flat ring, but fusion to a cyclohexane ring probably requires the latter to become somewhat flattened and the dioxolan-2-ylum ring to become somewhat puckered. This is supported by the recent X-ray analysis of 2-methylperhydro-1,3-benzodioxol-2-ylum perchlorate by Paulsen and Dammeyer,²² who have shown that the non-planar dioxolanylium ring adopts a twist conformation with a torsional angle O(1)-C(5)-C(4)-O(3) of 25.9° and that the cyclohexane ring lies between a chair and half-chair conformation. S_N2-Like displacement of the axial C-2 oxygen of a β -dioxolan-2-ylum ion as in 'parallel' or quasiequatorial opening (c) would lead not only to an unfavourable initial conformation¹⁸ of the product (3) but also to greater puckering of the heterocyclic system in the transition state. This would result in a diminution of resonance stabilization and considerable increase in angle strain. On the other hand the C-1 α -proton and



the C-2 oxygen are already very close to the antiperiplanar configuration (d) required for ready elimination. Also, increased acidity of the 1 α -proton may arise as a result of unsymmetrical hydrogen bridge formation.²³

Prévost reactions on 5 α -androst-2-ene were also carried out by using thallium(I) benzoate²⁴ (4 equiv.) and iodine (2 equiv.) in dry benzene at 80 °C for 4 h; no starting material then remained. These reactions gave five products of which four were identified as the 3 α -iodo-2 β -

benzoate (10) (5%), the 2 α -iodo-3 β -benzoate (2) (9%), the diaxial dibenzoate (8) (21%), and the 3 β -hydroxy-2 β -benzoate (24) (50%); the fifth product (trace) was not identified. In line with our previous experience²⁴ that thallium(I) carboxylates do not induce solvolysis at room temperature, reaction at 20 °C for 3 days gave only the 3 α -iodo-2 β -benzoate (10) (65%). Use of silver trifluoroacetate and iodine in the Prévost reaction gave a high yield of 3 α -iodo-5 α -androstan-2 β -yl trifluoroacetate (14), a result similar to that of Meakins *et al.*²⁵ for the action of the same reagents on 5 α -cholest-2-ene. However, chromatographic work-up resulted in some hydrolysis of the iodo-trifluoroacetate (14) to the iodohydrin (11).

In view of the isolation of additional products from the Prévost reaction with 5 α -androst-2-ene, Meakins' reaction of 5 α -cholest-2-ene in benzene at 20 °C for 3 days was repeated. In addition to the previously reported¹ diaxial dibenzoate (6) (27%) and diequatorial dibenzoate (1) (13%), the 2 α -iodo-3 β -benzoate (4) (2%), the iodo-dibenzoate (17) (17%), and the oxo-benzoate (22) (8%) were isolated. The difference between the present ratio (2 : 1) of diaxial dibenzoate to diequatorial dibenzoate and that found by Meakins *et al.* (9 : 1) may be due to the difficulty experienced by these workers in separating the products.

Incidentally to the present study, the four epimeric androstane-2,3-diols were all prepared for the first time. The 2 β ,3 α -diol (13) was formed by hydrolysis (74% yield) of the *trans*-diaxial dibenzoate (8) and also as a product of Cornforth oxidation¹⁰ of 5 α -androst-2-ene (see above). The *trans*-diequatorial 2 α ,3 β -diol (5) was obtained (95% yield) by reduction of the 2 α ,3 β -dibenzoate (3) with lithium aluminium hydride, and the 2 β ,3 β -diol (18) was prepared by similar reduction (93% yield) of the iodo-dibenzoate (16). A more satisfactory route (100% yield) to this latter product involved a modified¹ Woodward-Prévost reaction²⁶ in which 5 α -androst-2-ene was stirred with silver acetate and iodine in moist acetic acid under nitrogen at 20 °C for 20 h and the product reduced with lithium aluminium hydride. The 2 α ,3 α -diol (28) was the only product (96% yield) obtained by hydroxylation of 5 α -androst-2-ene with

TABLE 2
Chemical shifts

Compound	δ	$W_{1/2}/\text{Hz}$	Assignment
(13)	3.93	8	2-H 3-H
(5)	3.43	16	2-H 3-H
(28)	3.60	19	2-H
	3.96	8	3-H
(18)	3.60	22	3-H
	3.96	9	2-H

osmium tetroxide. Chemical shifts for the downfield protons of the diols are shown in Table 2; assignments for the 2 β ,3 β -diol agree well with those [δ 3.63 ($W_{1/2}$ 23

²¹ J. F. King and A. D. Allbutt, *Canad. J. Chem.*, 1969, **47**, 1445.

