FUNCTIONALIZATION OF LUPANE WITH CHROMIUM(VI) OXIDE. A REMARK ON THE STRUCTURE OF CLERODONE*

Jan SEJBAL[a1], Jiri KLINOT[a2] and Milos BUDESINSKY[b]

[a] *Department of Organic Chemistry, Charles University, 128 40 Prague 2, Czech Republic; e-mail: [1] sejbal@prfdec.natur.cuni.cz, [2] klinot@prfdec.natur.cuni.cz*

[b] *Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic, 166 10 Prague 6, Czech Republic; e-mail: budesinsky@uochb.cas.cz*

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The reaction of lupane (**1**) with chromium oxide gave lup-2-en-1-one (**3**), lupan-12-one (**2**), lupan-16-one (isolated after hydride reduction as lupan-16α-ol (**4**)), and lup-18-en-21-one (**5**) in low yields. The same oxidation of 3β,28-dimethoxylupane (**11**) afforded no products of functionalization in non-activated positions; only products of oxidation of the 3β-methoxy group and of the oxidation cleavage of the A ring were obtained, viz. 28-methoxylupan-3β-ol formate (**12**), 28-methoxylupan-3-one (**14**), and 28-methoxy-2-norlupane-1,3-dioic anhydride (**13**). The structure of the compounds obtained was confirmed by their ^{1}H NMR, ^{13}C NMR, and mass spectra. The lupan-12-one (**2**) prepared is not identical with clerodone, whose isolation from *Clerodendron infortunatum* BHAT. was described in 1965 and to which the structure of lupan-12-one was then ascribed.

Key words: Lupane; Chromium oxide; Functionalization; Clerodone.

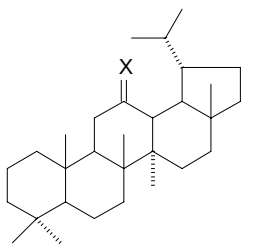
As continuation of our study of direct functionalization of lupane triterpenoids[2–4], this work is concerned with the functionalization of the non-activated positions in lupane (**1**) and its 3β,28-dimethoxy and dinitroxy derivatives (**11**) and (**9**), respectively, by reaction with chromium oxide.

As far as its direct functionalization is concerned, 3β,28-lupanediol is known[2–5] to be attacked in position 19 by radical agents (peroxo acids, dry ozonation); the nonselective chromium oxide also attacks other positions such as 11, 12, 13, 16, and 21. With lupane (**1**) and lupan-3β-ol acetate, which lack the 28-acetoxy group near position 19, the situation is more complicated even if selective radical agents (peroxo acids) are used: attack has been observed[4,6] in positions 13, 16, and 19.

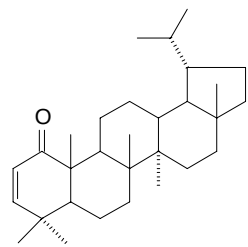
The reaction of lupane (**1**) with chromium oxide in boiling acetic acid gave a complex mixture of products, from which two compounds, viz. lupan-12-one (**2**) and lup-18-en-

* Part CVI in the series Triterpenes; Part CV: see ref.[1].

21-one (**5**), were directly isolated by column chromatography, and another derivative, viz. lupan-16α-ol (**4**), was obtained on reduction of one of the chromatographic fractions with lithium aluminium hydride; lup-2-en-1-one (**3**) (ref.[7]) was identified in another fraction by ^{1}H NMR. The reaction mixture contained 48% of the starting hydrocarbon; 28% of the starting compound had probably been subject to a deeper oxidation and did not pass into the organic phase during extraction, and out of the remaining 24% converted to products, 2.1% could be isolated as pure compounds and identified.



