TRITERPENES. XXII.*

DEHYDROGENATION OF DERIVATIVES OF 20(29)-LUPENE WITH MERCURIC ACETATE II.** DEGRADATION OF THE SIDE CHAIN

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It was shown that the dehydro derivative *IV* obtained on dehydrogenation of betulin (*I*) has an epoxide bond between the position 19β and 28. Derivatives were prepared by a modification of the side chain, the reactivity of which (*XXIIIa, b*), as well as their PMR spectra (*XVI, XXI, XXIIIa,b, XXIVa,b*) and other spectral properties are compatible only with a fully substituted atom $C_{(19)}$. The immediate proximity of this epoxidic bond to the side chain affects its conformation, as was shown on comparison with corresponding derivatives lacking this epoxidic bond (*VI, IX, XVII, XVIII, XXII, XXIIIa, b,* and other); maximum interaction of the side chain and the epoxide bond 19β,28 is manifested in ketol *XXVII* by an unusual intramolecular hydrogen bond by which the conformation of the whole side chain is fixed.

In our previous communication[1] we proposed the structure of 3β-hydroxy-19β,28-epoxy-20(29)-lupene (*IV*) for the product of dehydrogenation of betulin (*I*) with mercuric acetate; this structure was assigned on the basis of its spectroscopic properties and the course of acid catalysed isomerisation. In order to prove this proposition we now modified its side chain in a manner which would permit us to prove that the atom $C_{(19)}$ in dehydro derivative *IV* is fully substituted and that it must therefore be the second bonding atom of the new epoxide bond. From this point of view we considered dinoraldehyde *XXI* as our key-product.

According to earlier experiences[2] we started the modification of the side chain by the preparation of the unsaturated aldehyde *VI* and norketone *IX*. The unsaturated aldehyde *VI* was obtained on oxidation of acetate *V* with selenium dioxide[2,3]; its subsequent oxidation was carried out in the same manner as in the case of aldehyde *III* (ref.[2]), *i.e.* by ozone in acetic acid. The yield of acid *XI* (isolated in the form of ester *XII*) was not satisfactory in this case; the hypobromite oxidation of norketone *VIII* according to[4] did not take place satisfactorily and therefore we abandoned the preparation of dinor aldehyde *XXI* by means of acid *XI*. The procedure starting with

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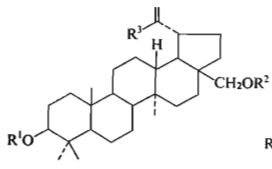
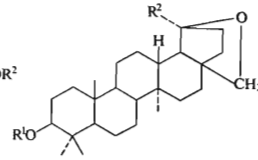
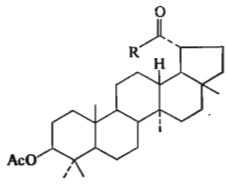
norketone *IX* was found more advantageous. We modified its described[5] synthesis by carrying out the ozonolysis of acetate *V* in acetic acid at room temperature; this increased its yield to 85% and the formation of by-products was suppressed. One of the isolated by-products was identified as saturated aldehyde *VII* which according to earlier analogies[6-8] was created evidently by the rearrangement of the intermediary 20,29-epoxy derivative. According to accessible criteria it can be judged that in this case the rearrangement of the supposed epoxy derivative took place stereospecifically under formation of a sole $C_{(20)}$-epimer. Although its $C_{(20)}$—$C_{(29)}$ bond is not directly connected with the polycyclic skeleton, its rotation must be rather limited as is evident from the pronounced Cotton effect of aldehyde *VII*. Acid by-products of ozonolysis – as formed from betulin diacetate (*II*) with ozone[2] or peracids[6] – were formed during the ozonolysis of acetate *V* in such low yields that





I, $R^1 = R^2 = H$, $R^3 = CH_3$
II, $R^1 = R^2 = Ac$, $R^3 = CH_3$
III, $R^1 = R^2 = Ac$, $R^3 = CH{=}O$

IV, $R^1 = H$, $R^2 = C(=CH_2)—CH_3$
V, $R^1 = Ac$, $R^2 = C(=CH_2)—CH_3$
VI, $R^1 = Ac$, $R^2 = C(=CH_2)—CH{=}O$
VII, $R^1 = Ac$, $R^2 = CH(CH{=}O)—CH_3$
VIII, $R^1 = H$, $R^2 = CO—CH_3$
IX, $R^1 = Ac$, $R^2 = CO—CH_3$
X, $R^1 = Ac$, $R^2 = C(=NOH)—CH_3$
XI, $R^1 = Ac$, $R^2 = COOH$
XII, $R^1 = Ac$, $R^2 = COOCH_3$
XIIIa,b, $R^1 = Ac$, $R^2 = CH(OH)—CH_3$
XIVa, $R^1 = Ac$, $R^2 = CH(OAc)—CH_3$
XVa,b, $R^1 = Ac$, $R^2 = CH(OBz)—CH_3$
XVI, $R^1 = Ac$, $R^2 = CH{=}CH_2$
XVII, $R^1 = Ac$, $R^2 = CO—CH_2Br$
XVIII, $R^1 = Ac$, $R^2 = CO—CHBr_2$
XIXa,b, $R^1 = Ac$, $R^2 = CH(OH)—CH_2Br$
XX, $R^1 = Ac$, $R^2 = CH—CH_2$ (epoxide)



XXV, $R = CH_3$
XXVI, $CH{=}CH—C_6H_5$

XXI, $R^1 = Ac$, $R^2 = CH{=}O$
XXII, $R^1 = Ac$, $R^2 = CO—CH{=}CH—C_6H_5$
XXIIIa,b, $R^1 = Ac$, $R^2 = CH(OH)—CH{=}CH—C_6H_5$
XXIVa,b, $R^1 = Ac$, $R^2 = CH(OAc)—CH{=}CH—C_6H_5$
XXVII, $R^1 = Ac$, $R^2 = CO—CH_2—OH$
XXVIII, $R^1 = Ac$, $R^2 = CO—CH_2—OAc$

they could not be either isolated or identified. The main (*IX*) and also the by-product (*VII*) of this reaction still contain the 19,28-epoxide bond as is evident from their PMR spectra[1,7]; in the record of the norketone *IX* spectrum the signal of the 19β proton could not be demonstrated, and in norketone *IX* and aldehyde *VII* the methylene group $C_{(28)}$ is again characterised as an AB system with one long range interaction[7] (p.p.m. = 4·045 dd + 3·40 d, J_{gem} = 7 Hz, $J_{l.r.}$ = 1·3 Hz). Reduction of norketone *IX* with sodium borohydride gave a mixture of epimeric hydroxy derivatives *XIIIa,b* in a 6 : 1 ratio, *i.e.* with a strong predominance of the more easily eluable epimer *XIIIa*; their configuration will be discussed in a subsequent communication. Dehydration of the mixture of these epimers gave vinyl derivative *XVI*, the PMR spectrum of which is an additional evidence of the fully substituted atom $C_{(19)}$. In contrast to the analogous 3β,28-diacetoxy-30-nor-20(29)-lupene[8] the signals of the side chain of the vinyl derivative *XVI* are simpler because the proton $C_{(20)}$ couples only with protons $C_{(29)}$ (p.p.m. = 6·00 d, $J_{20,29\text{-}trans}$ = 17·5 Hz, $J_{(20,29\text{-}cis}$ = = 10·5 Hz). As the yields of this dehydration were not satisfactory for further utilisation, we prepared the vinyl derivative *XVI* by another route: norketone *IX* was brominated under conditions determined earlier[2] to afford a mixture of bromo ketone *XVII* and dibromo ketone *XVIII*; dibromo ketone *XVIII* can be detected in the reaction mixture even in the initial phase of bromination when the starting norketone *IX* is still present in large excess. Reduction of bromo ketone *XVII* with sodium borohydride gave a mixture of epimeric bromohydrins *XIXa,b* and also a small amount of epoxide *XX*, which is the product of the subsequent reaction. Although the separation of this mixture was not difficult, the mixture formed was used directly for the next reaction step: its reduction with zinc in acetic acid followed by chromatographic separation gave vinyl derivative *XVI* in a better yield than in the case of the above described dehydration of hydroxy derivative *XIIIa,b*. The subsequent ozonolysis of the vinyl derivative *XVI* gave dinoraldehyde *XXI* in the PMR spectrum of which the signal of the aldehydic proton is substantial: As it appears as a sharp singlet (p.p.m. = 9·88 W 1/2 = 1·3 Hz) no proton can be bound in its neighbourhood, *i.e.* on $C_{(19)}$. This direct evidence eliminates the originally proposed localisation[5] of the epoxidic bond in dehydrobetulin *IV* to positions 13β,28.