²² H. Paulsen and R. Dammeyer, *Chem. Ber.*, 1976, **109**, 605.

²³ V. J. Shiner and J. G. Jewett, *J. Amer. Chem. Soc.*, 1965, **87**, 1382; 1964, **86**, 945.

²⁴ R. C. Cambie, R. C. Hayward, J. L. Roberts, and P. S. Rutledge, *J.C.S. Perkin I*, 1974, 1858.

²⁵ D. G. Hey, G. D. Meakins, and M. W. Pemberton, *J. Chem. Soc. (C)*, 1966, 1331.

²⁶ R. B. Woodward and F. V. Brutcher, jun., *J. Amer. Chem. Soc.*, 1958, **80**, 209.

Hz, 3-H) and 4.01 ($W_{1/2}$ 10 Hz, 2-H)] recorded for cholestane-2 β ,3 β -diol,²⁷ the only cholestane-2,3-diol for which ¹H n.m.r. data are available.

EXPERIMENTAL

Unless otherwise indicated, i.r. spectra were recorded for solutions in CHCl₃ with a Perkin-Elmer 237 or 337 spectrophotometer. Optical rotations were recorded with a Perkin-Elmer 241 polarimeter for solutions in CHCl₃ and the o.r.d. curve was measured with a JASCO ORD UV-5 spectrometer. ¹H N.m.r. spectra were measured for solutions in CDCl₃ with a Varian T60 spectrometer (tetramethylsilane as internal reference). Low resolution mass spectra were determined with a Varian-MAT CH7 spectrometer, and high resolution spectra with an A.E.I. MS9 instrument ($m/\Delta m$ 10⁴) interfaced with the A.E.I. mass spectrometry data system DS30, or with an A.E.I. MS30 instrument. Alumina for column chromatography was Spence type H material. T.l.c. was carried out on 0.5 mm thick plates of Kieselgel DG (Riedel de Haen); preparative t.l.c. (p.l.c.) was carried out on 1 mm thick plates of Kieselgel PF₂₅₄ + 366 (Merck). Compounds are listed in decreasing order of R_F values.

Prévost Reactions with 5 α -Androst-2-ene.—(a) *With silver benzoate at 80 °C.* Benzene (3 ml) was distilled from a mixture of 5 α -androst-2-ene²⁸ (0.20 g, 0.77 mmol) and silver benzoate (0.68 g, 2.96 mmol) in dry benzene, iodine (0.38 g, 1.48 mmol) was added, and the mixture was heated under reflux for 40 min. The solution was filtered, diluted with benzene, and worked up by washing successively with water, aqueous 2M-sodium carbonate, water, aqueous 5M-sodium disulphite, water, and brine. The organic phase was dried (MgSO₄) and evaporated under reduced pressure. P.l.c. (n-hexane-ether, 9:1) of the product (0.41 g) gave (i) 2 α -iodo-5 α -androst-3 β -yl benzoate (2) (23 mg), which crystallized from methanol as needles, m.p. 209–211°, $[\alpha]_D$ –13° (c 1.0) (Found: C, 62.0; H, 6.9; I, 24.9. C₂₆H₃₅IO₂ requires C, 61.7; H, 7.0; I, 25.1%), ν_{\max} 1710 and 1270 cm⁻¹ (OBz), δ 0.74 (s, 18-H₃), 0.90 (s, 19-H₃), 4.47 (m, $W_{1/2}$ 30 Hz, 2-H), 5.37 (m, $W_{1/2}$ 28 Hz, 3-H), and 7.57 and 8.10 (2 m, ArH), m/e 506 (M^{++}), 491 ($M^{++} - CH_3$), 384 ($M^{++} - PhCO_2H$), 379 ($M^{++} - I$), and 257 ($M^{++} - I - PhCO_2H$); (ii) 5 α -androstane-2 α ,3 β -diol dibenzoate (3) (80 mg), which crystallized from methanol as needles, m.p. 196–198°, $[\alpha]_D$ –64° (c 1.0) (Found: C, 79.0; H, 8.1. C₃₃H₄₆O₄ requires C, 79.2; H, 8.1%), ν_{\max} 1720 and 1275 cm⁻¹ (OBz), δ 0.70 (s, 18-H₃), 1.07 (s, 19-H₃), 5.43 (m, $W_{1/2}$ 28 Hz, 2 β -3 α -H), and 7.57 and 8.00 (2 m, ArH); (iii) 1 α -iodo-5 α -androstane-2 β ,3 β -diol dibenzoate (16) (60 mg), which crystallized from methanol as needles, m.p. 65–67°, $[\alpha]_D$ +10° (c 1.0), ν_{\max} 1720 and 1270 cm⁻¹ (OBz), δ 0.70 (s, 18-H₃), 1.10 (s, 19-H₃), 4.66 (d, J 2 Hz, 1-H), 6.00 (m, $W_{1/2}$ 6 Hz, 2 α -3 α -H), and 7.53 and 8.03 (2 m, ArH), m/e (M^{++} not observed) 504.150 8 ($M^{++} - PhCO_2H$) (C₂₆H₃₅IO₂ requires 504.149 3) and 499.291 2 ($M^{++} - I$) (C₃₃H₃₉O₄ requires 499.284 2); (iv) 5 α -androstane-2 β ,3 α -diol dibenzoate (8) (0.18 g), which crystallized from acetone as needles, m.p. 86–88°, $[\alpha]_D$ +43° (c 1.0) (Found: C, 79.2; H, 7.9. C₃₃H₄₀O₄ requires C, 79.2; H, 8.1%), ν_{\max} 1720 and 1270 cm⁻¹ (OBz), δ 0.67 (s, 18-H₃), 1.09 (s, 19-H₃), 5.32 (m, $W_{1/2}$ 6 Hz, 2 α ,3 β -H), and 7.50 and

