PREPARATION OF $C_{(18)}$-EPIMERIC 20,29,30-TRINORLUPANE DERIVATIVES. ^1H, ^{13}C NMR AND MASS SPECTRA*

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Reaction of amide *I* with nitrous acid gave the olefins *II*, *III* and *IV*. On allylic oxidation of olefin *IV* α,β-unsaturated ketone *V* is formed from which olefins *VIII* and *IX* were prepared by a sequence of further reactions. Addition of hydrogen to the double bond of olefin *IV* and α,β-unsaturated ketone *V* takes place on catalytic hydrogenation from the β-side and leads to derivatives with *cis*-annellated rings D/E. This made the preparation of hydrocarbons *VI* and *VII* epimeric on $C_{(18)}$ possible, which represent reference compounds for the study of the effect of substituents on the chemical shifts of the methyl groups and the saturated carbon atoms of 18αH and 18βH-lupane derivatives. The configuration of the hydroxyl group in epimers *XI* and *XII* were derived from ^1H NMR spectra. Deuteration of olefins *III*, *IV* and *IX* gave deuteriohydrocarbons *XVI* to *XVIII*. The ^1H, ^{13}C NMR and mass spectra of the substances prepared are discussed.

Some 20,29,30-trinorlupane derivatives were obtained earlier mostly by oxidative[1-5] or photolytic[6] cleavage of the side chain or by Barbier–Wieland degradation of 29,30-dinorlupan-20-oic acid[7-9]. In this study we used amide *I* as starting material for their preparation, which is formed by Beckmann rearrangement of the *E*-isomer of 20-hydroxyimino-30-norlupane, as described in our preceding communication[10]. On reaction of amide *I* with nitrous acid, carried out according to ref.[11], we obtained three isomeric olefins which we separated chromatographically on silica gel impregnated with 5% of silver nitrate. The most easily elutable olefin displays in its ^1H NMR spectrum signals of six methyl groups and no olefinic hydrogen atom. Its ^{13}C NMR spectrum showed the presence of a tetrasubstituted double bond (signals of sp^2 carbon atoms of the $>C=$ type at δ 130·72 and 138·51). This led to the proposal of structure *II* with the double bond in position 13(18), which was confirmed by mass spectroscopy. The character of the spectrum and the dominant ions (*a*, *m/z* 163; *b*, *m/z* 176 and *c*, *m/z* 147) correspond to an analogous fragmentation typical of 13(18)-oleanene derivatives[12], 19α-isopropyl-28,29,30-trinor-17ξ-olean-13(18)-ene[13] or 3β-acetoxy-19αH-lup-13(18)-ene[14]. The position of the double

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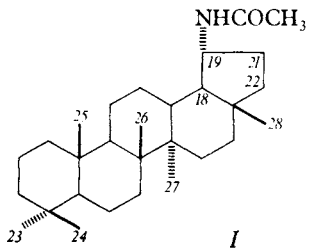
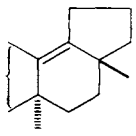
bonds of the two more strongly adsorbed olefins was determined from the ^1H and the ^{13}C NMR spectra. We assigned the structure *III* with the double bond 19(21) to the olefin with the disubstituted double bond (in ^1H NMR a multiplet of two olefinic hydrogens at δ 5·74 and in ^{13}C NMR the signals of two sp^2-carbon atoms of the —CH= type at δ 130·46 and 132·21). The alternative structure with the double bond 21(22) can be excluded because the ^1H NMR spectrum contains the signals of three allylic hydrogen atoms at δ 1·96 (2H) and 2·15 (1H) the coupling of which with the olefinic hydrogen atoms was proved by decoupling. The most strongly adsorbed olefin contains a trisubstituted double bond (in the ^1H NMR spectrum a one-proton multiplet at δ 5·05 and in the ^{13}C NMR the signals at δ 153·36 and 118·83, belonging to the sp^2-carbon atoms of the >C= and —CH= type, respectively) to which structure IV was assigned, with a double bond in the position 18(19). The structure of olefin IV was confirmed by its allylic oxidation to α,β-unsaturated ketone *V* according to ref.[15] in 83% yield. In its ^1H NMR spectrum a doublet of the H-19 atom is visible at δ 5·70 (with the allylic coupling $J_{19,13}$ = 1·6 Hz) as well as an isolated AB-system of two hydrogen atoms on $C_{(22)}$ (doublets at δ 2·20 and 2·30, resp., with a characteristic high value of the geminal coupling constant, J = = −18·5 Hz). This unsaturated ketone *V* is also formed in low yield (19%) by allylic oxidation of olefin *III* together with a series of further oxidation products which have not been identified. The dominant ion of the mass spectrum of ketone *V* is the ion *d* (*m*/*z* 177) which is formed by the cleavage of the $C_{(11)}-C_{(12)}$ and $C_{(8)}-C_{(14)}$ bonds in C ring, combined with a hydrogen transfer. Its homologue is ion *e* (*m*/*z* 163) and *f* (*m*/*z* 190) which is formed by cleavage of the C ring without hydrogen transfer.



I



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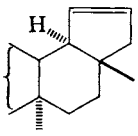

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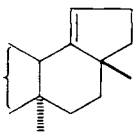

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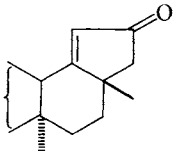
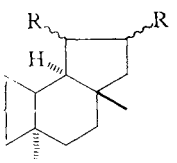
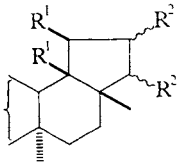


V

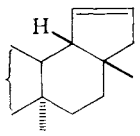
Analogous fragmentation was also found in 3β,28-diacetoxy-18-lupen-21-one[16]. Olefins *III* and *IV* were catalytically hydrogenated. While olefin *III* afforded the expected saturated 18αH-hydrocarbon *VI* (^{1}H and ^{13}C NMR data in Tables I and II), from olefin *IV* a different product was obtained. Addition of hydrogen to the double bond of olefin *IV* evidently takes place from the β-side, similarly as in derivatives with the side chain on $C_{(19)}$ (see refs[3,14,17,18]) under formation of 18βH--hydrocarbon *VII*. In contrast to the study in ref.[2] where the authors describe the formation of 18α and 18β isomers on catalytic hydrogenation of methyl 3β-acetoxy--20,29,30-trinorlup-18-en-28-oate, we could not detect the formation of the 18αH--isomer.