For further proof we made use of the procedure employed[9,10] for the elimination of the whole side chain of methyl ketones $CH_3—CO—CHR^1R^2$. The procedure consists in the transformation of the methyl ketone to styryl ketone by condensation with benzaldehyde and subsequent reduction of the carbonyl group; the formed hydroxy derivatives may be dehydrated to ω-phenylbutadiene derivative which is then submitted to ozonolysis. In the given case the critical step for the proof of the epoxide bond position consists in the possibility of dehydration of hydroxy derivatives *XXIIIa,b*. In order to find optimum conditions for the first reaction step we first investigated optimum conditions for base catalysed condensation of benzaldehyde with 3β-acetoxy-30-nor-20-lupanone[6] (*XXV*). As was found earlier[2]

TABLE I

Absorption in the Ultraviolet Region (Cyclohexane) and in the Infrared Region (Tetrachloromethane) of Ketones *XXII* and *XXVI*

UV nm, log ε	Isomer	IR, cm^{-1}						
		frequency		Δν1/2	ε^a	$B.10^{-2}$	r^B	Δν
		Ketone *XXII*						
294 (4·33)	*s-cis*	ν(C=O)	1 686	13·80	175·8	37·18	0·34	77
228 (4·04)		ν(C=C)	1 609	17·56	398·5	109·5		
222 (4·05)								
		Ketone *XXVI*						
281 (4·33)	*s-cis*	ν(C=O)	1 697	18·92	171·83	51·08	0·599	77
224 (4·01)		ν(C=C)	1 620	16·58	327·3	85·22		
219 (4·08)	*s-trans*	ν(C=O)	1 672	19·02	177·05	52·89	6·09	37
		ν(C=C)	1 635	15·10	36·6	8·68		

the epimerisation at $C_{(19)}$ does not take place under these conditions. This means that the original configuration 19β-H must be preserved in the benzal derivative *XXVI* formed. Benzal derivative *XXII* prepared under the same conditions gave on reduction with sodium borohydride a mixture of epimeric hydroxy derivatives *XXIIIa,b* in an approximately 3 : 2 ratio, *i.e.* the more easily eluted epimer *XXIIIa* prevailed only a little. According to our expectations the dehydration of hydroxy derivative *XXIIIa* or *XXIIIb* to ω-phenylbutadiene derivative did not take place; hence, the presence of hydrogen at $C_{(19)}$ is excluded. The PMR spectra of these hydroxy derivatives *XXIIIa* and *XXIIIb*, or of their O-acetyl derivatives *XXIVa* and *XXIVb*, lead to the same conclusion, because the signal of their proton at $C_{(20)}$ is split to a simple doublet by its coupling with the olefinic proton at $C_{(29)}$.

As follows from their optical rotation dispersion, norketones *IX* and *XXV* and similar derivatives described earlier[2] have a limited rotation of the $C_{(19)}$—$C_{(20)}$ bond; the limitation is caused by non-bonding interactions and it must necessarily be increased by a suitable substitution of the side chain. Such a case occurs in both benzal derivatives *XXII* and *XXVI*; as according to PMR spectra both ketones have a *trans*-configuration at the double bond ($J_{29,29'} = 16$ Hz), the increasing non-bonding interactions of the benzal residue with the more remote parts of the molecule may destabilise its *s-trans* form, which will cause the *s-cis* form to prevail in the equilibrium state. In order to diagnose this isomery the absorption of the carbonyl and the double bond group in the IR region was (Table I) found most suitable (*cf.*[11,12], *etc.*). As the intensity of the absorption of the double bond increases in the

s-cis form to the detriment of the intensity of the carbonyl absorption, the ratio $r^B = B(C{=}O) : B(C{=}C)$* is small, while the difference in the frequencies of the two absorption bands ($\Delta\nu = \nu_{C=O} - \nu_{C=C}$) ranges between 60–80 cm^{-1}. The opposite situation in the *s-trans* forms is characterised by a substantially higher $r^B(r^i)$ value and a low $\Delta\nu$ value.

The investigation of the absorption of ketones *XXII* and *XXVI* in the infrared region (tetrachloromethane, $c = 1 \cdot 10^{-1}$ mol/l) has shown that ketone *XXVI* is, under the given conditions, a mixture of *s-trans* and *s-cis* forms the superposed absorption bands of which had to be separated and quantitatively estimated numerically according to Vítek[14]. In contrast to this the absorption of ketone *XXII* may be interpreted as the absorption of the fixed *s-cis* form. As both ketones *XXII* and *XXVI* have almost identical and relatively high molar extinction coefficients of the UV absorption (Table I), the conformations distinctly differing from the planar arrangement of their conformers do not play a substantial role. Hence, it may be supposed that in ketone *XXII* the conformation of the whole side-chain is fixed to such an extent as to forbid even such a change of the dihedral angle of $C_{(19)}$—$C_{(20)}$ which would permit the energetically more favourable *s-trans* from.

In order to solve a later solution of the configuration or the conformation of the side-chain of these compounds we completed the series of 29-substituted 19β,28-epoxy-30-nor-20-lupanone derivatives to all analogues of the derivatives of 30-nor-20-lupanone described by us earlier[2]: bromo ketone *XVII* was converted to acetoxy ketone *XXVIII* by reaction with sodium acetate in acetic acid. The attempt at its partial hydrolysis at $C_{(29)}$ with an equivalent of alkali hydroxide dinor acid *XI* was formed as the main product, while hydroxy ketone was obtained in a lower yield. In addition to the strongly negative Cotton effect ($a = -247$, 309/263 nm) and intramolecular hydrogen bond ($\Delta\nu_{(OH)} = 130\ cm^{-1}$) the PMR spectrum of hydroxy ketone *XXVII* also contained signals of protons on $C_{(29)}$ distinctly differentiated by their chemical shift (162 Hz); from their low coupling constant ($J_{gem} = 7$ Hz) it follows that the π-orbital contribution of the $C_{(20)}$-carbonyl has a positive value. According to the general relationship[15] this corresponds to a torsion angle of $C_{(29)}$—OH and $C_{(20)}$ =O close to 90° or 150°C. The hydroxy group $C_{(29)}$ and the carbonyl $C_{(20)}$ are therefore not situated on one plane and the chelate cycle in the hydroxy ketone *XXVII* is non-planar, six-membered, with the hydroxy group on $C_{(29)}$ coordinated with the epoxidic oxygen 19β (*A*, *B*). These features distinguish this hydroxy ketone substantially from the analogous 3β,28-diacetoxy-29-hydroxy-30-nor-20-lupanone[2] or from 21-hydroxy-20-pregnanone derivatives[16,17] in the α-ketol system the terminal hydroxy group of which is always coordinated with the