8.03 (2 m, ArH); m/e (M^{++} not observed) 378.254 5 ($M^{++} - PhCO_2H$) (C₂₆H₃₄O₂ requires 378.253 1); and (v) 3-oxo-5 α -androstane-2 β -yl benzoate (21) (19 mg) which crystallized from methanol as needles, m.p. 118–120° (Found: C, 78.7; H, 9.1. C₂₆H₃₄O₃ requires C, 79.1; H, 8.7%), ν_{\max} 1720 and 1265 cm⁻¹ (OBz), δ 0.70 (s, 18-H₃), 1.13 (s, 19-H₃), 5.18 (dd, J_{aa} 7, J_{aa} 12 Hz, 2 α -H), and 7.50 and 8.06 (2m, ArH), m/e 394 (M^{++}), 379 ($M^{++} - CH_3$), 366 ($M^{++} - CO$), and 272 ($M^{++} - PhCO_2H$), o.r.d. (c 0.20 in CHCl₃) $[\phi]_{589}^{+31.5^\circ}$, $[\phi]_{436}^{+71.9^\circ}$, $[\phi]_{365}^{+154^\circ}$, $[\phi]_{330}^{+453^\circ}$, $[\phi]_{312}^{+990^\circ}$, and $[\phi]_{300}^{+470^\circ}$.

(b) *With silver benzoate at 20 °C.* Benzene (3 ml) was distilled from a mixture of 5 α -androst-2-ene (0.20 g, 0.77 mmol) and silver benzoate (0.68 g, 2.96 mmol) in dry benzene (15 ml). The mixture was cooled to 20 °C and stirred with iodine (0.38 g, 1.48 mmol) for 3 days. Work-up as above followed by p.l.c. gave a 1:3:5 ratio of the 2 α -iodo-3 β -benzoate (2), the 1 α -iodo-2 β ,3 β -dibenzoate (16), and the 2 β ,3 α -dibenzoate (8).

(c) *With silver benzoate in ether.* Iodine (0.15 g, 0.58 mmol) was added to a suspension of 5 α -androst-2-ene (75 mg, 0.29 mmol) and silver benzoate (0.27 g, 1.15 mmol) in anhydrous ether (15 ml) and the mixture was stirred at 20 °C for 3 days. Work-up as above and p.l.c. gave the iodo-benzoate (2) (7%), the iodo-dibenzoate (16) (9%), the dibenzoate (8) (19%), and 5 α -androstane-2 β ,3 β -diol 2-benzoate (24) (55%), which crystallized from methanol as needles, m.p. 161–163°, $[\alpha]_D$ –1° (c 0.55) (Found: C, 78.6; H, 9.0. C₂₆H₃₆O₃ requires C, 78.8; H, 9.2%), ν_{\max} 3420 (OH) and 1710 and 1270 cm⁻¹ (OBz), δ 0.70 (s, 18-H₃), 1.05 (s, 19-H₃), 3.90 (m, $W_{1/2}$ 22 Hz, 3-H), 5.50 (m, $W_{1/2}$ 8 Hz, 2-H), and 7.55 and 8.06 (2 m, ArH).

