Conformational Aspects of Some 5β-Methyl-19-nor-steroids

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The stereochemistry of the allylic alcohol (2) and of the epoxy-ketone (3) in the Westphalen-type rearranged steroid series has been elucidated. The n.m.r. spectra of various new and known compounds have been analysed, thus demonstrating the remarkable conformational flexibility of ring B in this series.

MORE than 20 years after Westphalen's discovery [1] of the skeletal rearrangement of 5α-cholestane-3β,5,6β-triol 3,6-diacetate, Petrow [2] obtained an allylic alcohol by oxidation of the rearrangement product (1a) with selenium dioxide. The structure (10b) proposed for this compound was questioned by Fieser and Goto,[3] who showed that the wavelength of its u.v. absorption is incompatible with a tetrasubstituted double bond and that no particular hindrance of an 11-OH (α or β) is evident from a model of such a compound. The alternative structure (2) was accordingly suggested, leaving open the orientation of the tertiary 10-OH group.

This structure (10β-OH) is now firmly established by analysis of the n.m.r. spectrum of the diacetate (2b), which displays narrow multiplets at δ 5.75, 5.0, and 4.78 for 11-, 3α-, and 6α-H, respectively, thus indicating the axial orientations of the corresponding 3β-OAc and 6β-OAc. These data are consistent with a *cis*-junction of rings A and B.[4] The spectrum of the diacetate (2b) in pyridine shows a downfield shift of the 5β-Me signal [Δ($CDCl_3$ — C_5D_5N) 0.28 p.p.m.] compatible only with a situation with the tertiary OH on the same side of the molecule as the 5β-Me. The relation between the double bond and the tertiary OH was confirmed by the downfield shift (0.30 p.p.m.) of the vinylic proton signal [5] in the n.m.r. spectrum of the trichloroacetyl carbamate (2c). The β orientation of the 10-OH in (2) can also be correlated with the isomerization of (1) and derivatives under equilibrating conditions to give the corresponding $\Delta^{9(11)}$-isomers, in which rings A and B are *cis*-fused.[6]

Oxidation of the diacetate (2b) with chromium trioxide [2] afforded the epoxy-ketone (3b); under such conditions an epoxy-group, whenever formed,[4,7] is on the same side of the molecule as the original hydroxy-group. The n.m.r. data of the epoxide (3b) indeed support the β-orientation of the 9,10-epoxy-group. In all the cases investigated so far,[4] allylic alcohols possessing the proper stereochemistry are oxidized by chromium trioxide in acidic medium to epoxy-ketones and in

[1] T. Westphalen, *Ber.*, 1915, **48**, 1064.
[2] V. A. Petrow, *J. Chem. Soc.*, 1939, 998.
[3] L. Fieser and T. Goto, *J. Amer. Chem. Soc.*, 1960, **82**, 1693.
[4] E. Glotter, S. Greenfield, and D. Lavie, *J. Chem. Soc.* (*C*), 1968, 1646.
[5] I. R. Trehan, C. Monder, and A. K. Bose, *Tetrahedron Letters*, 1968, 67.
[6] H. Aebli, C. A. Grob, and E. Schumacher, *Helv. Chim. Acta*, 1958, **41**, 774.
[7] J. Iriarte, J. N. Shoolery, and C. Djerassi, *J. Org. Chem.*, 1962, **27**, 1139.

pyridine to αβ-unsaturated ketones. However [8] with the latter reagent compound (2b) gives a mixture of the epoxy-ketone (3b) and the enone (4b).

Attempted confirmation of the structure of the epoxy-ketone (3b) by reduction with hydrazine hydrate [9] to the starting allylic alcohol (2b) did not succeed, probably owing to hindrance of the 11-oxo-group preventing the formation of the 11-hydrazone. The basic conditions inherent in this reaction were, however, enough to bring about partial hydrolysis of the acetate groups, yielding a mixture of the 3β,6β-diol (3a), the 3β,6β-diol 6-acetate (3c), and the 3β,6β-diol 3-acetate (3d). Hydrolysis of (3b) with dilute alkali afforded only the diol (3a).