* For unit intensity of absorption bands a simple relationship was used, $B = \pi/2 \cdot \Delta\nu 1/2 \cdot \varepsilon^a$, instead of the so-called integral absorption intensity A[13]. Therefore, the ratio of these magnitudes is indicated by r^B instead of the conventional symbol r^i.

neighbouring carbonyl group. The frequency shift $\Delta\nu_{(OH)} = 130\ cm^{-1}$ may seem unusually high for the proposed intramolecular hydrogen bond in the hydroxy ketone *XXVII*, because according to[18], for example, the value $\Delta\nu_{(OH)} \sim 87\ cm^{-1}$ would be more adequate for 3-alkoxy-1-alkanols. The observed increase of the frequency shift is evidently due to the fact that the sp^2 carbon atom of the carbonyl $C_{(20)}$ is a part of the considered chelate ring. The substantial argument for the structural arrangement shown in formula *A*, *B* is the fixation of the conformation in the whole side chain, *i.e.* at the $C_{(19)}$—$C_{(20)}$ and $C_{(20)}$—$C_{(29)}$ bonds, which is reflected in the already mentioned pronounced Cotton effect. As oxygen containing substituents of $C_{(19)}$ and $C_{(29)}$ are located symmetrically with respect to the carbonyl in both possible conformations, their effect on the optical rotatory dispersion is cancelled. Hence, the observed, highly negative amplitude is due to the skeletal residue. From the octant projection (Fig. 1 *a*,*b*) of the conformers represented in formula *A*, *B* it is evident that the octant scheme of the *1b* conformer fulfils this requirement (as represented in formula *B*), *i.e.* that its ring E is fixed in the envelope conformation and with the torsion angle of the bonds $C_{(19)}$—O— and $C_{(20)}$—$C_{(29)}$ close to 60°C.

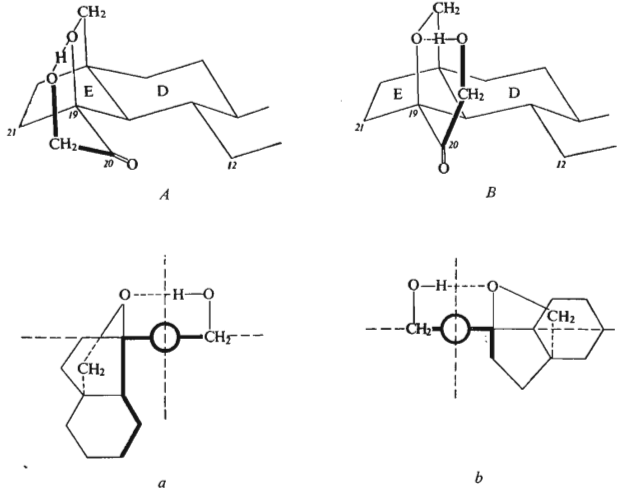


FIG. 1
Octant Projection of Conformation *a*) *A*, *b*) *B*

EXPERIMENTAL

The melting points were measured on a Kofler block and they are not corrected. Optical rotations were measured in chloroform solutions with a ±1—2° accuracy. For the measurement of the IR absorption chloroform solutions were also used (unless another solvent is mentioned) and the measurements were carried out on spectrometers ÚPT (ČSAV, Brno) and UR-10 (Zeiss, Jena), The UV spectra were registered on a Unicam SP-700 spectrometer, and the PMR spectra on a Varian HA-100 apparatus at 100 MHz frequency, using tetramethylsilane as the internal standard; deuteriochloroform was used as the solvent, unless stated otherwise. The ORD measurements were carried out in dioxan with a Jasco-ORD/UV-5 spectropolarimeter. Alumina for column chromatography and thin-layer chromatography was neutral (Reanal), activity II—III (according to Brockmann). Silica gel used for the same purpose was neutral (Spolana, Neratovice). Samples for elemental analysis and spectral measurements were dried over phosphorus pentoxide at 100°C and 0·1 Torr for 8—12 hours.

3β-Acetoxy-19β,28-epoxy-20(29)-lupen-30-al (*VI*)

To a solution of 300 mg of acetate[1,5] *V* in 90 ml glacial acetic acid 300 mg of selenium dioxide were added and the mixture was refluxed for 2 hours. After the addition of 200 mg of anhydrous sodium acetate the mixture was filtered (from the precipitated selenium) and the filtrate was evaporated to dryness under reduced pressure. The residue was extracted repeatedly with ether and the ethereal extract was washed several times with a saturated sodium hydrogen carbonate solution and water. After drying over magnesium sulfate and filtration ether was distilled off and the residue was dissolved in benzene and chromatographed on 15 g of alumina; 10 ml fractions were collected. Elution was carried out with a mixture of benzene and ether (9 : 1). From fractions 3—8 200 mg of a chromatographically pure residue were obtained. This material gave on crystallisation from chloroform–methanol 120 mg (40%) of aldehyde *VI*, m.p. 258—261°C; $[\alpha]_D$ +40·6° (*c* 0·86); UV cyclohexane: λ_{max} 212 nm, log ε 3·89, and 240 nm, log ε 3·52. UV ethanol: λ_{max} 212 nm, log ε 3·83, and 240 nm, log ε 3·46. IR spectrum: 1723, 1260, 1034 (CH_3COO), 1698, 1625 ($CH_2{=}C{-}CH{=}O$), 2740 (CH=O) cm^{-1}. PMR spectrum: 0·825 (3 × CH_3), 0·91, 0·98 (2 × CH_3), 2·01 (3β-CH_3COO), 3·92 d +3·305 d, J = 7 Hz (28-H_2), 4·45 m (3α-H), 6·64 d + 6·05 d, J_{gem} = 1·3 Hz ($CH_2{=}C$), 9·49 s (CH=O) p.p.m. ORD (*c* 0·11): $[\Phi]_{425}$ +657°, $[\Phi]_{400}$ +864°, $[\Phi]_{382}$ +891°, $[\Phi]_{338}$ +1595°, $[\Phi]_{308}$ +1173°, $[\Phi]_{290}$ +1877°, $[\Phi]_{287}$ +2346°. For $C_{32}H_{48}O_4$ (496·7) calculated: 77·37% C, 9·74% H; found: 77·51% C, 9·91% H.