(d) *With silver benzoate in dichloromethane.* The previous experiment was repeated with dry dichloromethane (15 ml) as solvent. Work-up as above and p.l.c. gave 2 β -iodo-5 α -androst-3 α -yl benzoate (9) (21%), which crystallized from methanol as plates, m.p. 172–174°, ν_{\max} 1710 and 1270 cm⁻¹ (OBz), δ 0.70 (s, 18-H₃), 1.23 (s, 19-H₃), 4.67 (m, $W_{1/2}$ 9 Hz, 2-H), 5.53 (m, $W_{1/2}$ 6 Hz, 3-H), and 7.50 and 8.03 (2 m, ArH), m/e (M^{++} not observed) 384.137 4 ($M^{++} - PhCO_2H$) (C₁₉H₂₉I requires 384.138 4) and 379.268 4 ($M^{++} - I$), (C₂₆H₃₅O₂ requires 379.263 6). The iodo-benzoate (2) (3%), dibenzoate (3) (9%), iodo-dibenzoate (16) (6%), dibenzoate (8) (12%), and hydroxy-benzoate (24) (40%) were also obtained.

(e) *With silver benzoate in chloroform.* The previous experiment was repeated in dry chloroform (15 ml). Work-up and p.l.c. gave the iodo-benzoate (2) (5%), dibenzoate (3) (10%), dibenzoate (8) (10%), oxo-benzoate (21) (13%), and hydroxy-benzoate (24) (47%).

(f) *With silver benzoate in carbon tetrachloride.* The previous experiment was repeated in dry carbon tetrachloride (15 ml). Work-up and p.l.c. gave the iodo-benzoate (2) (9%), iodo-dibenzoate (16) (24%), and dibenzoate (8) (60%).

(g) *With silver trifluoroacetate in dichloromethane.* Iodine (0.20 g, 0.73 mmol) and 5 α -androst-2-ene (0.10 g, 0.39 mmol) were added alternately in portions to a stirred suspension of silver trifluoroacetate (0.62 g, 1.5 mmol) in dry dichloromethane (30 ml) under nitrogen at 20 °C. The mixture was stirred for 4 h and filtered, and the filtrate worked-up as above. P.l.c. gave (i) 3 α -iodo-5 α -androst-2 β -yl trifluoroacetate (14) (70 mg, 36%) as an oil, $[\alpha]_D$ +61° (c 1.0),

²⁷ R. Wiechert, U. Kerb, P. Hocks, A. Furlenmeier, A. Furst, A. Langemann, and G. Waldvogel, *Helv. Chim. Acta*, 1966, **49**, 1581.

²⁸ J. M. Evans, G. D. Meakins, Y. Morisawa, and P. D. Woodgate, *J. Chem. Soc. (C)*, 1968, 2841.

ν_{\max} . 1 780 (CO) and 1 220 cm^{-1} (C-O), δ 0.73 (s, 18-H₃), 0.97 (s, 19-H₃), 4.60 (m, $W_{1/2}$ 6 Hz, 3-H), and 5.43 (m, $W_{1/2}$ 7 Hz, 2-H); and (ii) 3 α -iodo-5 α -androstan-2 β -ol (11) (50 mg, 32%), identical (¹H n.m.r., i.r.) with an authentic sample (see later).

(h) *With thallium(I) benzoate at 80 °C.* Benzene (2 ml) was distilled from a mixture of 5 α -androst-2-ene (50 mg, 0.19 mmol) and thallium(I) benzoate (0.15 g, 0.46 mmol) in dry benzene (10 ml). Iodine (0.10 g, 0.23 mmol) was added, and the mixture was heated under reflux for 4 h, filtered, diluted with benzene, and worked up as above. P.l.c. gave the 3 α -iodo-2 β -benzoate (10) (5%), the 2 α -iodo-3 β -benzoate (2) (9%), the dibenzoate (8) (21%), an unidentified product (trace), and the hydroxy-benzoate (24) (50%).

(i) *With thallium(I) benzoate at 20 °C.* The previous experiment was repeated at 20 °C for 3 days. Work-up as above and p.l.c. gave starting material (35%), and the iodo-benzoate (10) (65%).

Reduction of 2 α -Iodo-5 α -androstan-3 β -yl Benzoate.—The iodo-benzoate (2) (44 mg, 0.09 mmol) was stirred overnight with lithium aluminium hydride (40 mg) in dry ether (10 ml) at 20 °C. Work-up gave 5 α -androstan-3 β -ol (23 mg, 96%), needles, m.p. 148–150° (lit.,⁵ 150–151°).

1 β ,2 β -Epoxy-5 α -androstan-3 β -ol (23).—The iodo-dibenzoate (16) (80 mg, 0.13 mmol) was heated under reflux with potassium hydroxide (0.30 g, 5.4 mmol) in 95% ethanol (15 ml) for 2 h. The mixture was diluted with water and extracted with ether to give 1 β ,2 β -epoxy-5 α -androstan-3 β -ol (30 mg, 30%), which crystallized from methanol as plates, m.p. 147–150° (Found: C, 78.0; H, 11.0. C₁₉H₃₀O₂ requires C, 78.2; H, 10.8%), ν_{\max} . 3 580 and 3 360 cm^{-1} (OH), δ 0.73 (s, 18-H₃), 0.93 (s, 19-H₃), 3.26 (d, J 2 Hz, 1 α ,-2 α -H), and 3.93 (m, $W_{1/2}$ 26 Hz, 3-H).

