ON TERPENES. CCXXIII.*

THE STRUCTURE OF NEMOSENINS A, B, C, D, AND SENEMORIN, NEW FUROEREMOPHILANE DERIVATIVES FROM *Senecio nemorensis*, subsp. *fuchsii*

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From the light petroleum extract of the rhizomes of *Senecio nemorensis*, subsp. *fuchsii* five new furoeremophilane derivatives have been isolated to which the following structures were assigned on the basis of chemical and physical evidences: for nemosenin A 1β,10β-epoxy-3β-hydroxy-6β-angelyloxyfuroeremophilane, for nemosenin B 1β,10β-epoxy-3β-hydroxy-6β-dihydroangelyloxyfuroeremophilane, for nemosenin C 1β,10β-epoxy-3β-hydroxy-6β-isobutyryloxyfuroeremophilane, for nemosenin D 1β,10β-epoxy-3β-acetoxy-6β-isobutyryloxyfuroeremophilane, and for senemorin 1β,10β-epoxy-6β-angelyloxyfuroeremophilane. Of known eremophilanes 6β-hydroxyeremophilenolide (*XXIV*) has been isolated.

As was shown earlier, the quantitatively most important components of the light petroleum extracts of the rhizomes of various species of the *Senecioneae* tribe, *Asteraceae* family, are substances of the eremophilane type[1–4]. Up to the present time numerous species of the genera *Petasites* and *Ligularia* have been investigated, as well as representatives of the genera *Adenostyles*, *Homogyne*, *Cacalia* and *Euryops*[1]. However, the members of the most numerous genus, *Senecio*, have not yet been investigated. In this paper we present the proofs of the structures of nemosenins A, B, C, D (*I*–*IV*), and senemorin (*V*), which represent the most quantitatively important part of the light petroleum extract of the rhizomes of *Senecio nemorensis*, subsp. *fuchsii*, which is the most widespread species in Czechoslovakia.

On the basis of molecular formulas, IR, UV, and mass spectra (Table I) it was possible to assume that all three nemosenins contain a furan nucleus, an oxide group, a free hydroxyl, and an ester group. In the case of nemosenin A (*I*) the ester group is C_5-α,β-unsaturated, in nemosenin B (*II*) it is C_5-saturated, and in nemosenin C (*III*) it is C_4-saturated. The PMR spectra of nemosenins A, B, and C contained characteristic signals of one tertiary and one secondary C-methyl group and one C-methyl group of the type CH_3—C=CH—O (Table II). Hence, in view of previous

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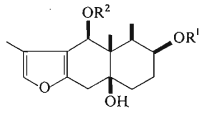
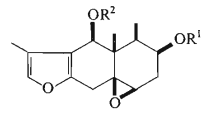
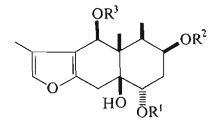
conclusions it could be supposed that they are substances of the furoeremophilane type. This supposition was confirmed by a detailed analysis of the PMR spectra from which it also followed that nemosenin A is 1β,10β-epoxy-3-hydroxy-6-angelyloxy-furoeremophilane (*I*), nemosenin B is 1β,10β-epoxy-3-hydroxy-6-dihydroangelyl-oxyfuremophilane (*II*), and nemosenin C is 1β,10β-epoxy-3-hydroxy-6-isobutyryl-oxyfuroeremophilane (*III*).







X, $R^1 = R^2 = H$
XI, $R^1 = R^2$ = acetyl

I, $R^1 = H$; R^2 = angelyl
II, $R^1 = H$; R^2 = dihydroangelyl
III, $R^1 = H$; R^2 = isobutyryl
IV, R^1 = acetyl; R^2 = isobutyryl
VIII, $R^1 = R^2 = H$
IX, $R^1 = R^2$ = acetyl

VI, $R^1 = R^2 = R^3 = H$
VII, $R^1 = R^2 = R^3$ = acetyl

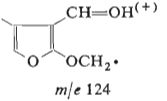
TABLE I
Characterisation of Nemosenins and Senemorin

Compound	IR[a] cm^{-1}	UV, λ nm[b] log ε	Mass spectra	$[\alpha]_D^{25}$[a] (R_F)
I (angelyl)	1 156, 1 565, 1 646, 1 709, 3 490, 3 600	220 (4·09)	346, 246, 100, 83, 55	−35·3° (0·57)[c]
II (dihydroangelyl)	1 157, 1 566, 1 724, 3 490, 3 600	218 (3·76)	348, 102, 85, 57	−19·0° *n* (0·555)[c]
III (isobutyryl)	1 157, 1 566, 1 724, 3 490, 3 600	218 (3·75)	334, 246, 264	−34·4° (0·52)[c]
IV (isobutyryl, acetyl)	1 255, 1 728, 1 562	217 (3·83)	376, 228, 88, 60	−27·5°[e] (0·10)[d]
V (angelyl)	1 158, 1 565, 1 645 1 705	219 (4·11)	330, 230	−20·2° (0·45)[d]

[a] In chloroform; [b] in ethanol; [c] thin-layer chromatography on silica gel G according to Stahl, developing solvent light petroleum–ether 6 : 4, fivefold elution; [d] light petroleum–ether (9 : 1); [e] m.p. 134—135°C.

The PMR spectra of nemosenins A, B, C differed distinctly from one another only by the signals of the O-acyl groups. The structure of nemosenins A, B and C followed from these facts: α-proton of the furan nucleus produced a complex signal at 7·06 p.p.m. and in addition to the usual allylic coupling with the methyl protons H_{13} ($^4J_{12,13} \approx 1{\cdot}3$ Hz) it displayed two side-chain interactions with two protons forming two broadened doublets at 3·20 and 2·20 p.p.m. The assignment, of these protons to the allylic position $C_{(9)}$ followed both from the magnitude of their coupling $J = 17-18$ Hz, which corresponds to a geminal coupling, with the increased $\sigma - \pi$ interaction, and the absence of significant long-range coupling of these protons with H_{13}. The presence of an acyloxy group in the second allylic position followed from the presence of the quartet of the protons of RO—CH type at 6·4 p.p.m. with two small coupling constants corresponding to homoallylic couplings with protons on $C_{(9)}$ (ref.[5-7]). From the absence of the vicinal couplings of protons on $C_{(9)}$ it further followed that the carbon atom $C_{(10)}$ must be tetrasubstituted. In the case of nemosenin B the secondary nature of the hydroxyl was confirmed directly from the comparison of its PMR spectrum with the spectrum of its adduct with trichloroacetylisocyanate prepared by the conventional *in situ* reacion[8]. From this comparison the assignment of the characteristic octet of one methine proton CH—OH followed which occurred in all three cases at 4·21 to 4·27 p.p.m. (Table II*a*). The multiplet of this proton indicated the presence of three vicinal interactions (Table II) and, therefore, also the presence of a fragment of the type —CH_2CH(OH)—CH<. Supposing that nemosenins A, B, and C have a furoeremophilane skeleton, which by itself does not follow *a priori* from the determination of the nature of the carbon atoms, an oxide ring must go out from the $C_{(10)}$ atom and close at $C_{(1)}$ or $C_{(2)}$ or $C_{(3)}$ atom. However, the methine protons of the oxide ring may form a doublet at 3·09—2·12 p.p.m. (Table I), and from the absence of a significant interaction with proton CH—OH both the connection of the oxide with $C_{(1)}$ and the position of the hydroxyl on $C_{(3)}$ followed.