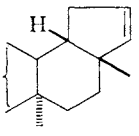
VI, R = H
XVI, R = ^{2}H



VII, $R^1 = R^2 = H$
XVII, $R^1 = {}^2H$, $R^2 = H$
XVIII, $R^1 = H$, $R^2 = {}^2H$



VIII



IX

For the preparation of olefins *VIII* and *IX* we started from α,β-unsaturated ketone *V*. Its hydrogenation on palladium resulted in the formation of saturated ketone *X*. In its ^{1}H NMR spectrum the singlet at δ 2·11 belongs to two protons on $C_{(22)}$ which could not be distinguished from one another even after addition of a shift reagent, tris(1,1,1,2,2,3,3-heptafluoro-7,7-dimethyloctane-4,6-dionato)europium ($Eu(fod)_3$)[21]. For a proof of configuration at $C_{(18)}$ the coupling constants of the H-18 atom at δ 1·92 are important, with hydrogen atoms on $C_{(19)}$ (δ 2·42 and 2·18) and H-13 atom. The observed values of $J_{18,19}$ = 12·0 Hz, $J_{18,19'}$ = 9·1 and especially $J_{18,13}$ = 5·4 Hz, together with the long-range coupling $J_{18,16}$ = 1·6 Hz demonstrate the configuration of 18β-H unambiguously. Reduction of ketone *X* with sodium borohydride gives a mixture of epimeric 21-hydroxy derivatives *XI* and *XII*. Both epimers were separated chromatographically and their configuration determined from the ^{1}H NMR spectra. Although we could identify all the signals of all hydrogens of cycle E in the spectra and determine their coupling constants, the determination of the configuration from these parameters was not unambiguous, owing to the conformational flexibility of the cyclopentane ring. Only the multiplets of the H-19α atom could be assigned configuratively for both epimers on the basis of the high $J_{19\alpha,18}$ value (*trans*, antiperiplanar arrangement of H-18 and H-19). In order to obtain convincing proofs concerning the configuration of the hydroxyl on $C_{(21)}$ we therefore carried out both the *in situ* acylation of the two hydroxy derivatives with trichloroacetyl isocyanate (TAI) in the NMR cell[19,20], under forma-

TABLE I

^{1}H NMR Parameters of 20,29,30-trinorlupane derivatives in deuteriochloroform

Proton	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*
					Methyl protons						
H(23)	0·863	0·850	0·844	0·853	0·843	0·846	0·841	0·847	0·850	0·846	0·846
H(24)	0·800	0·802	0·801	0·810	0·798	0·797	0·796	0·800	0·795	0·797	0·800
H(25)	0·863	0·841	0·872	0·893	0·840	0·836	0·853	0·847	0·840	0·829	0·836
H(26)	1·068	1·035	1·069	1·147	1·025	1·014	0·999	1·002	1·028	0·989	0·993
H(27)	0·915	0·960	0·783	0·816	0·914	0·969	0·901	1·002	0·988	1·009	0·962
H(28)	0·915	0·819	0·994	1·237	0·687	0·994	1·147	1·094	1·184	1·058	1·083
					Other protons[a]						
H(13)	—	[b]	2·22 m	2·66 bd	[b]	[b]	[b]	[b]	2·05 m	[b]	[b]
H(18)	—	2·15 m	—	—	[b]	[b]	1·93—2·27	[b]	1·92 m	[b]	[b]
H(19)	[b]	5·74 m	5·05 bq	5·70 d	[b]	[b]	5·80 m	2·41 m	2·42 dd	1·99 dt	2·08 m
H(19′)	[b]	—	—	—	[b]	[b]	—	2·16 m	2·18 dd	1·79 dt	1·52 m
H(21)	[b]	5·74 m	2·22 m	—	[b]	[b]	5·52 m	5·56 m	—	4·21 m	4·37 m
H(22)	[b]	1·96 m	[b]	2·30 d	[b]	[b]	1·93—2·27	5·62 m	2·11 s	1·84 dd	1·91 dd
H(22′)	[b]	1·96 m	[b]	2·20 d	[b]	[b]	1·93—2·27	—	2·11 s	1·43 dd	1·43 dd

[a] Coupling constants — *III*: $J_{18,13} = 12{\cdot}2$; $J_{18,19} = 2{\cdot}8$; $J_{18,21} = 1{\cdot}7$ Hz; *IV*: $J_{19,13} \approx J_{19,21} \approx J_{19,21'} \approx 2$ Hz; *V*: $J_{13,12} \approx 10$; $J_{13,12'} \neq \neq 0$; $J_{13,19} = 1{\cdot}6$; $J_{22,22'} = -18{\cdot}5$ Hz; *IX*: $J_{19,18} = 10{\cdot}8$; $J_{19,19'} = -16{\cdot}5$; $J_{19,21} = 1{\cdot}5$; $J_{19,22} = 1{\cdot}5$; $J_{19',18} = 8{\cdot}8$; $J_{19',21} = 2{\cdot}6$; $J_{19',22} = 1{\cdot}3$; $J_{21,22} = 5{\cdot}8$ Hz; *X*: $J_{18,13} = 5{\cdot}4$; $J_{18,16} = 1{\cdot}6$; $J_{18,19} = 12{\cdot}0$; $J_{18,19} = 9{\cdot}1$; $J_{19,19'} = -19{\cdot}6$ Hz; *XI*: $J_{19,18} = 7{\cdot}3$; $J_{19,19'} = -12{\cdot}7$; $J_{19,21} = 7{\cdot}1$; $J_{19',18} = 12{\cdot}7$; $J_{19',21} = 7{\cdot}1$; $J_{21,22} = 8{\cdot}6$; $J_{21,22'} = 4{\cdot}8$; $J_{22,22'} = -13{\cdot}7$ Hz; *XII*: $J_{19,18} = 11{\cdot}1$; $J_{19,19'} = -13{\cdot}3$; $J_{19,21} = 7{\cdot}0$; $J_{19',18} = 8{\cdot}0$; $J_{19',21} = 3{\cdot}1$; $J_{21,22} = 6{\cdot}6$; $J_{21,22'} = 5{\cdot}0$; $J_{22,22'} = -13{\cdot}6$ Hz. [b] The value of the parameter could not be determined.

