129. Madeiranes, a New Class of Pentacyclic Triterpenes: *D*-Friedomadeir-14-en-3β-ol and -3-one, *D*:*C*-Friedomadeir-7-en-3β-ol and -3-one

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Dedicated to Prof. Dr. *Albert Eschenmoser* on the occasion of his 66th birthday

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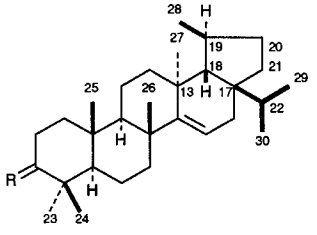
The pentacyclic triterpenes **1a**, **b** and **2a**, **b** are isolated from extracts of *Euphorbia mellifera* AIT. Their structures, determined by X-ray analysis, are supported in part by MS, NMR, and IR data. The skeleton differs from that of representatives of the lupane or hopane class by *i*) an unusual arrangement of the substituents in the cyclopentane ring E, the Me group being on C(19) and the i-Pr group in an angular position on C(17), and *ii*) a *cis* D/E ring junction. We propose to name the unknown pentacyclic parent 'madeirane', thus **1a**, **b** and **2a**, **b** are *D*-friedomadeir-14-ene and *D*:*C*-friedomadeir-7-ene derivatives. The biosynthesis of these compounds may be rationalized *via* 'spirodammaranol'-cation intermediates **5** and **5'** and madeiranol cation **6**, as outlined in *Scheme 2*.

Introduction. – *Euphorbia mellifera* AIT. is endemic to the archipelago of Madeira and of two of the Canary islands. In a recent investigation [1], we have screened the plant for triterpenoids and found in the mixture of the non-saponifiable part of the extract two novel representatives of the tetracyclic triterpenes called 'melliferol' and 'euferol', obviously products of an extended biosynthetic rearrangement sequence of tirucallenol C(9)-cation. A careful examination of other constituents of the extract has now allowed the isolation of products of a fundamentally new type of pentacyclic triterpene skeleton.

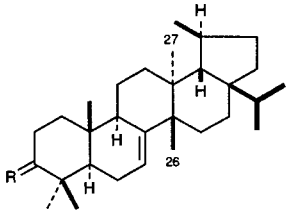
Results. – *Isolation of Products.* Acetone extracts of the aerial parts of *Euphorbia mellifera* AIT., from which a substantial quantity of a solid which crystallized has been removed, are separated into polar and less polar components by partition in hexane/90% aq. MeOH. The material in the hexane layer is saponified, and the neutral part of it is separated chromatographically on silica gel with hexane/AcOEt into 5 zones, monitored by TLC; two of these are investigated: *Zone II*, eluted with a 9:1 mixture, containing the majority of products, and *Zone III*, eluted with an 8:2 mixture (see *Exper. Part*).

[1]) Research grant fellow of the *Calouste Gulbenkian Foundation* 1986–88 at the Institute of Organic Chemistry, University of Lausanne.

The majority of the substance in *Zone II* is precipitated with acetone, and contains *ca.* 60% of lanosterol. The ketones **1a** and **2a** are isolated after chromatography of the mother liquor on silica gel from the front fractions[2]); the part that crystallizes in acetone contains ketone **1a** which is further purified by repeated chromatography on $AgNO_3$-coated silica gel and crystallization. Ketone **2a** is isolated from the respective mother liquors by fractional crystallization. *Zone III* contains considerable quantities of the alcohols **1b** and **2b** which are isolated by fractional crystallization from acetone/MeOH and acetone/$CHCl_3$. On acetylation with Ac_2O/pyridine, the alcohols are converted into the corresponding acetates **1c** and **2c**, respectively. Oxidation with *Jones'* reagent afforded the ketones **1a** and **2a**.



1a R = O
b R = H(α), OH(β)
c R = H(α), CH_3COO(β)