The structures of nemosenins A, B, and C were also corroborated by chemical correlations. The saponification of nemosenins A, B, and C with aqueous-ethanolic sodium hydroxide gave in all instances tetrol *VI* in a low yield, giving amorphous triacetate *VII* of the composition $C_{21}H_{28}O_8$. The determination of active hydrogen indicated the presence of four hydroxy groups, and hence, the opening of the epoxide to a vicinal diol, which was further confirmed by oxidative polarographic determination[7,10] with KIO_4. The mass spectrum of tetrol *VI* indicated – in agreement with the presence of the hydroxy group on $C_{(6)}$ – the presence of fragment *a* (*m/e* 124) which we have already found earlier in the mass spectra of some furoeremophilane substances[1].



m/e 124

a

We obtained the ordinary saponification product (*VIII*) of nemosenins A, B, and C when using methanolic barium hydroxide solution for hydrolysis. On reduction of nemosenins A, B, and C with lithium tetrahydridoaluminate in tetrahydrofuran we obtained quantitatively the triol *X*. Its acetylation with acetic anhydride in pyri-

TABLE II

Characteristic Parameters of PMR (100 MHz, first-order analysis)
a) Chemical shifts (δ(TMS)-values).

Comp.	H_1	$H_2{}^a$	$H_2{}^{a'}$	H_3	$H_4{}^a$	H_6	$H_9{}^a$	$H_9{}^{a'}$	H_{12}	H_{13}	H_{14}	H_{15}
I[b,c]	3·12	2·15	1·95	4·27	1·80	6·45	3·21	2·23	7·06	1·80	1·01	1·25
II[b,d]	3·09	2·22	1·94	4·21	1·60	6·37	3·20	2·21	7·06	1·85	1·00	1·24
III[b,e]	3·09	2·22	1·94	4·21	1·56	6·36	3·19	2·22	7·06	1·83	1·01	1·24
IV[b,f]	3·08	2·42	1·94	5·16	1·80	6·39	3·19	2·20	7·06	1·84	1·04	1·24
V[b,g]	3·10	—	—	—	—	6·45	3·22	2·18	7·05	1·81	1·07	1·21
II[b,h]	3·12	2·55	2·07	5·30	1·90	6·38	3·21	2·22	7·08	1·86	1·11	1·27
VIII[i,j]	3·4	—	—	3·90	—	4·72	2·99	2·10	7·14	2·00	0·89	1·00
IX[b,k]	3·08	—	—	5·21	1·83	6·40	3·18	2·22	7·06	1·86	1·04	1·22
XVII[b]	3·08	—	—	—	2·04	4·86	3·18	2·11	7·06	2·08	1·09	1·13
VI[i,l,m]	4·00	—	—	3·64	1·16	4·17	2·85	2·60	7·19	1·93	0·81	1·33
VII[b,n]	5·45	—	—	5·09	1·65	6·08	3·00	3·00	7·13	1·90	0·97	1·33
X[i,o]	—	—	—	3·76	—	4·47	—	—	7·08	1·97	0·94	1·20
XI[i,p]	—	—	—	5·14	—	6·14	—	—	7·15	1·80	1·05	1·03
XI[b,q]	—	—	—	4·99	1·60	6·15	3·11	2·72	7·10	1·89	0·98	1·24
XVIII[b,r]	—	—	—	—	—	4·55	3·21	2·55	7·11	2·03	0·76	1·22
XII[b]	—	—	—	—	2·60	—	3·79	3·02	7·15	2·17	0·85	1·10
XIII[b,s]	6·90	5·96	—	—	2·35	6·26	3·28	2·96	7·14	1·94	1·19	1·08
XIV[b]	—	—	—	—	—	—	6·58	—	7·11	2·23	1·12	1·19

[a] From double and triple resonance experiments; [b] in deuteriochloroform; [c] O-angelyl: β-H 6·18 qq, β-CH_3 ~ 2·03 dq, α-CH_3 ~ 1·94 dq; [d] O-dihydroangelyl: α-H 2·43; α-CH_3 1·23 d (J = 7); β-CH_3 0·96 t (J = 7·5); [e] O-isobutyryl: α-H 2·67; α-CH_3 1·23 d ($J \cong 7$) and 1·25 d ($J \cong 7$); [f] O-isobutyryl: α-H 2·64, α-CH_3 1·22 d (J = 7. 2) and 1·21 d (J = 7·2); O-acetyl: 2·02 s; [g] O-angelyl β-H 6·15 qq; [h] adduct with trichloroacetyl isocyanate, NH: 8·32 bs (1 H); [i] in hexadeuteriodimethyl sulfoxide; [j] 6-OH: 4·91 d ($J \cong 8$), 3-OH: 4·40 d ($J \cong 5$); [k] O-acetyls: 2·03 s and 2·15 s; [l] internal standard hexamethyldisiloxane (HMDS), δ(HMDS) = 0·06 p.p.m.; [m] 6-OH: 4·31 d ($J \cong 8$), 10-OH: 5·01 s, 1-OH and 3-OH: 4·41 d ($J \cong 7·5$) a 4·43 bs; [n] O-acetyls: 2·06 s (3 H) and 2·10 s (6 H); [o] at ~80°C; [p] O-acetyls: 2·10 s and 2·00 s; [q] O-acetyls: 2·07 s and 2·06 s; [r] 6-OH: 2·55 d ($J \cong 7$), 10-OH: 3·04 s; [s] O-angelyl: β-H 6·10 qq, β-CH_3 1·96 dq, α-CH_3 1·85 dq.

dine gave diacetate *XI*. Oxidation of triol *X* with chromium trioxide in pyridine led to diketoalcohol *XII*. Oxidation of nemosenin A (*I*) with chromium trioxide in pyridine afforded compound *XIII* of the composition $C_{20}H_{26}O_5$. Its infrared spectrum indicated the presence of an α,β-unsaturated oxo group and an α,β-unsaturated ester group. Its UV spectrum corresponds to a furan chromophore with superimposed chromophores of the α,β-unsaturated ester and α,β-unsaturated ketone. The structures of compounds *VI*–*XIII* were corroborated by a detailed analysis of their PMR spectra. For the correlation of nemosenins with furoeremophilane substances we

TABLE II

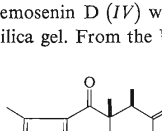
b) Coupling constants (splittings in Hz).