The very weak acidic properties of perbenzoic acid are insufficient to trigger the allylic rearrangement of (2) before epoxidation takes place; in the presence of this reagent (2b) is epoxidized at the 9,11-double bond to give mainly the 9β,11β-epoxide (7b), accompanied by small amounts of the 9α,11α-epoxide (8). Although the directing influence of the 10β-OH is the predominant factor in this process,[10] the lack of hindrance on the α-face of the molecule allows attack of the reagent (at least in part) from this side also. During chromatography, the α-epoxide (8) was obtained in pure form; however compound (7b) underwent partial hydrolysis to the 9β,11β-epoxy-3β,6β-diol 3-acetate (7a), which could then be reacetylated to (7b). The ready hydrolysis of the 6β-acetoxy-group must be due to assistance by the nearby epoxidic oxygen, which is not possible in the isomeric epoxide (8).

Attempted reduction of the enone (4b) with borohydride did not succeed, although similar treatment of the epoxy-ketone (3b) afforded stereospecifically the *trans*-epoxy-alcohol (9a). Reduction of (4b) with lithium aluminium hydride gave a mixture of two allylic alcohols (10a), epimeric at C-11. Treatment of this mixture with Jones reagent afforded the enetrione (11) and the epoxy-trione (12) in about the same ratio as found in the mixture of alcohols (10a). Unfortunately, the allylic alcohols could not be separated and purified by column or by thick-layer chromatography, since they decompose to give the heteroannular diene (5a) and other, unidentified products. The oxidation of the crude mixture of alcohols does not constitute therefore an unequivocal proof that only the Δ^9-11β-OH derivative is the source of the epoxy-trione (12).

N.m.r. data *

Compound	3-H	6-H	11-H	12-H	Methyl groups: 5β-Me	13-Me	Side chain	OAc
(1b)	5.10m ($W_{\frac{1}{2}}$ 9)	4.77dd (10; 5)			1.22s	0.82s	0.87d (6)	2.05; 2.08
(2b)	5.00m ($W_{\frac{1}{2}}$ 8)	4.78t (2.5)	5.75m		1.23s	0.66s	0.87d	2.03; 2.13
	[5.18]	[4.85]	[5.90]		[1.51]	[0.63]	[0.90]	[2.03; 2.10]
(2c)	5.07br,m	4.68br, m	6.05m		1.27s	0.90s	0.86d	2.05
(3a)	4.15m ($W_{\frac{1}{2}}$ 12)	3.37m ($W_{\frac{1}{2}}$ 9)			1.41s	0.77s	0.87d	
(3b)	*ca.* 5	*ca.* 4.9			1.22s	0.78s	0.87d	2.05
	Partly overlapped dd							
	{*ca.* 5.10}	{*ca.* 5.0}			{1.36}	{0.56}	[0.92]	{1.66}
(3c)	4.17t (6)	4.97dd (12; 5)			1.20s	0.77s	0.88d	2.06
(3d)	5.06br,m	3.35 narrow m			1.39s	0.78s	0.88d	2.08
(4b)	5.10m ($W_{\frac{1}{2}}$ 9)	4.80dd (7; 3.5)			1.28s	0.75s	0.87d	2.07
	{5.12t} (3)	{4.90dd} (8; 4)			{1.33}	{0.60}	{0.92}	{1.70; 1.73}
(5b)	5.13m ($W_{\frac{1}{2}}$ 10)	4.80m ($W_{\frac{1}{2}}$ 8)	6.31s	6.31s	1.25s	0.82s	0.87d	2.07
(6)	5.13m ($W_{\frac{1}{2}}$ 11)	4.53m ($W_{\frac{1}{2}}$ 9)	3.42d (4.5)	2.87d (4.5)	1.25s	0.90s	0.87d	2.06
(7a)	5.32dd (6; 2.5)	3.95m ($W_{\frac{1}{2}}$ *ca.* 18)	3.12t (2.5)		1.00s	0.80s	0.85d	2.08
(7b)	5.33 narrow m	4.92br, m	3.12t (2.5)		1.02s	0.82s	0.87d	2.02; 2.10
(8)	5.08m ($W_{\frac{1}{2}}$ 9)	4.82t (2.5)	3.42d (5)		1.20s	0.75s	0.87d	2.02; 2.15
(9b)	5.00m ($W_{\frac{1}{2}}$ *ca.* 17)	4.75dd (11; 5)	5.37dd (10; 5)		1.19s	0.89s	0.87d	2.03; 2.05
(11)					1.28s	0.81s	0.87d	
(12)					1.33s	0.83s	0.87d	

* Recorded at 60 MHz; solvent $CDCl_3$; chemical shifts in δ units; data for C_5D_5N solutions in square brackets; data for C_6D_6 solutions in braces; coupling constants (in Hz) in parentheses.

