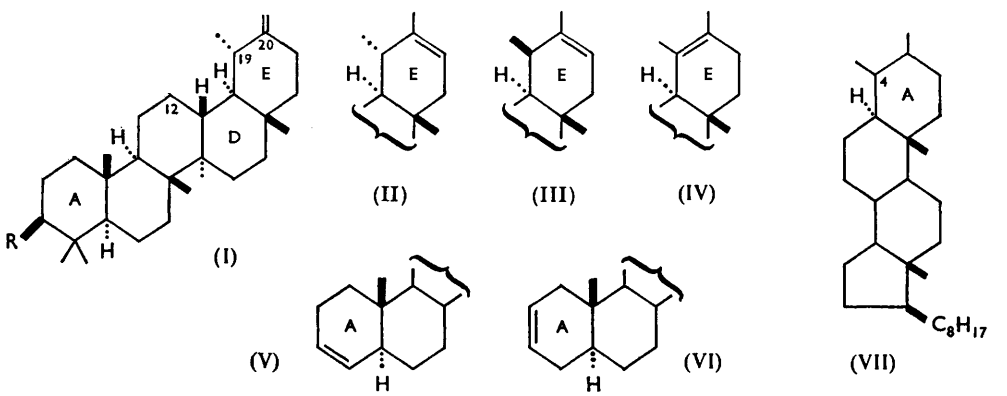
145. *The Chemistry of the Triterpenes and Related Compounds. Part XXX.* The Relative Stabilities of Ring-A Unsaturated Hydrocarbons Derived from 3 : 4-Dimethylcholestane and 3-Methyl-24-norurs-12-ene.*

By J. L. Beton, T. G. Halsall, E. R. H. Jones, and P. C. Phillips.

The conversion of cholestan-3-one into 4α- and 4β-methylcholestan-3-one (XII and XIII), the treatment of these ketones with methylmagnesium iodide, and the dehydration of the resulting tertiary alcohols (XIV, XV, XVI, and XVII) are described. The acid-catalysed isomerisations of the ring-A unsaturated hydrocarbons (XVIII, XIX, and XX) obtained have been studied and the results compared with the behaviour of taraxastene (I; R = H), ψ-taraxastene (II; R = H), and lupene-I (III; R = H).

A parallel series of experiments has been carried out with nor-β-boswellenone (XXVII).

Recent studies of the acid isomerisation of derivatives of taraxasterol (I; R = OH), ψ-taraxasterol (II; R = OH), and lupenol-I (III; R = OH) have shown that taraxastene (I; R = H) is isomerised to ψ-taraxastene (II; R = H) and this, in turn, gives lupene-I (III; R = H).[1] The second stage almost certainly involves compounds (IV) with the tetrasubstituted double bond. Such compounds have, however, never been isolated in our experiments and it is reasonable to conclude that the Δ^{20}-isomer (III) is more stable than the Δ^{19}-isomer (IV). Generally, compounds in which the double bond is fully



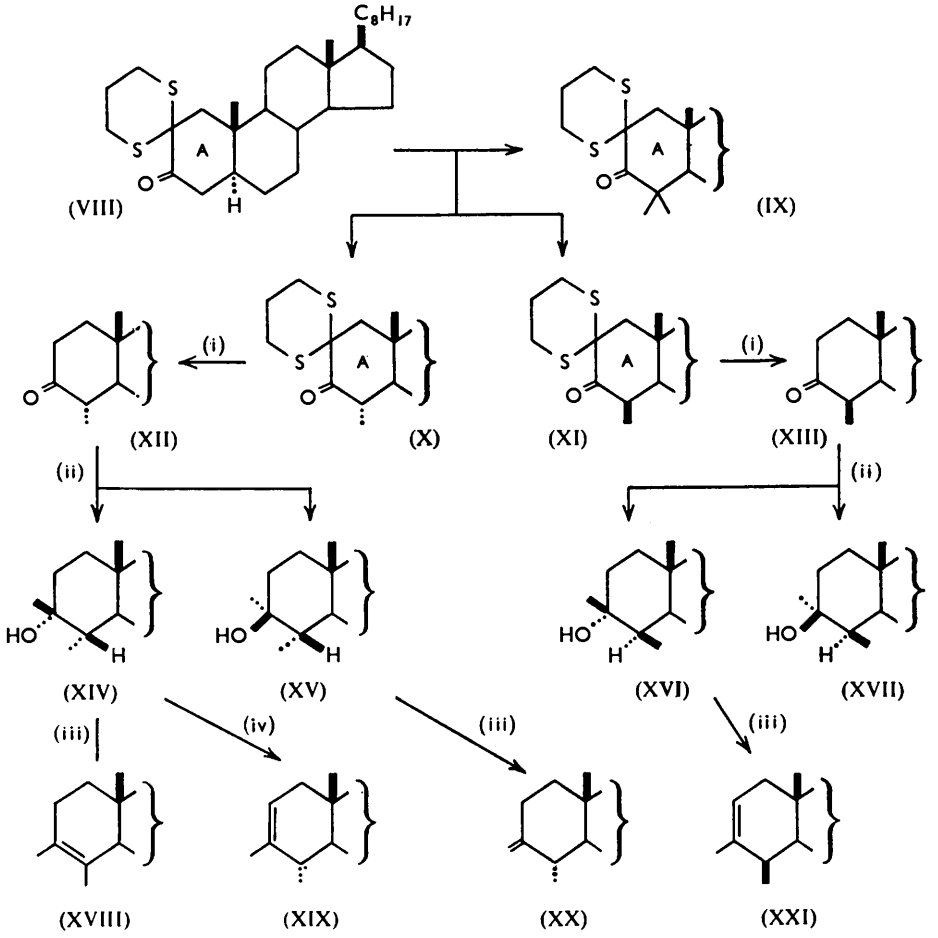
substituted are more stable than the corresponding isomers with trisubstituted double bonds. In the cases discussed above there are, however, two other factors which more than offset the effect of the degree of alkyl substitution. The first is the considerable non-bonded interaction in structure (IV) between the methyl group at $C_{(19)}$ and the $C_{(12)}$ methylene group. This is undoubtedly the predominating factor leading to the greater stability of lupene-I derivatives (III) in which the axial $C_{(19)}$ methyl group does not interact with the $C_{(12)}$ methylene group. The second factor concerns the relative stabilities of the

* Part XXIX, *J.*, 1956, 3172.

[1] Ames, Beton, Bowers, Halsall, and Jones, *J.*, 1954, 1905.

Δ^1- and Δ^2-octalin systems found in Δ^3- and Δ^2-cholestene (*e.g.*, V and VI) in which the double bond is disubstituted. Taylor [2] has suggested that the latter is stabilised relative to the former by hyperconjugation of its double bond with one more hydrogen atom.

A suitable carbon framework for a study of the importance of the second factor when the first, *i.e.*, the effect involving interaction between the $C_{(19)}$ methyl group and another ring, no longer applies, is that of 3:4-dimethylcholestane (VII), which may be compared with lupane-I. No non-bonded interaction can occur here between the $C_{(4)}$ methyl group and another ring. The first step was the preparation of the 4-methylcholestan-3-ones (XII) and (XIII). 4 : 4-Dimethylcholest-5-en-3-one can easily be made by methylating cholestenone.[3] Attempted monomethylation was unsuccessful, only small amounts of a product having the expected light absorption of 4-methylcholest-5-en-3-one ($\lambda_{max.}$ 2520 Å; ε = 15,000) being obtained.



(i) Raney nickel; CrO_3. (ii) MeMgI. (iii) $POCl_3$–pyridine. (iv) $SOCl_2$–benzene.

Fieser [4] carried out the $C_{(4)}$ monomethylation of cholest-4-ene-3 : 6-dione by addition of diazomethane and thermal decomposition of the resulting pyrazoline. However, on treatment of cholestenone with ethereal diazomethane for two days, a period far in excess of that used by Fieser, no pyrazoline was obtained.

[2] Taylor, *Chem. and Ind.*, 1954, 250.
[3] Woodward, Patchett, Barton, Ives, and Kelly, *J. Amer. Chem. Soc.*, 1954, **76**, 2852.
[4] Fieser, *ibid.*, 1953, **75**, 4386.