Comp.[a]	$J_{1,2}$	$J_{1,2'}$[b]	$J_{2,2'}$	$J_{2,3}$	$J_{2',3}$	$J_{3,4}$	$J_{4,14}$	$J_{6,9}$	$J_{6,9'}$	$J_{9,9'}$	$J_{12,13}$
I[c]	4·2	0	—	7·3	10·5	4·4	7·2	2·5	1·5	17·4	1·2
II[c]	5·0	0	15	7·2	10·8	4·3	7·3	2·5	1·2	17·5	1·3
III[c]	5·0	0	15	7·2	10·7	4·4	7·2	2·5	1·2	17·3	1·2
IV[c,d]	5·3	0	15	7·3	11	4	7·3	2·5	1·2	17·0	1·3
V	4·5	0	—	—	—	—	7·2	2·5	1·5	17	1·2
II[e]	5	0	15	7·5	11·5	4·5	7·3	2·5	1·5	17	1·3
VIII	5	0	—	—	—	—	7·2	—	—	17	1·2
IX	5·3	0	—	7	12	4	7·3	2·5	1·5	18	1·2
XVII	5	0	—	—	—	—	6·7	2·5	1·3	17	1·2
VI	6	11	—	*f*	*f*	*f*	7	—	—	18	1·2
VII	5·5	12	—	*f*	*f*	*f*	6·9	—	—	—	1·3

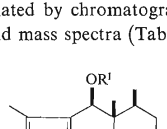
[a] Other compounds — *X*: $J_{4,14} \cong 7$, $J_{12,13} \cong 1{\cdot}2$; *XI*: (hexadeuteriodimethyl sulfoxide): $\Sigma\, {}^3J(H_4) \leqq 25$; $J_{4,14} \cong 7$; *XI*: $\Sigma\, {}^3J(H_3) \leqq 17$ ($W_{1/2} \cong 7-9$), $J_{4,14} = 6{\cdot}9$; $J_{9,9'} = 18$, $J_{9,13} \neq \neq 0$; $J_{12,13} = 1{,}3$; *XII*: $J_{4,14} = 6{,}7$; $J_{12,13} = 1{,}3$; $J_{9,9'} = 18$; *XIII*: $J_{1,2} = 10{,}3$; $J_{4,15} \neq 0$; $J_{4,14} = 6{,}8$; $J_{9,9'} = 17{,}9$; $J_{12,13} = 1{,}3$; *XIV*: $J_{4,14} \cong 7$; $J_{12,13} \cong 1{,}3$; *XVIII*: $J_{4,14} \cong 5{,}5$, $J_{9,9'} = 17{\cdot}7$, $J_{9,12} \neq 0$ and $J_{9',12} \neq 0$ $J_{6,9}$ and $J_{6,9'} \neq 0$, $J_{12,13} \neq 1{\cdot}3$; [b] $J_{1,2'}$ in general $< 0{\cdot}2$ in *I*—*III* $J_{1,2'} \neq 0$ (DR); [c] $J_{9,12} > J_{9,12} \neq 0 \ll 0{,}5$ (DR); [d] $J_{2,4} \cong 1$ (DR); [e] adduct with trichloroacetyl isocyanate; [f] $W_{1/2}(H_3) \cong 10$.

considered the dioxo alcohol *XII* as most suitable. Its dehydration with thionyl chloride in pyridine gave as the main product deoxy derivative *XIV*, further compound *XV*, and a small amount of a substance of m.p. 243–245°C. Hydrogenation of substance *XIV* (for its PMR spectrum see Table II) on 5% $Pd/SrCO_3$ in ethanol gave japonicindione *XVI* quantitatively. Its belonging to furoeremophilane derivatives, and also its absolute configuration at carbon atoms $C_{(4)}$, $C_{(5)}$ and $C_{(10)}$ was already proved[1].

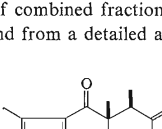
Nemosenin D (*IV*) was isolated by chromatography of combined fractions 5–7 on silica gel. From the UV and mass spectra (Table I) and from a detailed analysis



XII



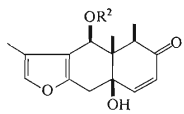
V, R^1 = angelyl
XVII, R^1 = H



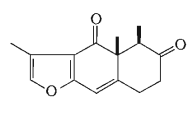
XVI, X = O
XIX, X = H_2

of the PMR spectra (Table II) it followed that nemosenin D is 1β,10β-epoxy-3,6-dihydroxyfuroeremophilane esterified with isobutyric acid and acetic acid in positions $C_{(3)}$ and $C_{(6)}$, or *vice versa*. On partial saponification of nemosenin D with methanolic barium hydroxide at room temperature nemosenin C (*III*) was formed. From this correlation it followed that isobutyric acid is bound to $C_{(6)}$ and acetic acid to $C_{(3)}$.

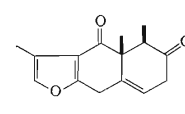
From the chromatographic fraction 4 another minor derivative was isolated, *i.e.* senemorin (*V*). From its IR, UV and mass spectra (Table I) and from a detailed analysis of its PMR spectrum (Table II) it followed that senemorin is 1β,10β-epoxy-6-angelyloxyfuroeremophilane. Its reduction with lithium tetrahydridoaluminate in ether gave a mixture of substances, *XVII* and *XVIII*. The structures of both compounds were corroborated by a detailed analysis of their PMR spectra (Table II). A sequence of reactions, analogous to the sequence $X \rightarrow XII \rightarrow XIV \rightarrow XVI$, diol *XVIII* also gave substance *XIX*, identical with petasalbone. The saponification of epoxy alcohol *XVII* with ethanolic potassium hydroxide gave rise to substance *XX*, identical according to its PMR spectrum in hexadeuteriodimethyl sulfoxide with euryopsol.



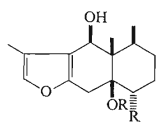
XIII, R^2 = angelyl



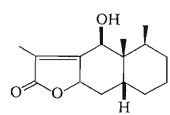
XIV



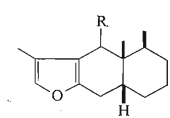
XV



XVIII, R = H
XX, R = OH



XXIV



XXI, R = β-OH
XXII, R = β-OAc
XXIII, R = α-OH

The stereochemistry of nemosenins and senemorins was inferred in the following manner: from the comparison of chemical shifts and coupling constants of skeletal protons of the basic common sesquiterpenic component (Table II) it follows that the conformation of the molecules, as well as the absolute configuration of all common centers of asymmetry are in these substances identical. The absolute configuration of the centra $C_{(5)}$ and $C_{(4)}$ followed in the case of nemosenins from a direct correla-