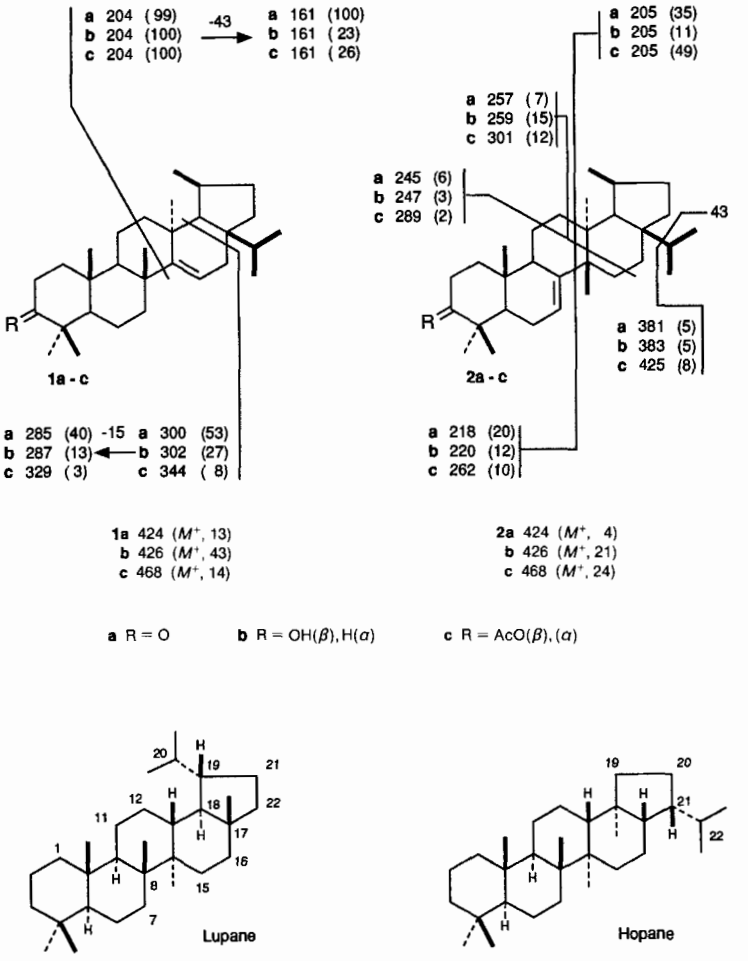
2a R = O
b R = H(α), OH(β)
c R = H(α), CH_3COO(β)

General Data of the Products **1** *and* **2**. The molecular formulae, $C_{30}H_{48}O$ of the ketones **1a** and **2a**, $C_{30}H_{50}O$ of the alcohols **1b** and **2b**, and $C_{32}H_{52}O_2$ of the corresponding acetates **1c** and **2c** are deduced by MS from the molecular peaks M^+ 424, 426, 468, respectively, and confirmed by elemental analysis in the cases of the ketones and alcohols. The nature of the functional groups becomes evident from IR: carbonyl bands for the ketones (1700 (**1a**), 1705 (**2a**) cm^{-1}), broad OH bands for the alcohols (3360 (**1b**), 3390 (**2b**) cm^{-1}), and ester bands for the acetates (1720 and 1240 (**1c**), 1725 and 1235 (**2c**) cm^{-1}). The ^{13}C-NMR spectra of the ketones show a typical C(3)=O resonance at δ 217.5 (**1a**) and 216.8 (**2a**). In the *sec*-alcohols, the signal of C(3) appears at δ 79.0 (**1b**) and 79.2 (**2b**), and in the corresponding acetates, the signal of C(3) is shifted to δ 81.0 (**1c**) and 81.2 (**2c**). The OH group of the alcohols must be in the equatorial position, since ^{1}H-NMR discloses an axial H–C(3) with the expected large coupling constant (δ 3.2 (*dd*, J = 11, 5 Hz, **1b**); 3.25 (*dd*, J = 11, 4 Hz, **2b**)). This is confirmed in the ^{1}H-NMR of the acetates (δ 4.47 (*dd*, J = 11, 5 Hz, **1c**); 4.53 (*dd*, J = 11, 4 Hz, **2c**)).

Data Relevant for Derivatives of Structure **1**. The fragmentation patterns in the MS of **1a–c** (*Scheme 1*) is consistent with that observed for pentacyclic triterpenes. Cleavage occurs across the bonds C(11)–C(12) and C(8)–C(14) in ring C which produces the parent peak m/z 204; this fragment involving rings D and E is, according to *Budzikiewicz et al.* [2], typical of triterpenoids with a C(14)–C(15) double bond (as *e.g.* in taraxer-14-enes) [2]. A further loss of variable abundance of mass 43 leading to m/z 161 indicates the presence of an i-Pr group, as encountered in other pentacyclic triterpenoids of hopane or

[2]) Some of the later fractions of this chromatography contain euferol and melliferol mentioned in [1].

Scheme 1. *MS Fragmentations of Friedomadeirane Derivatives. m/z* (rel. intensity in %).



lupane type. This fragmentation series leads to the conclusion that ring E must be five-membered. Evidence for the location of the double bond in ring D is provided by the presence of *retro-Diels-Alder* dienic moieties containing rings A, B, and C. Their *m/z* vary according to the substitution at C(3), appearing at 300, 302, and 344 for **1a**, **1b**, and **1c**, respectively, and they lose further 15 mass units attributed to the Me group at C(8) in allylic position to the double bond [2].

In the ^{1}H-NMR spectra of **1a–c**, the chemical shifts of the Me *s* resemble those of taraxer-14-enes [3–5], except for a missing fifth *s* of a Me group in angular position between the rings D and E as in the hopane or lupane series. Surprising is the presence of a Me group displaying a *d* at δ 1.04 indicating that it must be placed in a ring. The presence of an i-Pr group is confirmed (2 *d* at 0.72 and 0.78 in **1a–c**). The trisubstituted double bond (IR: 815 cm^{-1}; ^{13}C-NMR: 157.5, 118.2 ppm), which, according to the MS data, is located in ring D, is feasible only between C(14) and C(15). In a decoupling

experiment, one of the allylic CH_2 protons can be located at δ 2.11 (*dd*); on irradiation of the single olefinic proton at δ 5.41 (*dd*, H–C(15)), the signal of this allylic proton degenerates to a *d* (J_{gem} = 16.2 Hz). Hence the other position next to this CH_2 proton, C(17), must be tetrasubstituted and may be considered as the possible place of the i-Pr group.