Cholestan-3-one itself cannot be directly methylated at $C_{(4)}$. However, Woodward [5] has shown that treatment of a solution of 2-hydroxymethylenecholestanone with trimethylene ditoluene-*p*-thiosulphonate and potassium acetate leads to the dithioketal (VIII), and that methylation with methyl iodide and potassium *tert.*-butoxide gives the 4 : 4-dimethyl derivative (IX).

By varying the amounts of methyl iodide and potassium *tert.*-butoxide it was possible to convert the dithioketal (VIII) into a mixture, separated by chromatography, of the 4 : 4-dimethyl, 4α-methyl, and 4β-methyl derivatives [(IX), (X), and (XI)] of the dithioketal (VIII).

The structure of the dimethylated product (IX) was proved by comparison with a sample prepared directly from 4 : 4-dimethylcholestan-3-one obtained by hydrogenation of 4 : 4-dimethylcholest-5-en-3-one. The carbonyl stretching band in the infrared spectrum of the 4 : 4-dimethyl derivative (IX) was less intense and at a frequency (1685 $cm.^{-1}$) some 20 $cm.^{-1}$ lower than is usual for a carbonyl group in a saturated six-membered ring. A similar effect was found with the corresponding lupenone derivative but not with the monomethyl compounds (X) and (XI). It appears that all the hydrogen atoms on the carbon atoms adjacent to the carbonyl group must be substituted for this effect to occur.

A tentative decision on the configurations of the two monomethylated products was first made by assuming that the more easily eluted had the equatorial $C_{(4)}$ methyl group (*i.e.*, 4α-methyl). This was subsequently shown to be correct.

The 4β-methylated product (XI) was isomerised to the 4α-isomer (X) with potassium *tert.*-butoxide in *tert.*-butanol and benzene under the methylation conditions. This supports the stereochemical assignments since it corresponds to the reorientation of a methyl group from an axial to an equatorial position. From the relative amounts of the two monomethylated products (X) and (XI) obtained under varying conditions it appeared that the axial (4β-methyl) isomer was produced first and then subsequently isomerised to the equatorial (4α-methyl) isomer. By using insufficient base and methyl iodide the ratio of 4β- to 4α-isomer produced was increased.

Bromination of steroidal ketones gives, in the first instance, the isomer in which the bromine is axial,[6, 7] and it is probable that the stereochemistry of the methylation process is similar.

Treatment of the two dithioketals with Raney nickel and oxidation of the resulting 4-methylcholestanols gave 4α- (XII) and 4β-methylcholestan-3-one (XIII). It was not possible to isomerise the 4β(axial)-methylcholestanone to the 4α(equatorial)-isomer under mild alkaline conditions, whilst under more vigorous conditions only resinous material was obtained. This failure may be due to the tendency of cholestanones to enolise towards $C_{(2)}$ rather than $C_{(4)}$. Any tendency to $C_{(3)}$–$C_{(4)}$ enolisation may be diminished by the absence of an axial hydrogen atom at $C_{(4)}$. It has been suggested that it is the axial hydrogen atom which is abstracted preferentially during enolisation.[7]

Treatment of 4α-methylcholestanone (XII) with methylmagnesium iodide gave the two tertiary alcohols (XIV) and (XV), whilst the corresponding pair (XVI) and (XVII) were obtained from the 4β-isomer (XIII).

Dehydration of the alcohol (XIV), the configuration of which was first assumed from adsorption properties, with phosphoryl chloride and pyridine gave mainly 3 : 4-dimethylcholest-3-ene (XVIII) (no infrared band corresponding to trisubstituted double bond or vinylidene group), separated by crystallisation from a small amount of 3 : 4α-dimethylcholest-2-ene (XIX). This behaviour accords well with the designated configuration, elimination involving the *trans* and axial $C_{(3)}$ hydroxyl group and the $C_{(4)}$ hydrogen atom. The isomeric Δ^2-hydrocarbon arises by elimination with the axial $C_{(2)}$ hydrogen atom.

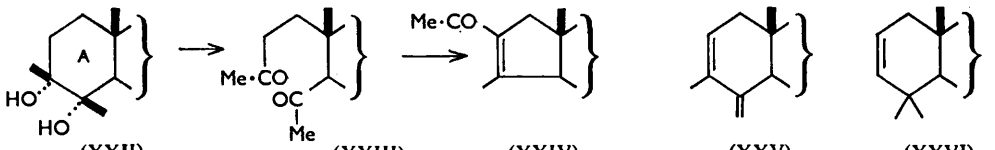
[5] Woodward, private communication (cf. Woodward, Patchett, Barton, Ives, and Kelly, *J.*, 1957, in the press).
[6] Corey, *Experientia*, 1953, **9**, 329.
[7] *Idem*, *J. Amer. Chem. Soc.*, 1954, **76**, 175.

The structure of the 3 : 4-dimethylcholest-3-ene was confirmed by conversion into the glycol (XXII) with osmium tetroxide. The α-configuration of the hydroxyl groups is assumed on the basis of attack from the less-hindered (α) face of the molecule. Periodic acid gave the diketone (XXIII) which cyclised on alumina to the acetyl*cyclo*pentene derivative (XXIV). This showed maximum ultraviolet light absorption at 2595 Å; the unusually long wavelength is typical of a 1-acetyl-2-methyl*cyclo*pentene.[8]

Dehydration of the glycol with phosphoryl chloride in pyridine gave a diene. Its ultraviolet and infrared spectra, with maximal absorption at 2360 Å and bands at 806 and 880 cm.$^{-1}$, indicative of a trisubstituted double bond and a vinylidene group, were consistent with formulation (XXV). The formation of the vinylidene group confirms that the hydroxyl group at $C_{(4)}$ in the glycol is equatorial (α).

Dehydration with phosphoryl chloride in pyridine of 3α : 4α-dimethylcholestan-3β-ol (XV) (hydroxyl group equatorial) gave the expected *exo*methylene derivative (XX). 3 : 4α-Dimethylcholest-2-ene (XIX) was best prepared by the dehydration of 3β : 4α-dimethylcholestan-3α-ol (XIV) with thionyl chloride in benzene. The formation of the Δ^2- rather than the Δ^3-isomer may well be due to the operation of a cyclic mechanism involving a *cis*-elimination of the hydroxyl group and the $C_{(2)}$ *cis*-(α)-hydrogen atom. At $C_{(4)}$ there is no *cis*-hydrogen atom. Evidence for this suggestion is provided by the dehydration with thionyl chloride in benzene of β-amyrin and lupanol to oleana-2 : 12-diene and lup-2-ene (ring A in each case as in XXVI), respectively. In these cases a cyclic *cis*-elimination almost certainly occurs since an ionic *trans*-elimination favours ring contraction as when β-amyrin is dehydrated with phosphorus pentachloride.[9]

The configurations of the two alcohols from 4β-methylcholestan-3-one (XIII) were established by dehydrating a small amount of the alcohol (XVI), thought to have the 3α(axial)-hydroxyl group, with phosphoryl chloride in pyridine. The product was shown by infrared examination to contain a trisubstituted double bond but no vinylidene group. If the hydroxyl group had had the β-configuration, *i.e.*, equatorial, a vinylidene group would have been formed.