TABLE II

^{13}C NMR Chemical shifts of 20,29,30-trinorlupane derivatives in deuteriochloroform

Carbon	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*
C(1)	40·51	40·32	40·50	40·39	40·36	40·39	40·48	40·41	40·26	40·34	40·39
C(2)	18·69	18·70	18·73	18·61	18·72	18·73	18·73	18·73	18·63	18·70	18·71
C(3)	42·07	42·12	42·10	41·95	42·15	42·14	42·13	42·13	42·03	42·10	42·13
C(4)	33·25	33·28	33·31	33·26	33·29	33·28	33·31	33·30	33·23	33·25	33·28
C(5)	56·51	56·38	56·66	56·51	56·46	56·44	56·20	56·50	56·22	56·33	56·41
C(6)	18·69	18·63	18·61	18·55	18·67	18·68	18·57	18·67	18·59	18·64	18·66
C(7)	34·77	34·02	34·47	34·22	34·14	32·97	33·31	33·14	32·59	32·81	32·91
C(8)	40·78	41·08	40·67	41·17	40·94	41·15	41·12	41·45	41·14	41·20	41·01
C(9)	50·73	50·35	51·27	50·87	50·57	50·67	51·55	51·21	50·62	50·86	51·00
C(10)	37·67	37·52	37·67	37·56	37·55	37·54	37·61	37·60	37·44	37·48	37·53
C(11)	21·14	20·58	20·73	20·20	20·81	21·33	21·58	21·32	20·91	21·17	21·23
C(12)	26·31	26·10	29·64	25·31	26·39	26·73	27·18	26·66	25·86	26·88	26·65
C(13)	130·72	33·80	37·39	39·16	36·83	33·80	35·10	33·80	32·37	33·25	33·34
C(14)	40·61	42·59	42·79	43·22	42·35	41·57	41·60	41·49	41·82	41·74	41·65
C(15)	27·01	27·51	28·28	27·40	27·46	26·83	28·76	27·84	27·81	28·17	28·18
C(16)	33·82	33·56	37·13	36·36	35·20	30·78	31·13	32·47	30·27	32·61	31·92
C(17)	44·24	45·72	45·63	45·46	41·48	40·28	41·25	45·28	38·12	39·41	40·02
C(18)	138·51	52·88	153·36	192·56	47·38	51·06	56·63	50·05	47·13	49·64	48·21
C(19)	27·55	132·21	118·83	126·12	25·49	28·38	134·28	34·89	39·82	37·98	37·40
C(21)	21·57	130·46	25·94	207·99	20·49	22·18	126·58	127·01	219·47	72·47	71·83
C(22)	42·56	47·14	41·53	52·49	40·46	42·25	48·51	143·30	55·58	51·63	52·52
C(23)	33·46	33·40	33·34	33·29	33·41	33·40	33·31	33·39	33·37	33·39	33·40
C(24)	21·66	21·57	21·54	21·50	21·57	21·59	21·55	21·58	21·57	21·57	21·58
C(25)	16·32	15·98	15·80	16·52	15·98	16·15	15·90	16·01	16·22	16·03	16·11
C(26)	17·97	15·98	16·59	15·97	16·09	16·18	16·51	16·25	15·92	16·17	16·16
C(27)	21·22	14·17	14·79	15·04	14·40	15·34	15·12	15·30	15·56	15·99	15·54
C(28)	24·07	18·63	23·73	25·34	17·24	26·39	24·53	25·63	25·06	26·49	26·51

tion of trichloroacetylcarbamoyl (TAC) derivatives XIII and XIV, and the measurement of the ^{1}H NMR spectra of hydroxy derivatives *XI* and *XII* with gradual addition of the lanthanide shift reagent ($Eu(fod)_3$ – see above)[21]. The results of the ^{1}H NMR experiments are summarized in Table III. The TAI-acylation did not affect the coupling constants of the hydrogen atoms of the E ring more distinctly (and hence the conformation), which permitted the interpretation of the induced acylation shifts from the structural point of view. These shifts are – as expected – maximum in the α-position to the hydroxyl group, *i.e.* for H-21 ($\Delta\delta$(TAC) ≈ 0·9).

TABLE III

^{1}H NMR characterization of 21-hydroxy derivatives *XI* and *XII*

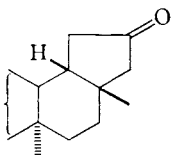
Proton	*XI* (21α-OH)			*XII* (21β-OH)		
	δ_H ($J_{H,H}$)	$\Delta\delta$(TAC)[a]	$\Delta\delta$(LIS)[b]	δ_H ($J_{H,H}$)	$\Delta\delta$(TAC)[c]	$\Delta\delta$(LIS)[b]
H(16)	1·84[d] (13; 13; 4·5)[d]	[e]	47·7	[e]	[e]	[e]
H(18)	[e]	[e]	[e]	1·76[d]	[e]	50·9
H(19)	1·79 (12·7; 12·7; 7·1)	0·20	77·8	2·08 (13·3; 11·1; 7·0)	0·12	37·1
H(19)	1·99 (12·7; 7·3; 7·1)	0·20	51·9	1·52 (13·3; 8·0; 3·1)	0·25	71·3
H(21)	4·21 (8·6; 4·8; 7·1; 7·1)	0·94	100·0	4·37 (6·0; 5·0; 7·0; 3·1)	0·91	100·0
H(22)	1·43 (13·7; 4·8)	0·23	74·7	1·91 (13·6; 6·6)	0·14	39·6
H(22)	1·84 (13·7; 8·6)	0·11	42·9	1·43 (13·6; 5·0)	0·20	68·9
H(23)	0·846	0·004	2·0	0·846	0·003	1·4
H(24)	0·795	0·004	2·2	0·797	0·001	1·6
H(25)	0·829	0·003	3·7	0·836	−0·001	3·2
H(26)	0·989	0·012	7·6	0·993	0·005	7·0
H(27)	1·009	0·037	15·5	0·962	0·020	10·9
H(28)	1·058	−0·012	21·0	1·083	0·025	20·2

[a] TAI-Acylation shifts (δ_H(*XIII*) − δ_H(*XI*)); [b] lanthanide-induced chemical shifts (using $Eu(fod)_3$); relative values are given (for H-21 ≈ 100·0%); [c] TAI-acylation shifts (δ_H(*XIV*) − δ_H(*XII*)); [d] the values were obtained from spectra after addition of $Eu(fod)_3$; [e] the parameters could not be determined.

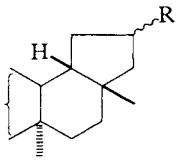
However, from the point of view of the configurational problem the acylation shifts in β-positions are of greater importance, *i.e.* those of the hydrogen atoms on $C_{(19)}$ and $C_{(22)}$, where the dependence on the relative orientation of the hydroxyl and the affected atom becomes apparent (it is known[20] that the acylation shifts are larger in *syn* than in *anti* arrangement). The differing values of $\Delta\delta$(TAC) for hydrogen atoms of both methylene groups were observed in the more polar epimer, while the higher $\Delta\delta$(TAC) values were assigned to the hydrogens *cis*-oriented with respect to OH. The assignment of the signal of H-19α atom carried out earlier permitted the determination of the *trans*-orientation of H-19α with respect to OH and thus the structure *XII* with the 21β-hydroxy for the more polar epimer. In the less polar epimer the differences in the acylation β-shifts are more distinct in hydrogens on $C_{(22)}$, while the hydrogen atoms on $C_{(19)}$ have equal $\Delta\delta$(TAC) (Table III), evidently in consequence of approximately equal dihedral angles of both H-19 with respect of OH. From the models it follows that such a situation occurs evidently in 21α-hydroxy derivative *XI*, where the steric interaction of 21α-OH with the methyl hydrogens H-27 leads to a conformation of type $^{18}T_{19}$ with a *gauche*-arrangement of OH and $C_{(19)}H_2$. Hence, the less polar epimer should have the structure *XI* with a 21α--hydroxy group. This configurational assignment was confirmed unambiguously by the ^{1}H NMR spectra with addition of the shift reagent. The lanthanide-induced shifts found ($\Delta\delta$(LIS)), expressed relatively with respect to the induced shift of H-21 atom, are listed in Table III. In the pairs of the methylene hydrogens on $C_{(19)}$ and $C_{(22)}$ distinctly higher $\Delta\delta$(LIS) were found for hydrogens *cis*-oriented to OH, than for trans-oriented ones. In the case of methyl groups the $\Delta\delta$(LIS) values decrease with the distance from the hydroxyl, and in agreement with the configurational assignment made the $\Delta\delta$(LIS) for methyl hydrogens H-27 is higher in 21α-OH derivative *XI*, where they are closer to the hydroxyl group according to models.