Methyl Ester of 3β-Acetoxy-19β,28-epoxy-29,30-dinorlupan-20-oic Acid (*XII*)

a) *From aldehyde* VI: Into a solution of aldehyde *VI* (200 mg) in acetic acid (40 ml) an oxygen stream containing 2% of ozone was introduced at room temperature for one hour. The solution was then concentrated under reduced pressure to 20 ml and after addition of 800 mg of zinc-dust the mixture was stirred for 12 hours. After filtration the solution was diluted with 200 ml of ether, washed several times with water, and evaporated. The residue was esterified with an ethereal solution of diazomethane, and after the conventional work-up crystallised four times from chloroform–methanol. Yield 44 mg of ester *XII*, m.p. 283—285°C, $[\alpha]_D$ +16° (*c* 0·37). IR spectrum: 1725, 1260, 1029 (CH_3COO), 1725, 1440, 1108 ($COOCH_3$) cm^{-1}. PMR spectrum: 0·835—0·865 (3 × CH_3), 0·925, 1·01 (2 × CH_3), 2·03 (3β-CH_3COO), 3·73 ($COOCH_3$), 3·4 d + + 4·07 bd, J = 7 Hz (28-H_2), 4·48 m (3α-H) p.p.m. For $C_{31}H_{48}O_5$ (500·7) calculated: 74·36% C, 9·66% H; found: 74·43% C, 9·54% H.

b) *From norketone* IX: To a solution of 160 mg of norketone *IX* in 18 ml of dioxan a solution of 6 g potassium hydroxide in 8 ml of water and 0·4 ml of bromine was added gradually. The mixture was shaken at room temperature for 7 days and then concentrated under reduced pressure. It was neutralised with dilute hydrochloric acid (1 : 4) under cooling with ice. The product was repeatedly extracted with ether and the extract was washed with a 5% sodium thiosulfate solution and then with water. The organic solution was evaporated to dryness and the residue esteri-

fied in the usual manner with diazomethane in ether. The formed ester was acetaylated with acetic anhydride in pyridine (3 ml, 1 : 2) by heating for 2 hours on a boiling water bath.

The crude ester *XII* was chromatographed on 10 g of alumina using benzene–ether 9 : 1 as eluent. The residue (40 mg) of chromatographically pure eluate was crystallised four times from chloroform–methanol to afford 15 mg of analytically pure ester *XII*, m.p. 278—280°C, which was identical according to all criteria with the preparation prepared under *a*).

c) *From* 29-*acetoxy ketone* XXVIII: A solution of 215·4 mg of ketone *XXVIII* in 7 ml of benzene was mixed with 7·1 ml of 0·058M ethanolic potassium hydroxide solution (46·6 mg KOH) and the mixture was allowed to stand at room temperature for 3 days. After dilution with 50 ml of ether the mixture was washed with water and dilute hydrochloric acid (1 : 6). The residue of the ethereal solution was dissolved in benzene and chromatographed on 18 g of silica gel. Elution of fractions, 10 ml each, was carried out with benzene (100 ml), then benzene–ether 9 : 1 (200 ml). The residue of fractions 13—22 (90 mg) was esterified with diazomethane in ether and the product was crystallised from n-heptane. Yield: 50 mg of ester *XII*, identical with the preparations prepared as under *a*) and *b*). From the residue of fraction 6 hydroxy ketone *XXVII* was isolated.

Ozonisation of Acetate *V* in Acetic Acid

Oxygen containing approximately 2% of ozone was introduced into a solution of 10·1 g acetate *V* in 600 ml of acetic acid at room temperature for 3/4 hours. The working up was carried out as in the case of ozonisation of aldehyde *VI*. The neutral products were chromatographed on 700 g of alumina with benzene–ether 9 : 1 (200 ml fractions). The residue of fraction 17—24 was crystallised from chloroform–methanol giving 7·9 g of norketone *IX*, m.p. 316—317°C, $[\alpha]_D$ +3·3 (*c* 0·90); lit.[5] m.p. 317—319°C, $[\alpha]_D$ +3°. IR spectrum: 1720, 1264, 1025, (CH_3COO), 1716 (C=O), 1424 (α-CH_2) cm^{-1}. ORD (*c* 0·09): $[\Phi]_{400}$ −483°, $[\Phi]_{350}$ −712°, $[\Phi]_{336}$ −916°, $[\Phi]_{307}$ −1883°, $[\Phi]_{276}$ ±0°, $[\Phi]_{270}$ +203°, $[\Phi]_{264}$ ±0°, $[\Phi]_{250}$ −1221°. PMR spectrum: 0·83 (2 × CH_3), 0·85, 0·91, 1·01 (3 × CH_3), 2·015 (3β-CH_3COO), 2·24 (CH_3CO—C), 3·39 d +4·045 d, J = 7·3 Hz (28-H_2), 4·45 m (3α-H) p.p.m. For $C_{31}H_{48}O_4$ (484·7) calculated: 76·81% C, 9·98% H; found: 76·75% C, 10·03% H.

Oxime *X*: 220 mg of ketone *IX* and 200 mg of hydroxylamine hydrochloride in 5 ml of pyridine were heated on a boiling water bath for 4 hours. After the conventional working up the crude product was chromatographed on 20 g of alumina. Elution was carried out with benzene–ether 4 : 1. The residue of chromatographically pure fractions was crystallised four times from chloroform–methanol. Oxime *X* had m.p. 259—269°C, $[\alpha]_D$ +39° (*c* 0·81). IR spectrum (chloroform): 1725, 1260, 1030 (CH_3COO), 3580, 3260 (OH) cm^{-1}; (tetrachloromethane, *c* 5 . 10^{-3} mol/l): 3247, 3443, 3599 cm^{-1}. For $C_{31}H_{49}NO_4$ (499·7) calculated: 74·51% C, 9·88% H, 2·80% N; found: 74·45% C, 9·79% H, 2·75% N.

The residue of fractions 28—32 (70 mg) was rechromatographed on 7 g of silica gel with benzene–ether 99 : 1 (10 ml fractions). From fractions 8—25 20 mg of product were obtained which was crystallised from chloroform–methanol and chloroform–heptane. Yield 12 mg of aldehyde *VII*, m.p. 265—266°C, $[\alpha]_D$ +51·6° (*c* 0·50). IR spectrum: 1724, 1258, 1029 (CH_3COO), 1715, 2735 (CH=O) cm^{-1}. ORD (*c* 0·083): $[\Phi]_{400}$ +784°, $[\Phi]_{350}$ +1508°, $[\Phi]_{326·5}$ +3137°, $[\Phi]_{322-320}$ +2956°, $[\Phi]_{316}$ +3077°, $[\Phi]_{280}$ −1327, $[\Phi]_{270}$ −1025°. For $C_{32}H_{50}O_4$ (498·7) calculated: 77·06% C, 10·11% H; found: 76·83% C, 9·82% H. The residue of fractions 38—40 (150 mg) was rechromatographed on 7 g of silica gel. Elution of fractions (8 ml each) was done with benzene–ether mixture (99 : 1). From fractions 12—24 (65 mg) 45 mg of the by-product of ozonolysis were obtained after crystallisation from chloroform–methanol; m.p. 270—272°C, $[\alpha]_D$ +23° (*c* 0·43). IR spectrum: 1722, 1258, 1030 (CH_3COO), 1711 (C=O), 1418 (α-CH_2) cm^{-1}.

ORD (*c* 0·06) $[\Phi]_{400}$ ±0°, $[\Phi]_{350}$ −555°, $[\Phi]_{335}$ −1419°, $[\Phi]_{330}$ −1789°, $[\Phi]_{328}$ −2005°, $[\Phi]_{320}$ −1727°, $[\Phi]_{300}$ +1542°, $[\Phi]_{285}$ +3331°, $[\Phi]_{273}$ +3455°, $[\Phi]_{262}$ +2097°. PMR spectrum: 0·865 (2 × CH_3), 0·925 (2 × CH_3), 1·11 (CH_3), 2·03 (3β-CH_3COO), 2·36 m 2 H (α-CH_2), 3·52 d +4·07 dd, $J_{gem} = 7$, $J_{l.r.} = 3$ Hz (28-H_2), 4·49 m (3α-H) p.p.m.. For $C_{29}H_{44}O_4$ (456·64) calculated: 76·27% C, 9·71% H; found: 76·47% C, 9·71% H.