(XXII) (XXIII) (XXIV) (XXV) (XXVI)

The acid-catalysed isomerisations of the hydrocarbons (XVIII), (XIX), and (XX) and of the dehydration product from 3β : 4β-dimethylcholestan-3α-ol (XVI) were studied by keeping them with 10% ethanolic sulphuric acid–benzene at 20° for several days. Spectral analysis revealed that identical mixtures were obtained in all cases. The infrared spectra showed that the isomerisation products did not contain an isomer with a vinylidene group. The ultraviolet and the infrared spectra together were consistent (see Experimental section) with the isomerisation product's being a mixture of 35—40% of the trisubstituted olefin (XIX) and 60—65% of the isomer (XVIII) with the tetrasubstituted double bond. Repeated crystallisation of the isomerisation product obtained from 3 : 4α-dimethylcholest-2-ene (XIX) afforded the Δ^3-isomer (XVIII). The satisfactory agreement between the analytical figures based on spectral data showed that there was no significant amount of the Δ^4-isomer (3β : 4-dimethylcholest-4-ene) present. The ultraviolet absorption of this isomer in the low-wavelength region would have been appreciably more intense than that of the Δ^3-isomer (XVIII) owing to its exocyclic double bond,[10] and had it been present the calculations of the composition of the isomerisation mixture made on the assumption

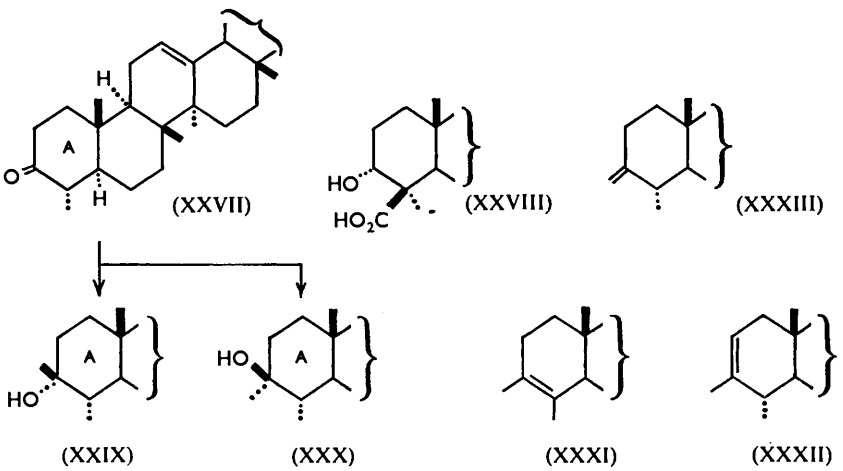
[8] Schubert and Sweeney, *ibid.*, 1955, **77**, 2297.
[9] Barton and Cookson, *Quart. Rev.*, 1956, **10**, 69.
[10] Bladon, Henbest, and Wood, *J.*, 1952, 2737.

that only the isomers (XVIII) and (XIX) were present would not have agreed. In particular, calculations based on ultraviolet data would have given a ***higher*** value for the percentage of the Δ^3-isomer (XVIII) present than those based on infrared data.

It is extremely unlikely that the Δ^2-3 : 4β-isomer (XXI) was present in the isomerisation mixture from the Δ^3-isomer (XVIII); the isomer (XXI) would be appreciably less stable than the 4α-isomer (XIX) because of the non-bonded interaction between the $C_{(4)}$- and the $C_{(10)}$β(axial)-methyl group.

The composition of the isomerisation mixture shows that under the conditions of its formation the free energies of the two isomers (XVIII) and (XIX) are approximately equal. The differences in ring strain produced by the Δ^3-(Δ^1-*trans*-octalin type)- and Δ^2-(Δ^2-*trans*-octalin type)-bonds must be approximately equal to the extra stabilisation energy associated with a tetrasubstituted as compared with a trisubstituted double bond. This conclusion confirms the view that the greater stability of the Δ^{20}-isomer (III) than of the Δ^{19}-isomer (IV) is due to the non-bonded interaction in the latter between the $C_{(19)}$-methyl group and the $C_{(12)}$-methylene group.

In a second system investigated the ursane derivative nor-β-boswellenone (XXVII) [11] was the starting material. Since this is obtained from β-boswellic acid (XXVIII) ***via*** the β-keto-acid and ***in situ*** decarboxylation, it may be assumed that the $C_{(4)}$-methyl group of nor-β-boswellenone is in the more stable equatorial (α) conformation.[12] Treatment of the ketone with methylmagnesium iodide gave two alcohols (XXIX) and (XXX). The 3α-hydroxyl compound (XXIX), eluted more readily from alumina, was dehydrated with phosphoryl chloride in pyridine to the Δ^3-isomer (XXXI) with a tetrasubstituted double bond. This proves the axial conformation not only of the hydroxyl group at $C_{(3)}$ but also of the hydrogen atom at $C_{(4)}$, confirming the allocation of the α-configuration to the $C_{(4)}$ methyl group. On the other hand, dehydration of the alcohol (XXIX) with thionyl chlorine in benzene gave the trisubstituted isomer (XXXII) as in the cholestane series. The trisubstituted nature of the double bond in the Δ^2-isomer (XXXII) was confirmed by oxidation ***via*** a glycol to a keto-acid. Dehydration with phosphoryl chloride in pyridine of the alcohol (XXX) with the equatorial hydroxyl group gave, as expected, the hydrocarbon (XXXIII) with the vinylidene group.



(XXVII) (XXVIII) (XXXIII)

(XXIX) (XXX) (XXXI) (XXXII)

Acid treatment of the Δ^3-isomer (XXXI) gave a mixture from which the Δ^2-isomer (XXXII) was obtained in about 35% yield. Spectroscopic examination indicated that the mixture contained approximately equal amounts of the Δ^2- and the Δ^3-isomer (XXXII) and (XXXI). In this case the presence of the original trisubstituted double bond in

[11] Beton, Halsall, and Jones, *J.*, 1956, 2904.
[12] Klyne, *Experientia*, 1956, **12**, 119.

ring C made the analysis much less reliable than with the dimethylcholestenes. The result, however, is consistent with that obtained with the latter and confirms the conclusions already reached about the energy relation between the Δ^2- and the Δ^3-isomer.

The ratios of the yields of the two alcohols from the action of methylmagnesium iodide in the cases of the two 4-methylcholestanones and nor-β-boswellenone are: (i) 4α-methylcholestanone, $3\alpha/3\beta = 7/3$; (ii) 4β-methylcholestanone, $3\alpha/3\beta = 1/1$; (iii) nor-β-boswellenone, $3\alpha/3\beta = 4/1$. To elucidate the orientating effect of the $C_{(4)}$-methyl group cholestan-3-one was treated with methylmagnesium iodide. Previously, Bolt and Backer [13] had obtained a 70% yield of an alcohol, m. p. 129—130°, from this reaction. Farmer and Kon [14] obtained a mixture from which was isolated the epimeric alcohol, m. p. 147°, whilst Kuwada and Miyasaka [15] had obtained both epimers, m. p.s 125° and 147—148°, from the action of methylmagnesium iodide on cholestanone cyanohydrin. In none of these cases was the stereochemistry of the alcohols elucidated when the work described here was undertaken.

In our experiment the two alcohols, m. p.s 128·5—129° and 148—150°, were obtained in the ratio of 5 : 4. The alcohol, m. p. 128·5—129°, is 3β-methylcholestan-3α-ol since the hydrocarbon, m. p. 84° (Kuwada and Miyasaka [15] give m. p. 84° for a methylcholestene), obtained with phosphoryl chloride and pyridine contained a trisubstituted double bond (infrared spectrum) and not the vinylidene group which would have resulted from an equatorial 3β-hydroxyl group. The dehydration product from the other alcohol, 3α-methylcholestan-3β-ol, had an infrared spectrum which indicated that it was a mixture of 3-methylenecholestane and 3-methylcholest-2(or 3)-ene. Since the above work was carried out Barnes and Palmer [16] have reached the same conclusions, and Barton [17] has announced that he has also determined the configurations of the two alcohols.

The product ratios indicate that absence of a $C_{(4)}$-methyl group or presence of an axial (4β) methyl group gives an equal chance of the Grignard reagent's approaching from either the α- or the β-side. On the other hand, the presence of the equatorial (4α) methyl group reduces appreciably the amount of isomer produced by attack of the reagent from the α-face of the molecule.

Experimental

Rotations were determined in chloroform at room temperature. M. p.s were determined on a Kofler block and are corrected. The alumina used for chromatography had activity I—II, unless otherwise stated. Light petroleum refers to the fraction, b. p. 60—80°. Ultraviolet spectra were determined in ethanol and infrared spectra in carbon disulphide.

2-Hydroxymethylenecholestan-3-one.—Cholestanone (20 g.) in ether (500 c.c.) was treated with sodium methoxide (from 15 g. of sodium) in methanol (150 c.c.) and ethyl formate (240 c.c.) for 5 days at 20° with occasional shaking. The mixture was then treated with a buffered phosphate solution (pH = 8). Extraction with ether afforded 2-hydroxymethylenecholestan-3-one as pale yellow crystals (from chloroform–methanol), m. p. 180—181°. Light absorption in ethanol: Max. 2850 Å; $\varepsilon = 16{,}600$.

