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OXIDATION BY MERCURIC ACETATE IN THE LUP-20(29)-ENE AND RELATED SERIES[1]

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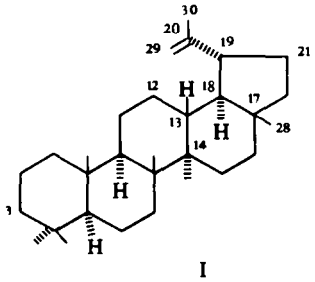
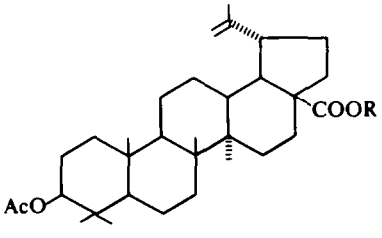
Abstract—The oxidation of acetylbetulic acid (III) by mercuric acetate affords the γ-lactone (X). A related lactone (XI) is formed from the product (IV) of oxidation of methyl acetylbetulate (II) by mercuric acetate. 3β,28-Dihydroxy-20,29,30-trisnor-18ξ-lupan-19-one is shown to be more stable in the 18β-H configuration (XV). Dihydroceanothenic acid (IX) is oxidized by mercuric acetate to a lactone involving exclusive participation by the C-17 carboxyl group.

THE oxidation by mercuric acetate of triterpenes in the lup-20(29)-ene series (I) possessing no free carboxyl group at C-17, was originally thought to give additional unsaturation at C-12,13.[2,3] Later work,[4–6] indicated C-13,18 as the site of the additional double bond. This result was based on the absence of vinyl proton resonance in the NMR spectra of the dihydro-derivative (V) [obtained from the product (IV) of oxidation of methyl acetylbetulate (II) by mercuric acetate] and of the corresponding compounds derived from ceanothic acid, ceanothenic acid, and melaleucic acid. Direct evidence[6] for the location of the double bond at C-13, 18 in the dihydro-derivative (V) was obtained through oxidation, leading to the diketone (VII), which was shown to possess a carbonyl group in a 5-membered ring. No evidence was presented to establish the stereochemistry at C-19 in these products of oxidation by mercuric acetate. NMR spectral evidence was invoked[7] to assign tentatively the 19β-configuration to the isopropenyl group in the product from dimethyl dihydroceanothenate (VIII) and more recently Khastgir and Bose[8] have suggested that a similar inversion of the isopropenyl group occurs during the mercuric acetate oxidation of methyl acetylbetulate.



I



II: R = Me
III: R = H

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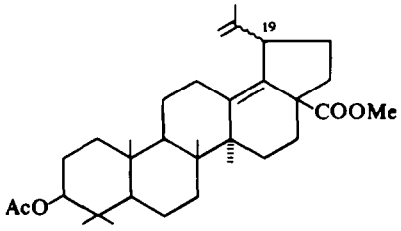
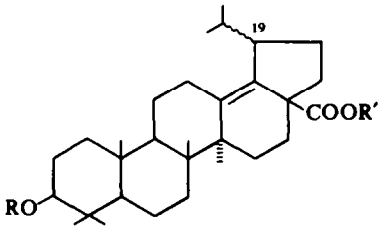
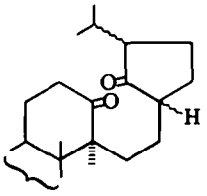


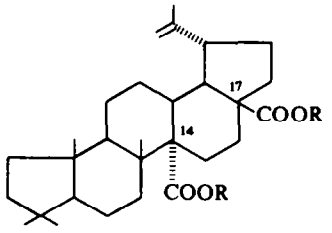
IV



V: R = Ac; R' = Me
VI: R = H; R' = H



VII



VIII: R = Me
IX: R = H

The oxidation by mercuric acetate of similar triterpenes possessing a free hydroxymethyl group or carboxyl group at C-17 was shown[3] to afford the cyclic ether and tertiary γ-lactone, respectively. Since spectral evidence indicated retention of the isopropenyl group, cyclization towards C-13 or C-19 was proposed. The C-28,19-lactone (X) was discounted on the grounds of its non-identity with the acetate of thurberogenin, thus leading to the adoption of the C-28, 13-lactone as the proposed structure.[3] The recent revision[9] of the structures of thurberogenin and stellatogenin as C-28, 21-lactones invalidated this argument.