Dehydration of the mixture of hydroxy derivatives *XI* and *XII* with phosphorus oxychloride did not afford olefins, but chloro derivative *XV* was obtained (probably a mixture of epimers). Only when dehydrohalogenated a mixture of the expected olefins *VIII* and *IX* was formed, which were separated by preparative thin-layer chromatography on silica gel impregnated with silver nitrate. The more easily elutable olefin contains a disubstituted double bond (in the ^{1}H NMR spectrum there are the signals of two olefinic hydrogen atoms at δ 5·52 and 5·80 which interact with three allylic hydrogen atoms in the δ 1·93–2·27 region; in the ^{13}C NMR spectrum there are the signals of two sp^2-carbon atoms of the —CH= type at δ 134·28 and 126·58). The presence of three hydrogen atoms in positions next to the double bond leads to its localization into position 19(21), *i.e.* to olefin *VIII*. The more strongly adsorbed olefin also contains a disubstituted double bond (in the ^{1}H NMR spectrum olefinic hydrogen atoms at δ 5·56 and 5·62 and the multiplets of the two allylic hydrogens interacting with them at δ 2·41 and 2·16; in the ^{13}C NMR spectrum the signals of two sp^2-carbon atoms of the —CH= type at δ 143·30 and 127·01).

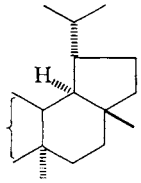
The two hydrogen atoms in the neighbourhood of the double bond indicate its position as 21(22) and confirm the structure *IX*. Since catalytic hydrogenation of olefin *IX* gives the saturated hydrocarbon *VII*, it is evident that the addition of the hydrogen to the double bond of the α,β-unsaturated ketone *V* must proceed from the β-side, the same as in olefin *IV*.



X

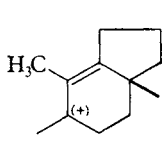


XI, R = α-OH
XII, R = β-OH
XIII, R = α-OCONHCOCCl$_3$
XIV, R = β-OCONHCOCCl$_3$
XV, R = Cl

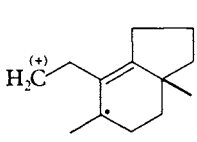


XIX

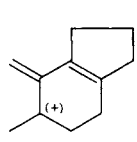
The mass spectra of unsaturated 20,29,30-trinorlupane derivatives *III*, *IV*, *VIII* and *IX* show a very similar fragmentation as in the case of saturated derivatives *VI* and *VII*. The double bond in the E ring does not affect the fragmentation of the pentacyclic skeleton distinctly. In addition to the expected important ion *m/z* 191, belonging to rings A and B, we found in all the spectra of unsaturated derivatives distinct ions *m/z* 147 and *m/z* 161 (except olefin *IV*). In saturated derivatives *VI* and *VII* the ions larger by 2 mass units, *i.e.* with *m/z* 149 and *m/z* 163, correspond to them. These ions are formed by C ring cleavage and they belong to the D and E rings, which was demonstrated by dideuterated derivatives *XVI*–*XVIII*. Their structure is analogous to the ions observed in the mass spectra of methyl 3β-acetoxy--20,29,30-trinorlup-18-ene-28-oate[2] or 3β,28-diacetoxy-20,29,30-trinorlup-18-ene[5]. Different behaviour is displayed by olefin *IV* with the double bond 18(19) where the dominant ion is *g* (*m/z* 162) with the preserved methyl group in position 17 and the corresponding higher homologue *h* (*m/z* 176). The ion *i* (*m/z* 147) is not very



a (*m/z* 163)



b (*m/z* 176)

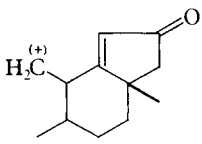


c (*m/z* 147)

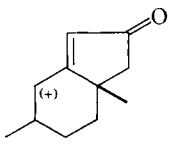
pronounced. From this it may be judged that the splitting off of the methyl group from position 17 is less easy in the case of the double bond 18(19) than in isomeric

olefins *III*, *VIII* and *IX*: The fragmentation of 18-lupene[22] and 3β-acetoxy-18-lupene[14] is in full agreement with this statement. On the other hand, the splitting off of another substituent, different from methyl, from position 17 (for example —$COOCH_3$, ref.[2], or —CH_2OCOCH_3, ref.[5]) is favoured and the ions of type *g* and *h* are absent or are indistinct. From the analysis of the mass spectra of saturated dideuterated derivatives *XVI*–*XVIII* it may be inferred that the E ring remains intact during the fragmentation of the skeleton in the region of higher and medium masses.

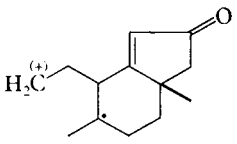
The use of ^1H and ^{13}C NMR spectra of compounds *II*–*XII* for structural identification has already been discussed. Another motive for their NMR study was the fact that they represent a set of 20,29,30-trinorlupane derivatives of which the saturated hydrocarbons *VI* and *VII* represent ideal reference compounds for the study of the effect of substituent in both series of 18αH- and 18βH-lupane derivatives. The unsaturated hydrocarbons described, *II*–*IV*, *VIII* and *IX*, permit the observation of the effect of an introduction of a double bond into position 13(18), 18(19), 19(21) and 21(22), while the ketones *V* and *X*, or hydroxy derivatives *XI* and *XII* show the effect of the introduction of the carbonyl or the hydroxyl group into position 21.



d (*m*/*z* 177)

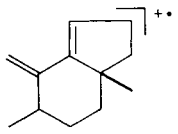


e (*m*/*z* 163)

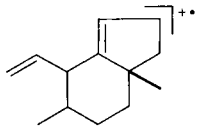


f (*m*/*z* 190)