3-Oxocholestane-2-spiro-2′-(1′:3′-dithian) (VIII).—2-Hydroxymethylenecholestan-3-one (10 g.) and trimethylene ditoluene-*p*-thiosulphonate (12 g.) in ethanol (300 c.c.) were treated with potassium acetate (25 g.) in ethanol (500 c.c.). The mixture was heated under reflux under carbon dioxide for 7½ hr. and then the solvent was removed. The residual solid was partitioned between benzene and water. The benzene phase was washed and dried and put on alumina (300 g.; activity II). Elution with benzene (3 l.) afforded *3-oxocholestane-2-spiro-2′-(1′:3′-dithian)* as fibrous needles (7·4 g.) (from chloroform–methanol), m. p. 182—183°, $[\alpha]_D$ +114° (*c*, 1·5) (Found: S, 13·3. $C_{30}H_{50}OS_2$ requires S, 13·05%).

4α-Methyl-, 4β-Methyl-, and 4:4-Dimethyl-3-oxocholestane-2-spiro-2′-(1′:3′-dithian).—3-Oxocholestane-2-*spiro*-2′-(1′:3′-dithian) (10 g.) was heated under reflux in a mixture of benzene (100 c.c.) and a solution of potassium *tert.*-butoxide in *tert.*-butanol (100 c.c.; 1·08M). Methyl

[13] Bolt and Backer, *Rec. Trav. chim.*, 1937, **56**, 1139.
[14] Farmer and Kon, *J.*, 1937, 414.
[15] Kuwada and Miyasaka, *J. Pharm. Soc. Japan*, 1938, **58**, 115.
[16] Barnes and Palmer, *Austral. J. Chem.*, 1956, **9**, 105.
[17] Barton, "Experientia Supplementum II," Birkhäuser Verlag, Basel und Stuttgart, 1955, p. 121.

iodide (6 c.c.) was added to the hot solution, which was heated for a further 20 min. After addition of water and removal of solvent under reduced pressure, ethereal extraction afforded a solid which was adsorbed from light petroleum–benzene (1 : 1) on alumina (1 kg.). Elution with light petroleum–benzene (1 : 1) gave three fractions as follows: (a) 4 : 4-*Dimethyl*-3-*oxocholestane*-2-spiro-2′-(1′ : 3′-*dithian*) (IX) (1·85 g.; 17%), plates (from chloroform–methanol), m. p. 128—129° undepressed on admixture with a sample prepared from 4 : 4-dimethylcholestan-3-one (see below), $[\alpha]_D$ −19° (*c*, 1·52) (Found: C, 73·95; H, 10·55; S, 12·45. $C_{32}H_{54}OS_2$ requires C, 74·1; H, 10·5; S, 12·35%). Infrared absorption: band at 1686 cm.$^{-1}$. (b) 4α-*Methyl*-3-*oxocholestane*-2-spiro-2′-(1′ : 3′-*dithian*) (X) (4·9 g.; 48%), plates (from chloroform–methanol) with a double m. p., 127—130° and 159—162°. On crystallisation from methanol it had m. p. 159—162°; a sublimate had a single m. p. 160—161°. $[\alpha]_D$ +70° (*c*, 1·73) (Found: S, 13·3. $C_{31}H_{52}OS_2$ requires S, 12·9%). Infrared absorption: band at 1702 cm.$^{-1}$. (c) 4β-*Methyl*-3-*oxocholestane*-2-spiro-2′-(1 : 3′-*dithian*) (XI) (760 mg.; 8%) fibrous needles (from chloroform–methanol), m. p. 161—162° depressed on admixture with the 4α-methyl derivative, $[\alpha]_D$ +89° (*c*, 1·21) (Found: S, 13·1%). Infrared absorption: band at 1703 cm.$^{-1}$. Further elution with light petroleum–benzene (1 : 1) afforded a small amount of starting material.

4 : 4-*Dimethylcholestan*-3-*one*.—(*a*) 4 : 4-Dimethyl-3-oxocholestane-2-*spiro*-2′-(1′ : 3′-dithian) (1·2 g.) in ethanol (100 c.c.) was heated under reflux with Raney nickel (12 g.) for 6 hr. Removal of the nickel and the solvent gave a solid which displayed a strong hydroxyl band in the infrared spectrum and contained no sulphur. The solid in hot acetic acid (40 c.c.) and sodium dichromate (1 g.) in hot acetic acid (40 c.c.) were heated on the steam-bath for 1 hr. and then kept at 20° overnight. Dilution with water, isolation with ether, and crystallisation from methanol gave 4 : 4-*dimethylcholestan*-3-*one* as needles, m. p. 100—101° undepressed on admixture with a sample prepared from 4 : 4-dimethylcholest-5-en-3-one (see below), $[\alpha]_D$ +8° (*c*, 1·42) (Found: C, 83·9; H, 12·1. $C_{29}H_{50}O$ requires C, 84·0; H, 12·15%).

(*b*) 4 : 4-Dimethylcholest-5-en-3-one [3] (520 mg.) was hydrogenated in acetic acid (60 c.c.) in the presence of Adams's catalyst (150 mg.) at 75—80°. The uptake of hydrogen was complete after 1 hr. Removal of the catalyst, dilution with water, and extraction with ether afforded a solid. Any 4 : 4-dimethylcholestanyl acetate produced was hydrolysed. The product (480 mg.) showed a strong hydroxyl band at 3625 cm.$^{-1}$. A solution in hot acetic acid (10 c.c.) and sodium dichromate (300 mg.) in hot acetic acid (5 c.c.) were heated on the steam-bath for 1 hr. and then kept at 20° overnight. Dilution with water, isolation by ether extraction, and crystallisation from methanol gave 4 : 4-dimethylcholestan-3-one as long needles (210 mg.), m. p. 100—101°, $[\alpha]_D$ +8° (*c*, 1·16).

Preparation of 4 : 4-*Dimethyl*-3-*oxocholestane*-2-spiro-2′-(1′ : 3′-*dithian*) (IX) *from* 4 : 4-*Dimethylcholestan*-3-*one*.—4 : 4-Dimethylcholestan-3-one (155 mg.) (prepared from 4 : 4-dimethylcholest-4-en-3-one as described above) in ether (10 c.c.) was treated with a suspension of sodium methoxide (from 1 g. of sodium) in ethyl formate (20 c.c.). The mixture was kept for 6 days at 20° and shaken occasionally. More ether was then added and the mixture was shaken with phosphate buffer solution (pH = 7). From the ether layer 2-hydroxymethylene-4 : 4-dimethylcholestan-3-one (101 mg.), m. p. 131—138° (from acetone–methanol), was obtained. The hydroxymethylene derivative, trimethylene ditoluene-*p*-thiosulphonate (100 mg.), and potassium acetate (250 mg.) in ethanol (20 c.c.) were heated under reflux for 10 hr. in carbon dioxide. After removal of solvent and addition of water, extraction with benzene afforded a product which was adsorbed from benzene on alumina (10 g.). Elution with benzene yielded 4 : 4-dimethyl-3-oxocholestane-2-*spiro*-2′-(1′ : 3′-dithian) as plates (65 mg.) (from chloroform–methanol), m. p. 128—129°, $[\alpha]_D$ −19° (*c*, 1·50). The infrared spectrum was identical with that of the compound obtained by methylation of 3-oxocholestane-2-*spiro*-2′-(1′ : 3′-dithian).

4α-*Methylcholestan*-3-*one* (XII).—4α-Methyl-3-oxocholestane-2-*spiro*-2′-(1′ : 3′-dithian) (10 g.) in ethanol (500 c.c.) was heated under reflux with efficient stirring with Raney nickel (100 g.) for 7 hr. Removal of the nickel and the solvent gave a solid which was dissolved in acetic acid (100 c.c.) and treated with sodium dichromate (4·5 g.) in acetic acid (100 c.c.). The mixture was heated on the steam-bath for 20 min. and then kept at 20° overnight. Dilution with water and extraction with ether afforded 4α-*methylcholestan*-3-*one* (5·76 g.) as plates (from methanol), m. p. 118—120° raised by repeated crystallisation from methanol to 122—122·5°, depressed on admixture with 4β-methylcholestan-3-one to 110—120°, $[\alpha]_D$ +25° (*c*, 2·17) (Found: C, 83·9; H, 11·7. $C_{28}H_{48}O$ requires C, 83·95; H, 12·1%). Infrared absorption: band at 1708 cm.$^{-1}$.