*Reaction of 5 α -Androst-2-ene with Cornforth's Reagent.*¹⁰—

(a) 5N-Sulphuric acid (0.5 ml), iodine (0.25 g, 1.0 mmol), and potassium iodate (0.11 g, 0.50 mmol) were added to a suspension of 5 α -androst-2-ene (0.50 g, 2.0 mmol) in water (12.5 ml) and dioxan (12.5 ml), and the mixture was stirred at 20 °C for 20 h. Ether and sodium chloride were added and the mixture was worked up as for the Prévost reactions. P.l.c. gave (i) starting material (20 mg, 4%); (ii) 3 α -iodo-5 α -androstan-2 β -ol (11) (0.42 g, 52%), which crystallized from methanol as needles, m.p. 114–116°, $[\alpha]_{\text{D}} + 47^\circ$ (c 1.0), ν_{\max} . 3 605 cm^{-1} (OH), δ 0.70 (s, 18-H₃), 1.03 (s, 19-H₃), 4.33 (m, $W_{1/2}$ 7 Hz, 3-H), and 4.53 (m, $W_{1/2}$ 7 Hz, 2-H), m/e 402 (M^{+}), 369 ($M^{+} - \text{CH}_3 \cdot - \text{H}_2\text{O}$), 275 ($M^{+} - \text{I} \cdot$), and 257 ($M^{+} - \text{I} \cdot - \text{H}_2\text{O}$); (iii) a mixture of the iodohydrins (11) and (12) (24 mg, 3%); and (iv) 5 α -androstan-2 β ,3 α -diol (13) (0.15 g, 22%), m.p. and mixed m.p. 200–201° (see later) [benzoate (8), m.p. and mixed m.p. 86–88°].

(b) The previous experiment was repeated at 20 °C for 15 h. Work-up and n.m.r. analysis showed the presence of starting material (45%), the iodohydrin (11) (30%), 2 β ,3 β -epoxy-5 α -androstan-2 β -ol (25) (17%), and the diol (13) (8%). Repetition of the reaction at 20 °C for 72 h gave only the diol (13) (72%).

Reaction of Iodohydrin (11) with Methanolic Potassium Carbonate.—A suspension of potassium carbonate (40 mg, 0.29 mmol) in 50% aqueous methanol (5 ml) containing 3 α -iodo-5 α -androstan-2 β -ol (60 mg, 0.14 mmol) was heated under reflux for 30 min and then poured into water. The mixture was extracted with ether and the ethereal solution was washed with water, 5M-sodium disulphite solution, and brine. Removal of solvent from the dried solution and

p.l.c. gave starting material (19%); 2 β ,3 β -epoxy-5 α -androstan-2 β -ol (25) (56%), m.p. 72–74° (lit.,¹¹ 73–74°), ν_{\max} . 1 245 cm^{-1} (C-O), δ 0.66 (s, 18-H₃), 0.83 (s, 19-H₃), and 3.11 (m, $W_{1/2}$ 6 Hz, 2 α ,-3 α -H); and 5 α -androstan-2 β ,3 α -diol (13) (25%).

Benzoylation of the Iodohydrin (11).—3 α -Iodo-5 α -androstan-2 β -ol (35 mg, 0.08 mmol) was heated under reflux with benzoyl chloride (0.5 ml) and dry pyridine (2.5 ml) for 2 h. Work-up gave 3 α -iodo-5 α -androstan-2 β -yl benzoate (10) (41 mg, 97%), which crystallized from methanol as plates, m.p. 153–154°, $[\alpha]_{\text{D}} + 93^\circ$ (c 1.0) (Found: C, 61.9; H, 7.1; I, 24.8. C₂₆H₃₅IO₂ requires C, 61.7; H, 7.0; I, 25.1%), ν_{\max} . 1 720 and 1 270 cm^{-1} (OBz), δ 0.70 (s, 18-H₃), 1.08 (s, 19-H₃), 4.70 (m, $W_{1/2}$ 7 Hz, 3-H), and 5.50 (m, $W_{1/2}$ 7 Hz, 2-H), m/e (M^{+} not observed) 384.130 2 ($M^{+} - \text{PhCO}_2\text{H}$) (C₁₉H₂₉I requires 384.131 5), 379.264 9 ($M^{+} - \text{I} \cdot$) (C₂₆H₃₅O₂ requires 379.263 6), 257.226 6 ($M^{+} - \text{PhCO}_2\text{H} - \text{I} \cdot$) (C₁₉H₂₉ requires 257.226 8), and 105.033 9 (PhC≡O⁺), (C₇H₅O requires 105.034 0).