We decided to distinguish unequivocally between the C-28, 13- and C-28, 19-lactone possibilities by oxidative skeletal degradation. This method has now shown that the lactone derived from acetylbetulic acid has the structure X and this finding raises some doubt as to the validity of the method devised by Khastgir and Bose[8] to establish the stereochemistry of the isopropenyl group in the products of oxidation by mercuric acetate.

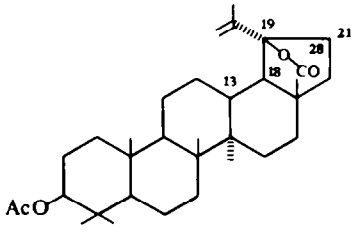
Acetylbetulic acid (III) was oxidized by mercuric acetate under conditions including those described previously.[3] The only detectable product, obtained in 30–70% yield in a series of experiments, was the γ-lactone (X). The higher yields were obtained by omitting the usual treatment of the reaction mixture with hydrogen sulphide. Evidently the lactone is formed directly during the oxidation, and the need to decompose any intermediate mercury complex does not arise. In the case of the oxidation of methyl acetylbetulate, however, the treatment with hydrogen sulphide was necessary. The lactone (X) was further characterized by hydrogenation and hydrolysis to the hydroxylactone (XI). The lactone (X) was ozonised in methanol–chloroform at $-10°$ to give the norketone (XII).

A comparison of the physical constants of the above three compounds derived from acetylbetulic acid during the current work with those recorded previously is given in Table 1, which also contains a similar comparison for the product (IV) of

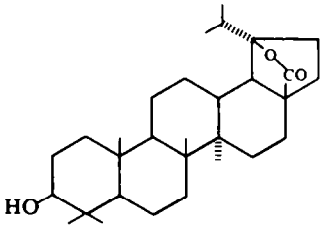
TABLE 1.

Compound	m.p.	$[\alpha]_D$
3β-Acetoxylup-20(29)-en-28,19β-olide (X)	>350°	+55°
3β-Acetoxy-19ξ-lup-20(30)-en-28,13β-olide[3]	315–317°	+60°
Ref. 8	300–302°	+58°
3β-Hydroxylupan-28,19β-olide (XI)	321–322°	+32°
3β-Hydroxy-19ξ-lupan-28,13β-olide[3]	314–316°	+41°
3β-Acetoxy-20-oxo-30-norlupan-28,19β-olide (XII)	>350°	+8°
3β-Acetoxy-20-oxo-19ξ-30-norlupan-28,13β-olide[3]	317–319°	+2°
3β-Acetoxy-20-oxo-19α(H)-30-norlupan-28,13β-olide[8]	301–303°	−9°
3β-Acetoxy-20-oxo-30-norlupan-28,13β-olide[8]	300–302°	−24°
Methyl 3β-acetoxy-19ξ-lupa-13(18),20(29)-dien-28-oate (IV)	214–215°	+56°
Methyl 3β-acetoxy-19ξ-lupa-12,20(29)-dien-28-oate[3]	217–219°	+60°
3β-Hydroxy-19ξ-lup-13(18)-en-28-oic acid (VI)	292–293°	+12·5°
3β-Hydroxy-19ξ-lup-12-en-28-oic acid[3]	287–289°	+11°

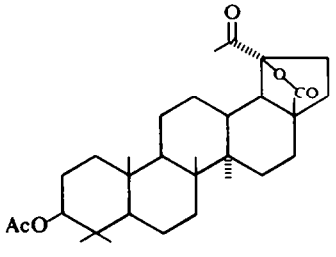
mercuric acetate oxidation of methyl acetylbetulate and the related dihydrohydroxy-acid (VI). The two groups have been related in the current work by the conversion of the dihydrohydroxyacid (VI) into the dihydrohydroxylactone (XI).