4β-*Methylcholestan*-3-*one* (XIII).—4β-Methyl-3-oxocholestane-2-*spiro*-2′-(1′ : 3′-dithian) (760 mg.) in ethanol (70 c.c.) was heated under reflux with Raney nickel (7·6 g.) for 6 hr. Removal of the nickel and the solvent gave crude 4β-methylcholestanol (590 mg.), m. p. 128—135°, which was dissolved in hot acetic acid (8 c.c.) and treated with a solution of sodium dichromate (300 mg.) in hot acetic acid (3 c.c.). The mixture was heated on the steam-bath for 20 min. Dilution with water and extraction with ether gave 4β-*methylcholestan*-3-*one* (455 mg.), plates, m. p. 125—127° (after crystallisation from acetic acid), $[\alpha]_D$ +36° (*c*, 1·71) (Found: C, 83·8; H, 12·05%). Infrared absorption: band at 1708 cm.$^{-1}$.

Attempted Isomerisation of 4α- *and* 4β-*Methylcholestan*-3-*one*.—Treatment of 4β-methylcholestan-3-one as follows led only to the recovery of starting materials: (*a*) Shaking an ethereal solution of the ketone with saturated aqueous potassium carbonate for 15 min. (*b*) Heating the ketone under reflux with a solution of sodium methoxide in methanol (2½%) for 1 hr. (*c*) Allowing the ketone in benzene to remain on alumina for 28 hr.

Heating the ketone under reflux with potassium *tert.*-butoxide in *tert.*-butanol (1·3M) for 1 hr. produced a yellow gum from which no crystals could be obtained. A similar result was obtained by heating 4β-methylcholestan-3-one for 2 hr. at 170° with a 10% solution of potassium hydroxide in ethylene glycol.

Attempts to isomerise 4α-methylcholestan-3-one under all these conditions except (*a*) merely gave starting material.

Isomerisation of 4β-*Methyl*-3-*oxocholestane*-2-spiro-2′-(1′ : 3′-*dithian*) (XI).—The thioketal (120 mg.) in benzene (20 c.c.) was heated under reflux for 1 hr. with potassium *tert.*-butoxide in *tert.*-butanol (10 c.c.; 1·3M). After removal of the solvents under reduced pressure extraction with ether afforded a product which was adsorbed from light petroleum–benzene (1 : 1) on alumina (20 g.). The same solvent eluted a fraction which was mainly the 4α-isomer. Crystallisation from methanol gave material, m. p. 154—158° undepressed on admixture with the 4α-isomer (mixed m. p. 154—160°), depressed on admixture with 4β-isomer (mixed m. p. 142—158°). The mixed m. p. of the two authentic isomers was 143—159°. Crystallisation of the isomerisation product from chloroform–methanol gave plates which exhibited the characteristic double melting (m. p.s 127—130° and 157—160°).

Treatment of 4β-*Methylcholestan*-3-*one with Methylmagnesium Iodide*.—4β-Methylcholestan-3-one (455 mg.) in ether (15 c.c.) and methylmagnesium iodide in ether (from 1 g. of magnesium) were kept at 20° overnight. Decomposition with ammonium chloride solution and extraction with ether afforded a product which was adsorbed from benzene on alumina (50 g.). Benzene–ether (1 : 1) eluted 3β : 4β-*dimethylcholestan*-3α-*ol* (XVI) (230 mg.; 48%), which crystallised from methanol as needles, m. p. 126·5—128°. At 170°/0·1 mm. the needles gave a sublimate, m. p. 120—121°, $[\alpha]_D$ +27° (*c*, 1·34) (Found: C, 84·1; H, 12·85. $C_{29}H_{52}O$ requires C, 83·6; H, 12·6%). Further elution, with ether–methanol (19 : 1), gave 3α : 4β-*dimethylcholestan*-3β-*ol* (XVII) which at 170°/0·1 mm. gave a sublimate, m. p. 135—137°, $[\alpha]_D$ +28° (*c*, 1·52) (Found: C, 84·0; H, 12·6%).

Treatment of 4α-*Methylcholestan*-3-*one with Methylmagnesium Iodide*.—4α-Methylcholestan-3-one (5·6 g.) in ether (150 c.c.) was set aside overnight with methylmagnesium iodide in ether (150 c.c.) (from 10 g. of magnesium) at 20°. Decomposition with ammonium chloride solution and extraction with ether afforded a solid (5·7 g.) which was adsorbed from benzene on alumina (450 g.). Elution with benzene–ether (1 : 1) gave 3β : 4α-*dimethylcholestan*-3α-*ol* (XIV) (4·0 g.; 70%), needles (from methanol), m. p. 133—134°, $[\alpha]_D$ +13·5° (*c*, 2·52) (Found: C, 83·9; H, 12·7. $C_{29}H_{52}O$ requires C, 83·6; H, 12·6%). Further elution, with ether–methanol (19 : 1), afforded 3α : 4α-*dimethylcholestan*-3β-*ol* (XV) (1·72 g.; 30%), fine needles (from methanol), m. p. 142—143·5°, $[\alpha]_D$ +27° (*c*, 2·72) (Found: C, 83·6; H, 12·6%).

4α-*Methyl*-3-*methylenecholestane* (XX).—3α : 4α-Dimethylcholestan-3β-ol (800 mg.) in pyridine (40 c.c.) was heated under reflux with phosphoryl chloride (8 c.c.) for 30 min. Careful decomposition of the excess of reagent with water and extraction with ether gave a solid which was adsorbed from pentane on alumina (50 g.). Elution with pentane yielded 4α-*methyl*-3-*methylenecholestane* (690 mg.), flakes (on recrystallisation from acetone), m. p. 66—67°, $[\alpha]_D$ +12·5° (*c*, 2·17) (Found: C, 87·2; H, 12·6. $C_{29}H_{50}$ requires C, 87·35; H, 12·65%). Infrared absorption: bands at 887 and 1643 cm.$^{-1}$.

3 : 4α-*Dimethylcholest*-2-*ene* (XIX).—3β : 4α-Dimethylcholestan-3α-ol (425 mg.) in benzene (40 c.c.) was heated under reflux with freshly distilled thionyl chloride (1 c.c.) for 4½ hr. The benzene solution was then washed free from acids with water and potassium hydrogen carbonate solution,

dried, and poured on alumina (40 g.; activity II). Elution with benzene gave 3 : 4α-*dimethylcholest-2-ene* (400 mg.), needles (from acetone), m. p. 111·5—113°, $[\alpha]_D$ +20° (*c*, 1·1). A sublimed sample had m. p. 113—113·5° (Found: C, 87·4; H, 12·8. $C_{29}H_{50}$ requires C, 87·35; H, 12·65%). Infrared absorption: bands at 777 and 810 cm.$^{-1}$.

Dehydration of 3β : 4β-*Dimethylcholestan-3α-ol* (XVI).—The alcohol (30 mg.) was heated under reflux for 1 hr. in pyridine (3 c.c.) with phosphoryl chloride (0·5 c.c.). Dilution with water and extraction with ether gave a solid which was dissolved in pentane and filtered through alumina (5 g.). The product, m. p. 75—80°, could not be purified further owing to the small amount available. Its spectrum had a band at 789 cm.$^{-1}$ indicative of a trisubstituted double bond, but none indicative of an *exo*cyclic methylene group. This shows that the product is mainly 3 : 4β-dimethylcholest-2-ene.

3 : 4-*Dimethylcholest-3-ene* (XVIII).—3β : 4α-Dimethylcholestan-3α-ol (1·2 g.) in pyridine (60 c.c.) was heated under reflux with phosphoryl chloride (12 c.c.) for ½ hr. Dilution with water and extraction with ether gave a solid which was adsorbed from pentane on alumina (60 g.). Elution with the same solvent (300 c.c.) and two crystallisations from acetone gave needles, m. p. 100—101·5°, $[\alpha]_D$ +9·6° (*c*, 1·83). The infrared spectrum suggested that these contained a small amount of 3 : 4α-dimethylcholest-2-ene. This was removed by repeated crystallisation from acetone to give pure 3 : 4-*dimethylcholest-3-ene* as fibrous needles, m. p. 106·5—108°, $[\alpha]_D$ +5° (*c*, 0·57) (Found: C, 87·5; H, 12·4. $C_{29}H_{50}$ requires C, 87·35; H, 12·65%).