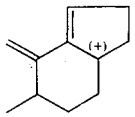
In the ^1H NMR spectra of triterpenes the chemical shifts of the methyl groups represent important NMR parameters. In order to determine the effect of substitution the methyl groups must be assigned reliably. In our case, we based our considerations on: *a*) unambiguously assigned signals of the methyl groups in lupane (*XIX*)[23], *b*) the assumption of the decreasing effect of substitution with distance, *c*) the use of $Eu(fod)_3$ in the case of oxygen-containing compounds *V*, *X*–*XII*. The chemical



g (*m*/*z* 162)



h (*m*/*z* 176)



i (*m*/*z* 147)

shifts of structurally assigned methyl groups (with an about ±0·002 ppm accuracy) are given in Table I. When using hydrocarbons *VI* and *VII* as reference compounds

the substitution effects are expressed in Table IV, and the effect of the change of configuration on $C_{(18)}$. In view of the occurrence of substituents in the E ring (only in *II* they are in the D ring) it is not surprising that more distinct effects ($\geqq$0·05 ppm) are as a rule observed only in the case of methyl group hydrogen atoms H-27 and H-28. The change of configuration on $C_{(18)}$ is manifested by a distinct shift (0·31 ppm) of the methyl group hydrogen atoms H-28 in 18βH-derivatives with a *cis*-annellated five-membered ring.

The ^{13}C NMR data of triterpenes with a lupane skeleton are described in refs[23-29] for about 50 compounds, which, however, do not include 20,29,30-trinorlupane derivatives. When assigning the carbon atom signals in compounds *II*–*XII* we started from *a*) a described complete assignment in lupane (*XIX*)[23], *b*) the information concerning the number of directly bonded hydrogens (APT spectra[30]), *c*) the assumption of decreasing effect with increasing distance, *d*) approximately known values of the effect of substituents. The structurally assigned ^{13}C chemical shifts in compound *II*–*XII* are given in Table II. Similarly as in the case of ^1H NMR spectra we expressed the effects of substitution on the chemical shifts of saturated carbon atoms by using reference compounds *VI* and *VII* (Table V). Since the effect on the carbon atoms of the A and B rings and the methyls 23, 24 and 25 is generally $\leqq$0·3 ppm, these carbon atoms are not included in the table. The most distinct downfield effects appear in the closest proximity of the substitution (α- or β-positions). The change of configuration on $C_{(18)}$ is most prononuced on the methyl carbon atom $C_{(28)}$ (downfield shift by 9·2 ppm in *VII* in comparison with *VI*);

TABLE IV
Substituent effects on methyl proton signals

Methyl protons	18αH-Series[a]						18βH-Series[b]				
	19α-iPr	$\Delta^{13(18)}$	Δ^{18}	Δ^{18}, 21-oxo	$\Delta^{19(21)}$	18β→18α[c]	$\Delta^{19(21)}$	Δ^{21}	21-oxo	21α-OH	21β-OH
	XIX	*II*	*IV*	*V*	*III*	*VII*–*VI*	*VIII*	*IX*	*X*	*XI*	*XII*
H(23)	0·00	0·02	0·00	0·01	0·01	0·00	0·00	0·00	0·00	0·00	0·00
H(24)	0·00	0·00	0·00	0·01	0·00	0·00	0·00	0·00	0·00	0·00	0·00
H(25)	0·00	0·02	0·03	0·05	0·00	0·00	0·02	0·01	0·00	0·01	0·00
H(26)	0·01	0·04	0·04	0·12	0·01	−0·01	−0·01	−0·01	0·01	−0·02	−0·02
H(27)	0·02	0·00	−0·13	−0·10	0·05	0·05	−0·07	0·03	0·02	0·04	−0·01
H(28)	0·07	0·23	0·31	0·55	0·13	0·31	0·15	0·10	0·19	0·06	0·09

[a] Reference compound *VI*; [b] reference compound *VII*; [c] the effect of configuration change from 18αH to 18βH (defined as $\delta_H(VII)-\delta_H(VI)$).

a similar effect of the ring annellation is described[31] for example for the pair *cis*- and *trans*-9-methyldecalin. Further more distinct effects (>1 ppm) on carbon atoms 13, 16–19, 21 and 22 also depend on the change of annellation of the D and E rings. The chemical shifts of the ^{13}C atoms in hydrocarbons *VI* and *VII* and the substitution effects observed (Table IV and V) can be used either for the structure elucidation or for the study of the substitution effects in other lupane derivatives.

EXPERIMENTAL

The melting points were determined on a Kofler block and they are not corrected. Optical rotations were measured in chloroform (*c* 0·3–0·7) on an automatic ETL-NPL (Bendix–Ericsson) polarimeter, with a ±2° accuracy. The infrared spectra were measured in chloroform (unless stated otherwise) on a UR-20 (Zeiss, Jena) spectrophotometer, or a PE 684 (Perkin–Elmer) instrument. The ultraviolet spectrum was recorded on an SP 700 (Unicam) instrument, in ethanol, the CD spectra on a Roussel–Jouan 185 dichrographe in dioxane. The NMR spectra were measured on an FT-NMR spectrometer Varian XL-200 (^1H, 200 MHz; ^{13}C, 50·31 MHz) in deuterio-

TABLE V

Substituent effects at saturated carbons of rings C, D and E and their methyl carbons

	18αH-Series[a]						18βH-Series[b]				
Atom	19α-iPr	$\Delta^{13(18)}$	Δ^{18}	Δ^{18}, 21-oxo	$\Delta^{19(21)}$	18β-18α[c]	$\Delta^{19(21)}$	Δ^{21}	21-oxo	21α-OH	21β-OH
	XIX[d]	*II*	*IV*	*V*	*III*	*VII*–*VI*	*VIII*	*IX*	*X*	*XI*	*XII*
C(8)	0·2	−0·2	−0·3	0·2	0·1	0·2	0·0	0·3	0·0	0·0	−0·1
C(9)	−0·3	0·2	−0·3	0·3	−0·2	0·1	0·9	0·5	−0·1	0·2	0·3
C(11)	0·1	0·3	−0·1	−0·6	−0·2	0·5	0·2	0·0	−0·4	−0·2	−0·1
C(12)	0·1	−0·1	0·2	−1·1	−0·3	0·3	0·4	−0·1	−0·9	0·1	−0·1
C(13)	1·0	—	0·6	2·3	0·0	−3·0	1·3	0·0	−1·4	−0·5	−0·5
C(14)	0·7	−1·7	0·4	0·9	0·2	−0·8	0·0	−0·1	0·2	0·2	0·1
C(15)	−0·1	−0·5	0·8	−0·1	0·0	−0·6	1·9	1·0	1·0	1·3	1·3
C(16)	0·4	−1·4	1·9	1·2	0·4	−4·4	0·3	1·7	0·5	1·8	1·1
C(17)	1·6	2·8	4·1	4·0	4·2	−1·2	1·0	5·0	−2·2	−0·9	−0·3
C(18)	0·3	—	—	—	5·5	3·7	5·6	−1·0	−3·9	−1·4	−2·8
C(19)	19·3	2·1	—	—	—	2·9	—	6·5	11·4	9·6	9·0
C(21)	1·4	1·1	5·1	—	—	1·7	—	—	—	50·3	49·6
C(22)	0·0	2·1	1·1	12·0	6·7	1·8	6·3	—	13·3	9·4	10·3
C(26)	0·0	1·9	0·5	0·4	−0·1	0·1	0·3	0·1	−0·3	0·0	0·0
C(27)	0·1	6·8	0·4	0·6	−0·2	0·9	0·2	0·0	0·2	0·6	0·2
C(28)	0·8	6·8	6·5	8·1	1·4	9·2	−1·9	−0·8	−1·3	0·1	0·1