The diene (5a) gave on acetylation the diacetate (5b), identical with that obtained [2] by treatment of (2b) with acid. Epoxidation of (5b) afforded the diepoxide (6). Of the two alternative orientations of the 9,10-epoxy-group in the latter, the 9α-10α-structure is preferred. In the n.m.r. spectrum, both 3α-H and 6α-H display narrow multiplets, at δ 5.13 and 4.53 respectively, indicating a chair form of ring A with the 3β-OAc axial, and a monoplanar 6β-form of ring B, with the 6β-OAc axial. If this compound were to possess the 9,10-epoxy-group in the alternative β-configuration, there would be no reason for the 3α-H and 6α-H signals to be different from those of (3b) or (9). With regard to the orientation of the 11,12-epoxy-group, the observation of two doublets for the 11-H and 12-H at δ 2.87 and 3.42 (J 4.5 Hz) does not allow an unequivocal distinction between the two alternatives. According to literature data,[11] a 11α,12α-epoxy-group deshields the 13-Me by 0.12 p.p.m., whereas a 11β,12β-epoxide deshields the same methyl by 0.09 p.p.m. In a 9α,10α-epoxy-5β-methyl-19-norcholestane derivative, the 13-Me resonates at δ 0.75.[12] The downfield shift due to the 11,12-epoxy-group is therefore 0.15 p.p.m. [the

[8] C. A. Grob and E. Schumacher, *Helv. Chim. Acta*, 1958, **41**, 924.

[9] P. S. Wharton and D. H. Bohlen, *J. Org. Chem.*, 1961, **26**, 3615.

[10] H. B. Henbest and R. A. L. Wilson, *J. Chem. Soc.*, 1957, 1958.

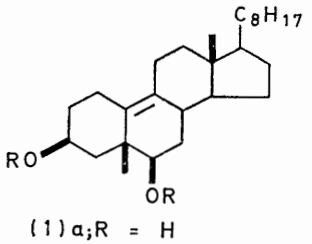
[11] K. Tori, T. Komeno, and T. Nakagawa, *J. Org. Chem.*, 1964, **29**, 1136.

[12] J. C. Guilleux and M. Mousseron-Canet, *Bull Soc. chim. France*, 1967, 24.

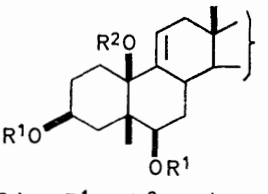
13-Me in (6) resonates at δ 0.90], thus suggesting an α-orientation of this epoxy-group.

Of the various conformational analyses of 5β-methyl-19-norsteroids,[12-15] the most accurate seems to be that of Mousseron-Canet *et al.*,[12,15] who suggest a conformation close to a diplanar 1—4,6α-form [16] for ring B in (1) and a monoplanar 6β-conformation [16] for ring B in the 9β,10β-epoxy-derivative (13a). A similar conclusion can be drawn from the work of Marples *et al.*[17] on the reduction of the 9β,10β-epoxide (13b) to the 10β-hydroxy-derivative with lithium aluminium hydride.

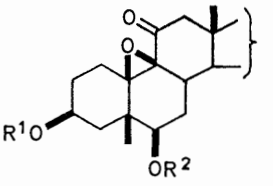
The conformation of the epoxy-ketone (3b) seems to be different from that of the 9β,10β-epoxide (13a). The n.m.r. spectrum of the latter did not give a clear-cut 3α-H and 6α-H signal pattern (the signals overlap [12]); however the overall width of the signals strongly suggests an equatorial orientation. In the case of (3b), the 3α-H and 6α-H display double doublet patterns (partially overlapped), indicating equatorial orientations of the corresponding 3β-OAc and 6β-OAc. This fact can be interpreted only in terms of a ring A boat with C-1 and C-4 upwards and ring B in a monoplanar 7β-conformation.