Oxidation of 3 : 4-*Dimethylcholest-3-ene* (XVIII) *with Osmium Tetroxide*.—3 : 4-Dimethylcholest-3-ene (1·4 g.) in pyridine (25 c.c.) and benzene (25 c.c.) and osmium tetroxide (1 g.; 1·1 mol.) were kept at 20° for 18 days. The solvents were then removed under reduced pressure and the residue was heated under reflux with a mixture of benzene (40 c.c.), methanol (40 c.c.), ethanol (40 c.c.), water (20 c.c.), mannitol (8 g.), and potassium hydroxide (8 g.) for 3½ hr. Sodium sulphite (1·4 g.) was then added and the heating continued for 1 hr. After removal of the solvents, extraction with ether afforded a solid which was adsorbed from benzene on alumina (100 g.; activity II). Elution with benzene (400 c.c.) afforded starting material (220 mg.). Elution with ether (1700 c.c.) and crystallisation from methanol gave 3β : 4β-*dimethylcholestane*-3α : 4α-*diol* (XXII) as plates (740 mg.), m. p. 162·5—163°, $[\alpha]_D$ +1·3° (*c*, 2·39) (Found: C, 80·45; H, 12·05. $C_{29}H_{52}O_2$ requires C, 80·5; H, 12·1%). Further elution with ether–methanol (19 : 1) gave a fraction (80 mg.) which crystallised with difficulty from methanol to give a small amount of solid, m. p. 195—203°; this is probably impure 3β : 4β-diol.

Oxidation of 3β : 4β-*Dimethylcholestane*-3α : 4α-*diol* (XXII).— The 3α : 4α-diol (106 mg.) in dioxan (10 c.c.) was treated with periodic acid (125 mg.) in water (1 c.c.) for 24 hr. at 20°. Dilution with water, extraction with ether, and crystallisation from aqueous methanol gave 2-*acetyl*-2 : 3-seco*cholestan*-4-*one* (XXIII) as needles (85 mg.), m. p. 99—100·5°, $[\alpha]_D$ +10° (*c*, 1·23) (Found: C, 80·7; H, 11·8. $C_{29}H_{50}O_2$ requires C, 80·85; H, 11·7%).

Cyclisation of 2-*Acetyl*-2 : 3-seco*cholestan*-4-*one* (XXIII).—2-Acetyl-2 : 3-*seco*cholestan-4-one (50 mg.), dissolved in the minimum amount of light petroleum, was adsorbed on alumina (10 g.). Elution after 1 hr. with benzene (80 c.c.) and benzene–ether (9 : 1; 160 c.c.) gave starting material. Further elution with benzene–ether (4 : 1; 40 c.c.) gave 2-*acetyl*-3-*methyl*-A-*norcholest-2-ene* (XXIV), plates (from aqueous methanol), m. p. 105—108°. Light absorption: max. 2595 Å, ε = 9550; band at 1670 cm.$^{-1}$. The ketone gave a positive iodoform test and was characterised as its 2 : 4-*dinitrophenylhydrazone*, m. p. 225—227·5° (Found: N, 9·55. $C_{35}H_{52}O_4N_4$ requires N, 9·45%). Light absorption: max. 2950 Å; ε = 23,400.

Dehydration of 3β : 4β-*Dimethylcholestan*-3α : 4α-*diol* (XXII).—The diol (100 mg.) in pyridine (10 c.c.) was heated under reflux for 1 hr. with phosphoryl chloride (2 c.c.). Dilution with water and extraction with ether gave a product which was adsorbed from light petroleum on alumina (5 g.; activity II). Elution with the same solvent (50 c.c.) and three crystallisations of the product from acetone gave 3-*methyl*-4-*methylenecholest-2-ene* (XXV) as long needles (40 mg.), m. p. 92—99°, $[\alpha]_D$ +85° (*c*, 0·85) (Found: C, 87·85; H, 12·25. $C_{29}H_{48}$ requires C, 87·8; H, 12·2%). Light absorption: max. 2360 Å, ε = 15,100; bands at 806 (w) and 880 (s) cm.$^{-1}$.

Isomerisation of 4α-*Methyl*-3-*methylenecholestane* (XX).—4α-Methyl-3-methylenecholestane (160 mg.) in ethanolic sulphuric acid (70 c.c.; 10% v/v) and benzene (25 c.c.) was kept at 20° for 4 days. Dilution with water and extraction with ether gave a solid whose solution in pentane was filtered through alumina (5 g.). The product, m. p. 87—98°, $[\alpha]_D$ +11° (*c*, 1·76), was analysed as follows:

(*a*) Ultraviolet absorption measured by a " Unicam S.P. 500 " spectrophotometer specially

chosen for its good optical characteristics in the region 2000—2200 Å and not exhibiting a false maximum above 2000 Å:

Intensity (ε) *of absorption.*

λ, Å	2000	2050	2100	2150	2200	2230	2250
3 : 4-Dimethylcholest-3-ene	7900	6500	4550	2700	1565	1165	930
Isomerisation mixture	6650	5220	3500	1980	1100	800	600
3 : 4α-Dimethylcholest-2-ene	4550	3170	1900	860	230	100	75
% of 3 : 4-dimethylcholest-3-ene (calc.)	63	62	60	61	65	66	62

(*b*) Infrared absorption. The intensity of absorption (ε) is calculated from the equation $\varepsilon = (1/cl) \log_{10} \{(100 - y)/(100 - x)\}_\nu$, where c = concentration in mole/l., l = cell length in cm., x = % absorption at ν cm.$^{-1}$ with solution in sample beam of light and solvent in reference beam, and y = % absorption at ν cm.$^{-1}$ with solvent in both beams. This calculation does not give strictly true values since it does not take account of slit widths, but the error due to this is small at *ca.* 800 cm.$^{-1}$ as the slit width is small. Since the spectra of the pure hydrocarbons and of the isomerisation mixture are obtained under similar conditions the intensities obtained should give a reasonably accurate analysis of the mixture:

Intensity (ε) *of absorption.*

ν, cm.$^{-1}$	810	777
3 : 4-Dimethylcholest-3-ene	7·5	4
Isomerisation mixture	19	13
3 : 4α-Dimethylcholest-2-ene	42	31
% of 3 : 4-dimethylcholest-3-ene (calc.)	67	67

Repeated crystallisation of the isomerisation mixture from acetone gave pure 3 : 4-dimethylcholest-3-ene, m. p. 103—105° undepressed on admixture with an authentic sample.

Isomerisation of 3 : 4-*Dimethylcholest*-3-*ene* (XVIII) *and* 3 : 4α-*Dimethylcholest*-2-*ene* (XIX).—These were isomerised by treatment for 11 days at 20° with the same reagents as were used with 4α-methyl-3-methylenecholestane. In both cases the isomerisation product, as indicated by ultraviolet and infrared absorption analysis, was identical with that from 4α-methyl-3-methylenecholestane.

Isomerisation of 3 : 4β-*Dimethylcholest*-2-*ene* (XXI).—The crude 3 : 4β-dimethylcholest-2-ene (26 mg.), prepared from 3β : 4β-dimethylcholestan-3α-ol, was dissolved in acetic acid (10 c.c.) and benzene (5 c.c.) and concentrated sulphuric acid (1 c.c.) was added. The mixture was kept at 20° for 7 days and shaken occasionally. Dilution with water and extraction with ether gave a product identical with that described above. Isomerisation of 3 : 4α-dimethylcholest-2-ene under these conditions gave the same product.

Preparation of Nor-β-*boswellenone* (3-*Oxo*-24-*norurs*-12-*ene*) (XXVII).—Using Simpson and Williams's [18] method (oxidation with chromic acid in acetic acid at 20°) we obtained the yield they record and the nor-β-boswellenone contained up to 2% of the corresponding 9(11)-dehydro-derivative [3-oxo-24-norursa-9(11) : 12-diene.] Treatment of β-boswellic acid, containing some dehydro-derivative as impurity, with chromic acid in acetone containing a little sulphuric acid gave a poor yield and the diene system persisted. The modification of Simpson and Williams's method described below gave nor-β-boswellenone containing only 0·5—0·6% of the corresponding 9(11) : 12-diene and this material was used for the experiments described (unless otherwise stated).