Data Relevant for Derivatives of Structure **2**. The MS data of **2a–c** give much less information. A cleavage of the C(12)–C(13) and of the C(8)–C(14) bonds is probably the cause for the appearance of the fragment *m/z* 205 and of the fragments 218, 220, and 262 for **2a**, **2b**, and **2c**, respectively; this fragmentation may indicate the presence of angular Me groups at C(13) and C(14). Other less abundant peak series probably arise from cleavages of the bonds C(15)–C(16), C(13)–C(14), and C(11)–C(12) or C(12)–C(13). The presence of a trisubstituted double bond is established by the IR (810 cm^{-1}), ^{13}C-NMR (δ 116.9 and 145.4), and ^{1}H-NMR (δ 5.44) data; the ^{13}C-NMR shifts indicate C(7)=C(8) as the site of this double bond [6]. Such an assignment is supported by the observed deshielding effect exerted by C(7)=C(8) on the neighboring Me groups at C(10) and C(14), as deduced from the close analogy with data of known compounds, in particular, that of motiol [7]. One Me group is on a tertiary C-atom (^{1}H-NMR: at δ 1.08), and an i-Pr group is present as well.

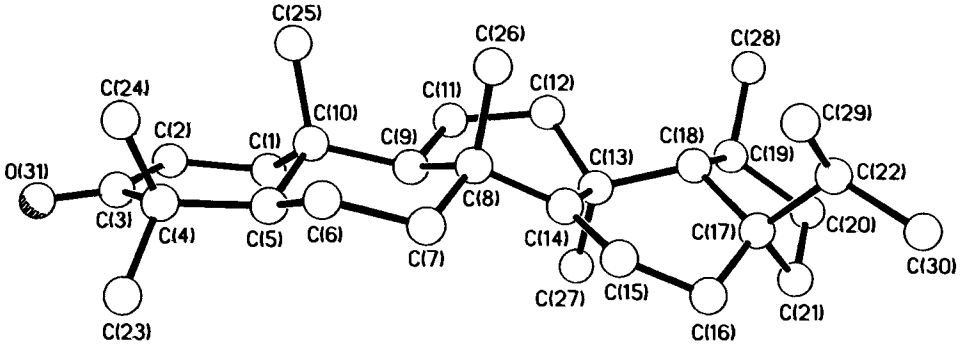


Fig. 1. *Molecular Structure of* D-*Friedomadeir-14-en-3-one* (**1a**)

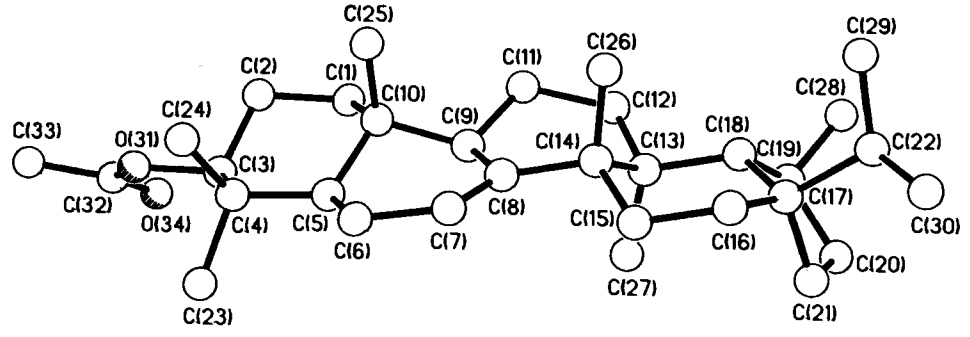


Fig. 2. *Molecular Structure of* D:C-*Friedomadeir-7-en-3β-yl Acetate* (**2c**)

Molecular Structure. The structure and configuration of **1a** and **2c** were established unambiguously by X-ray analysis. The perspective drawings in *Figs. 1* and *2* reveal an unprecedented feature of a pentacyclic triterpene with an i-Pr group in angular position between rings D and E and a Me group in ring E. The position of the double bond between C(14) and C(15) in **1a** and C(7) and C(8) in **2c** is evident from the shorter bond length (1.32 Å) and the planar geometries at C(14) and C(8), respectively. The representations provide a comparative view of the two conformations: in ketone **1a**, ring A assumes a half-chair and ring B a chair conformation, whereas rings C and D clearly appear in twist conformations; in acetate **2c**, rings A and D are chairs and rings B and C twisted.