Reduction of the Iodo-benzoate (10).—3 α -Iodo-5 α -androstan-2 β -yl benzoate (80 mg, 0.16 mmol) was stirred overnight with lithium aluminium hydride (80 mg, 1.8 mmol) in dry ether (8 ml) at 20 °C. Work-up gave 5 α -androstan-2 β -ol (42 mg, 81%), needles (from methanol), m.p. 131–133° (lit.,¹¹ 134–135°), ν_{\max} . 3 570–3 230 cm^{-1} (OH), δ 0.70 (s, 18-H₃), 1.06 (19-H₃), and 4.17 (m, $W_{1/2}$ 9 Hz, 2 α -H).

Solvolysis of the Iodo-benzoate (10).—(a) A mixture of 3 α -iodo-5 α -androstan-2 β -yl benzoate (0.10 g, 0.2 mmol) and silver benzoate (0.18 g, 0.8 mmol) was heated under reflux in benzene (10 ml) for 40 min. Work-up as for the Prévost reaction and p.l.c. gave starting material (22 mg), and a 1:1.2 ratio of 5 α -androstan-2 β ,3 α -diol dibenzoate (8) and 5 α -androstan-2 β ,3 β -diol 2-benzoate (24). When the reaction was carried out with a ratio of 1:1.2 equiv. of reactants, a considerable amount of starting material remained.

(b) A mixture of the iodo-benzoate (54 mg, 0.11 mmol), silver benzoate (98 mg, 0.43 mmol), and iodine (54 mg, 0.21 mmol) was heated under reflux in benzene (10 ml) for 40 min. The mixture was filtered and worked up as in (a) to give a product which contained (¹H n.m.r. analysis) 1 α -iodo-5 α -androstan-2 β ,3 β -diol dibenzoate (16) and the dibenzoate (8) in the ratio 1:1.4.

2 α ,3 α -Epoxy-5 α -androstan-2 β -ol (26).—A solution of *m*-chloroperbenzoic acid (0.17 g, 1.0 mmol) in dichloromethane (5 ml) was added over 10 min to a solution of 5 α -androst-2-ene (0.25 g, 0.93 mmol) in dichloromethane (5 ml), and the mixture was stirred at 20 °C for 6 h. Work-up in the normal manner gave 2 α ,3 α -epoxy-5 α -androstan-2 β -ol (0.25 g, 96%), which was purified by Kugelrohr distillation; m.p. and mixed m.p. 39–40°, $[\alpha]_{\text{D}} + 15^\circ$ (c 1.0), ν_{\max} . 1 240 cm^{-1} (C-O), δ 0.67 (s, 18-H₃), 0.79 (s, 19-H₃), and 3.00 (m, $W_{1/2}$ 3 Hz, 2 β ,-3 β -H).

2 β -Iodo-5 α -androstan-3 α -ol (12).—The epoxide (26) (0.26 g, 0.93 mmol) was added at –17 °C to a suspension of sodium iodide (0.20 g, 1.4 mmol) and sodium acetate (19 mg, 0.23 mmol) in glacial acetic acid (0.25 ml) and ethyl acetate (2 ml), and the mixture was stirred at 0 °C for 72 h. Ether and sodium chloride were added, and the organic layer was washed with saturated sodium hydrogen carbonate solution, aqueous 2N-sodium disulphite, and brine. Removal of solvent from the dried solution at low temperature gave light-sensitive 2 β -iodo-5 α -androstan-3 α -ol (0.28 g, 72%),

²⁹ G. W. Rewcastle, M.Sc. Thesis, University of Auckland, 1976.

which crystallized from methanol as needles, m.p. 110–111°, ν_{\max} 3 610 and 3 420 cm^{-1} (OH), δ 0.70 (s, 18-H₃), 1.13 (s, 19-H₃), and 4.42 (m, $W_{1/2}$ 10 Hz, 2 α ,3 β -H), m/e (M^{+} not observed) 369.105 2 ($M^{+} - \text{CH}_3 - \text{H}_2\text{O}$) ($\text{C}_{18}\text{H}_{26}\text{I}$ requires 369.102 7) and 275.235 6 ($M^{+} - \text{I}$) ($\text{C}_{19}\text{H}_{31}\text{O}$ requires 275.233 7).