β-Boswellic acid [containing 23% of the corresponding 9(11) : 12-diene] (13 g.) in acetic acid (500 c.c.) and chromic acid (4 g.) in water (10 c.c.) and acetic acid (100 c.c.) were kept at 0° for 4 hr. After the addition of an excess of sodium sulphate solution the mixture was heated on a steam-bath for 6 hr. Dilution with water followed by extraction with ether yielded a crystalline product (10 g.). This showed maximum light absorption at 2530 Å (ε = 2650) indicating the presence of *ca.* 22% of 3 : 11-dioxo-24-norurs-12-ene. The product was adsorbed from benzene on alumina (500 g.). Elution with benzene (1200 c.c.) gave a fraction (4·25 g.) which crystallised from chloroform–methanol to give nor-β-boswellenone as plates, m. p. 194—196°, $[\alpha]_D$ +120° (*c*, 0·62). The light-absorption intensity at 2810 Å (ε = 60) indicates the presence of 0·5—0·6% of 3-oxo-24-norursa-9(11) : 12-diene.

[18] Simpson and Williams, *J.*, 1938, 686, 1712.

Heating of nor-β-boswellenone (1·41 g.) in benzene (30 c.c.) with 10% ethanolic potassium hydroxide (100 c.c.) under reflux for 6 hr. did not cause isomerisation.

Treatment of Nor-β-boswellenone with Methylmagnesium Iodide.—Nor-β-boswellenone (1·7 g.) in ether (100 c.c.) and methylmagnesium iodide (from 1 g. of magnesium) in ether (50 c.c.) were kept at 20° overnight. After careful addition of sulphuric acid (3N), the ethereal solution was worked up to give a product which was adsorbed from light petroleum on alumina (100 g.). After elution with light petroleum (300 c.c.), elution with benzene (600 c.c.) and ether (300 c.c.) afforded a fraction (1·42 g.) which from chloroform–methanol gave 3β-*methyl*-24-*norurs*-12-*en*-3α-*ol* (XXIX) as plates, m. p. 85—88°, $[\alpha]_D$ +95° (*c* 0·83) (Found: C, 84·25; H, 11·75. $C_{30}H_{50}O$ requires C, 84·45; H, 11·8%). Further elution with 5% methanol in ether (300 c.c.) afforded 3α-*methyl*-24-*norurs*-12-*en*-3β-*ol* (XXX) (340 mg.) as needles (from aqueous methanol), m. p. 191—192°, $[\alpha]_D$ +107° (*c*, 0·67) (Found: C, 83·15, 83·2; H, 11·55, 11·65. $C_{30}H_{50}O,\frac{1}{2}MeOH$ requires C, 83·05; H, 11·5%). This compound could not be obtained crystalline without solvent of crystallisation; hence it was characterised as its acetoacetate. The alcohol (97 mg.) in chloroform (10 c.c.) was refluxed with diketen (0·2 c.c.) and triethylamine (2 drops) for 1½ hr. After removal of the solvent under reduced pressure, the product was percolated through alumina (50 g.; deactivated with 1·5 c.c. of 10% acetic acid) with benzene (200 c.c.). Crystallisation from aqueous methanol then gave 3α-*methyl*-24-*norurs*-12-*en*-3β-*yl acetoacetate* as needles, m. p. 145—147°, $[\alpha]_D$ +106° (*c*, 1·3) (Found: C, 80·2; H, 10·75. $C_{34}H_{54}O_3$ requires C, 79·95; H, 10·65%). It gave a red colour with alcoholic ferric chloride.

3-*Methyl*-24-*norursa*-3 : 12-*diene* (XXXI).—3β-Methyl-24-norurs-12-en-3α-ol (600 mg.) in pyridine (50 c.c.) was heated under reflux with phosphoryl chloride (3 c.c.) for 40 min. After careful dilution with water extraction with ether gave a product (550 mg.) which was percolated through alumina (50 g.) with light petroleum (300 c.c.). Crystallisation from chloroform–methanol then gave 3-*methyl*-24-*norursa*-3 : 12-*diene* as plates (500 mg.), m. p. 129—131°, $[\alpha]_D$ +123° (*c*, 0·86) (Found: C, 88·0; H, 12·05. $C_{30}H_{48}$ requires C, 88·15; H, 11·85%). Comparison of the infrared spectrum with that of the starting material indicated that the double bond formed on dehydration was neither trisubstituted nor present in a vinylidene group.

3-*Methylene*-24-*norurs*-12-*ene* (XXXIII).—3α-Methyl-24-norurs-12-en-3β-ol (255 mg.) in pyridine (20 c.c.) was heated under reflux with phosphoryl chloride (2 c.c.) for 1 hr. After careful addition of water extraction with ether gave a solid which was percolated through alumina (50 g.) with light petroleum (300 c.c.). Crystallisation of the product (200 mg.) from chloroform–methanol gave 3-*methylene*-24-*norurs*-12-*ene* as plates, m. p. 150—151°, $[\alpha]_D$ +109° (*c*, 0·54) (Found: C, 88·35; H, 12·0. $C_{30}H_{48}$ requires C, 88·15; H, 11·85%). Infrared absorption: bands at 1640 and 886 cm.$^{-1}$

Treatment of 3β-*Methyl*-24-*norurs*-12-*en*-3α-*ol* (XXIX) *with Thionyl Chloride in Benzene.*—3β-Methyl-24-norurs-12-en-3α-ol (450 mg.) in benzene (100 c.c.) was heated under reflux with thionyl chloride (5 c.c.) for 3 hr. Sodium carbonate solution was then added and the product isolated in the usual manner. It was percolated through alumina (100 g.) in light petroleum (300 c.c.) to give a resin (350 mg.) which after several crystallisations from chloroform–methanol afforded rhombs, m. p. 147—149°, of 3-methyl-24-norursa-2 : 12-diene contaminated with a small amount of a chlorine-containing impurity (Beilstein test). The low carbon and hydrogen analyses indicated the presence of about 1% of chlorine. The m. p. of a mixture with a pure sample of the diene was the same as that of the rhombs. To eliminate the impurity the crude product was heated with sodium *iso*propoxide in *iso*propanol for several hours. In a typical experiment, with halogen-free reagents, the crude product was found to contain *ca.* 2% of chlorine, estimated as silver chloride, and gave 3-*methyl*-24-*norursa*-2 : 12-*diene* (XXXII) as rhombs (from chloroform–methanol), m. p. 145—148°, $[\alpha]_D$ +135° (*c*, 0·64) (Found: C, 88·1; H, 11·65. $C_{30}H_{48}$ requires C, 88·15; H, 11·85%). The infrared spectrum had a band at 813 cm.$^{-1}$ of medium intensity not shown by 3-methylene-24-norurs-12-ene or 3-methyl-24-norursa-3 : 12-diene.

Ultraviolet Absorption Spectra of 3-*Methyl*-24-*norursa*-2 : 12- *and* -3 : 12-*dienes and of* 3-*Methylene*-24-*norurs*-12-*ene.*—The spectra were determined on the " Unicam S.P. 500 " spectrophotometer already referred to.