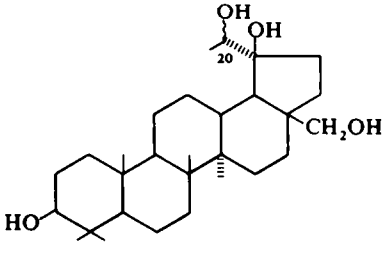
X



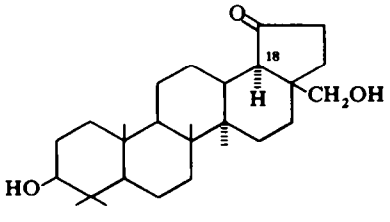
XI



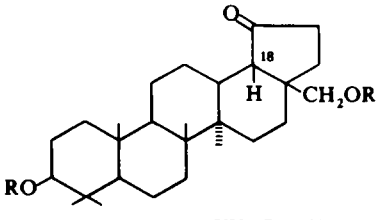
XII



XIII

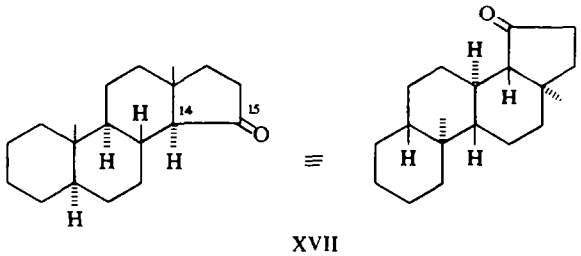


XIV

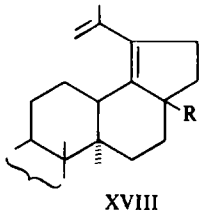


XV: R = H
XVI: R = Ac

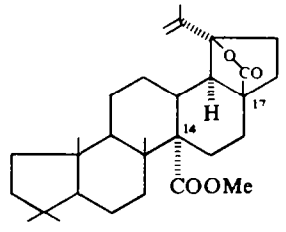
The norketone (XII) was reduced by LAH to the tetrol (XIII) which was cleaved by lead tetra-acetate in chloroform–benzene at 25° to give the sparingly soluble trisnorketone (XIV) whose IR absorption at 1738 and 1410 cm^{-1} (Nujol) was that expected for a cyclopentanone with methylene adjacent to the carbonyl group. The stereochemistry at C-18 followed from the minimum in the CD curve ($[\theta]_{296}$ −8220°) and from the negative Cotton effect in the ORD curve ($[\phi]_{312}$ −5340°, $[\phi]_{273}$ +6200°; amplitude −115).[10]



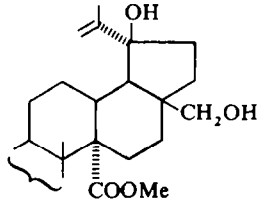
XVII



XVIII



XIX



XX

The 18α(H)-trisnorketone was isomerized, by heating its solution in 0·1N methanolic potassium hydroxide or in acetic acid,[11] to the ketone (XV) epimeric at C-18. This ketone had been obtained initially from the cleavage of the tetrol (XIII) by lead tetra-acetate in acetic acid at 90° followed by treatment with alkali.[1] The ketone (XV) showed IR absorption at 3280, 1735, and 1414 cm^{-1} (Nujol) and the derived diacetate (XVI) had IR absorption at 1743, 1734, and 1411 cm^{-1} (CCl_4). The ketone was also characterized as the oxime. The stereochemistry at C-18 followed from the maximum in the CD curve ($[\theta]_{313}$ +7260°)* and the positive Cotton effect in the ORD curve ($[\phi]_{328}$ +4930°, $[\phi]_{284}$ −5180°; amplitude +101). These results are consistent[10] only with a *cis*-D/E ring fusion in the ketone (XV).