3β-Hydroxy-19β,28-epoxy-30-nor-20-lupanone (*VIII*)

A 10% ethanolic solution of potassium hydroxide (4 ml) was added to a solution of 200 mg acetate *IX* in 4 ml of benzene and the mixture was refluxed for 2 hours. The cooled mixture was diluted with ether (50 ml), extracted with water, dilute hydrochloric acid, and then evaporated to dryness. Fourfold crystallisation of the residue gave 146 mg of hydroxy derivative *VIII*, m.p. 192–194°C, $[\alpha]_D$ −8·7 (*c* 0·63). IR spectrum: 1708 (C=O), 1422, 1363 (CH_3—CO—$C_{(19)}$), 1028, 3620 (OH) cm^{-1}. ORD (*c* 0·07): $[\Phi]_{350}$ −676°, $[\Phi]_{325}$ −1419°, $[\Phi]_{307}$ −2114°, $[\Phi]_{271}$ +131°, $[\Phi]_{250}$ −1419°. For $C_{29}H_{46}O_3$ (442·7) calculated: 78·68% C, 10·47% H; found: 78·71% C, 10·29% H.

Reduction of Norketone *IX* with Sodium Boro-hydride

To a solution of 150 mg of norketone *IX* in 50 ml of dioxan a solution of 150 mg of sodium borohydride in a mixture of 5 ml of water and 20 ml of dioxan was added and allowed to stand at room temperature for 2 days. The reaction mixture was diluted with ether and extracted gradually with water, dilute hydrochloric acid (1 : 4), and water, and the ethereal layer was evaporated to dryness. The residue was chromatographed on 15 g of silica gel first with benzene–ether 95 : 5 (fractions 1–15) and then with benzene–ether 9 : 1 (fractions 16–29). Fractions 12–21 contained 120 mg of the more easily eluted hydroxy derivative *XIIIa*. The analytically pure sample, crystallised from n-heptane, had m.p. 266–268°C, $[\alpha]_D$ +39·8° (*c* 0·65). IR spectrum: 1724, 1258, 1028 (CH_3COO), 1084, 3608 (OH) cm^{-1}. PMR spectrum: 0·845 (2 × CH_3), 0·875, 0·935, 1·01 (3 × CH_3), 1·21 d, $J = 6{\cdot}2$ Hz (CH_3—CH—OH), 2·02 (3β-CH_3COO), 3·325 d +3·97 bd, $J_{gem} = 7$, $J_{l.r.} = 2{\cdot}4$ Hz (28-H_2), 4·07 bq, $J = 6{\cdot}2$ Hz (20-H), 4·49 m (3α-H) p.p.m. For $C_{31}H_{50}O_4$ (486·7) calculated: 76·50% C, 10·36% H; found: 76·17% C, 10·36% H. Acetylation of hydroxy derivative *XIIIa* gave *diacetate XIVa*, m.p. 283–284° C, $[\alpha]_D$ +32·7° (*c* 0·64). IR spectrum: 1727, 1258, 1028, 1019 (CH_3COO) cm^{-1}. For $C_{33}H_{52}O_5$ (528·75) calculated: 74·96% C, 9·91% H; found: 74·98% C, 9·90% H. Benzoylation of hydroxy derivative *XIIIa* was carried out with benzoyl chloride in pyridine by standing at room temperature for 2 days and working up in the usual manner. After crystallisation (chloroform–methanol) the 20-O-*benzoyl derivative XVa* had m.p. 262–264°C, $[\alpha]_D$ −3° (*c* 0·65). IR spectrum: 1713–1724, 1257–1286 (CH_3COO and C_6H_5COO), 1028 (CH_3COO), 1604, 1587, 1115 (C_6H_5—COO) cm^{-1}.

From the chromatographic fractions 24–29 20 mg of epimeric hydroxy derivative *XIIIb* were isolated. The analytical sample was crystallised twice from n-heptane; m.p. 256–257°C, $[\alpha]_D$ +41° (*c* 0·48). IR spectrum: 1725, 1258, 1030 (CH_3COO), 1083, 3585 (OH) cm^{-1}. PMR spectrum: 0·845 (2 × CH_3), 0·875, 0·91, 1·015 (3 × CH_3), 1·15 d, $J = 6$ Hz (CH_3—CH—OH), 2·03 (3β-CH_3COO), 3·33 d +3·955 bd, $J_{gem} = 7$, $J_{l.r.} = 2$ Hz (28-H_2), 4·285 bd, $J = 6$ Hz (20-H), 4·485 m (3α-H) p.p.m. 20-O-*Benzoyl derivative XVIb* was prepared in the same manner as benzoate *XVa*. Compound *XVb* was crystallised from n-heptane; m.p. 150–153°C, $[\alpha]_D$ +65·8° (*c* 0·62). IR spectrum: practically identical with the spectrum of epimer *XVa*.

Bromination of 3β-Acetoxy-19β,28-epoxy-30-nor-20-lupanone (*IX*)

To a solution of 129·4 mg of ketone *IX* in 10 ml of chloroform 0·1 ml of a 10% solution of hydrogen bromide in acetic acid was added, followed by the addition of several portions of 0·3 ml of a solution of bromine in acetic acid (24·96 mg Br/ml). The total addition of the bromide solution was 2·4 ml. Before each addition the course of the reaction was controlled by thin-layer chromatography on silica gel; after the first phase of the bromination the reaction mixture contained the starting ketone *IX*, bromo ketone *XVII*, and dibromo ketone *XVIII*. When the addition was finished the mixture was poured into water and the chloroform layer (after its separation) was slowly added dropwise into a saturated aqueous solution of sodium hydrogen carbonate. This operation was repeated without previous shaking of the phase. After further conventional working up the reaction mixture was separated by chromatography on 13 g silica gel with benzene (10 ml fractions). Fractions 12—16 contained 20 mg of dibromo ketone *XVIII* which was crystallised from chloroform–methanol to give 16 mg of product, m.p. 180°C (decomp.); $[\alpha]_D$ −24·2° (*c* 0·52). IR spectrum: 1 725, 1 256, 1 030 (CH_3COO) cm^{-1}. ORD (*c* 0·09): $[\Phi]_{400}$ −1 101°, $[\Phi]_{375}$ −1 652°, $[\Phi]_{350}$ −4 100°, $[\Phi]_{332}$ −6 058°, $[\Phi]_{309}$ ±0°, $[\Phi]_{284}$ +7 221°, $[\Phi]_{275}$ +6 487°. PMR spectrum: 0·84 (2 × CH_3), 0·865, 0·915, 1·01 (3 × CH_3), 2·025 (3β-CH_3COO), 3·495 d + 4·05 d, J = 7·5 Hz (28-H_2), 4·47 m (3α-H), 5·50 s (29-H) p.p.m. For $C_{31}H_{46}Br_2O_4$ (642·5) calculated: 57·95% C, 7·22% H, 24·88% Br; found: 57·94% C, 7·19% H, 24·68% Br. Fractions 22—28 contain 95 mg of bromo ketone *XVII* which after crystallisation from chloroform–heptane weighed 49 mg, m.p. 255—257°C, $[\alpha]_D$ −19·6° (*c* 0·49). IR spectrum: 1 725, 1 256, 1 029 (CH_3COO), 1 710 (C=O) cm^{-1}. ORD (*c* 0·09): $[\Phi]_{400}$ −616°, $[\Phi]_{350}$ −1 478°, $[\Phi]_{325}$ −2 156°, $[\Phi]_{312·5}$ −2 408°, $[\Phi]_{300}$ −1 601°, $[\Phi]_{275}$ +1 109, $[\Phi]_{270}$ +1 170°, $[\Phi]_{265}$ +985°. PMR spectrum: 0·84 (2 × CH_3), 0·87, 0·915, 1·015 (3 × CH_3), 2·04 (3β-CH_3COO), 3·445 d + 4·05 d, J_{gem} = 7·5 Hz (28-H_2), 4·31 s (29-H_2), 4·47 m (3α-H) p.p.m. For $C_{31}H_{47}BrO_4$ (563·8) calculated: 66·06% C, 8·39% H, 14·18% Br; found: 66·11%, 8·39% H, 14·53% Br.