	X
1	H_2
2	O



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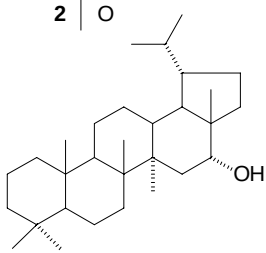

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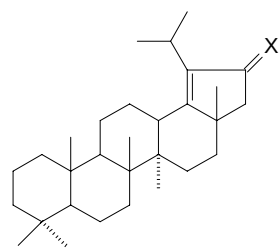
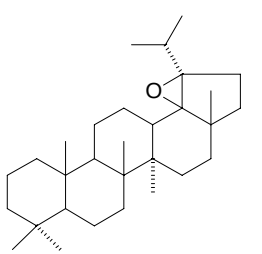


	X
5	O
6	H_2



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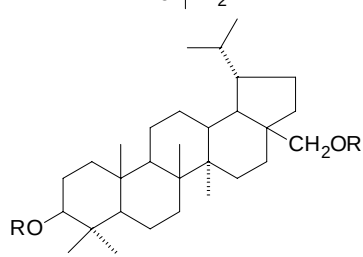
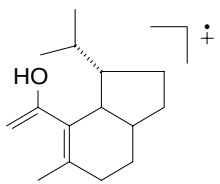
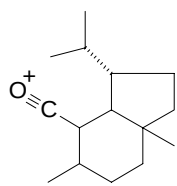


	X
8	H
9	NO_2

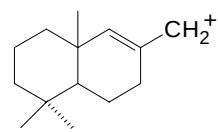
The structure of lupan-12-one (**2**) was confirmed by its infrared spectrum (1 704 cm^{-1}, a six-membered ketone) and by its mass and ^1H NMR spectra compared with those of a series of known 12-oxolupane derivatives. The formation of all the important ion maxima in the mass spectrum of the ketone **2** can be explained based on fragmentation of lupan-12-ones as described in ref.[8]. The following ions are particularly characteristic of the position of the keto group: *m/z* 234 (*I*), 221 (*II*), and 219 (*I*-CH_3). These arise[8] from the cleavage of ring C and involve rings D and E. The ion with *m/z* 191 (*III*), involving rings A and B, also emerges from the cleavage of ring C. In the ^1H NMR spectrum of the ketone **2**, the signals of all methyl groups (Table I) can be assigned based on analogies (see, for instance, ref.[9] and references therein). The effect of the 12-keto group ($\Delta\delta$(**2** – **1**) in Table I) manifests itself most markedly in downfield shifts of the 8β-methyl (H-26) and 10β-methyl (H-25) groups and an upfield shift of the 14α-methyl (H-27) group, in accordance with ref.[9]. The signals of all the remaining protons at ring C were also identified, whereby the presence of the 12-oxo group was confirmed unambiguously. The complete assignment is as follows: δ 1.65 (H-9); 2.17 (H-11α); 2.35 (H-11β) and 2.74 (H-13), J(11α,11β) = 11.8, J(9,11α) = 3.8, J(9,11β) = 13.5, J(11β,13) = 0.8, J(13,18) = 10.6.



I (*m/z* 234)



II (*m/z* 221)



III (*m/z* 191)

The structure of the unsaturated ketone **5** was elucidated based on a similarity of the spectral data with those of the analogous 3β,28-diacetoxylup-18-en-21-one[2]. The infrared spectra of both compounds exhibit unsaturated ketone band pairs at 1 680 and 1 597 cm^{-1}, and their ^1H NMR spectra involve characteristic septets at δ 3.14 (H-19). The fragmentation in the mass spectrum of the ketone **5** is also analogous to that reported[2] for 3β,28-diacetoxylup-18-en-21-one. For a comparison, the ketone **5** was prepared by oxidation of lup-18-ene (**6**) with chromium oxide in analogy with ref.[2]; the epoxide **7** (ref.[4]) was also obtained as a next reaction product.