The isomerization of the 18α(*H*)-trisnorketone (XIV) by alkali gave a mixture containing approximately 85% of the 18β(*H*)-isomer (XV), calculated from the $[\alpha]_D$ of the mixture from the isomerization reaction. Interestingly, the relative

* Incorrectly given as +8250° in Ref. 1.

instability of the *trans*-D/E ring fusion in the 18α(*H*)-trisnorketone (XIV) is parallelled in the 14α-androstan-15-one series.[12] Thus the equilibrium mixture of the 14ξ-androstan-15-ones, formed under alkaline conditions, also contains approximately 85% of the *cis*-isomer [14β(*H*)-androstan-15-one]. The ORD curves of the trisnorketones (XIV and XV) are near-reflections of, and have nearly the same amplitudes as, those of androstan-15-one (XVII) and its 14β(*H*)-isomer, respectively (Table 2) whose ring systems are essentially enantiomeric with the B/C/D/E rings in the two trisnorketones.

TABLE 2.

Compound	λ (Å)	[M]	Amplitude*
3β,28-Dihydroxy-20,29,30-trisnor-lupan-19-one (XIV)	3120	−5340°	
	2730	+6200°	−115
Androstan-15-one[12]	3120	+6134°	
	2700	−7741°	+139
3β,28-Dihydroxy-20,29,30-trisnor-18β(H)-lupan-19-one (XV)	3280	+4930°	
	2840	−5180°	+101
14β(H)-androstan-15-one[12]	3220	−4553°	
	2750	+5801°	−104

* Amplitude is the difference between the [M] × 10^{-2} at the peak and trough of the ORD curve.

Since the first-formed, less stable, trisnorketone has 18α-*H* stereochemistry, this stereochemistry must be present in the three preceding intermediates, the lactone (X), the norketone (XII) and the tetrol (XIII). This had previously been undefined since the mechanism of formation of the lactone (X) is not known.

This evidence is compatible only with the structure X for the lactone from acetylbetulic acid. Clearly there can be no ambiguity in the stereochemistry at C-19 in this lactone and, indeed, the norketone (XII) was recovered unchanged after treatment with alkali (i.e. with re-acetylation of the 3β-hydroxyl group where necessary) including the method of Khastgir and Bose.[8]

Methyl acetylbetulate (II) was converted as described previously[3] into methyl 3β-acetoxy-19ξ-lupa-13(18),20(29)-dien-28-oate (IV) which was catalytically hydrogenated and then hydrolysed to give the hydroxy acid (VI). Treatment of this hydroxy acid with HCl/chloroform during 45 min is reported[3] to afford the C-28,13-lactone. In our hands the hydroxy acid was recovered essentially unchanged after treatment under these conditions, whereas treatment with HCl/chloroform at 0° for 3 days gave, in 30% yield, a hydroxy-γ-lactone identical (m.p., mixed m.p., IR spectrum) with the C-28,19-lactone (XI) derived from acetylbetulic acid (see above). If the introduced double bond is correctly placed at C-13, 18 in the product (VI), rearrangement must precede or accompany the lactonization of this acid.

Khastgir and Bose[8] suggest that the initial product in these mercuric acetate oxidations is the conjugated diene (XVIII). Their suggestion implies that these oxidations do in fact follow an accepted course for mercuric acetate oxidations, allylic activation (*via* free radical, ionic and/or metal-organic intermediates)[13] leading to their proposed intermediate (XVIII). In view of the revised structure for

the lactone from acetylbetulic acid, a modification of their suggested mechanism can give a satisfactory explanation for the formation of the lactone (X). This lactone could be formed through allylic activation at C-19 with subsequent or synchronous participation across the β-face of ring E by the carboxyl group at C-17. In the absence of a free carboxyl group (or hydroxymethyl group) at C-17, participation by the C-17 substituent does not occur. Instead, a double bond is eventually introduced into, presumably, the C-13, 18 position considered[8] by Khastgir and Bose to be the thermodynamically most favourable.