Reaction of 3-*Methyl*-24-*norursa*-2 : 12-*diene* (XXXII) *with Osmium Tetroxide.*—The diene (480 mg.) and osmium tetroxide (500 mg.) in ether (30 c.c.) were kept at 20° for 4 days. The residue obtained by evaporation of the solvent was heated under reflux with alcohol (100 c.c.), sodium sulphite, and water (50 c.c.) for 3 hr. Extraction with benzene afforded a product

which was adsorbed from benzene on alumina (50 g.). Elution with benzene (200 c.c.) gave a resin (250 mg.); elution with ether–methanol (200 c.c.; 9 : 1) then gave another resin (260 mg.) which was presumably a mixture of 2α : 3α-dihydroxy- and 2β : 3β-dihydroxy-3-methyl-24-norurs-12-ene. The resin (260 mg.) in acetone (100 c.c.) and chromium trioxide in dilute

Compound	Intensity (ε) of absorption at 2100 Å	2150 Å	2200 Å	2250 Å
a 3-Methyl-24-norursa-2 : 12-diene	6200	2700	700	200
b 3-Methyl-24-norursa-3 : 12-diene	6700	3450	1500	750
c 3-Methylene-24-norurs-12-ene	5000	1900	760	450
d Urs-12-ene	3000	1400	300	100
Calculated values for :				
a − *d*	3200	1300	400	100
b − *d*	3600	2050	1200	650
c − *d*	2000	500	460	350

sulphuric acid (0·5 c.c.; 8N) were kept for 5 min. Excess of ethanol was added and the product was isolated and adsorbed from benzene on alumina (50 g.). After elution of a number of small fractions (65 mg. total wt.) with benzene and benzene–ether (9 : 1) elution with acetic acid–methanol (100 c.c.; 1 : 1) gave a crystalline product (110 mg.) which was methylated (ethereal diazomethane). Purification of the product by chromatography and crystallisation from methanol afforded *methyl* 3-*methyl*-3-*oxo*-24-*nor*-2 : 3-seco*urs*-12-*en*-21-*oate* as needles, m. p. 108—110°, $[\alpha]_D$ +118° (*c*, 0·4) (Found : C, 77·6; H, 10·7. $C_{31}H_{50}O_3,\frac{1}{2}MeOH$ requires C, 77·75; H, 10·75%). Infrared absorption : bands at 1712 (ketone) and 1737 (ester) cm.$^{-1}$.

Treatment of 3-*Methyl*-24-*norursa*-3 : 12-*diene* (XXXI) *in Benzene with Ethanolic Sulphuric Acid at* 20°.—3-Methyl-24-norursa-3 : 12-diene (260 mg.) in benzene (50 c.c.) and ethanol (100 c.c.) was kept with sulphuric acid (20 c.c.) (added dropwise with cooling) at 20° for 48 hr. Dilution with water and extraction with benzene yielded a resin (260 mg.) which was examined spectroscopically. Attempts to calculate the amount of the $\Delta^{2:12}$-diene from the intensity of infrared and ultraviolet absorption were made difficult by the presence of the trisubstituted $C_{(12)}$–$C_{(13)}$ double bond. The intensity of absorption at 813 cm.$^{-1}$ compared with that of the pure $\Delta^{2:12}$- and $\Delta^{3:12}$-diene indicated that the amount of 3-methyl-24-norursa-2 : 12-diene present was *ca.* 50%. Crystallisation of the resin (225 mg.) from chloroform–methanol gave 3-methyl-24-norursa-2 : 12-diene as rhombs (83 mg.; 37%), m. p. 147—149° after recrystallisation, undepressed on admixture with an authentic sample, $[\alpha]_D$ +130° (*c*, 1·54).

In a second experiment with 450 mg. of 3-methyl-24-norursa-3 : 12-diene, chromatography and two crystallisations gave the 2 : 12-diene as rhombs (144 mg.), m. p. 147—149° after further crystallisations, $[\alpha]_D$ +131° (*c*, 1·8). Crystallisation of the residues from the mother liquors afforded starting material, m. p. 128—130°, $[\alpha]_D$ +123° (*c*, 0·35).

Treatment of β-*Amyrin and Lupanol with Thionyl Chloride.*—(*a*) β-Amyrin (750 mg.) in benzene (100 c.c.) was heated under reflux with thionyl chloride (5 c.c.) for 3 hr. After the benzene solution had been washed with water the product was isolated and adsorbed from light petroleum on alumina (100 g.). Elution with light petroleum (300 c.c.) gave a fraction (550 mg.) which was crystallised from acetone and ethyl acetate–methanol to give oleana-2 : 12-diene (β-amyrilene-II) as needles, m. p. and mixed m. p. 147—149°, $[\alpha]_D$ +145° (*c*, 0·5).

(*b*) Lupanol (890 mg.), treated similarly, gave lup-2-ene as plates, m. p. and mixed m. p. 189—191°, $[\alpha]_D$ +13·5° (*c*, 0·95).

Treatment of Cholestanone with Methylmagnesium Iodide.—Cholestanone (1·0 g.) in ether (50 c.c.) and methylmagnesium iodide (prepared from 0·5 g. of magnesium) in ether were kept overnight at 20°. Addition of water and extraction with ether gave a resin (1·0 g.) which was adsorbed from light petroleum on alumina (100 g.). Elution with ether (800 c.c.) gave a fraction (510 mg.) which was crystallised from aqueous methanol to give 3β-methylcholestan-3α-ol as needles, m. p. 128·5—129°, $[\alpha]_D$ +26° (*c*, 1·15) (Found : C, 83·65; H, 12·6. Calc. for $C_{28}H_{50}O$: C, 83·5; H, 12·5%). Elution with methanol–ether (1 : 19) yielded a fraction (380 mg.) which, when crystallised from aqueous acetone, gave 3α-methylcholestan-3-ol as plates, m. p. 148—150°, $[\alpha]_D$ +38° (*c*, 0·6) (Found : C, 83·0; H, 12·3%).

Dehydration of 3β-*Methylcholestan*-3α-*ol with Phosphoryl Chloride in Pyridine.*—The alcohol (370 mg.) in pyridine (15 c.c.) was heated under reflux with phosphoryl chloride (2 c.c.) for 1 hr. Dilution with water and extraction with ether afforded a product (280 mg.) which was crystallised from methanol, giving 3-methylcholest-2(or 3)-ene as rhombs, m. p. 83—84°, $[\alpha]_D$

+65° (*c*, 1·5) (Found: C, 87·5; H, 12·35. Calc. for $C_{28}H_{48}$: C, 87·4; H, 12·6%). Kuwada and Miyasaka give m. p. 84° for a 3-methylcholestene. Infrared absorption: band at 791 cm.$^{-1}$.

Dehydration of 3α-Methylcholestan-3β-ol with Phosphoryl Chloride in Pyridine.—The alcohol (200 mg.) in pyridine (10 c.c.) was heated under reflux with phosphoryl chloride (2 c.c.) for ½ hr. Dilution with water and extraction with ether afforded a product (150 mg.) which was passed through alumina in light petroleum and then crystallised from methanol. The resulting plates, m. p. 62—63° with some crystals melting at 72°, $[\alpha]_D$ +53° (*c*, 1·26), were probably a mixture of 3-methylenecholestane and 3-methylcholest-2(or 3)-ene since their infrared spectrum had bands at 887 and 791 cm.$^{-1}$, characteristic of a vinylidene grouping and a trisubstituted double bond, respectively.

Preparation of 3-Oxolup-20-ene-2-spiro-2′-(1′ : 3′-dithian)—Lupenone (580 mg.) in ether (15 c.c.) was treated with sodium methoxide (from 1 g. of sodium) in ethyl formate (20 c.c.). The mixture was kept for 6 days at 20° and occasionally shaken. After addition of phosphate buffer solution (pH = 7·5), extraction of the mixture with ether afforded a solid which was crystallised from chloroform–methanol to give 2-hydroxymethylenelup-20-en-3-one (460 mg.), m. p. 220—225°. The hydroxymethylene derivative, trimethylene ditoluene-*p*-thiosulphonate (400 mg.), and potassium acetate (1 g.) in ethanol (50 c.c.) were heated under reflux for 12 hr. in an atmosphere of carbon dioxide. After removal of the solvent and addition of water, extraction with benzene afforded a product which was adsorbed from benzene on alumina (20 g.; activity II). Elution with benzene (250 c.c.) afforded a fraction which was crystallised from chloroform–methanol, giving *3-oxolup-20-ene-2-spiro-2′-(1′ : 3′-dithian)* as rhombs (315 mg.), m. p. 257—258·5°, $[\alpha]_D$ −14·4° (*c*, 5·53) (Found: C, 74·55; H, 10·35; S, 11·7. $C_{33}H_{54}OS_2$ requires C, 74·6; H, 10·2; S, 12·1%). Infrared absorption: band at 1688 cm.$^{-1}$. The intensity of the band was less than that usually found for a *cyclo*hexanone.

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THE UNIVERSITY, MANCHESTER, 13.
THE DYSON PERRINS LABORATORY, OXFORD UNIVERSITY. [*Received, September 7th*, 1956.]