Reduction of Bromoketone *XVII* with Sodium Borohydride

Sodium boro-hydride (200 mg) dissolved in a mixture of water (5 ml) and dioxan (15 ml) was added to a solution of bromo ketone *XVII* (750 mg) in dioxan (60 ml) and the mixture was allowed to stand at room temperature for 4 hours. It was then concentrated under reduced pressure, diluted with 200 ml of ether and the solution washed repeatedly with 5% tartaric acid solution. After washing with water the solvents were distilled off. The residue weighed 740 mg. A part of it (100 mg) was chromatographed on 8 g of silica gel. Elution with benzene–ether 95 : 5 (5 ml fractions) gave 70 mg of material in the first fraction, which after crystallisation from chloroform–methanol yielded 60 mg of the more easily eluted bromohydrin *XIXa*, m.p. 294—296°C, $[\alpha]_D$ +47·3° (*c* 0·61). IR spectrum: 1 721, 1 257, 1 029 (CH_3COO), 3 582 (OH) cm^{-1}. PMR spectrum: 0·845 (2 × CH_3), 0·88, 0·935, 1·015 (3 × CH_3), 2·04 (3β-CH_3COO), 3·29 d + 3·765 dd, J_{gem} = 7 Hz, $J_{1.r.}$ = 2·4 Hz (28-H_2), 3·33 t, $J_{29,29'}$ = 10·2 Hz, $J_{29,20}$ = 9·9 Hz (29-H), 3·38 d, J = 2·5 Hz (20-OH), 4·25 ddd, $J_{20,OH}$ = 2·5 Hz, $J_{20,29}$ = 9·9 Hz, $J_{20,29'}$ = 1·8 Hz (20-H), 4·48 m (3α-H) p.p.m. For $C_{31}H_{49}BrO_4$ (565·6) calculated: 65·82% C, 8·72% H; found: 65·96% C, 8·70% H. The dry residue of the second fraction (20 mg) was crystallised from chloroform–n-heptane to give 12 mg of epoxide *XX*, m.p. 268—272°C. IR spectrum: 1 726, 1 257, 1 030 (CH_3COO), 878 (epoxide) cm^{-1}. PMR spectrum: 0·845 (2 × CH_3), 0·875, 0·925, 1·03 (3 × CH_3), 2·035 (3β-CH_3COO), 2·71 m (29-H_2), 3·13 m (20-H), 3·32 + 3·98 dd, J_{gem} = 7 Hz, $J_{1.r.}$ = 2·3 Hz (28-H_2), 4·49 m (3α-H) p.p.m.. For $C_{31}H_{48}O_4$ (484·7) calculated: 76·81% C, 9·98% H; found: 76·73% C, 10·05% H. From the dry residue of fractions 3—7 the more strongly adsorbed bromohydrin *XIXb* (6 mg) was isolated after repeated crystallisation from chloroform–n-heptane. M.p. 220—226°C;

IR spectrum: 1726, 1258, 1028 (CH_3COO), 3540, 3585 (OH) cm^{-1}. PMR spectrum: 0·845 (2 × CH_3), 0·88, 0·92, 1·02 (3 × CH_3), 2·03 (3β-CH_3COO), 2·73 d, $J \sim 3$ Hz (20-OH), 3·17 to 3·55 m + 3·98 d, (28-H_2), 3·17 to 3·55 m (29-H_2), 4·23 ddd, $J_{20,OH} \sim 3$ Hz (20-H), 4·49 m (3α-H) p.p.m.

3β-Acetoxy-19β,28-epoxy-30-nor-20(29)-lupene (*XVI*)

a) *Preparation by dehydration of hydroxy derivative* XIIIa,b: A solution of a mixture of epimers *XIIIa,b* (150 mg) in 16 ml of pyridine was cooled to 0°C and then mixed with a solution of 3 ml of phosphorus oxychloride in 15 ml of pyridine at the same temperature. The reaction mixture was allowed to stand at room temperature for 20 hours and then decomposed with ice and extracted with ether. The extract was washed with water, dilute hydrochloric acid (1 : 3), 5% aqueous solution of sodium hydroxide and again with water. After the evaporation of ether the residue (30 mg) was chromatographed on 2 g of silica gel. On elution with a mixture of benzene and ether (99 : 1) 20 mg of residue were obtained which after treble crystallisation from chloroform–methanol gave vinyl derivative *XVI*, m.p. 236—237°C, $[\alpha]_D$ +38° (*c* 0·65), identical with the preparation prepared as under *b*).

b) *Preparation from the mixture of bromohydrins* XIXa, b: To a solution of 650 mg of the reaction mixture after the reduction of bromo ketone *XVII* in 60 ml of acetic acid zinc dust (3 g) was added in small portions under stirring at room temperature. According to chromatographic control (TLC on silica gel) the composition of the reaction mixture did not change further after 11 hours and therefore the mixture was filtered and the filtrate evaporated under reduced pressure to dryness. The residue was extracted thoroughly with chloroform. The extract was washed with water and evaporated. The residue was chromatographed on 64 g of silica gel with benzene (70 ml fractions). From fractions 4—7 (140 mg) crystallisation from chloroform–methanol gave 90 mg of vinyl derivative *XVI*, m.p. 236·4—237°C, $[\alpha]_D$ +38·1° (*c* 0·66). IR spectrum: 1727, 1258, 1028 (CH_3COO), 1648, 907, 3092 (CH_2=C) cm^{-1}. PMR spectrum: 0·84 (2 × CH_3), 0·875, 0·925, 1·03 (3 × CH_3), 2·03 (3β-CH_3COO), 3·37 d + 4·00 dd, $J_{gem} = 7$ Hz, $J_{1,r.} = 2{\cdot}5$ Hz (28-H_2), 4·49 m (3α-H), 5·035 dd, $J_{29,20} = 10{\cdot}5$ Hz, $J_{29,29'} = 2{\cdot}5$ Hz (29-H), 5·25 dd, $J_{29',20} = 17{\cdot}5$ Hz, $J_{29',29} = 2{\cdot}5$ Hz (29'-H), 6·00 dd, $J_{20,29'} = 17{\cdot}5$ Hz, $J_{20,29} = 10{\cdot}5$ Hz (20-H) p.p.m.. For $C_{31}H_{48}O_3$ (468·7) calculated: 79·43% C, 10·32% H; found: 79·40% C, 10·12% H. The residue (180 mg) of fractions 13—29 was identified as one of the unreacted bromohydrins *XIXa*.