Crystal Data[3]). **1a**: $C_{30}H_{48}O$, $M = 424.7$, monoclinic, $a = 14.413(4)$, $b = 6{,}461(2)$, $c = 15.113(4)$ Å, $\beta = 115.81(2)°$; $V = 1267$ Å^3, space group $P2_1$, $Z = 2$, $D_c = 1.11$ gcm^{-3}, Cu radiation, $\lambda = 1.54178$ Å, μ(Cu-K_α) = 5 cm^{-1}, $F(000) = 472$. **2c**: $C_{32}H_{52}O_2$, $M = 468.8$, monoclinic, $a = 9.629(1)$, $b = 9.523(1)$, $c = 16.019(2)$ Å, $\beta = 107.17(1)°$, $V = 1403$ Å^3, space group $P2_1$, $Z = 2$, $D_c = 1.11$ gcm^{-3}, μ(Cu-K_α) = 5 cm^{-1}, $F(000) = 520$.

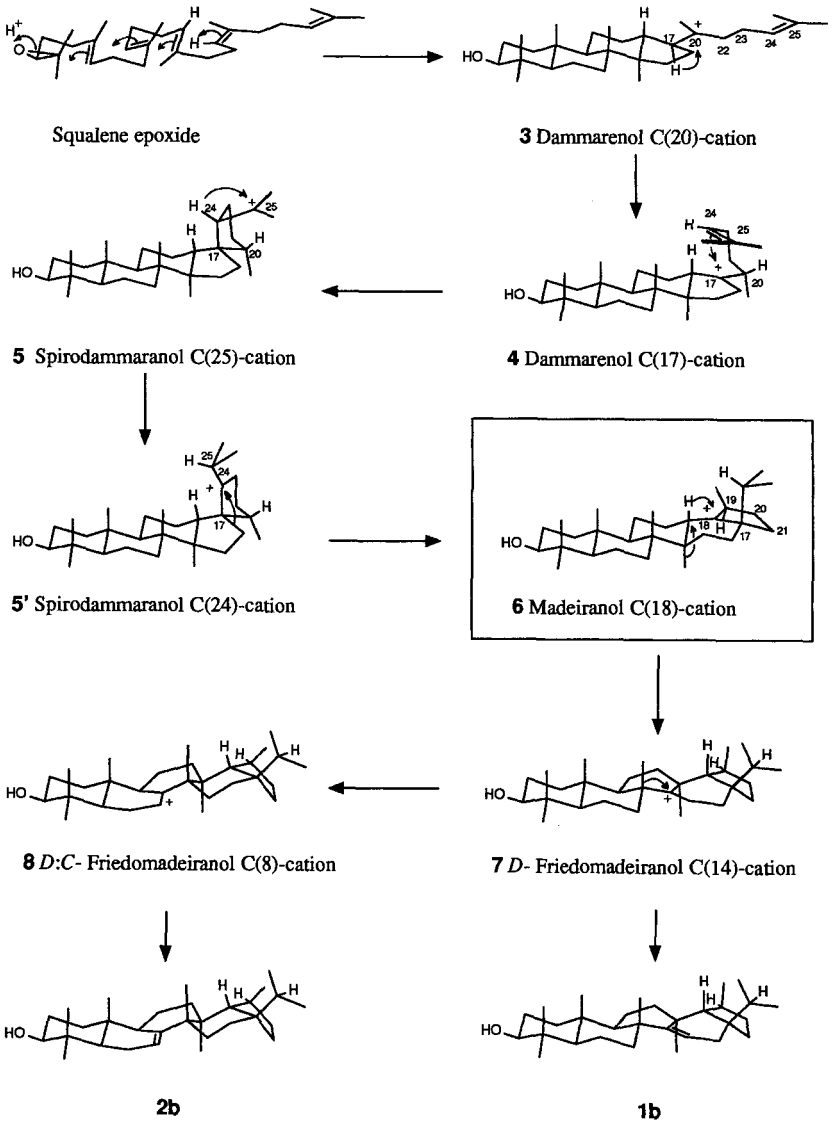
Data were measured on a *Nicolet-R3m* diffractometer with Cu-K_α radiation (graphite monochromator) using ω-scans. For **1a**, 1882, and for **2c**, 2034 independent reflections ($2\theta < 116°$) were measured, for which 1812 and 1697, respectively, had $|F_o| > 3\sigma(|F_o|)$ and were considered to be observed. The data were corrected for *Lorentz* and polarisation factors; no absorption corrections were applied. Both structures were solved by direct methods. The non H-atoms were refined anisotropically. The positions of the H-atoms were idealised (C–H = 0.96 Å), assigned isotropic thermal parameters ($U(H) = 1.2\ U_{eq}(C)$), and allowed to ride on their parent C-atoms. The Me groups were refined as rigid bodies. Refinement was by block-cascade full-matrix least-squares, in **1a** to $R = 0.039$, $R_w = 0.044$ ($w^{-1} = \sigma^2(F) + 0.00152\ F^2$), and in **2c** to $R = 0.048$, $R_w = 0.052$ ($w^{-1} = \sigma^2(F) + 0.00095\ F^2$). The maximum and minimum residual electron densities in the final ΔF maps were in **1a** 0.19 and −0.16 eÅ^{-3}, and in **2c** 0.15 and −0.13 eÅ^{-3}, respectively. The mean and maximum shifts/error in the final refinements were in **1a** 0.038 and 0.491, and in **2c** 0.008 and 0.034, respectively. Computations were carried out on an *Eclipse-S140* computer using the SHELXTL program system.