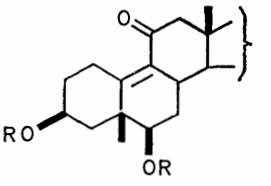
(1) a; R = H
b; R = Ac



(2) a; R^1 = R^2 = H
b; R^1 = Ac, R^2 = H
c; R^1 = Ac, R^2 = $Cl_3CO{\cdot}NH{\cdot}CO$



(3) a; R^1 = R^2 = H
b; R^1 = R^2 = Ac
c; R^1 = H, R^2 = Ac
d; R^1 = Ac, R^2 = H



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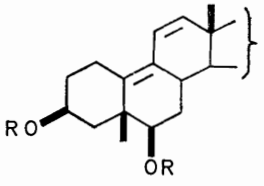
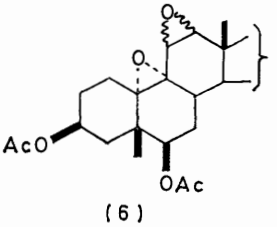
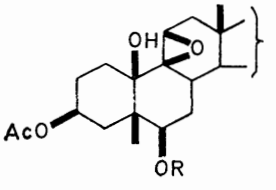
b; R = Ac



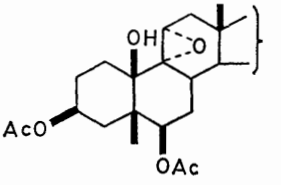
(5) a; R = H
b; R = Ac



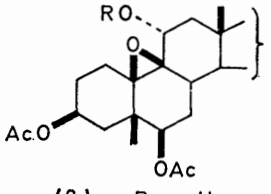
(6)



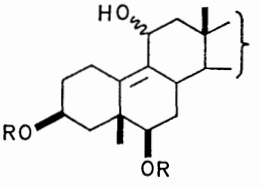
(7) a; R = H
b; R = Ac



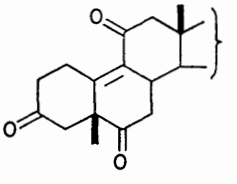
(8)



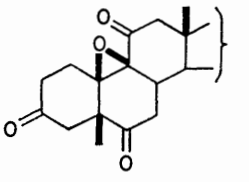
(9) a; R = H
b; R = Ac



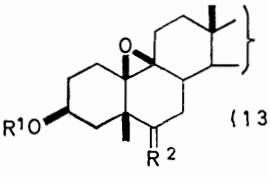
(10) a; R = H
b; R = Ac



(11)



(12)



(13) a; R^1 = Me, R^2 = β-OH, α-H
b; R^1 = $PhCH_2$, R^2 = β-OH, α-H

The nonbonded interactions between 1α-H and 11α-H in (13α) are relieved by the 11-oxo-group present in (3b), so that ring C may assume either a chair form with the carbonyl upwards, or a flattened form in which the carbonyl is at right angles to the C(13)–Me bond. Since

[13] D. N. Jones and G. H. R. Summers, *J. Chem. Soc.*, 1959, 2594.

[14] C. R. Narayanan and K. N. Iyer, *Tetrahedron Letters*, 1966, 285.

[15] M. Mousseron-Canet and J. C. Brial, *Bull. Soc. chim. France*, 1966, 3867.

[16] R. Bucourt, *Bull. Soc. chim. France*, 1964, 2080, and footnote at p. 26 in ref. 12.

[17] J. G. Ll. Jones and B. A. Marples, *J.C.S. Perkin I*, 1972, 792.

the benzene-induced shift of the 13-Me signal is +0.22 p.p.m., whereas that found in 5α-androstan-11-one is +0.11 p.p.m., it is possible that ring C in (3b) does not exist in the chair conformation. These assignments are confirmed by analysis of the n.m.r. spectra of compounds (3a, c, and d).