Furthermore, when carboxyl groups are present at both C-14 and C-17, competitive participation by the C-14 carboxyl group would not be expected, and in fact the oxidation of dihydroceanothenic acid (IX) does produce only one lactone, formed from the C-17 carboxyl group. Thus, oxidation of dihydroceanothenic acid by mercuric acetate followed by esterification by diazomethane gave a mixture containing only one lactone-ester. This lactone–ester was reduced by LAH to give a dihydroxy-ester which retained the methoxycarbonyl group. This inertness towards reduction is known to distinguish between methoxycarbonyl groups at C-14 and C-17.[cf. 5] Consequently, the lactone group must be formed from the carboxyl group at C-17. By analogy with the mercuric acetate oxidation of acetylbetulic acid, the lactone–ester is formulated as XIX and the derived dihydroxy-ester as XX. It is also of interest that the acid (VI) does not lactonize under the conditions of the mercuric acetate oxidation.

EXPERIMENTAL

M.ps were determined on a Kofler hot-stage unless otherwise stated. Specific rotations were for ca. 1% solns in chloroform; IR spectra for Nujol mulls on a Hilger Infrascan Spectrophotometer; NMR spectra were for $CDCl_3$ solns, with TMS as internal reference, on a Varian A-60 spectrometer unless otherwise stated. ORD and CD curves were determined for ca. 0·1% solns in dioxan. Mass spectra were determined on an A.E.I. MS-9 spectrometer. Alumina for chromatography was Peter Spence H. Light petroleum refers to the fraction b.p. 68–72°.

Oxidation of acetylbetulic acid (III) *by mercuric acetate*

Method 1. Acetylbetulic acid (1·00 g) was oxidized by mercuric acetate under conditions described previously[3] (including treatment with H_2S). The only isolable product was X (0·37 g) shown by $[\alpha]_D$ and IR spectrum to be identical with that obtained by method 2.

Method 2. The acid (1·0 g) in $CHCl_3$ (10 ml) was added to freshly prepared mercuric acetate (10 g) in AcOH (190 ml). The soln was heated at reflux during 3 hr, cooled, diluted with water (800 ml) and extracted with $CHCl_3$ (5 × 50 ml). The combined organic layers were washed with water (3 × 50 ml), dried (Na_2SO_4) and concentrated *in vacuo* to 30 ml. After addition of MeOH (150 ml) the product, 3β-*acetoxylup*-20(29)-*en*-28,19β-*olide* (X) separated on standing and crystallized from light petroleum as prisms (720 mg), m.p. >350°, $[\alpha]_D$ +55°; ν_{max} 3085, 1773, 1730, 1644, 1249, 1170, 1072, 1025, 977, 920, 898 cm^{-1}; NMR 0·85–0·95 (5 CH_3 singlets), 1·79 (vinylic Me), 2·04 (acetoxy H), 4·48 (multiplet for 3α-H), 4·95 and 5·33 δ (1H-multiplets for 29-H). (Found: M mass spectrum, 496. C, 77·5; H, 9·7. $C_{32}H_{48}O_4$ requires: M 496; C, 77·4; H, 9·7%).

3β-*Hydroxylupan*-28,19β-*olide* (XI). The lactone X (150 mg) in AcOH (150 ml) absorbed H_2 (1 mole), in the presence of Adams platinum oxide catalyst (15 mg), during 38 hr at 25°. The crude product, isolated by dilution with water (650 ml) and filtration, was hydrolysed by 0·1N NaOH in MeOH (50 ml) at 60° during 20 min. Subsequent dilution with water (200 ml), acidification (pH 2·5) and filtration afforded XI (120 mg) which formed fine needles, from MeOH, m.p. 322–323° (*in vacuo*); $[\alpha]_D$ +28°; ν_{max} 3250, 1770, 1035 cm^{-1}; NMR 0·78–1·12 (7 Me groups), 3·29 (multiplet for 3α-H), 3·42 δ (OH, removed by D_2O). (Found: C, 78·7; H, 10·7. $C_{30}H_{48}O_3$ requires: C, 78·9; H, 10·6%).