3β-Acetoxy-19β,28-epoxy-29,30-dinor-20-lupanal (*XXI*)

A current of oxygen containing approx. 2% of ozone was introduced into a solution of 90 mg of vinyl derivative *XVI* in 35 ml of ethyl acetate under cooling with solid carbon dioxide in methanol for 30 minutes. The reaction mixture was evaporated to dryness under reduced pressure and the residue was dissolved in 20 ml of ether. Acetic acid (0·15 ml) and zinc dust (150 mg) were added to the solution which was then shaken at room temperature for 2 hours. After filtration and working up in the usual manner the residue was chromatographed on 8 g of silica gel first with benzene–ether 99 : 1 (fractions 1—13) and then with the same mixture in the 98 : 2 ratio (fractions 14—20). The volume of single fractions was 10 ml. The residue of fractions 10—18 (85 mg) was crystallised from n-heptane (2×) and from ethyl acetate (3×) to give 47·2 mg of aldehyde *XXI*, m.p. 272—274°C, $[\alpha]_D$ +0·7 to −1·1° (*c* 0·64). IR spectrum: 1727, 1258, 1028 (CH_3COO), 1727, 2722 (CH=O) cm^{-1}. ORD (*c* 0·07): $[\Phi]_{400}$ −636°, $[\Phi]_{350}$ −1655°, $[\Phi]_{349}$ −1717°, $[\Phi]_{340}$ −2862°, $[\Phi]_{335}$ −3498°, $[\Phi]_{332{\cdot}5}$ −3625°, $[\Phi]_{327}$ −3434°, $[\Phi]_{324}$ −3690°, $[\Phi]_{315}$ −2099°, $[\Phi]_{291}$ +3243°, $[\Phi]_{280}$ +3880°, $[\Phi]_{275}$ +3689°; PMR spectrum:

0·84 (2 × CH_3), 0·86, 0·915, 1·01 (3 × CH_3), 2·03 (3β-CH_3COO), 3·46 d + 4·08 d, J = 7 Hz (28-H_2), 4·48 m (3α-H), 9·88 s (CH=O) p.m.m. For $C_{30}H_{46}O_4$ (470·7) calculated: 76·55% C, 9·85% H; found: 76·85% C, 10·00% H.

3β-Acetoxy-29-benzal-30-nor-20-lupanone (*XXVI*)

To a solution of 120 mg of ketone *XXV* (ref.[6]) in 10 ml of benzene a solution of 330 mg of sodium in 10 ml of methanol and 0·3 ml of freshly distilled benzaldehyde were added and the mixture stirred at room temperature for 50 hours. It was then poured into water and extracted with ether. The extract was washed with dilute hydrochloric acid (1 : 4), evaporated under reduced pressure and the unreacted benzaldehyde was steam distilled. The dried unvolatile residue was acetylated in the conventional manner with acetic anhydride and pyridine. The crude acetyl derivative was dissolved in benzene and chromatographed on 10 g of silica gel with benzene. The residue of the first 15 ml of the benzene eluate (35 mg) was crystallised from chloroform–methanol and the crystalline material was combined with the residue of the subsequent fractions 2–4. The total amount (110 mg) of chromatographically pure fraction was crystallised four times from chloroform–methanol to give 80 mg of benzal derivative *XXVI*, m.p. 139–143°C, $[\alpha]_D$ +47° (*c* 0·55). UV spectrum (cyclohexane): λ_{max} 281 nm, log ε 4·33; 224 nm, log ε 4·01, 219 nm, log ε 4·08. IR spectrum: 1 730, 1 258, 1 030 (CH_3COO), 1 688, 1 615, 1 583 (C_6H_5—CH=CH—C=O) cm^{-1}. ORD (*c* 0·11): $[\Phi]_{425}$ +936°, $[\Phi]_{400}$ +1 508, $[\Phi]_{379}$ +1 872°, $[\Phi]_{370}$ +1 582°, $[\Phi]_{356}$ +1 144°, $[\Phi]_{353}$ +884°, $[\Phi]_{336}$ +468°, $[\Phi]_{324}$ +936°. PMR spectrum: 0·825 to 0·855 (4 × CH_3), 0·985, 1·03 (2 × CH_3), 2·02 (3β-CH_3COO), 2·87 m (19β-H), 6·77 d, $J_{29,29a}$ = 16 Hz (29-H), 7·56 d, $J_{29a,29}$ = 16 Hz (29a-H), 4·45 m (3α-H) p.p.m.

3-Acetoxy-19β,28-epoxy-29-benzal-30-nor-20-lupanone (*XXII*)

Condensation of 200 mg of ketone *IX* with benzaldehyde was carried out as in the preceding case. The crude reaction product was chromatographed on 100 g of alumina with benzene–ether mixture 3 : 1 (fractions 25 ml each). The residue of fractions 3–6 (180 mg) was crystallised from chloroform–methanol. Yield 120 ml of benzal derivative *XXII*, m.p. 276–277°C, $[\alpha]_D$ +34° (*c* 0·59). UV spectrum (cyclohexane): λ_{max} 294 nm, log ε 4·35; 228 nm, log ε 4·04; 222 nm, log ε 4·05. IR spectrum: 1 723, 1 258, 1 030 (CH_3COO), 1 682, 1 605, 1 578 (C_6H_5—CH=CH—C=O) cm^{-1}. ORD (*c* 0·09): $[\Phi]_{450}$ +114°, $[\Phi]_{400}$ +143°, $[\Phi]_{390}$ +162°, $[\Phi]_{380}$ +143°, $[\Phi]_{370}$ +228°, $[\Phi]_{360}$ +328°, $[\Phi]_{350}$ +476°, $[\Phi]_{320-321}$ +1 523°, $[\Phi]_{312}$ +761°, $[\Phi]_{310}$ −1 808°. PMR spectrum: 0·81 to 0·84 (3 × CH_3), 0·94, 1·015 (2 × CH_3), 2·015 (3β-CH_3COO), 3·475 d + + 4·12 d, J_{gem} = 7 Hz (28-H_2), 4·47 m (3α-H), 7·26 d, $J_{29,29a}$ = 16 Hz (29-H), 7·71 d, $J_{29a,29}$ = = 16 Hz (29a-H) p.p.m. For $C_{38}H_{52}O_4$ (572·8) calculated: 79·68% C, 9·15% H; found: 79·76% C, 9·16% H.