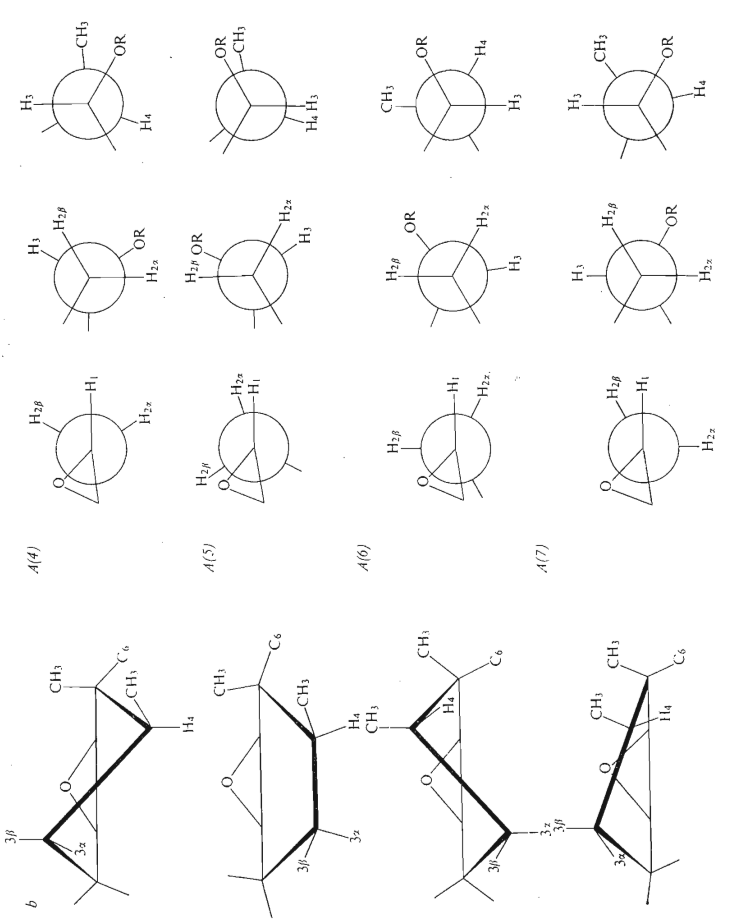
tion with 3,6-dioxofuroeremophilane (*XVI*) and in the case of senemorin from its correlation with 6-oxofuroeremophilane (*XIX*). Although the correlation of nemosenins does not exclude the possibility of the epimerisation on the center $C_{(4)}$ during the transition from substance *X* to *XII* unambiguously, the α-configuration of the $C_{(4)}$-methyl in native substances is very improbable. In addition to biogenetic reasons concerning senemorin, the correlation of which with *XIX* is unambiguous with respect to the center $C_{(4)}$, this also follows from the correlation of the PMR spectra of nemosenins with that of senemorin. From the comparison of the PMR spectra of nemosenins, A, B, C and D the acetylation of the hydroxyl at $C_{(3)}$ does not possess any significant effect on the chemical shifts of methyl protons $H_{(14)}$ and $H_{(15)}$. The contribution of the electric field effect of the OR group to the chemical shift of $H_{(14)}$ and $H_{(15)}$ is therefore negligible. In accordance with this the chemical shifts of $H_{(14)}$ and $H_{(15)}$ in the PMR spectra of nemosenins and senemorin are practically identical, under the supposition of the identity of the absolute configuration on the center $C_{(4)}$. The absence of the acylation effect is also in agreement with the equatorial position of the substituent at $C_{(3)}$, which is indicated by the occurrence of the diaxial vicinal coupling $^3J = 10-12$ Hz in the multiplets of the $H_{(3)}$ protons.

The solution of the absolute configuration on the centers $C_{(1)}$, $C_{(10)}$ of all native substances and the absolute configuration on the center $C_{(3)}$ of nemosenins is conditioned by the determination of the conformation of the ring A. The 1β,10β-epoxide ring limits the arrangement of the ring A to the conformations of the semichair or semiboat type with a quasiaxial or quasiequatorial methyl group on $C_{(4)}$. The probable conformations of the ring A, deduced from Dreiding models, are represented in Fig. 1*a* for the case of α-epoxide (*trans* fusion of the rings A and B), and in Fig. 1*b* for β-epoxide (*cis* fusion of the rings A and B). The differentiation between these possibilities can be carried out on the basis of the topological continuity of the vicinal and long-range interactions of protons on $C_{(1)}-\ldots-C_{(4)}$, which could be determined in the case of nemosenins A–D by double resonance experiments and which is represented schematically in Fig. 2*a*. From the point of view of the known stereospecificity of the mechanism of the vicinal ^3J coupling and the long-range ^4J interaction ($\sigma-\sigma$) (single bond coupling path)[5], such conformations may be preferred on the basis of $^3J_{1,2'} = 0$ and $^4J_{2,4} = 1$ Hz (the stereochemical implication is represented in Fig. 2*b*), in which one of the dihedral angles occurring on the $C_{(1)}-C_{(2)}$ fragment is close to 90° and in which the methyl group on $C_{(4)}$ assumed a quasiequatorial position. As follows from the Newman projections in Fig. 1 these sterical requirements may be fulfilled within certain limits only in the case of conformations *A*(3) and *A*(6). Other cases are less probable also from the point of view of the observed value of the vicinal coupling $^3J_{3,4} = 4-5$ Hz which excludes the quasi-*anti*-periplanar configuration $H_{(3)}-H_{(4)}$, and which is too low even for a quasi-*syn*-periplanar configuration $H_{(3)}-H_{(4)}$ (Fig. 1). However, optimum sterical conditions for $^3J_{1,2'}$ and $^4J_{2,4}$ are strictly fulfilled in the case of the conformation

FIG. 1

Schematic Representation of Ring A Conformations of 1(10)-Epoxyfuroeremophilane and Newman Projections of the Fragment $C_{(1)}$···-$C_{(4)}$ with a Pseudoequatorial Position of the OR Group on $C_{(3)}$

a α-Epoxide (*trans*-fusion of the A-ring); *b* β-epoxide (*cis*-fusion of the A-ring).


A(4)
A(5)
A(6)
A(7)
b
3β
3α
CH3
C6
H4
O
OR
H1
H2β
H2α
H2β OR
H3
H5

A(6) only, which may be considered, therefore, as most probable. The conformation *A*(3) also may be considered as less probable in view of the sterically disadvantageous *syn*-periplanar configuration of the methyl groups at $C_{(4)}$ and $C_{(5)}$. Hence, it may be assumed that the absolute configuration on the centers $C_{(1)}$ and $C_{(10)}$ of all native substances, as well as the absolute configuration of the OR-group on $C_{(3)}$ in nemosenins (the OR group is equatorial) is β.