For chromatographically inseparable fractions obtained by oxidation of lupan-3β,28-diol diacetate, their reduction with lithium aluminium hydride has proved to be a convenient approach[1,3]: the oxidation products mostly contain keto groups, and the hydroxy derivatives obtained by their reduction can often be separated. With lupane, however, the reduction with lithium aluminium hydride failed to provide separable product mixtures in the majority of chromatographic fractions. In one fraction only, lupan-

16α-ol (**4**) could be isolated following the reduction. The structure of this compound was elucidated based on spectral measurements: the base peak in its mass spectrum (*m/z* 191) corresponds to fragment *III*, involving rings A and B, and gives evidence that the hydroxy group (3 612 cm^{-1} in the IR spectrum) is not located at those rings. The ^1H NMR spectrum displays an isolated three-proton system in the $–CH_2–CH–O–$ arrangement, whose coupling constants reveal that the hydroxy group is located at the six-membered ring and is axial. Such a system is only feasible in the lupane skeleton if the compound is a 15β- or 16α-hydroxy derivative. As compared to the spectrum of lupane (**1**), the signal of one methyl group only is significantly shifted downfields (14α-CH_3, see Δδ(**4** – **1**) in Table I); this is consistent with the presence of the 16α-hydroxy group, which is in the 1,3-synaxial interaction with the 14α-methyl group. The effect of this hydroxy group on the shifts of the 14α-methyl group and the remaining methyl groups (Table I) agrees with the effects observed for the 16α-hydroxy derivatives[10]. Consistent with the structure **4** is also the long-range coupling between the protons of the 14α-CH_3 group and the axial H-15β (J(15β,26) = 1 Hz). The presence of the axial 16α-hydroxy group in compound **4** is also borne out by its ^{13}C NMR spectrum, which in comparison with that of lupane[11] (**1**) exhibits a significant upfield shift of the γ-carbon atoms C-18 and C-22 (–7.2 ppm) and a downfield shift of the β-carbon atoms C-15 and C-17 (+6.9 and +4.4 ppm, respectively). The signals of the remaining carbon atoms are only negligibly affected.

Two other lupane derivatives have also been reacted with chromium oxide: the dinitrate **9**, synthesized by esterification of the diol **8** with acetyl nitrate, and the dimethyl ether **11**, obtained by hydrogenation of dimethyl ether betuline[12] (**10**). In neither case, however, any product of functionalization of the lupane system in the non-activated positions could be isolated from the complex reaction mixture. Only the diol **8** was isolated following basic hydrolysis from the mixture emerging from the oxidation of

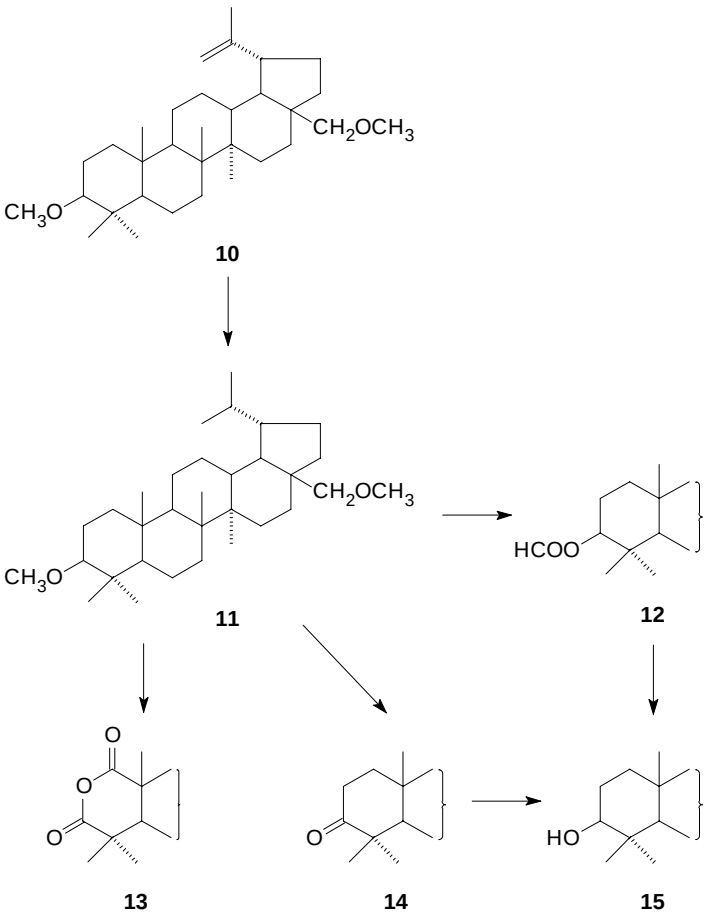
TABLE I
Chemical shifts (δ, ppm) of methyl protons in compounds **1**, **2** and **4**