[a] Reference compound *VI*; [b] reference compound *VII*; [c] the effect of configuration change from 18αH to 18βH (defined as $\delta_c(VII)-\delta_c(VI)$); [d] data taken from ref.[23].

chloroform, using tetramethylsilane as internal reference. The chemical shifts and the coupling constants of hydrogens were obtained by 1st order analysis from expanded spectra (1—2 Hz/cm), using a weighing function for increasing resolution. The TAI-acylations were carried out by adding a slight excess of trichloroacetyl isocyanate to a solution of hydroxy derivative in chloroform in an NMR cell (according to ref.[20]). The ^{1}H NMR experiments with the shift reagent were carried out by gradual addition of small amounts of $Eu(fod)_3$ (without weighing it) to a solution of hydroxy derivative in deuteriochloroform, and the spectrum was recorded after each addition. A linear dependence of the induced shift on the amount of $Eu(fod)_3$ was found for all assignable signals (adjusted *via* the H-21 signal), and the values of the induced shifts were expressed relatively with respect to the H-21 shift (100%). The chemical shifts of the ^{13}C atoms and the information on the number of directly bonded hydrogen atoms were obtained from "proton decoupled attached proton test" spectra[30]. The mass spectra were measured on a Varian MAT 311 instrument at 70 eV energy of the ionizing electrons and 1 mA of the ionizing current. The ion source temperature was 200°C and the temperature of the direct inlet system 80—200°C. The mentioned composition of the ions was checked by means of high resolution, with an error smaller than 5 ppm. Chromatography was carried out on neutral alumina (Reanal, activity II) or silica gel (Silpearl, Kavalier). For preparative thin-layer chromatography (PTLC) silica gel Merck 60 G was used, 10 g per a 20 × 20 cm plate, layer thickness 0·7 mm. Detection was carried out in UV light (254 nm) after spraying the plate with a 0·2% solution of morin in methanol. Analytical samples were dried over phosphorus pentoxide at 100°C in a vacuum. Under "conventional work-up" the following procedure is understood: dilution of the mixture with water, extraction with ether, washing of the extract with dilute hydrochloric acid (1 : 4), then 5% sodium carbonate solution, drying over sodium sulfate and evaporation to dryness. Deuterium for hydrogenation was obtained by heavy water (99·9% ^2H_2O) electrolysis; tris(triphenylphosphine)rhodium chloride was prepared according to ref.[32]. The acetone used in deuterations did not contain any deuterium (proof by high resolution mass spectrometry).

Reaction of 19α-Acetylamino-20,29,30-trinorlupane (*I*) with Nitrous Acid

Sodium nitrite (3 g) was added to a solution of amide *I* (0·86 g; prepared according to ref.[10]) in a mixture of acetic acid (8 ml) and acetic anhydride (40 ml). The addition was carried out under cooling for 5 h, so that the temperature did not exceed 0°C. After 24 h standing at 0°C the mixture was poured onto ice and submitted to the conventional work-up. The residue was dissolved in light petroleum and freed from the polar components by filtering it through a layer of alumina. The mixture obtained (0·79 g) was chromatographed on silica gel (55 g) impregnated with 5% silver nitrate. Light petroleum (100 ml) eluted 50 mg of olefin *II*, m.p. 169—170°C and after resolidification 173—175°C (ether–hexane), $[\alpha]_D$ −37°C. Mass spectrum, *m/z* (%): 368 (M^+, 27), 353 (6), 215 (8), 205 (24), 192 (55), 191 (87), 187 (41), 177 (100), 164 (64). For $C_{27}H_{44}$ (368·6) calculated: 87·97% C, 12·03% H; found: 87·73% C, 11·75% H. Further elution using a mixture of light petroleum with 1% of ether (1 200 ml) gave 100 mg of olefin *III*, m.p. 170 to 171°C (hexane), $[\alpha]_D$ +76°. IR spectrum (CCl_4): 3 060, 710, 680 cm^{-1} (—CH=CH—). Mass spectrum, *m/z* (%): 368 (M^+, 16), 353 (9), 327 (7), 231 (11), 191 (95), 176 (17), 161 (35), 147 (100). For $C_{27}H_{44}$ (368·6) calculated: 87·97% C, 12·03% H; found: 88·02% C, 11·80% H. — Elution with the same mixture (600 ml) gave 610 mg of olefin *IV*, m.p. 195—196°C (ether–hexane), $[\alpha]_D$ −26°. IR spectrum (CCl_4): 3 053, 1 655, 698 cm^{-1} (—CH=CH—). Mass spectrum, *m/z* (composition, %): 368 (M^+, $C_{27}H_{44}$, 29), 353 (14), 312 ($C_{23}H_{36}$, 2·5), 259 (17), 215 (12), 191 (76), 176 (65), 162 ($C_{11}H_{15}$, 100), 147 (82). For $C_{27}H_{44}$ (368·6) calculated: 87·97% C, 12·03% H; found: 87·92% C, 12·23% H.

20,29,30-Trinorlupane (*VI*)

A solution of olefin *III* (70 mg) in ethyl acetate (50 ml) was hydrogenated on Adams catalyst. After filtration off of the catalyst and concentration of the filtrate 40 mg of hydrocarbon *VI* crystallized out, m.p. 187·5–188·5°C, $[\alpha]_D$ +18°. IR spectrum: characteristic of a hydrocarbon. Mass spectrum, *m/z* (%): 370 (M^+, 40), 355 (20), 314 (2), 259 (3), 232 (9), 217 (11), 191 (100), 177 (17), 176 (11), 163 (23), 149 (47). For $C_{27}H_{46}$ (370·6) calculated: 87·49% C, 12·51% H; found: 87·69% C, 12·44% H.