For nemosenins these conclusions were also confirmed by the PMR spectra of triol *X* and terol *VI*. The PMR spectrum of triol *X*, measured in hexadeuteriodimethyl sulfoxide at room temperature, could not be directly correlated with the supposed structure of this substance. However, basic structural changes during the reduction of nemosenins with lithium tetrahydridoaluminate were excluded on the basis of the PMR spectrum of diacetate *XI* in deuteriochloroform (Table II), exhibiting all structural details confirming the reaction course as indicated in the scheme. Therefore, it may be supposed that the non-correlability of the PMR spectrum of compound *X* in dimethyl sulfoxide is a consequence of the conformational mobility. This supposition was confirmed by PMR spectra at elevated temperatures (Fig. 3). From these experiments it followed clearly that the conformation of triol *X* is not rigid and that a *cis*-fusion of the rings A and B may be assumed, and hence also the β-configuration of the hydroxyl on $C_{(10)}$. The conformational mobility of the molecule also followed from the comparison of the PMR spectra of the diacetate *XI* solutions in deuteriochloroform and hexadeuteriodimethyl sulfoxide (Table II); from the spectrum it followed that in the deuteriochloroform solution the ring A in *XI* assumes a conformation with an axial position of the acetoxy group on $C_{(3)}$ (half-width of the signal $H_{(3)}$ 7–9 Hz, $^3J = 17$ Hz), while in dimethyl sulfoxide (a structurally correlable PMR spectrum) the conformation dominates which has an equatorial position of the

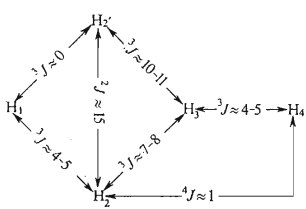


FIG. 2*a*

Topological Continuity of the Coupling Constants of Protons on the Fragment $C_{(1)}$-...-$C_{(4)}$ Found in the PMR Spectra of Nemosenins

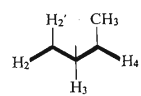


FIG. 2*b*

Optimal Stereochemical Assignment of the Vicinal Coupling Constants of Protons on $C_{(2)}$-...-$C_{(4)}$ Fragment and Long-range Couplings $^4J_{2,4}$ (W-type coupling, determined in the PMR spectrum of *IV*)

acetoxy group on $C_{(3)}$ (broad signal $H_{(3)}$, $^3J_3 = 25$ Hz). This behaviour of the molecule of triol *X* also agrees with the β-configuration of the OH-group on $C_{(3)}$, as in this case the hydroxy group on $C_{(3)}$ is axial in the expected stable steroid chair-conformation with an equatorial methyl on $C_{(4)}$, and simultaneously 1,3-diaxial with respect to $C_{(5)}$-methyl group. The increase in the conformational preference of the ring A in diacetate *XI* is in accord with the decrease of the van der Waals effect of the hydroxy group after acetylation (delocalisation of the free electron pairs, and hence the decrease of the effective volume of the O-atom).

In contrast to triol *X* the PMR spectrum of tetrol *VI* and of its triacetate *VII* (Table II) indicated the preferred conformation of the ring A, in agreement with the increase of the torsional barrier, due to the presence of the vicinal diol. The proton $H_{(3)}$ in both cases formed a relatively narrow multiplet with $\sum^3 J \leqq 10$ Hz and indicated an axial position of the OR group on $C_{(3)}$ in *X*, and the proton $H_{(1)}$ formed a quartet with $J_1 \cong 5-6$ Hz and $J_2 \cong 11-12$ Hz and indicated an equatorial position of the OR group on $C_{(1)}$. The configuration of the hydroxy groups is in full accord with the assumed *cis*-fusion of the rings A and B and the normal steroid conformation of the A-ring, and therefore also with the assumption of the formation of the *trans*-diol on $C_{(1)}$ to $C_{(10)}$. In the alternative case of a *trans*-fusion of the rings A and B in substances *VI* and *VII*, and under the supposition of an α-epoxide or a possible inversion of the configuration on $C_{(10)}$ in the case of a β-epoxide in native substances, the requirement of a diaxial coupling $H_{(1)}-H_{(2)}$ leads to the α-configuration of the OR group on $C_{(1)}$ and, hence, also to the supposition of the epoxide ring opening to an α-*cis*-diol.

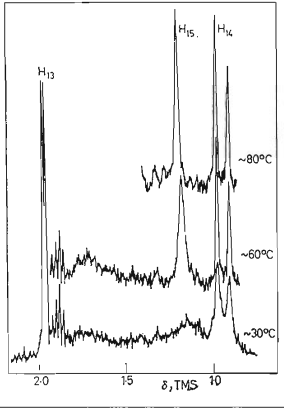


FIG. 3

High-field Part of the PMR Spectrum of Triol X in Hexadeuteriodimethyl Sulfoxide (100 MHz) at 30, 60 and 80°C

The β-configuration of the hydroxy group at $C_{(6)}$ may be assumed on biogenetic grounds, because it was found in all presently known native derivatives of 6-hydroxyfuroeremophilane. The direct inference of the configuration on the $C_{(6)}$ center of nemosenins and senemorin may be carried out in principle on the basis of the determined magnitudes of the long-range couplings ${}^5J_{6,13} \cong 0$, ${}^5J_{6,9} \cong 2{\cdot}5$, and ${}^5J_{6,9'} \cong 1{\cdot}5$ Hz (single path interfurylic couplings), the geminal coupling ${}^2J_{9,9'} = 17-18$ Hz (strong $\sigma-\pi$ interaction), and the magnitude of the internal chemical shift of protons on $C_{(9)}$ ($\sim$ 1 p.p.m.) and its stereochemical assignment. However, in view of the fact that the conformation of the ring B in substances with 1β,10β-epoxidic ring is not determined unambiguously by A-ring conformation (with the exception of the half-boat conformations which are equivalent from the point of view of the independent solution of the B-ring stereochemistry from the PMR spectra, and which are possible only in the cases of the conformations *A*(4) and *A*(5) – and therefore excluded), this deduction is very problematical; the stereochemical implications of the above mentioned parameters will be discussed elsewhere in another context. More suitable for the solution of the stereochemistry of the $C_{(6)}$-center are substances *VI*, *VII*, *XI*, and *XVIII* for which a steroidal conformation of the ring A with an equatorial methyl on $C_{(4)}$ and a half-chair conformation of the B-ring with a pseudoequatorial methyl at $C_{(5)}$ may be assumed, similarly as in the case of $C_{(6)}$-epimers of 6-hydroxyfuroeremophilane, *XXI*–*XXIII*[11]. The differentiation between the α- and β-configuration of the OR group on $C_{(6)}$ may be carried out on the basis of simultaneous correspondence of the chemical shifts of protons $H_{(6)}$ and $H_{(14)}$ (in deuteriochloroform) in the derivatives of nemosenins and senemorin and in substances *XXI*–*XXIII*. The chemical shifts of $H_{(6)}$ of acetyl derivatives *VII* (6·08 p.p.m.) and *XI* (6·15 p.p.m.) correspond to the chemical shift of $H_{(6)}$ in *XXII* (6·18 p.p.m.) (ref.[11]), just as the chemical-shift of $H_{(6)}$ in *XVIII* (4·55 p.p.m.) corresponds to the chemical shift of $H_{(6)}$ in *XXI* (4·70 p.p.m.)[11] (the chemical shift of $H_{(6)}$ in *XXIII* is 4·31 p.p.m.)[11]. Of course, this correspondence in itself has only a relative meaning, *i.e.* consisting in the fact that it may be expected under the supposition of the 6β configuration of the OR group in substances *VII*, *XI*, and *XVIII*, because in this case the proton $H_{(6)}$ is pseudoequatorial and its chemical shift is determined predominantly by the anisotropy of the shielding field of the furan nucleus. However, it does not imply the β-configuration directly, as in the case of α-configuration proton $H_{(6)}$ assumes a pseudoaxial position; therefore, in the case of substances with a hydroxyl at $C_{(10)}$, it may be expected that the diamagnetic shift $H_{(6)}$ (axial) will be compensated relatively to $H_{(6)}$ (equatorial) (shielding effect of the furan ring) by a deshielding-effect of the $C_{(10)}$-hydroxyl ($H_{(6)}$-β and $C_{(10)}$—OH are in the considered conformations 1,3-diaxial). In the case of the β-configuration of the hydroxyl at $C_{(6)}$ we can expect simultaneously the determined correspondence of the chemical shifts of protons $H_{(14)}$ in substances *XVIII* (0·76 p.p.m.) and *XXI* (0·88 p.p.m.)[11] because in the considered conformations the contribution of the $C_{(10)}$-hydroxyl