In the 3β,6β-diol (3a), the 3α-H and 6α-H signals are narrow multiplets at δ 4.15 and 3.37, respectively, which can be interpreted in terms of hydrogen bonding between the 9β,10β-epoxy-group and the 6β-OH, constraining the latter in an axial configuration; this results in a conformational change of ring B, from the monoplanar 7β-form in (3b) to a monoplanar 6β-form similar to that existing in (13a). Such a change requires the flipping of ring A from boat to chair with the 3β-OH axial, in order to minimize the nonbonded interactions between 3α-H and 7α-H. If this interpretation is correct, then the conformation of ring B in the monoacetate (3c) (6β-OAc) should be the same as that found in (3b); indeed, the 6α-H signal is a double doublet δ 4.97 (*J* 12 and 5 Hz), whereas the pattern of the 3α-H signal (triplet, δ 5.17, *J* 6 Hz) is close to that found in (3a). Finally, in the monoacetate (3d) (3β-OAc) ring B possesses the same conformation as in (3a) owing to hydrogen bonding between the axial 6β-OH and the epoxidic oxygen (6α-H, narrow multiplet, δ 3.35).

The allylic alcohol (2b) poses no conformational problems. The lack of 9-ene or of a 9,10-epoxide allows rings A and B to adopt the normal conformation of AB-*cis*-steroids with both rings in the chair form, in which the 6β-OAc and the 3β-OAc are axial (narrow multiplet for 3α-H at δ 5.00, and very narrow triplet for 6α-H at δ 4.78). The same conclusion can be drawn from the n.m.r. data of the isomeric allylic alcohols [Δ^{8} instead of $\Delta^{9(11)}$] obtained by Marples [compounds (16) and (17) in ref. 17.]

An interesting development takes place in (2c), the 10-trichloroacetyl carbamate derivative of (2b). In this case the 3α-H signal is a multiplet at δ 5.07, larger than that found in the case of (2b) whereas the 6α-H signal is a broad, unresolved multiplet at δ 4.68. The trichloroacetylcarbamoyl group, which is very bulky, does not allow the 6β-OAc to exist in the axial configuration and induces a distortion of ring B from chair to a flexible form in which the 6β-OAc is quasiequatorial. Ring A is also distorted in order to relieve the interaction with the 3β-OAc.

In the 9α,11α-epoxide (8), the 11β-H signal is a doublet at δ 3.42 with *J* 5 Hz, which fits well with the α-orientation of the epoxy-group (torsion angle between 11β-H and 12α-H, *ca.* 90°), as well as with available data.[11] The chemical shift of the 13-Me (δ 0.75) is in line with this assignment. It is reasonable to assume that a 9α,11α-epoxy-group does not influence the conformations of rings A and B, which are the same as in the allylic alcohol (2b), as reflected by a narrow multiplet at δ 5.08 for the 3α-H and a narrow triplet at δ 4.82 for the 6α-H.

In the 9β,11β-epoxide (7b), the 11α-H signal is a narrow triplet at δ 3.12, as required for this proton, which is equally distant from the C-12 protons. The conformation of ring B is necessarily changed in this compound, as compared with (2) and (8), in order to accomodate the *cis*-junction between rings B and C. According to the n.m.r. data (3α-H, narrow multiplet, δ 5.33; 6α-H broad, unresolved multiplet, δ 4.92), ring A remains in the chair form; however, in order to relieve the severe nonbonded interactions between 4α-H and 7α-H, ring B is forced into a flexible conformation in which the 6β-acetate is quasiequatorial.

In the heteroannular diene (5), ring B is in a conformation different from that present in compound (1) (6α-H, narrow multiplet, δ 4.81). This may be a result of easy flipping of this ring from the diplanar 1—4 form in (1) to the monoplanar 6β-form.

EXPERIMENTAL

M.p.s. were taken on a Fisher–Johns apparatus. Optical rotations were recorded with an automatic Perkin-Elmer 141 polarimeter and refer to solutions in chloroform. I.r. spectra were recorded for solutions in chloroform with a Perkin-Elmer Infracord 137 spectrophotometer. U.v. spectra were recorded with a Cary 14 instrument for solutions in ethanol. N.m.r. spectra were determined with Varian A-60 and NV-14 instruments. T.l.c. was carried out on chromatoplates of silica gel G (Merck) and spots were developed with iodine vapour. Mass spectra were taken by I. Fröhlich with a Finnigan 1 015 S/L instrument.