20,29,30-Trinor-18β-lupane (*VII*)

a) Hydrogenation of olefin *IV* (180 mg) was carried out in the same manner as in the case of olefin *III*. Yield, 160 mg of hydrocarbon *VII*, m.p. 193–194°C (ethyl acetate), $[\alpha]_D$ 0°. IR spectrum: characteristic of a hydrocarbon. Mass spectrum, *m/z* (%): 370 (M^+, 37), 355 (17), 314 (2), 232 (6), 217 (6), 206 (8), 191 (100), 177 (15), 176 (15), 163 (27), 149 (42). For $C_{27}H_{46}$ (370·6) calculated: 87·49% C, 12·51% H; found: 87·70% C, 12·58% H.

b) Hydrogenation of olefin *IX* (40 mg) carried out in the same manner as of olefin *III* gave hydrocarbon *VII* (20 mg), m.p. 193–194°C (ethyl acetate), $[\alpha]_D$ 0°.

20,29,30-Trinorlup-18-en-21-one (*V*)

a) Chromium trioxide-pyridine complex[15] (2 g) was added to a solution of olefin *IV* (150 mg) in dichloromethane (30 ml) and the mixture was shaken for 22 h. After conventional work-up the residue was separated by PTLC in light petroleum–ether (4 : 1). Yield, 130 mg of ketone *V*, m.p. 213–214·5°C (light petroleum), $[\alpha]_D$ −117°. UV spectrum: λ_{max} 228 nm ($\log \varepsilon = 4{\cdot}25$). IR spectrum: 1 678, 1 608 (C=C—C=O), 1 410 cm^{-1} (α-CH_2). CD (c 1·6 . 10^{-3} mol l^{-1}) λ_{max} ($\Delta\varepsilon$): 346 nm (−1·3), 331 nm (−2·9), 319 nm (−3·1), 235 nm (−10·2). Mass spectrum, *m/z* (composition, %): 382 (M^+, 90), 367 (17), 364 (4), 245 (21), 205 (32), 192 (34), 191 (75), 190 ($C_{13}H_{18}O$, 63), 178 (55), 177 ($C_{12}H_{17}O$, 100), 163 ($C_{11}H_{15}O$, 54). For $C_{27}H_{42}O$ (382·6) calculated: 84·75% C, 11·07% H; found: 84·70% C, 11·30% H.

b) A solution of olefin *III* (100 mg) in dichloromethane (20 ml) was oxidized with the chromium trioxide–pyridine complex (1 g) under the same conditions as olefin *IV*. The residue was separated by PTLC in light petroleum–ether (4 : 1). 20 mg of ketone *V* could be isolated, m.p. 210–212°C (benzene–ethanol), $[\alpha]_D$ −117°.

20,29,30-Trinor-18β-lupan-21-one (*X*)

A solution of the α,β-unsaturated ketone *V* (1·7 g) in benzene (15 ml) was diluted with ethanol (150 ml) and after addition of catalyst (10% of palladium on charcoal) the mixture was shaken under hydrogen for 24 h. The catalyst was filtered off and the filtrate evaporated. The residue was chromatographed on silica gel (100 g). Elution with light petroleum–ether (9 : 1) mixture (600 ml) gave 1·6 g of ketone *X*, m.p. 165–167°C (ether–light petroleum), $[\alpha]_D$ −52°. IR spectrum: 1 742 (five-membered ketone), 1 410 cm^{-1} (α-CH_2). CD (c 3·8 . 10^{-3} mol l^{-1}) λ_{max} ($\Delta\varepsilon$): 298 nm (−2·4). Mass spectrum, *m/z* (%): 384 (M^+, 100), 369 (32), 366 (10), 328 (5), 260 (4), 231 (4), 206 (12), 191 (85). For $C_{27}H_{44}O$ (384·6) calculated: 84·31% C, 11·53% H; found: 84·41% C, 11·27% H.

20,29,30-Trinor-18β-lupan-21α-ol (*XI*) and
20,29,30-Trinor-18β-lupan-21β-ol (*XII*)

Sodium borohydride (1·3 g) was added to a solution of ketone *X* (1·3 g) in benzene (10 ml) and

ethanol (50 ml) and the mixture was allowed to stand at room temperature for 24 h. The conventional work-up gave a crude product (1·3 g) which was separated chromatographically on silica gel (100 g). Elution with a mixture of light petroleum with 10% of ether (2900 ml) gave the less polar epimer *XI* (1·04), m.p. 224–225°C (ether–light petroleum), $[\alpha]_D$ −1·7°. IR spectrum: 3 614, 1 045 cm^{-1} (OH). Mass spectrum, *m/z* (%): 368 (M^+, 30), 384 (14), 371 (6), 369 (10), 368 (11), 353 (6), 327 (11), 221 (13), 206 (13), 191 (100). For $C_{27}H_{46}O$ (386·6): calculated: 83·87% C, 11·99% H; found: 83·85% C, 12·23% H. Elution with the same solvent mixture (970 ml) gave a mixture of epimeric alcohols *XI* and *XII* (160 mg) and further elution with the same solvent mixture (1 040 ml) gave the more polar epimer *XII* (90 mg), m.p. 234–236°C (ether–light petroleum), $[\alpha]_D$ +5·2°. IR spectrum: 3 614, 1 029 cm^{-1} (OH). Mass spectrum, *m/z* (%): 386 (M^+, 16), 384 (12), 371 (11), 369 (10), 368 (9), 353 (5), 329 (16), 206 (11), 191 (100). For $C_{27}H_{46}O$ (386·6) calculated: 83·87% C, 11·99% H; found 83·97% C, 11·88% H.

20,29,30-Trinor-18β-lup-19-ene (*VIII*) and
20,29,30-Trinor-18β-lup-21-ene (*IX*)

A mixture of alcohols *XI* and *XII* (195 mg) was dissolved in pyridine (15 ml) and phosphorus oxychloride (5 ml) was added to it. After heating over a boiling water bath for 3 h the mixture was decomposed with ice and submitted to conventional work-up to give chloro derivative *XV* (160 mg), m.p. 166–173°C (light petroleum). Mass spectrum, *m/z* (composition, %): 404 (M^+, $C_{27}H_{45}Cl$, 9), 389 (4), 368 ($C_{27}H_{44}$, 37), 353 (12), 327 (5), 259 (5), 231 (11), 191 (100), 176 (31), 162 (41), 147 (80).