to the chemical shift of the protons of the equatorial methyl group at $C_{(4)}$ may be considered as negligible, as the chemical shift of $H_{(14)}$ should be larger in the case of α-configuration (with respect to the deshielding effect in the 1,3-diaxial position of $C_{(6)}$—OH and $C_{(4)}$—CH_3), similarly as in the case of compound *XXIII* (1·04 p.p.m.)[11]. From the point of view of these aspects it may be supposed that the configuration of the OR groups on $C_{(6)}$ is β. The correlation of senemorin (*V*) and euryopsol (*XX*) is also in agreement with the stereochemistry of centers $C_{(6)}$ and 1β,10β-epoxide. By this correlation the stereochemistry of euryopsonol (*XX*), which was also deduced from the PMR spectra using solvent effects[12], is simultanesusly confirmed.

Of known substances of the eremophilene type we isolated 6β-hydroxyeremophilenolide *XXIV* which was described for the first time by ourselves as occurring in *Petasites albus* L.[10]. The identification of furoeremophilane derivatives in the *Senecio* genus is an additional proof of the importance of eremophilane type substances as a chemotaxonomic character for the whole *Senecioneae* tribe.

EXPERIMENTAL

The melting points were measured on a Kofler block. The infrared spectra were measured in chloroform, unless stated otherwise, on a Unicam SP 200 spectrophotometer. The UV spectra were measured in ethanol on an Optica Milano CF 4 apparatus. The spectra of proton magnetic resonance (PMR) were measured on a Varian HA-100 machine in deuteriochloroform using tetramethylsilane as internal standard. For thin-layer chromatography silica gel G according to Stahl (Merck) and light petroleum, ether, benzene, ethanol, and their mixtures were used in ratios depending on the polarity and the mobility of the chromatographed substances. Detection was carried out by spraying the plates with conc. sulfuric acid and heating by direct flame. For column chromatography silica gel according to Pitra containing 13% of water, was used (Service laboratories of the Institute of Organic Chemistry and Biochemistry, Czechoslovak Academy of Sciences, Prague - Lysolaje), which was graded for size by sedimentation, as well as neutral alumina of medium activity, containing 6% of water (Woelm). For isolation rhizomes of *Senecio nemorensis* L., subsp. *fuchsii* were used collected in autumn 1967 and 1968 in Malá Úpa in the Giant Mountains, Bohemia.

Isolation of Substances

The dry, ground material (23·5 kg) was extracted with light petroleum at room temperature. The extract (200 g) was chromatographed on a column of neutral alumina (5·5 kg) of medium activity. Single fractions afforded the following material (solvent, volume in ml, weight of the dry residue): 1, light petroleum, 2000, 22·0; 2, light petroleum, 2000, 3·5; 3, light petroleum–benzene (1 : 1), 3000, 16·4; 4, benzene, 1500, 9·5; 5, benzene, 1500, 5·4; 6, benzene, 1000, 8·0; 7, benzene, 1500, 8·5; 8, benzene, 2500, 10·8; 9, benzene, 2500, 3·5; 10, benzene–5% ethanol, 2000, 10·8; 11, benzene–5% ethanol, 2000, 77·3; 12, benzene–5% ethanol, 1000, 16·0; 13, benzene–5% ethanol, 500, 4·5; 14, benzene–5%ethanol, 1500, 2·6.

By chromatography on a thin-layer of silica gel (in light petroleum–ether 4 : 1) it was found that the majority of furanoid compounds is in fractions 11—14, a smaller amount of further substances in fractions 4 and 5—7. Chromatography of the fraction 11 (25 g) on a column of neutral alumina Woelm (5 kg; 6% H_2O) with a light petroleum–ether mixture (1 : 1) gave substance *I* (7·2 g), substance *II* (3·4 g), and substance *III* (2·9 g). Their purity was checked by multiple thin-layer chromatography on silica gel in light petroleum–ether (6 : 4); after five runs substance *I* had R_F 0·57, substance *II* R_F 0·55, and substance *III* R_F 0·52.

Nemosenin A (I): For $C_{20}H_{26}O_5$ (346·4) calculated: 69·34% C, 7·57% H; found: 69·25% C, 7·54% H. IR spectrum: 1156, 1565, 1646, 1709, 3490, 3600 cm^{-1}. UV spectrum: λ_{max} 220 nm (log ε 4·09). Mass spectrum: *m/e* 346, 246, 100, 83, 55. $[\alpha]_D^{25}$ −35·3 (chloroform, *c* 0·44).

Nemosenin B (II). For $C_{20}H_{28}O_5$ (348·4) calculated: 68·94% C, 8·01% H; found: 68·81% C, 8·02% H. IR spectrum: 1157, 1566, 1724, 3490, 3600 cm^{-1}. UV spectrum: λ_{max} 218 nm (log ε 3·76). Mass spectrum: *m/e* 348, 102, 85, 57. $[\alpha]_D^{25}$ −19·0 (chloroform, *c* 0·35).

Nemosenin C (III). For $C_{19}H_{26}O_5$ (334·4) calculated: 68·24% C, 7·84% H; found: 68·05% C, 7·79% H. IR spectrum: 1157, 1566, 1724, 3490, 3600 cm^{-1}. UV spectrum: λ_{max} 218 nm (log ε 3·75). Mass spectrum: *m/e* 334, 246, 264. $[\alpha]_D^{25}$ −34·4 (chloroform, *c* 0·46).