Epoxidation of the Allylic Alcohol (2b).—To a solution of the alcohol (2b)[2] (300 mg) in dry benzene (10 ml), a 10% excess of perbenzoic acid in benzene was added. After 24 h at room temperature the excess of reagent was removed by washing with aqueous 5% sodium carbonate, the solution was washed until neutral, and the solvent was removed. The product was chromatographed on neutral alumina (Woelm, activity III). Elution with hexane–ether afforded the α-epoxide (8) (25 mg), followed by the β-epoxide monoacetate (7a) (200 mg). 9,11α-*Epoxy*-5-*methyl*-19-*nor*-5β-*cholestane*-3β,6β,10-*triol* 3,6-*diacetate* (8) crystallized from methanol; m.p. 155—156°, $[\alpha]_D$ −11.8° (*c* 0.10), $\nu_{max.}$ 1 725 cm^{-1} (Found: C, 71.85; H, 9.7%; M^+, 518. $C_{31}H_{50}O_6$ requires C, 71.8; H, 9.7%; *M*, 518). 9,11β-*Epoxy*-5-*methyl*-19-*nor*-5β,9β-*cholestane*-3β,6β,10-*triol* 3-*acetate* (7a) crystallized from methanol–water; m.p. 150—151°, $[\alpha]_D$ *ca.* 0° (*c* 0.1), $\nu_{max.}$ 3 460 and 1 725 cm^{-1} [Found: C, 72.9; H, 10.05%; *m/e*, 458 (M^+ −18). $C_{29}H_{48}O_5$ requires C, 73.1; H, 10.15%; *M*, 476].

Treatment of (7a) (50 mg) with acetic anhydride (1 ml) and pyridine (1 ml) overnight at room temperature gave the *epoxy-diacetate* (7b), which could not be induced to crystallize; $[\alpha]_D$ −6.3° (*c* 0.27), $\nu_{max.}$ 3 460, 1 730, and 1 725 cm^{-1} (Found: C, 71.9; H, 9.6%; M^+, 518. $C_{31}H_{50}O_6$ requires C, 71.8; H, 9.7%; *M*, 518).

Reduction of the Epoxy-ketone (3b).—To a stirred solution of the epoxy-ketone (3b)[2] (200 mg) in methanol (50 ml), sodium borohydride (100 mg) was added over a few minutes. After 2 h at room temperature, the solution was neutralized with dilute hydrochloric acid, most of the solvent was removed, water was added, and the product was isolated with ether. Acetylation as described above afforded 9,10-*epoxy*-5-*methyl*-19-*nor*-5β,9β-*cholestane*-3β,6β,11α-*triol triacetate* (9b) (180 mg), which could not be induced to crystallize; $[\alpha]_D$ +60.6° (*c* 0.23), $\nu_{max.}$ 1 730 and 1 725 cm^{-1} [Found: C, 70.8; H, 9.4%; *m/e*, 500 (M^+ − 60). $C_{33}H_{52}O_7$ requires C, 70.7; H, 9.35%; *M*, 560].

Hydrolysis of the Epoxy-ketone (3b).—A methanolic solution (15 ml) of the epoxy-ketone (3b) (150 mg) containing methanolic 5% potassium hydroxide (4 ml) was set aside overnight at room temperature. Water was then added and, after neutralization with dilute hydrochloric acid, the product was isolated with ether and crystallized from acetone–hexane to give the *diol* (3a) (100 mg), m.p. 223—224°, $[\alpha]_D$ +122.0° (*c* 0.1), $\nu_{max.}$ 3 400—3 500br and 1 705 cm^{-1} (Found: C, 74.8; H, 10.2%; M^+, 432. $C_{27}H_{44}O_4$ requires C, 74.95; H, 10.25%; *M*, 432).

Oxidation of the Epoxy-dihydroxy-ketone (3a).—To a stirred solution of the ketone (3a) (100 mg) in acetone (20 ml), a solution of Jones reagent was added dropwise at 15 °C. After the usual work-up, the crude product, in benzene solution, was filtered through neutral alumina and then crystallized from methanol to give 9,10-*epoxy*-5-*methyl*-19-*nor*-5β,9β-*cholestane*-3,6,11-*trione* (12) (70 mg), m.p. 164—165°, $[\alpha]_D$ +158° (*c* 0.4), $\nu_{max.}$ 1 725 and 1 716 cm^{-1} (Found: C, 75.5; H, 9.4%; M^+, 428. $C_{27}H_{40}O_4$ requires C, 75.7; H, 9.4%; *M*, 428).