Lithium chloride (2 g) was added to a solution of chloro derivative *XV* (160 mg) in dimethylformamide (50 ml) and the mixture was refluxed for 4 h. After conventional work-up the product was separated by PTLC (silica gel with 5% silver nitrate) in light petroleum–ether (98 : 2), giving the more easily elutable olefin *VIII* (22 mg) and the more strongly adsorbed olefin *IX* (102 mg). Olefin *VIII* had m.p. 163–164°C (ether–methanol). $[\alpha]_D$ −55°. IR spectrum (CCl_4): 3 051, 1 605, 687, 676 cm^{-1} (—CH=CH—). Mass spectrum, *m/z* (composition, %): 368 (M^+, $C_{27}H_{44}$, 33), 353 (7), 327 ($C_{24}H_{39}$, 10), 231 (11), 215 (5), 191 (92), 161 (33), 147 (100). For $C_{27}H_{44}$ (368·6) calculated: 87·97% C, 12·03% H; found: 88·10% C, 11·85% H. Olefin *IX* had m.p. 152–153·5°C (ether–methanol), $[\alpha]_D$ −35°. IR spectrum (CCl_4): 3 041, 1 609, 690 cm^{-1} (—CH=CH—). Mass spectrum, *m/z* (composition, %): 368 (M^+, $C_{27}H_{44}$, 42), 353 (25), 327 (2), 215 (8), 191 (100), 161 (26), 147 (72). For $C_{27}H_{44}$ (368·6) calculated: 87·97% C, 12·03% H; found: 87·94% C, 11·91% H.

20,29,30-Trinor(19,21-$^2H_2$)lupane (*XVI*)

Olefin *III* (30 mg) and tris(triphenylphosphine)rhodium chloride (30 mg) were dissolved in acetone (6 ml) and the mixture was stirred under deuterium in a hydrogenation apparatus for 18 h. The mixture was then evaporated and the deuterated product was separated by PTLC (silica gel with 10% silver nitrate) in light petroleum–ether (18 : 1). After crystallization from a mixture of light petroleum and ether 17 mg (56%) of dideuterio derivative *XVI* were obtained, m.p. 181–185°C, $[\alpha]_D$ +23°. Mass spectrum, *m/z* (%): 372 (M^+, 38), 357 (13), 316 (3), 261 (3), 234 (9), 219 (10,) 206 (5), 191 (100), 177 (13), 165 (14), 151 (35).

20,29,30-Trinor-18β-(18,19-$^2H_2$)lupane (*XVII*)

Olefin *IV* (20 mg) and tris(triphenylphosphine)rhodium chloride (20 mg) were dissolved in acetone (5 ml) and deuterated and then worked up in the same manner as in the case of olefin *III*. Crystallization from a mixture of light petroleum and ether gave 10 mg (50%) of dideuterio derivative

XVII, m.p. 186–189°C, $[\alpha]_D$ +2°. Mass spectrum, *m/z* (%): 372 (M^+, 29), 357 (15), 316 (3), 261 (4), 234 (9), 219 (10), 206 (7), 205 (7), 191 (100), 177 (16), 165 (16), 151 (36).

20,29,30-Trinor-18β-(21,22-$^2H_2$)lupane (*XVIII*)

Olefin *IX* (27 mg) and tris(triphenylphosphine)rhodium chloride (27 mg) were deuterated in acetone (6 ml) for 18 h and then processed as in the case of olefin *III*. Crystallization from a mixture of light petroleum and ether gave 15 mg (55%) of dideuterio derivative *XVIII*, m.p. 187 to 191 C, $[\alpha]_D$ +6°. Mass spectrum, *m/z* (%): 372 (M^+, 38), 357 (13), 316 (3), 261 (3), 234 (6), 219 (6), 206 (10), 191 (100), 177 (14), 165 (15), 151 (31).

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REFERENCES

1. Vystrčil A., Budějínský M.: This Journal *35*, 295 (1970).
2. Aplin R. T., Chan R. P. K., Halsall T. G.: J. Chem. Soc. C *1969*, 2322.
3. Suokas E., Hase T.: Acta Chem. Scand. B*28*, 793 (1974).
4. Baddeley G. V., Eade R. A., Ellis J., Harper P., Simes J. J. H.: Tetrahedron *25*, 1643 (1969).
5. Pouzar V., Protiva J., Lisá E., Klinotová E., Vystrčil A.: This Journal *40*, 3046 (1975).
6. Kolc J.: *Thesis*. Charles University, Prague 1961.
7. Ruzicka L., Huber W., Jeger O.: Helv. Chim. Acta *28*, 195 (1945).
8. Djerassi C., Hodges R.: J. Amer. Chem. Soc. *78*, 3534 (1956).
9. Davy G. S., Jones E. R. H., Halsall T. G.: Rec. Trav. Chim. Pays-Bas *69*, 368 (1950).
10. Vystrčil A., Křeček V., Protiva J., Budějínský M.: This Journal *51*, 581 (1986).
11. White E. H.: J. Amer. Chem. Soc. *77*, 6011 (1955).
12. Budzikiewicz H., Wilson J. M., Djerassi C.: J. Amer. Chem. Soc. *85*, 3688 (1963).
13. Vystrčil A., Křeček V., Protiva J.: unpublished results.
14. Suokas E., Hase T.: Acta Chem. Scand. B*31*, 633 (1977).
15. Dauben W. G., Lorber M., Fullerton D. S.: J. Org. Chem. *34*, 3587 (1969).
16. Sejbal J.: unpublished results.
17. Klinotová E., Protiva J., Klinot J., Vystrčil A.: This Journal *49*, 141 (1984).
18. Suokas E., Hase T.: Acta Chem. Scand. B*31*, 231 (1977).
19. Goodlett V. W.: Anal. Chem. *37*, 431 (1965).
20. Samek Z., Budějínský M.: This Journal *44*, 558 (1979).
21. Reuben J.: Prog. Nucl. Magn. Reson. Spectrosc. *9*, 1 (1975).
22. Sejbal J., Klinot J., Vystrčil A.: This Journal, in press.
23. Ammann W., Richarz R., Wirthlin T., Wendisch D.: Org. Mag. Res. *20*, 260 (1982).
24. Wenkert E., Baddeley G. V., Burfitt I. R., Moreno L. N.: Org. Mag. Res. *11*, 337 (1978).
25. Carpenter R. C., Sotheeswaran S., Sultanbawa M. U. S., Ternai B.: Org. Mag. Res. *14*, 462 (1980).
26. Blunt J. W., Munro M. H. G.: Org. Mag. Res. *13*, 26 (1980).
27. Sholichin M., Yamasaki K., Kasai R., Tanaka O.: Chem. Pharm. Bull. *28*, 1006 (1980).
28. Dantanarayana A. P., Kumar N. S., Muthukuda P. M., Wazzer H. I. M.: Phytochemistry *21*, 2065 (1982).
29. Monaco P., Previtera L.: J. Natural. Prod. *47*, 673 (1984).
30. Le Cocq C., Lallemand J.- Y.: J. Chem. Soc., Chem. Commun., *1981*, 150.
31. Dalling D. K., Grant D. M., Paul E. G.: J. Amer. Chem. Soc. *95*, 3718 (1973).
32. Osborne J. A., Jardine F. H., Young J. F., Wilkinson G.: J. Chem. Soc. *1966*, 1711.

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