Compound	H-23	H-24	H-25	H-26	H-27	H-28	H-29[a]	H-30[a]
1[b]	0.846	0.799	0.846	1.040	0.933	0.755	0.758[c]	0.836[c]
2[d]	0.856	0.817	0.912	1.289	0.817	0.769	0.785[e]	0.926[e]
4[d]	0.845	0.799	0.836	1.017	1.171[f]	0.792	0.797[g]	0.853[g]
Δδ(**2** – **1**)	+0.010	+0.018	+0.066	+0.249	–0.116	+0.014	+0.027	+0.090
Δδ(**4** – **1**)	–0.001	0.000	–0.010	–0.023	+0.238	+0.037	+0.039	+0.017

[a] Doublet. [b] Recorded at 100 MHz, for the assignment see ref.[4]. [c] J = 6.5 Hz. [d] Recorded at 200 MHz. [e] J = 7.0 Hz. [f] Doublet, J = 1.0 Hz. [g] J = 6.8 Hz.

the dinitrate **9**, whereas the oxidation of the dimethoxy derivative **11** gave rise to compounds formed by oxidation of the methoxy group in position 3 or by oxidation cleavage of ring A, viz. the formate **12**, ketone **14**, and anhydride **13** (see Scheme 1). Reduction of the ketone **14** with sodium borohydride gave 28-methoxylupan-3β-ol (**15**), which also emerged from basic hydrolysis of the formate **12**. The structure of the anhydride **13** was confirmed by infrared spectroscopy (1 798 and 1 753 cm^{-1}, six-membered anhydride). In agreement with this structure, the ^1H NMR spectrum of the anhydride **13** displays a significant downfield shift of three methyl groups at ring A, viz. 4α, 4β, and 10β (δ 1.17, 1.33, and 1.33.

Manzoor-i-Khooda[13] attributed the lupan-12-one structure to clerodone (isolated from *Clerodendron infortunatum* BHAT.) based on the occurrence of the band at 1 700 cm^{-1} in the IR spectrum, absence of olefinic proton signals in the ^1H NMR spectrum (other



SCHEME 1

signals have not been reported), mass spectrum patterns (only the M^+ *m/z* value of 426 has been given), and comparison with other 12-oxolupane derivatives described in the same paper[13]. However, the infrared spectrum of clerodone reproduced in ref.[14] is substantially different from that of lupan-12-one (**2**), and the melting temperatures are different as well (clerodone: 260 °C, our lupan-12-one: 184–186 °C). Based on those facts, we suggest that the structure given in ref.[13] is incorrect.

EXPERIMENTAL

The melting temperatures were determined on a Kofler stage and are not corrected. Optical rotatory power measurements of chloroform solutions were performed on an ETL-NPL automatic polarimeter (Bendix–Ericsson) with a precision of ±2° (concentration 0.4–0.8). Infrared spectra were measured in chloroform solutions using a Perkin–Elmer PE684 spectrophotometer (wavenumbers are given in cm^{-1}), ultraviolet spectra were scanned on a Unicam SP-700 instrument. The ^1H NMR spectra were measured in deuteriochloroform solutions; the instruments were a Tesla BS 487 A spectrometer (80 MHz, CW mode), using hexamethyldisiloxane as the internal standard (the chemical shifts are relative to tetramethylsilane using the value of δ(HMDS) = 0.063 and are rounded to 2 decimal places), and Varian HA-100 (100 MHz, CW mode) and Varian XL-200 (200 MHz, FT mode) spectrometers, using tetramethylsilane as the internal standard. The chemical shifts (δ-scale, ppm) and coupling constants (Hz) were obtained by first-order analysis. The ^{13}C NMR spectra in deuteriochloroform were run on a Varian XL-200 instrument (50.31 MHz, "attached proton test" technique). The chemical shifts were related to the signal of the solvent and converted by using the value of $\delta(CDCl_3) = 77.0$. The mass spectra were measured on a Varian MAT 311 spectrometer; ionizing electron energy 70 eV, direct inlet temperatures 150 to 180 °C. The data are given in the format: *m/z* (%).