Discussion. – The skeleton of the pentacyclic triterpenes **1** and **2** has not previously been encountered in nature nor conceived by biosynthetic considerations. Quite unusual compared to the structures of the lupane and hopane class is the substitution pattern in ring E as well as the *cis*-configuration of the D/E-ring junction. Naming **1** and **2** following accepted terpene nomenclature rules (*IUPAC* or *Chemical Abstracts*) is rather complicated. Thus, we propose the name 'madeirane' for their parent triterpenoid skeleton, giving importance to the unique geographic homeland of the plant from where the compounds were isolated. Our proposal of a new term appears justified as explained below from the point of view of a biogenetic rationale for its formation.

Our rationale for the formation of the madeirane structure (*Scheme 2*) fully respects the requirements of stereoelectronic control as postulated by the biosynthetic isoprene rule of *Eschenmoser et al.* [8]. Initially, the known cyclisation sequence from 2,3-oxidosqualene to dammarenol C(20)-cation **3** has to take place which would be followed by H-migration from C(17) to C(20) leading to dammarenol C(17)-cation **4**. Unprecedented is the next step: the cyclization of **4** by addition of C(17)-cation on C(24) from the *Re*-side

[3]) Atomic coordinates, bond lengths and angles, and thermal parameters have been deposited at the *Cambridge Crystallographic Data Centre* (U.K.).

Scheme 2. *Suggested Biosynthetic Pathway Leading to the Madeirane Class*



of the double bond leads to a cation **5** with a new skeleton which could be named 'spirodammaranol C(25)-cation'. An antiperiplanar H-shift in **5** from C(24) to C(25) leads to 'spirodammaranol C(24)-cation' **5'**, ready to undergo a shift of the bond C(16)–C(17) to give C(16)–C(24) which involves the enlargement of ring D with formation of the cation **6**, the fundamental skeleton of madeirane. This yet unknown pentacyclic triterpene skeleton is renumbered according to the rules of *Chemical Abstracts*: the site of the cation in **6**, formerly C(17) in dammarenol, is now indexed as C(18). Three

more consecutive antiperiplanar 1,2-migrations of H–C(13), Me–C(14), and Me–C(8) can be envisaged leading from cation **6** to cations **7** and **8** of *D*-friedo- and *D:C*-friedo-madeiranol, respectively, which are the immediate precursors of **1b** and **2b**, respectively.

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Experimental Part

General. Column chromatography (CC): silica gel *Merck 9385* or the same support impregnated with 20% $AgNO_3$ according to [9]. TLC: precoated plates of silica gel *Merck 60* F_{254} (0.25 mm); detection by spraying with H_2SO_4/MeOH 1:1 followed by heating at 100° for 2 min. Prep. TLC: 0.5-mm plates *Merck* silica gel *60* F_{254}; the plates were impregnated in 20% aq. $AgNO_3$ soln. and dried at 120° for 2 h. GLC: *Hewlett Packard-5730A*; capillary column *methyl silicone* (0.3 mm, 25 m); isothermally at 280°, with He as carrier gas, flow rate 30 ml/min; injection and detection temp. 300°; retention times t_R rel. to t_R of cholesterol acetate. M.p.: *Mettler-FP-52* apparatus. $[\alpha]_D$: *Perkin-Elmer-241* polarimeter. IR spectra (in cm^{-1}): KBr pellets; *Perkin-Elmer-1420.* ^1H- and ^{13}C-NMR spectra ($CDCl_3$): *Bruker-WH-360* at 360 and 90.6 MHz, resp.; chemical shifts in ppm rel. to TMS (= 0 ppm) as internal standard. MS (*m/z* (%)): at 70 eV on *Nermag-R 10–10C.* Elemental analysis: *Carlo-Erba-1106* analysator.

Extraction. The air-dried aerial parts of *Euphorbia mellifera* AIT. (4 kg) were extracted 5 times for 24 h with acetone (20 l) at r.t. with stirring. Each extract was filtered on a *Büchner* funnel and evaporated. The total, concentrated to *ca.* 2 l of solvent, was cooled and a smaller part which precipitated filtered off (40 g of acetone-insoluble part). The filtrate was evaporated: 224 g of acetone-soluble part. The acetone-soluble part was suspended in 1 l of 90% MeOH/H_2O and extracted 4 times with 0.5 l of hexane. Complete extraction of the triterpenes was ascertained by TLC. The combined hexane extracts gave 185 g.

Saponification of the Hexane Fraction. A 10% KOH soln. in EtOH (1 l) was added to the hexane fraction (148 g) which was stirred with gentle heating until complete dissolution. The mixture was left at r.t. for 24 h. After removal of the EtOH at reduced pressure, the residue was suspended in 1 l of H_2O and extracted 4 times with 0.5 l of CH_2Cl_2. The emulsions formed were separated efficiently by centrifugation. The combined extract containing the unsaponifiable part was dried (Na_2SO_4) and evaporated: 71 g.