3β-*Acetoxy*-20-*oxo*-30-*norlupan*-28,19β-*olide* (XII). A soln of X (1·0 g) in MeOH–$CHCl_3$ (20:1; 315 ml)

was treated with ozonized O_2 (ca. 3%; 150 l.) at $-10°$ during 1·5 hr. Excess of O_3 was removed in a stream of O_2 during 5 min and the soln was then treated with Me_2S (20 ml) for 18 hr at 20°. The norketone (XII) was isolated by evaporation *in vacuo* and formed plates (740 mg), from MeOH, m.p. >350°; $[\alpha]_D$ +8°; ν_{max} 1790, 1730, 1712, 1249, 1013 cm^{-1}; NMR 0·84–0·95 (5 Me singlets), 2·04 (acetoxy H), 2·37 (29-H), 4·48 δ (multiplet for 3α-H). (Found: M, mass spectrum· 498. C, 74·5; H, 9·3. $C_{31}H_{46}O_5$ requires: M 498 C, 74·7; H, 9·2%).

30-*Norlupane*-3β,19,20ξ,28-*tetrol* (XIII). The norketone XII (500 mg) was reduced by LAH (2 g) in dioxan (200 ml) during 20 hr. Excess of LAH was destroyed by EtOAc and, after acidification (0·2N HCl; 1 l.), the tetrol was isolated through ether and crystallized from EtOAc as fine needles (400 mg), m.p. 294–296°; $[\alpha]_D$ +27°; ν_{max} 3350, 1138, 1080, 1020 cm^{-1}; NMR (in DMSO) 0·68–1·04 (6 Me groups), 2·9–4·4 δ (complex multiplets for 8H reduced to 4H by treatment with D_2O). (Found: M, mass spectrum, 462; C, 75·1; H, 10·8. $C_{29}H_{50}O_4$ requires: M 462; C, 75·3; H, 10·9%).

3β,28-*Dihydroxy*-20,29,30-*trisnorlupan*-19-*one* (XIV). The tetrol XIII (400 mg) was cleaved by lead tetra-acetate (2 g) in $CHCl_3$–benzene (5:1; 300 ml) at 25° during 3 hr. The mixture was washed with water, dried ($MgSO_4$), filtered and evaporated to give the trisnorketone as fine needles (80 mg), from THF, m.p. 286–287°; $[\alpha]_D$ −37° (in DMF); ORD $[\phi]_{312}$ −5340°, $[\phi]_{294}$ 0°, $[\phi]_{273}$ +6200°; CD $[\theta]_{296}$ −8220°; ν_{max} 3380, 1738, 1410, 1270, 1165, 1035 cm^{-1}; NMR (in DMSO at 100°) 0·78–0·98 (5 Me singlets), 3·20 (multiplet for 3α-H and 28-H), 3·80 (3-OH), 4·18 δ (28-OH). (Found: M, mass spectrum, 416; C, 78·0; H, 10·4. $C_{27}H_{44}O_3$ requires: M 416; C, 77·8; H, 10·7%).

Epimerization of the trisnorketone (XIV)

(i) The trisnorketone (50 mg) was heated at 60° in 0·1N methanolic KOH (10 ml) during 2 hr. The soln was neutralized (AcOH) and diluted with water (150 ml). The isomeric XV (38 mg) was removed by filtration and recrystallized from MeOH to give needles shown by m.p., m.m.p., $[\alpha]_D$ and IR spectrum to be identical with an authentic specimen (see below).

(ii) The trisnorketone (40 mg) was isomerized in AcOH (80 ml) at 90° during 30 hr to give, after isolation through ether. XV shown (as above) to be identical with an authentic specimen.