Treatment of the Epoxy-ketone (3b) *with Hydrazine Hydrate.*—100% Hydrazine hydrate (1 ml) and acetic acid (0.5 ml) were added to a solution of the epoxy-ketone (3b) (190 mg) in propan-2-ol (5 ml). The solution was heated on a steam-bath for 30 min, then set aside overnight. After addition of water the product was extracted with ethyl acetate and the extract was washed, dried, and evaporated. The residue (170 mg) showed four spots on a chromatoplate. Chromatography on neutral alumina (elution with hexane–ether) afforded unchanged (3b) (65 mg), the monoacetate (3d) (25 mg), and the monoacetate (3c) (50 mg). Further elution with chloroform afforded the diol (3a) (20 mg). Acetylation of compounds (3a, c, and d) resulted in starting material (3b). The 6-*acetate* (3c) could not be induced to crystallize; $\nu_{max.}$ 3 500—3 400, 1 725, and 1 715 cm^{-1} (Found: C, 73.5; H, 9.65%; M^+, 474. $C_{29}H_{46}O_5$ requires C, 73.4; H, 9.8%; *M*, 474). The 3-*acetate* (3d) had m.p. 181—183° (from acetone–hexane), $[\alpha]_D$ +105.5° (*c* 0.13), $\nu_{max.}$ 3 480, 1 725, and 1 715 cm^{-1} (Found: C, 73.35; H, 9.7%; *M*, 474).

Oxidation of the Diol (4a).—The acetate (4b) [8] (100 mg) was treated with methanolic potassium hydroxide as described for (3b). The crude diol (4a) (80 mg) was oxidized in acetone with Jones reagent and the product was filtered through neutral alumina and crystallized from acetone–hexane to give 5-*methyl*-19-*nor*-5β-*cholest*-9-*ene*-3,6,11-*trione* (11), m.p. 103—104°, $[\alpha]_D$ −85.4° (*c* 0.1), $\nu_{max.}$ 1 718 and 1 618 cm^{-1}, $\lambda_{max.}$ 250 nm (ε 7 650) (Found: C, 78.65; H, 9.8%; M^+, 412. $C_{27}H_{40}O_3$ requires C, 78.6; H, 9.7%; *M*, 412).

Reduction of the Enone (4b).—A solution of the enone (4b) (650 mg) in dry tetrahydrofuran (75 ml) was added dropwise to a stirred slurry of lithium aluminium hydride (350 mg) in tetrahydrofuran (50 ml), and the mixture was heated to reflux for 3 h. Work-up was carried out with ethyl acetate and saturated aqueous sodium sulphate. The crude product obtained after filtration and evaporation showed two spots on a chromatoplate.

Oxidation with Jones reagent of the freshly prepared mixture of triols (150 mg) afforded a mixture of triones (11) and (12). Chromatography on neutral alumina (elution with hexane–benzene) afforded (12) (30 mg), m.p. 164—165°, followed by mixtures of (11) and (12), and finally pure (11) (15 mg), m.p. 103—104°, both identical with the compounds described above.

Epoxidation of the Diene (5b).—Epoxidation of the diene (5b) [18] (80 mg) as described for compound (2b) gave 9,10;11,12-*diepoxy*-5-*methyl*-19-*nor*-5β,10α-*cholestane*-3β,6β-*diol diacetate* (6), m.p. 106—108° (from methanol), $[\alpha]_D$ +16.5° (*c* 0.11), $\nu_{max.}$ 1 725 cm^{-1} (Found: C, 71.9; H, 9.45%; M^+, 516. $C_{31}H_{48}O_6$ requires C, 72.1; H, 9.4%; *M*, 516).

[5/678 *Received*, 10*th April*, 1975]

[18] B. Ellis and V. A. Petrow, *J. Chem. Soc.*, 1952, 2246.