Column Chromatography of the Unsaponifiable Part. Separation of the above mentioned extract (71 g) was performed by CC on silica gel (750 g) with hexane/AcOEt mixtures of increasing polarity. The eluated fractions of 100 to 200 ml (TLC monitoring) were collected in 5 parts (see *Table 1*). Part of the material in *Zone II* precipitated (1.45 g) on addition of some MeOH to an acetone soln. and cooling. The solid contained as main component (62%) a substance with t_R 1.17. Three consecutive crystallizations from acetone and acetone/MeOH gave a pure compound (123 mg), identified as lanosterol: t_R 1.17, m.p. 139.5–140°.

Table 1. *Column Chromatography of the Unsaponifiable Part*

Zone	*Fractions*	Amount [g]	Eluent (*v/v*)		TLC (CH_2Cl_2) R_f
			hexane	AcOEt	
I	*5–13* (1.6 l)	3.1	90	10	0.70
II	*14–22* (1.6 l)	30.2	90	10	0.70, 0.55, 0.50
III	*23–33* (1.6 l)	15.9	80	20	0.50
IV	*34–47* (2.6 l)	7.9	80–70	20–30	0.35
V	*48–77* (3.4 l)	10.1	60–0	40–100	0.20

Isolation of **1a** *and* **2a**. The residue of the mother liquor of *Zone II* (26 g) was submitted to another CC on silica gel (500 g; hexane/AcOEt mixtures), yielding 6 fractions (TLC and GLC control). The first, strongly colored fraction (1.4 l of hexane/AcOEt 97.5:2.5; 5 g) was dissolved in hot acetone. On cooling, a mixture (1.1 g) crystallized showing one spot (R_f 0.7) on TLC (CH_2Cl_2), but 3 components (t_R (1.11 (15%), 1.16 (34%), and 1.40

(37%)) in GLC. The mother liquor was concentrated and twice recrystallized from acetone/CH_2Cl_2 to give pure **2a** (35 mg), t_R 1.39.

The crystalline 3-component mixture was submitted to CC on 100 g of $AgNO_3$ impregnated silica gel with hexane/Et_2O. Most of the material was found in the front eluates of 2 closely following zones. The tail contained a compound (18 mg) with t_R 1.40. The CC of the front eluates was repeated twice, followed by prep. TLC with CCl_4/CH_2Cl_2 5:1. Recrystallization of the less polar zone (prep. TLC) from acetone/CH_2Cl_2 gave pure **1a** (16 mg), t_R 1.16.

D-*Friedomadeir-14-en-3-one* (**1a**). t_R 1.16. M.p. 177–179°. $[\alpha]_D = +27.5$ ($CHCl_3$, $c = 0.8$). IR: 2945, 2870, 1700, 1460, 1385, 1375, 1005. ^{1}H-NMR: *Table 2*. ^{13}C-NMR: *Table 3*. MS: 424 (13, M^+), 409 (19), 381 (12), 300 (53), 285 (40), 271 (8), 257 (9), 243 (8), 232 (8), 204 (99), 189 (30), 175 (100), 159 (20), 149 (39), 147 (30), 145 (23), 135 (31), 133 (62), 131 (17), 123 (51), 121 (42), 119 (46), 109 (39), 107 (53), 105 (49), 95 (55), 93 (36), 91 (32), 83 (21), 81 (66), 69 (43), 55 (50), 43 (30). Anal. calc. for $C_{30}H_{48}O$: C 84.84, H 11.39; found: C 84.79, H 11.41.

D:C-*Friedomadeir-7-en-3-one* (**2a**). t_R 1.39. M.p. 201.5–202.8°. $[\alpha]_D = -19.8$ ($CHCl_3$, $c = 0.6$). IR: 2940, 2860, 1705, 1465, 1450, 1385, 1365. ^{1}H-NMR: *Table 2*. ^{13}C-NMR: *Table 3*. MS: 424 (4, M^+), 409 (2), 381 (5), 285 (2), 257 (7), 245 (6), 218 (20), 205 (35), 189 (3), 187 (4), 177 (4), 175 (7), 173 (6), 163 (7), 161 (6), 159 (6), 149 (15), 147 (10), 145 (9), 135 (11), 134 (11), 131 (8), 123 (15), 121 (12), 119 (10), 117 (19), 109 (18), 107 (19), 105 (10), 95 (16), 93 (14), 91 (14), 84 (45), 69 (43), 55 (41), 49 (100). Anal. calc. for $C_{30}H_{48}O$: C 84.84, H 11.39; found: C 84.75, H 11.37.