3β,28-*Dihydroxy*-20,29,30-*trisnor*-18βH-*lupan*-19-*one* (XV). The tetrol (XIII) (300 mg) was cleaved by lead tetra-acetate (2 g) in AcOH (200 ml) at 90° during 40 hr. A crude product was isolated through $CHCl_3$ and treated with 0·1N methanolic KOH (40 ml) at 60° for 1 hr. The product was isolated through $CHCl_3$ and absorbed on alumina (18 g). Elution with benzene–$CHCl_3$ (1:1) gave a gum (60 mg). Elution with $CHCl_3$ gave XV (108 mg) which crystallized from MeOH as platelets, m.p. 254–256°; $[\alpha]_D$ +40·5° (in DMF); ORD $[\phi]_{328}$ +4930°, $[\phi]_{307}$ 0°, $[\phi]_{284}$ −5180°; CD $[\theta]_{313}$ +7260°; ν_{max} 3280, 1735, 1414, 1060, 1035 cm^{-1}; NMR (in DMSO at 100°) 0·70–0·98 (5 Me singlets), 3·20 (3α-H), 3·38 (28-H), 3·80 (3-OH), 4·34 δ (28-OH). (Found: M, mass spectrum, 416; C, 77·9; H, 10·8. $C_{27}H_{44}O_3$ requires: M 416; C, 77·8; H, 10·7%).

The *di-acetate* (XVI) was prepared by the Ac_2O–pyridine method. Crystallization from MeOH–water and then from light petroleum gave fine needles, m.p. 194–195°, $[\alpha]_D$ +2°; ν_{max} (CCl_4)* 1743, 1734, 1411 cm^{-1}; NMR 0·84–1·03 (5 Me singlets), 2·02 (3β- and 28-acetoxy H), 4·00 (28-H), 4·30 (3α-H). (Found: C, 74·2; H, 9·7. $C_{31}H_{48}O_5$ requires: C, 74·4; H, 9·7%).

The *oxime* was prepared in MeOH by treatment with hydroxylamine hydrochloride–KOAc–pyridine and crystallized from MeOH as fine needles, m.p. 272–275° (dec); $[\alpha]_D$ +22°; ν_{max} 3390, 3180, 1650 (w), 1112, 1038 cm^{-1}. (Found: C, 75·4; H, 10·3; N, 3·5. $C_{27}H_{45}NO_3$ requires: C, 75·1; H, 10·5; N, 3·3%).

Treatment of the norketone (XII) *with base*

(i) The norketone (100 mg) in benzene (50 ml) was treated with potassium t-butoxide (500 mg) at 20° during 6 days. The solution was neutralized (AcOH), washed with water, dried and evaporated to give, after crystallization from MeOH, a product shown by m.p., m.m.p., $[\alpha]_D$ and IR spectrum to be identical with the starting material.

(ii) Treatment of the norketone with (a) NaOAc in benzene–MeOH (1:1) at reflux for 4 days or (b) NaOH in dioxan–water (3:1) at 30° during 7 day afforded a product which was re-acetylated by the Ac_2O–pyridine method to give the original norketone, identical with an authentic specimen.

Lactonization[cf. 3] *of* 3β-*hydroxy*-19ξ-*lup*-13(18)-*en*-28-*oic acid* (VI). The acid (400 mg) in $CHCl_3$ (100 ml) at 0° was subjected to a stream of dry HCl for 4 hr and allowed to stand at 20° for 3 days. The soln was

* Recorded on a Hitachi EP1-G2 spectrophotometer.

evaporated and the residue was adsorbed from benzene on alumina (15 g). Elution with benzene gave a gum (60 mg) whose IR spectrum showed no OH absorption. Elution with benzene–$CHCl_3$ (4:1) gave the XI (120 mg; 30%) which formed fine needles, from methanol, m.p. 321–322° (*in vacuo*) m.m.p., with an authentic specimen, 320–322°); $[\alpha]_D$ +32°. This lactone was shown by IR and NMR spectra and by TLC to be identical with that previously obtained (see above) from acetylbetulic acid.