Benzoylation of the Iodohydrin (12).—2 β -Iodo-5 α -androstan-3 α -ol (95 mg, 0.22 mmol) was stirred overnight with benzoyl chloride (0.5 ml) and dry pyridine (3.5 ml) at 20 °C. Work-up gave 2 β -iodo-5 α -androstan-3 α -yl benzoate (9) (0.11 g, 95%), as an oil. The i.r. and ¹H n.m.r. spectra were identical with those recorded earlier.

Solvolysis of the Iodo-benzoate (9).—A mixture of 2 β -iodo-5 α -androstan-3 α -yl benzoate (39 mg, 0.08 mmol) and silver benzoate (70 mg, 0.31 mmol) was heated under reflux in dry benzene for 40 min. Work-up and p.l.c. gave starting material (5 mg) and 5 α -androstan-2 α ,3 β -diol dibenzoate (3) (28 mg, 73%).

Prévost Reaction with 5 α -Cholest-2-ene.—5 α -Cholest-2-ene (0.28 g, 0.37 mmol) was treated with silver benzoate (0.34 g, 1.5 mmol) and iodine (0.19 g, 0.74 mmol) in dry benzene (12 ml) at 20 °C for 3 days as previously described.¹ P.l.c. (n-hexane-ether, 9:1) gave (i) 2 α -iodo-5 α -cholestan-3 β -yl benzoate (4) (4 mg, 2%), which crystallized from methanol as needles, m.p. 113–115°, ν_{\max} 1 710 and 1 270 cm^{-1} (OBz), δ 0.66 (s, 18-H₃), 0.82 (s, 19-H₃), 0.93 (3 Me), and 4.47 (m, $W_{1/2}$ 30 Hz, 2 β -H), 5.37 (m, $W_{1/2}$ 28 Hz, 3 α -H), and 7.57 and 8.10 (2 m, ArH); (ii) 5 α -cholestane-2 α ,3 β -diol dibenzoate (1) (30 mg, 13%), needles (from methanol), m.p. 147–149° (lit.,¹ 148–149°), ν_{\max} 1 730 and 1 275 cm^{-1} (OBz), δ 0.70 (s, 18-H₃), 1.06 (s, 19-H₃), 0.83, 0.93, and 0.93 (3 Me), 5.35 (m, $W_{1/2}$ 17 Hz, 2 β -,3 α -H), and 7.50 and 8.15 (2 m, ArH); (iii) 1 α -iodo-5 α -cholestane-2 β ,3 β -diol dibenzoate (17) (47 mg, 17%), which crystallized from methanol as needles, m.p. 176–177°, $[\alpha]_{\text{D}} + 6^{\circ}$ (c 1.0) (Found: C, 66.8; H, 7.5. $\text{C}_{41}\text{H}_{55}\text{IO}_4$ requires C, 66.7; H, 7.5%), ν_{\max} 1 720 and 1 270 cm^{-1} (OBz), δ 0.63 (s, 18-H₃), 1.03 (s, 19-H₃), 0.83, 0.93, and 0.93 (3 Me), 4.63 (d, J 2 Hz, 1 β -H), 6.03 (m, $W_{1/2}$ 7 Hz, 2 α ,3 α -H), and 7.43 and 8.00 (2m, ArH); (iv) 5 α -cholestane-2 β ,3 α -diol dibenzoate (6) (60 mg, 27%), needles (from methanol), m.p. 126–128° (lit.,¹ 127–129°), ν_{\max} 1 720 and 1 270 cm^{-1} (OBz), δ 0.66 (s, 18-H₃), 1.10 (s, 19-H₃), 0.80, 0.93, and 0.93 (3 Me), 5.35 (m, $W_{1/2}$ 6 Hz, 2,3 β -H), and 7.50 and 8.10 (2m, ArH); (v) 3-oxo-5 α -cholestan-2 β -yl benzoate (22) (15 mg, 8%), which crystallized from methanol as plates, m.p. 38–40° (Found: M^{+} 506.378 7. $\text{C}_{34}\text{H}_{50}\text{O}_3$ requires M 506.376 0), ν_{\max} 1 720 and 1 265 cm^{-1} (OBz), δ 0.67 (s, 18-H₃), 1.10 (s, 19-H₃), 0.80, 0.93, and 0.97 (3 Me), 5.20 (dd, J_{ae} 7, J_{aa} 12 Hz, 2 α -H), and 7.50 and 8.06 (2m, ArH); and (vi) a fraction (62 mg) containing unidentified compounds.