Table 2. *^{1}H-NMR Data of the Friedomadeirane Derivatives* **1** *and* **2**

	1a	**1b**	**1c**	**2a**	**2b**	**2c**
Me_α–C(4)	1.07	0.97	0.85	1.04	0.97	0.85
Me_β–C(4)	1.08	0.80	0.87	1.11	0.86	0.93
Me_β–C(10)	1.07	0.92	0.93	1.00	0.75	0.77
Me_β–C(8)	1.06	1.02	1.02			
Me_α–C(13)	0.94	0.94	0.94	0.94	0.92	0.92
Me_β–C(14)				0.95	0.95	0.95
Me_β–C(19)	1.05 (*d*, $J = 6.8$)	1.04 (*d*, $J = 6.8$)	1.04 (*d*, $J = 6.8$)	1.08 (*d*, $J = 7.3$)	1.08 (*d*, $J = 7.3$)	1.08 (*d*, $J = 7.3$)
Me(29) or Me(30)	0.72 (*d*, $J = 6.8$)	0.72 (*d*, $J = 6.8$)	0.72 (*d*, $J = 6.8$)	0.83 (*d*, $J = 6.8$)	0.83 (*d*, $J = 6.8$)	0.83 (*d*, $J = 6.8$)
Me(30) or Me(29)	0.78 (*d*, $J = 6.8$)	0.78 (*d*, $J = 6.8$)	0.78 (*d*, $J = 6.8$)	0.95 (*d*, $J = 6.8$)	0.94 (*d*, $J = 6.8$)	0.94 (*d*, $J = 6.8$)
H_α–C(3)		3.20 (*dd*, $J = 5.0, 11.0$)	4.47 (*dd*, $J = 5.0, 11.0$)		3.24 (*dd*, $J = 4.0, 11.0$)	4.53 (*dd*, $J = 4.0, 11.0$)
H–C(15)	5.45 (*dd*, $J = 2.5, 7.8$)	5.41 (*dd*, $J = 2.5, 7.8$)	5.41 (*dd*, $J = 2.5, 7.8$)			
H–C(7)				5.51 (*m*, $\omega_{1/2} = 11$)	5.44 (*m*, $\omega_{1/2} = 11$)	5.44 (*m*, $\omega_{1/2} = 11$)
AcO_β–C(3)			2.06			2.06

Table 3. *^{13}C-NMR Data of Friedomadeirane Derivatives* **1** *and* **2**[a])

	1a	**1b**	**1c**	**2a**	**2b**	**2c**
CH_3	14.71	15.31	15.38	12.78	13.08	13.17
	16.71	15.47	16.61	17.02	14.69	15.87
	19.01	16.75	16.75	17.30	17.03	17.07
	19.62	19.03	19.03	21.57	17.31	17.35
	21.52	19.63	19.59	23.11	22.95	21.30
	24.47	24.44	21.26	24.28	24.15	23.00
	24.84	25.18	24.45	24.56	25.76	24.27
	26.12	28.04	25.20	25.74	27.59	25.79
	–	–	28.01	–	–	27.60

Table 3 (cont.)

	1a	1b	1c	2a	2b	2c
CH_2	17.10	17.17	17.18	17.10	16.84	16.90
	19.95	18.82	18.71	22.15	22.19	22.20
	30.28	27.21	23.51	24.56	24.15	24.01
	32.25	30.37	30.33	28.54	27.74	24.27
	33.37	32.45	32.41	31.06	28.46	28.52
	34.16	33.43	33.42	34.91	31.07	31.12
	38.39	37.84	37.47	35.25	35.30	35.32
	38.51	38.50	38.50	35.91	35.88	35.93
	41.02	41.78	41.67	38.35	37.03	36.72
CH	34.08	34.14	34.13	33.57	33.56	33.60
	34.42	34.47	34.47	35.20	35.16	35.21
	48.90	49.54	49.44	48.14	48.59	48.56
	55.76	55.53	55.62	52.02	50.30	50.50
	63.50	63.52	63.53	56.70	56.66	56.72
	118.46	79.06	81.06	116.93	79.25	81.23
	–	118.25	118.25	–	116.92	116.84
C	29.69	29.70	29.70	35.33	35.16	35.21
	37.71	38.02	37.71	37.07	37.03	37.11
	39.00	38.78	37.91	40.63	38.47	37.80
	47.57	39.05	39.03	46.80	40.46	40.53
	50.24	50.33	50.31	47.75	46.82	46.86
	157.03	157.53	157.42	145.61	145.44	145.61
CO	217.51	–	170.94	216.85	–	170.97

[a]) The number of protons bound to a C-atom was established by attached-proton test.

Isolation of **1b** *and* **2b**. Fractional crystallizations of the material in *Zone III* from acetone/MeOH and from acetone/$CHCl_3$ gave 300 mg of **1b** (t_R 1.21) and 150 mg of **2b** (t_R 1.49).

D-*Friedomadeir-14-en-3β-ol* (**1b**). t_R 1.21. R_f (CH_2Cl_2) 0.5. M.p. 250–250.5°. $[\alpha]_D = +27.2$ ($CHCl_3$, $c = 0.4$). IR: 3360, 2935, 2860, 1460, 1380, 1370, 1130, 1100, 1030, 990, 945, 915, 850, 815. ^{1}H-NMR: *Table 2*. ^{13}C-NMR: *Table 3*. MS: 426 (43, M^+), 411 (10), 393 (4), 383 (7), 365 (1), 350 (1), 343 (1), 331 (2), 309 (2), 302 (27), 287 (13), 284 (2), 273 (3), 269 (6), 257 (7), 229 (3), 227 (5), 204 (100), 189 (14), 175 (8), 161 (23), 159 (12), 148 (12), 147 (10), 145 (10), 135 (17), 133 (16), 131 (17), 123 (18), 121 (19), 119 (27), 109 (13), 107 (15), 105 (26), 95 (19), 93 (23), 91 (17), 85 (49), 83 (79), 81 (63), 69 (51), 57 (67), 43 (51). Anal. calc. for $C_{30}H_{50}O$: C 84.44, H 11.81; found: C 84.24, H 11.79.