Oxidation of dihydroceanothenic acid (IX) *by mercuric acetate.* The acid (500 mg) was oxidized by mercuric acetate (12 g) in $CHCl_3$ (23 ml) and AcOH (120 ml) at reflux during 5 hr. A crude product was isolated as above (method 1) and was treated with an excess of diazomethane in ether. The methylated product was dissolved in light petroleum–benzene (1:1) and filtered through alumina (9 g) to give 19β-*hydroxy-A*(1)-*norlup*-20-*ene*-27,28-*dioic acid* 28,19-*lactone* 27-*methyl ester* (XIX) which formed needles (100 mg), from MeOH–water, m.p. 211–213°, $[\alpha]_D$ +60°; ν_{max} 1762, 1719, 1640, 895; ν_{max} (CCl_4) 1782, 1715 cm^{-1}; NMR 0·79–0·99 (4 Me singlets), 1·82 (vinylic Me), 3·71 (COOMe), 4·96 and 5·33 δ (1H-multiplets for 29-H). (Found: C, 76·0; H, 9·3. $C_{30}H_{44}O_4 \cdot \frac{1}{2}CH_3OH$ requires: C, 75·6; H, 9·6%).

Methyl 19β,28-*dihydroxy-A*(1)-*norlup*-20-*en*-27-*oate* (XX). The lactone–ester XIX (60 mg) was reduced by an excess of LAH in ether at 25° during 1·5 hr. The dihydroxy-ester XX was isolated through ether and crystallized from ether–light petroleum as fine needles (50 mg), m.p. 250–252°, $[\alpha]_D$ +50°; ν_{max} 3180, 1709, 1635, 882 cm^{-1}; NMR 0·81–1·07 (4 Me singlets), 1·83 (vinylic Me), 2·90 (2H hydroxyl-multiplet removed by addition of D_2O), 3·71 (COOMe), 3·48 and 4·15 (1H-doublets, J = 12 c/s; 28-H), 4·79 and 5·03 δ (1H-multiplets for 29-H). (Found: C, 76·5; H, 10·0. $C_{30}H_{48}O_4$ requires: C, 76·2; H, 10·2%).

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REFERENCES

[1] Preliminary communication: G. V. Baddeley, R. A. Eade, J. Ellis, P. Harper and J. J. H. Simes, *Chem. Comm.*, 961 (1968).
[2] J. M. Allison, W. Lawrie, J. McLean and J. M. Beaton, *J. Chem. Soc.* 5224 (1961).
[3] J. M. Allison, W. Lawrie, J. McLean and G. R. Taylor, *Ibid.* 3353 (1961).
[4] H. Budzikiewicz, J. I. Braumann and C. Djerassi, *Tetrahedron* **21**, 1855 (1965).
[5] R. A. Eade, J. Ellis and J. J. H. Simes, *Austral. J. Chem.* **18**, 591 (1965).
[6] C. S. Chopra and D. E. White, *Tetrahedron* **22**, 897 (1966).
[7] P. de Mayo and A. N. Starratt, *Canad. J. Chem.* **40**, 1632 (1962).
[8] H. N. Khastgir and S. Bose, *Tetrahedron Letters* 39 (1968).
[9] M. Marx, J. Leclercq, B. Tursch and C. Djerassi, *J. Org. Chem.* **32**, 3150 (1967).
[10] P. Crabbe, *Optical Rotatory Dispersion and Circular Dichroism in Organic Chemistry* Holden-Day, San Francisco, (1965).
[11] G. V. Baddeley, T. G. Halsall and E. R. H. Jones, *J. Chem. Soc.* 1715 (1960).
[12] A. R. Van Horn and C. Djerassi, *J. Am. Chem. Soc.* **89**, 651 (1967).
[13] S. Wolfe, P. G. C. Campbell and G. E. Palmer, *Tetrahedron Letters* 4203 (1966).