5 α -Androstane-2 β ,3 α -diol (13).—The dibenzoate (8) (44 mg, 0.88 mmol) was heated under reflux with potassium hydroxide (0.30 g) in 95% ethanol (25 ml) for 2 h. The

solution was diluted with water and extracted with ether, and the ethereal solution was worked up to give 5 α -androstan-2 β ,3 α -diol (19 mg, 74%), which crystallized from methanol as needles, m.p. 200–201°, $[\alpha]_{\text{D}} + 19^{\circ}$ (c 1.3) (Found: C, 78.0; H, 11.1. $\text{C}_{19}\text{H}_{32}\text{O}_2$ requires C, 78.0; H, 11.0%), ν_{\max} 3 420 (OH) and 1 090 cm^{-1} (C–O), δ 0.70 (s, 18-H₃), 1.00 (s, 19-H₃), and 3.93 (m, $W_{1/2}$ 8 Hz, 2 α -,3 β -H).

5 α -Androstane-2 α ,3 β -diol (5).—The dibenzoate (3) (52 mg, 0.10 mmol) was stirred overnight with lithium aluminium hydride (50 mg) in dry ether (20 ml) at 20 °C. Work-up gave 5 α -androstan-2 α ,3 β -diol (29 mg, 95%), which crystallized from methanol as plates, m.p. 168–170°, $[\alpha]_{\text{D}} - 4^{\circ}$ (c 1.0) (Found: C, 77.7; H, 10.8. $\text{C}_{19}\text{H}_{32}\text{O}_2$ requires C, 78.0; H, 11.0%), ν_{\max} 3 560–3 060 (OH) and 1 030 cm^{-1} (C–O), δ 0.70 (s, 18-H₃), 0.83 (s, 19-H₃), and 3.43 (m, $W_{1/2}$ 16 Hz, 2 β -,3 α -H).

5 α -Androstane-2 β ,3 β -diol (18).—(a) The iodo-dibenzoate (16) (60 mg, 0.10 mmol) was heated under reflux with lithium aluminium hydride (60 mg) in dry ether (20 ml) for 5 h. Work-up gave 5 α -androstan-2 β ,3 β -diol (26 mg, 93%), which crystallized from methanol as needles, m.p. 144–145°, $[\alpha]_{\text{D}} + 18^{\circ}$ (c 1.0) (Found: C, 77.9; H, 11.0. $\text{C}_{19}\text{H}_{32}\text{O}_2$ requires C, 78.0; H, 11.0%), ν_{\max} 3 560–3 060 (OH) and 1 030 cm^{-1} (C–O), δ 0.70 (s, 18-H₃), 1.00 (s, 19-H₃), 3.60 (m, $W_{1/2}$ 22 Hz, 3 α -H), and 3.96 (m, $W_{1/2}$ 9 Hz, 2 α -H).

(b) Iodine (0.76 g, 0.30 mmol) was added in portions over 10 min to a stirred mixture of 5 α -androst-2-ene (60 mg, 0.20 mmol) and silver acetate (0.11 g, 0.70 mmol) in glacial acetic acid (10 ml) under nitrogen at 20 °C. After 30 min, water (0.1 ml) was added and stirring was continued for 20 h. Ether was added, the mixture was filtered, and the filtrate was washed with water, aqueous 2N-sodium carbonate, and water. Solvent was evaporated from the dried solution and the residue was treated under reflux with lithium aluminium hydride (20 mg) in dry ether (10 ml) for 1 h. Work-up gave the diol (18) (68 mg, 100%), m.p. and mixed m.p. 144–145°.

5 α -Androstane-2 α ,3 α -diol (28).—A mixture of 5 α -androst-2-ene (0.20 g, 0.72 mmol) in dry benzene (10 ml) and osmium tetroxide (0.21 g, 0.80 mmol) in dry pyridine (10 ml) was stirred at 20 °C for 90 h. Solvent was removed and the residue was heated under reflux with a mixture of mannitol (1.5 g), potassium hydroxide (1.5 g), ethanol (15 ml), benzene (6 ml), and water (3 ml) for 4 h. Work-up gave 5 α -androstan-2 α ,3 α -diol (0.21 g, 93%), which crystallized from methanol-ether as needles, m.p. 143–145°, $[\alpha]_{\text{D}} + 12^{\circ}$ (c 1.0) (Found: C, 78.0; H, 11.1. $\text{C}_{19}\text{H}_{32}\text{O}_2$ requires C, 78.0; H, 11.0%), ν_{\max} 3 560–3 060 (OH) and 1 030 cm^{-1} (C–O), δ 0.70 (s, 18-H₃), 0.83 (s, 19-H₃), 3.60 (m, $W_{1/2}$ 19 Hz, 2 β -H), and 3.96 (m, $W_{1/2}$ 8 Hz, 3 β -H), m/e 292 (M^{+}), 274 ($M^{+} - \text{H}_2\text{O}$), 259 ($M^{+} - \text{CH}_3 - \text{H}_2\text{O}$), and 256 ($M^{+} - 2\text{H}_2\text{O}$).

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