D-*Friedomadeir-14-en-3β-yl Acetate* (**1c**). At r.t., **1b** (20 mg) was acetylated with Ac_2O/pyridine 1:1 overnight. Usual workup followed by crystallization from acetone gave **1c**. M.p. 220°. t_R 1.48. $[\alpha]_D = +26.5$ ($CHCl_3$, $c = 0.6$). IR: 2940, 2860, 1720, 1460, 1365, 1310, 1240, 1165, 1140, 1100, 1030, 1000, 945, 920, 895, 820, 800. ^{1}H-NMR: *Table 2*. ^{13}C-NMR: *Table 3*. MS: 468 (14, M^+), 453 (4), 425 (1), 365 (1), 344 (8), 329 (3), 284 (1), 269 (2), 257 (2), 245 (2), 231 (4), 229 (4), 218 (32), 204 (100), 175 (5), 161 (26), 159 (10), 149 (11), 148 (9), 147 (10), 145 (9), 135 (16), 133 (13), 131 (6), 123 (12), 121 (11), 119 (12), 109 (9), 107 (12), 105 (16), 95 (20), 93 (18), 91 (24), 85 (26), 83 (41), 81 (45), 69 (41), 55 (30).

Oxydation of **1b**. A stirred soln. (N_2 bubbling) of **1b** (10 mg) in acetone (5 ml) was titrated at 10–15° with *Jones'* reagent (0.01 ml). After usual workup, the product was crystallized twice from acetone/CH_2Cl_2: 3 mg of **1a**, identical with authentic material (see above) in m.p., mixed m.p., and t_R.

D:C-*Friedomadeir-7-en-3β-ol* (**2b**). t_R 1.49. R_f (CH_2Cl_2) 0.5. M.p. 228–229°. $[\alpha]_D = -32.7$ ($CHCl_3$, $c = 0.7$). IR: 3390, 2940, 2860, 1460, 1380, 1365, 1160, 1100, 1070, 1030, 985, 970, 910, 850, 810. ^{1}H-NMR: *Table 2*. ^{13}C-NMR: *Table 3*. MS: 426 (21, M^+), 411 (9), 393 (1), 383 (5), 365 (3), 287 (3), 273 (1), 259 (15), 255 (3), 247 (3), 243 (4), 241 (6), 229 (7), 220 (12), 207 (4), 206 (15), 205 (11), 204 (6), 202 (2), 189 (4), 187 (5), 177 (3), 175 (4), 173 (6), 163 (6), 161 (6), 159 (6), 151 (5), 149 (12), 147 (9), 145 (8), 135 (16), 133 (11), 131 (7), 123 (14), 122 (11), 121 (13), 119 (18), 117 (8), 109 (20), 108 (10), 107 (39), 105 (27), 95 (40), 93 (26), 91 (26), 83 (77), 69 (41), 55 (43), 43 (100). Anal. calc. for $C_{30}H_{50}O$: C 84.44, H 11.81; found: C 84.50, H 11.83.

D:C-*Friedomadeir-7-en-3β-yl Acetate* (**2c**). As described for **1b**, **2b** (70 mg) was acetylated. Acetate **2c** crystallized from acetone. t_R 1.81. M.p. 212–213°. $[\alpha]_D = -59.5$ ($CHCl_3$, $c = 0.8$). IR: 2950, 2860, 1725, 1465, 1385, 1360,

1235, 1165, 1105, 1025, 1010, 990, 970, 900, 865, 855, 825, 815. ^{1}H-NMR: *Table 2.* ^{13}C-NMR: *Table 3.* MS: 468 (24, M^+), 453 (15), 425 (8), 408 (3), 393 (1), 365 (6), 329 (3), 316 (3), 301 (12), 281 (8), 289 (2), 267 (4), 262 (10), 257 (5), 255 (2), 243 (8), 241 (10), 229 (16), 221 (6), 206 (22), 205 (49), 204 (22), 203 (10), 202 (15), 189 (13), 187 (15), 173 (17), 171 (6), 169 (8), 163 (15), 161 (10), 159 (14), 157 (9), 149 (21), 147 (15), 145 (17), 135 (18), 133 (11), 131 (9), 123 (22), 122 (12), 121 (20), 119 (25), 117 (11), 109 (34), 108 (14), 107 (76), 105 (47), 95 (65), 93 (56), 81 (47), 69 (66), 55 (100).

Oxidation of **2b**. As described for **1b**, **2b** (10 mg) was treated with *Jones'* reagent. The product, crystallized from acetone/CH_2Cl_2 (6 mg), was identical with **2a** in m.p., mixed m.p. and t_R.

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