Tetrol *VI*

To an ethanolic solution of sodium hydroxide (5% solution; 20 ml) fraction 11 (0·65 g) was added. After having checked that nemosenins A, B, and C give on saponification and reduction with $LiAlH_4$ identical substances the crude fraction 11 was used for the preparative scale work. The solution was saturated with nitrogen for half an hour, boiled for 6 h under nitrogen, freed from ethanol by evaporation, diluted with water, and extracted with ether. The ethereal solution was dried over sodium sulfate and evaporated. The residue was chromatographed on silica gel. A substance was obtained (0·04 g), m.p. 236—238°C with the following maxima in the IR spectrum (nujol): 3500, 3600, 1570 cm^{-1}. Mass spectrum: *m/e* 282, 124. For $C_{15}H_{22}O_5$ (282·3) calculated: 63·81% C, 7·85% H, 1·58% H act.; found: 63·51% C, 7·65% H, 1·7% H act. Triacetate *VII*: $C_{21}H_{28}O_5$, *m/e* 408; non-crystalline, prepared in the usual manner, for PMR values see Table II. The determination of the vicinal hydroxy group of tetrol *VI* was carried out polarographically[6] in phosphate buffer (pH 6·8) with the addition of 10% of dimethylformamide. The concentration of the substances was 10^{-4}M. Ratio of IO_4^-: substance = 3 : 1. As standards which did not contain a vicinal diol grouping substances *I* and *X* were oxidized under the same conditions. Consumption of IO_4^- (M) after 6 h was: *I*, 0·61; *VI*, 2·14; *X*, 0·90; after 24 hours: *I*, 0·99; *VI*, 2·38; *X*, 1·46.

Epoxide *VIII*

To a methanolic solution of barium hydroxide (100 ml of a 5% solution) fraction 11 (2 g) was added and the solution refluxed for 24 h. After evaporation of methanol, ether was added to the residue and washed several times with water. After evaporation of ether the mixture was dissolved in dioxane and filtered through a small column of silica gel. After evaporation and crystallisation compound *VIII* (400 mg) was obtained, m.p. 246—248°C. For $C_{15}H_{20}O_4$ (264·3) calculated: 68·16% C, 7·63% H; found: 68·29% C, 7·54% H. Mass spectrum: *m/e* 264, 124; IR spectrum (nujol): 1563, 1650, 3280, 3330 cm^{-1}; UV spectrum: λ_{max} 219 nm (log ε 3·80).

Diacetate IX: it was prepared in the conventional manner, m.p. 164—166°C; IR spectrum: 1250, 1565, 642, 1728 cm^{-1}; UV spectrum: 219 nm (log ε 3·80). For $C_{19}H_{24}O_6$ (358·4) calculated: 65·50% C, 6·94% H; found: 65·37% C, 7·04% H.

Triol *X*

A solution of fraction 11 (1·5 g) in tetrahydrofuran (10 ml) was gradually added to a suspension of lithium tetrahydridoaluminate (0·5 g) in tetrahydrofuran (100 ml). The reaction mixture was refluxed for 3 h and then additioned consecutively with ethyl acetate and a saturated solution of sodium sulfate, and filtered. The filtrate was dried over anhydrous sodium sulfate and

evaporated under partly reduced pressure. Crystallisation from tetrahydrofuran gave 0·5 g of product, m.p. 252—255°C; IR spectrum (nujol): 1008, 1029, 3280, 1589, 1569, 1650 cm^{-1}; UV spectrum: λ_{max} 218 nm (log ε 3·8); mass spectrum: *m/e* 266, 124; $[\alpha]_D^{25}$ +5·0° ± 1. For $C_{15}H_{22}O_4$ (266·3) calculated: 67·64% C, 8·33% H, 1·19% H act.; found: 67·55% C, 8·19% H, 1·30% H act.

Diacetate XI, prepared in the usual manner with acetic anhydride in pyridine, m.p. 144—148°C; IR spectrum: 1240, 1565, 1645, 1712, 3540 cm^{-1}; UV spectrum: λ_{max} 217 nm (log ε 3·86). For $C_{19}H_{26}O_6$ (350·4) calculated: 65·12% C, 7·48% H; found: 65·27% C, 7·47% H.

Diketone *XII*

A solution of triol *X* (0·9 g) in pyridine (50 ml) was added to a suspension of chromium trioxide (2·4 g) in pyridine (50 ml) under cooling with ice. The reaction mixture was allowed to stand at room temperature for 24 h and then poured onto ice and extracted with ether. The extract was washed with an aqueous tartaric acid solution, sodium hydrogen carbonate and water, and dried over sodium sulfate. Yield 250 mg of diketone *XII*, m.p. 201—202°C. IR spectrum: 3500, 3600, 1710, 1678, 1570 cm^{-1}; UV spectrum: λ_{max} 210 nm (log ε 4·03), 271 nm (log ε 3·54). For $C_{15}H_{18}O_4$ (262.3) calculated: 68·68% C, 6·92% H; found: 68·41% C, 6·75% H.

Dehydration: To a solution of diketone *XII* (500 mg) in pyridine (20 ml) thionyl chloride (0·3 ml) was added at —30°C and the mixture allowed to stand at room temperature for 15 min. The reaction mixture was melted with ice, allowed to stand at room temperature for 30 minutes, extracted with ether and evaporated. The residue (450 mg) was chromatographed on silica gel. Elution with benzene and ether (4 : 1) gave substance *XIV* (300 mg), m.p. 145—146°C. IR spectrum: 1556, 1625, 1660, 1708 cm^{-1}; UV spectrum: λ_{max} 218 nm (log ε 4·14), 234 nm (log ε 3·86), 241 nm (log ε 3·88), 272 nm (log ε 2·84), 337 nm (log ε 3·71). For $C_{15}H_{16}O_3$ (244·3) calculated: 73·75% C, 6·60% H; found: 73·72% C, 6·62% H. Immediately after substance *XIV* substance *XV* was eluted, m.p. 212°C; IR spectrum: 1565, 1620, 1680, 1710 cm^{-1}; UV spectrum: λ_{max} 242 nm, (log ε 3·13), 271 nm (log ε 3·52). For $C_{15}H_{16}O_3$ (244·3) calculated: 73·75% C, 6·60% H; found: 73·68% C, 6·70% H. Further elution with the same solvent mixture gave a small amount of a substance m.p. 243—245°C.

Compound *XIII*

A solution of nemosenin A (*I*) (1 g) in pyridine (30 ml) was mixed at 0°C with a suspension of chromium trioxide (1·5 g) in pyridine (50 ml). After three days standing the reaction mixture was poured onto ice and extracted with ether. The ethereal extract was washed consecutively with a tartaric acid solution, sodium hydrogen carbonate solution, and water, then dried over sodium sulfate and evaporated. The residue was purified by chromatography on neutral alumina of medium activity with light petroleum–ether mixture (85 : 15). Yield 250 mg of an amorphous substance, chromatographically pure. IR spectrum: 1570, 1680, 1708, 3580 cm^{-1}; UV spectrum: λ_{max} 222 nm (log ε 4·22). For $C_{20}H_{24}O_5$ (344·4) calculated: 69·75% C, 7·02% H; found: 69·95% C, 7·12% H.