Reduction of Ketone *XXII* with Sodium Borohydride

To a solution of 210 mg of ketone *XXII* in 40 ml of dioxan sodium borohydride (200 mg) dissolved in 30 ml of dioxan–water mixture 2 : 1 was added and the mixture was allowed to stand at room temperature for 16 hours. The working up was carried out as in the case of reduction of ketone *IX*. The residue was chromatographed on 40 g of alumina with benzene (15 ml fractions). Fractions 4–10 gave 120 mg of hydroxy derivative *XXIIIa*; the sample for analysis was crystallised from n-heptane; m.p. 163–178°C (decomp.), [α]+45° (*c* 0·50). UV spectrum (ethanol): λ_{max} 250 nm, log ε 4·22. IR spectrum: 1 722, 1 258, 1 028 (CH_3COO), 1 602, 1 577 (C_6H_5—CH= =CH—), 3 600 (OH) cm^{-1}. PMR spectrum: 0·85 (2 × CH_2), 0·885, 0·945, 1·03 (3 × CH_3),

2·025 (3β-CH_3COO), 3·345 d + 4·00 bd, J_{gem} = 7 Hz (28-H_2), 4·49 m (3α-H), 4·58 d, J = 6 Hz (20-H), 6·315 dd, $J_{29,20}$ = 6 Hz, $J_{29,29a}$ = 16 Hz (29-H), 6·67 d, $J_{29a,29}$ = 16 Hz (29a-H) p.p.m.. For $C_{38}H_{54}O_4$ (574·8) calculated: 79·40% C, 9·47% H; found: 79·34% C, 9·62% H. *Acetate XXIVa* was prepared from hydroxy derivative *XXIIIa* on acetylation with acetic anhydride and pyridine at room temperature. After crystallisation from n-heptane it had m.p. 205–208°C, $[\alpha]_D$ +37·2° (*c* 0·12). PMR spectrum: 0·85 (2 × CH_3), 0·875, 0·94, 1·03 (3 × CH_3), 2·03 (3β-CH_3COO), 2·07 (20–CH_3COO), 3·335 d + 3·99 bd, J_{gem} = 7 Hz, $J_{1.r.}$ = 2·5 Hz (28-H_2), 4·49 m (3α-H), 5·58 bd, $J_{20,29}$ = 6·5 Hz, $J_{20,29a} \neq 0 < 1$ Hz (20-H), 6·13 dd, $J_{20,29a}$ = 16 Hz, $J_{29,20}$ = 6·5 Hz, (29-H), 6·64 bd, $J_{29a,29}$ = 16 Hz, $J_{29a,20} \neq 0 < 1$ (29a-H), 7·15–7·45 m (AR–H) p.p.m. For $C_{40}H_{56}O_5$ 616·8) calculated: 77·88% C, 9·15% H; found: 77·74% C, 9·01% H. Chromatographic fractions 20–23 contained epimer *XXIIIb* (81 mg) which could not be obtained in crystaline state; $[\alpha]_D$ −74° (*c* 0·45); UV spectrum (ethanol): λ_{max} 251–252 nm, log ε 4·24. IR spectrum: 1724, 1258, 1023 (CH_3COO), 1602, 1580, (C_6H_5–CH=CH–) cm^{-1}. PMR spectrum: 0·83–0·85 (2 × CH_3), 0·87, 0·93, 1·03 (3 × CH_3), 2·035 (3β-CH_3COO), 3·35 d + 3·99 bd, J_{gem} = 7 Hz, $J_{1.r.}$ = 2 Hz (28-H_2), 4·49 m (3α-H), 4·72 bd, J = 4·5 Hz (20-H), 6·185 dd, $J_{29,29a}$ = 16 Hz, $J_{29,20}$ = 4·5 Hz (29-H), 6·75 d, $J_{29a,29}$ = 16 Hz (29a-H) p.p.m. *Acetate XXIVb*, prepared in the usual manner is also amorphous; $[\alpha]_D$ −12° (*c* 0·49); UV spectrum (cyclohexane): λ_{max} 251 nm, log ε 4·19; IR spectrum: 1726, 1255, 1027 (CH_3COO), 1600, 1579, 813 (C_6H_5–CH=CH–) cm^{-1}. PMR spectrum: 0·835 (2 × CH_3), 0·875, 0·895, 1·015 (3 × CH_3), 2·025 (3β-CH_3COO), 2·125 (20-CH_3COO), 3·32 d + 3·99 bd, J_{gem} = 7 Hz, $J_{1.r.}$ = 2·5 Hz (28-H_2), 4·47 m (3α-H), 5·90 bd, $J_{20,29}$ = 5 Hz, $J_{20,29a} \neq 0 < 1$ (20-H), 6·14 dd, $J_{29,20}$ = 5 Hz, $J_{29,29a}$ = 16 Hz (29-H), 6·57 bd, $J_{29,29a}$ = 16 Hz, $J_{29a,20} \neq 0 < 1$ Hz (29a-H) p.p.m.

3β,29-Diacetoxy-19β,28-epoxy-30-nor-20-lupanone (*XXVIII*)

To a solution of 460 mg of bromoketone *XVII* in a mixture of acetic acid (40 ml) and acetic anhydride (1 ml) 2 g of freshly remelted sodium acetate were added and the mixture was refluxed for 10 hours. After evaporation to dryness under reduced pressure the residue was extracted with ether and the extract was washed with sodium hydrogen carbonate solution and water. After drying over magnesium sulfate and filtration ether was distilled off. By repeated crystallisation (4 times) from chloroform–methanol 320 mg of acetate *XXVIII* were obtained, m.p. 305–306°C; $[\alpha]_D$ −17·6° (*c* 0·62), IR spectrum: 1727, 1257, 1028 (3β-CH_3COO), 1749, 1240, 1017 (29-CH_3COO) cm^{-1}. ORD (*c* 0·065): $[\Phi]_{400}$ −588°, $[\Phi]_{350}$ −925°, $[\Phi]_{330}$ −1177°, $[\Phi]_{302}$ −1850°, $[\Phi]_{301}$ −2102°, $[\Phi]_{274}$ −1345°, $[\Phi]_{265}$ −1640°. PMR spectrum: 0·84 (2 × CH_3), 0·875, 0·915, 1·025 (3 × CH_3), 2·02 (3β-CH_3COO), 2·15 (29-CH_3COO), 3·41 d + 4·04 d, J_{gem} = = 7·5 Hz (28-H_2), 4·47 m (3α-H) p.p.m.. For $C_{33}H_{50}O_6$ (542·7) calculated: 73·03% C, 9·29% H; found: 73·10% C, 9·31% H.

3β-Acetoxy-19β,28-epoxy-29-hydroxy-30-nor-20-lupanone (*XXVII*)

Fraction 6, described earlier (see ester *XII*) and isolated after partial hydrolysis of acetate *XXVIII* and chromatography, was evaporated to dryness and crystallised from n-heptane, yielding 46 mg of hydroxy ketone *XXVII*, m.p. 277–279°C; $[\alpha]_D$ +15° (*c* 0·35). IR spectrum: 1718–1723, 1256, 1029 (CH_3COO), 1718–1723 (C=O), 3475 (OH) cm^{-1}; ν(OH) (tetrachloromethane, $c = 5 \cdot 10^{-3}$ mol/l): 3462 cm^{-1}. ORD (*c* 0·08): $[\Phi]_{400}$ −600°, $[\Phi]_{350}$ −1950°, $[\Phi]_{325}$ −6100°, $[\Phi]_{318}$ −9160°, $[\Phi]_{309}$ −9770°, $[\Phi]_{300}$ −5370°, $[\Phi]_{275}$ +12700°, $[\Phi]_{263}$ +14900°, $[\Phi]_{250}$ +14650°. PMR spectrum: 0·845 (2 × CH_3), 0·875, 0·92, 1·045 (3 × CH_3), 2·03 (3β-CH_3COO), 3·51 d + 4·13 d, J_{gem} = 7 Hz (28-H_2), 3·70 d + 5·32 d, J_{gem} = 7 Hz (29-H_2), 4·48 m (3α-H) p.p.m.. For $C_{31}H_{48}O_5$ (500·7) calculated: 74·36% C, 9·66% H; found: 74·13% C, 9·58% H.

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