Japonicindione (*XVI*)

Substance *XIV* (250 mg) was hydrogenated in ethanol on 5% $Pd/SrCO_3$ (200 mg). After working up, a mixture of substances (150 mg) was obtained which was separated chromatographically on silica gel. Elution with a benzene–ether mixture (9 : 1) gave 100 mg of substance, m.p. 148°C; IR spectrum: 1565, 1670, 1705 cm^{-1}; UV spectrum: λ_{max} 210 nm (log ε 4·05), 269 nm (log ε 3·52). For $C_{15}H_{18}O_3$ (246·3) calculated: 73·14% C, 7·37% H; found: 73·13% C, 7·40% H.

Nemosenin D (*IV*)

Chromatography of fractions 5—7 (21·9 g) on silica gel (600 g) with light petroleum–ether mixture (9 : 1) afforded substance *IV* (900 mg), m.p. 134—135°C; $[\alpha]_D^{25}$ −27·5° (chloroform, *c* 0·13); mass spectrum: *m/e* 376, 228, 88, 60; IR spectrum: 1225, 1728, 1562 cm^{-1}; UV spectrum: λ_{max} 217 nm (log ε 3·83). For $C_{21}H_{28}O_6$ (376·4) calculated: 67·00% C, 7·50% H; found: 67·22% C, 7·55% H. Partial saponification: To nemosenin D (260 mg) in methanol (5 ml) a solution of barium hydroxide (0·9 g) in methanol (30 ml) was added and the mixture allowed to stand in a refrigerator for 20 min. After working up a chromatographically pure, non-crystalline substance (220 mg) was obtained, identical with nemosenin C (*III*).

Senemorin (*V*)

Using chromatography of fraction 4 (9·5 g) on a silica gel column (800 g) with light petroleum–ether mixture (99 : 1) chromatographically pure compound *V* was isolated; $[\alpha]_D^{25}$ −20·2° (chloroform, *c* 0·21); mass spectrum: *m/e* 330, 230; IR spectrum: 1158, 1565, 1645, 1705 cm^{-1}; UV spectrum: λ_{max} 218 nm (log ε 4·11). For $C_{20}H_{26}O_4$ (330·4) calculated: 72·70% C, 7·93% H; found: 72·80% C, 7·99% H.

Substances *XVII* and *XVIII*

Senemorin (50 mg) was reduced with lithium tetrahydridoaluminate in ether (20 ml) and the reaction course was followed by thin-layer chromatography in light petroleum–ether (4 : 1). When all the starting compound had disappeared the reaction was interrupted and the reaction mixture worked up and chromatographed on silica gel (10 g). Elution with light petroleum–ether (9 : 1) first gave compound *XVII* (20 mg); mass spectrum: *m/e* 248; IR spectrum: 1568, 1642, 3485, 3600 cm^{-1}. For $C_{15}H_{20}O_3$ (248·3) calculated: 72·55% C, 8·12% H; found: 72·38% C, 8·20% H. Next, substance *XVIII* was eluted (10 mg), m.p. 132—133·5°C; mass spectrum: *m/e* 250, 124, 232; IR spectrum: 1570, 1650, 3500, 3600 cm^{-1}. For $C_{15}H_{22}O_3$ (250·3) calculated: 71·97% C, 8·86% H; found: 71·87% C, 8·70% H.

6-Oxo-10βH-furoeremophilane

Substance *XVIII* (40 mg) was oxidized with chromium trioxide (500 mg) in pyridine (10 ml). After working up the amorphous product was dehydrated by the method described for dehydration of substance *XII*. Hydrogenation of the resulting dehydrocompound on 5% $Pd/SrCO_3$ (20 mg) in ethanol gave a material which on chromatography on a silica gel column (5 g) gave substance *XIX* (15 mg), m.p. 67°C, indetical with a product which we described earlier[10,11].

Euryopsol (*XX*)

Senemorin (400 mg) was refluxed in a 5% ethanolic solution (25 ml) of sodium hydroxide under nitrogen for 24 h and then worked up in the usual manner and chromatographed on silica gel (40 g) with benzene–ether (4 : 1). Compound *XX* was obtained, m.p. 204—205°C, $[\alpha]_D^{25}$ +21·2° ± ± 1·5° (ethanol, *c* 0·14); composition $C_{15}H_{22}O_4$; mass spectrum: *m/e* 266, 124; UV spectrum: λ_{max} 220 nm (log ε 3·85).

6β-Hydroxyeremophilenolide (*XXIV*)

Chromatography of fraction 14 (2·6 g) on a silica gel column (300 g) using light petroleum–ether mixture (1 : 1) for elution gave a product (200 mg) of m.p. 205—206°C, which according to its mixture melting point and infrared spectrum was identical with compound *XXIV*.

Elemental analyses were carried out in the Analytical Department of this Institute by Mrs V. Rusová, under the direction of Dr J. Horáček. The IR spectra were measured by Mrs S. Holubová and Mrs K. Matoušková, the UV spectra by Mr P. Formánek. Optical rotations were determined by Mrs J. Větrovská, mass spectra were measured by Mrs M. Vokáčová. Our thanks are due to all those mentioned above as well as to Mrs J. Tichá and Mrs M. Snopková for technical assistance.

REFERENCES

1. Novotný L.: *Thesis.* Czechoslovak Academy of Sciences, Prague 1970.
2. Novotný L., Toman J., Starý F., Marquez A. D., Herout V., Šorm F.: Phytochemistry *1966*, 1281.
3. Novotný L., Toman J., Herout V.: Phytochemistry *1968*, 1349.
4. Herout V., Šorm F. in: *Progress in Phytochemistry*, p. 139. Academic Press, London 1969.
5. Sternhell S.: Quart. Rev. *23*, 236 (1969).
6. Novotný L., Samek Z., Harmatha J., Šorm F.: This Journal *34*, 336 (1969).
7. Benešová V., Samek Z., Herout V., Šorm F.: This Journal *34*, 582 (1969).
8. Trehan R. I., Monder C., Bose K. A.: Tetrahedron Letters *1968*, 67.
9. Zuman P., Krupička J.: This Journal *23*, 598 (1958).
10. Novotný L., Herout V., Šorm F.: This Journal *29*, 2189 (1964).
11. Ishii R., Tozyo T., Minato H.: Tetrahedron *21*, 2605 (1965).
12. Eagle G. A., Rivett D. E. A., Williams H. D., Wilson G. R.: Tetrahedron *25*, 5227 (1969).

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Note added in proof: Further furoeremophilane derivatives from the genus *Senecio* have been recently reported in *S. tournefortii* (Panžo F. M., Rodriquez B , Valverde S.: Ann. de Quim. *66*, 571 (1970), *S. silvaticus* (Schild W.: Tetrahedron *27*, 5735 (1971).