The identity of the samples prepared by various procedures was checked by thin layer chromatography, IR, and ^1H NMR spectroscopy. Thin layer chromatography was performed on silica gel G plates (Merck) applying detection by spraying with 10% sulfuric acid and heating, and on Silufol plates (Kavalier, Votice) applying detection with 5% ethanolic phosphomolybdic acid and heating. Kieselgel 60 G (Merck) and Silpearl (Kavalier, Votice) were employed for thin layer preparative chromatography and column chromatography, respectively. Conventional treatment consisted of the following steps: pouring the reaction mixture into water, extraction of the products into ether, extraction of the ether layer consecutively with water, dilute (1 : 4) hydrochloric acid, water, saturated sodium hydrogen carbonate solution, and water, drying with anhydrous sodium sulfate, and evaporation of the solvent at a reduced pressure. The analytical samples were dried in a vacuum over phosphorus pentoxide at room temperature.

Oxidation of Lupane (**1**) with Chromium Oxide

To a solution of chromium oxide (2.0 g, 20 mmol) in acetic acid (80 ml) was added lupane (**1**) (5.0 g, 12.1 mmol), and the whole was refluxed for 15 min. Subsequently, the mixture was evaporated at a reduced pressure to a small volume and treated conventionally. Double crystallization of the evaporation residue (3.6 g) from a chloroform–methanol mixture gave the starting hydrocarbon **1** (2.1 g, 42%). The combined mother liquors were chromatographed on a silica gel column (100 g) using a 25 : 1 mixture of light petroleum and ether. A total of 12 chromatographically uniform fractions were obtained, out of which, however, only fractions 1 (starting hydrocarbon **1**; 0.3 g, 6%), 4, and 9 were individual compounds.

Fraction 4 was crystallized from methanol to obtain lupan-12-one (**2**) (27 mg, 0.5%), m.p. 184–186 °C, $[\alpha]_D$ –10°. IR spectrum: 1 704 (C=O). ^{1}H NMR spectrum (200 MHz): 0.769 s, 3 H, 0.785 d, 3 H, J = 7, 0.817 s, 6 H, 0.856 s, 3 H, 0.912 s, 3 H, 0.926 d, 3 H, J = 7 and 1.289 s, 3 H (8 × CH_3); 1.65 dd, 1 H (H-9); 2.17 dd, 1 H, J(11α,11β) = 11.8, J(9,11α) = 3.8 (H-11α); 2.35 ddd, 1 H, J(11α,11β) = 11.8, J(9,11β) = 13.5, J(11β,13) = 0.8 (H-11β); 2.74 bd, 1 H, J(11β,13) = 0.8, J(13,18) = 10.6 (H-13); 1.86 dd, 1 H, J = 13.5 and 5.2; 1.98 ddd, 1 H, J = 13.5, 6.6, and 2.3. Mass spectrum: 426 (M^+, 43), 411 (11), 408 (10), 393 (8), 383 (8), 301 (11), 288 (8), 257 (8), 234 (35), 221 (22), 219 (38), 206 (20), 191 (100), 177 (55). For $C_{30}H_{50}O$ (426.7) calculated: 84.44% C, 11.81% H; found: 84.61% C, 11.82% H.

Fraction 6 gave an ^{1}H NMR spectrum (200 MHz) displaying signals of the H-2, H-3, and methyl group protons in lup-2-en-1-one (**3**). An authentic sample of the ketone **3** was prepared following ref.[7]. Melting temperature 192–193 °C (ref.[7]: 190–191 °C). IR spectrum: 1 683 cm^{-1} (C=O). UV spectrum: λ_{max} 220 nm (log ε 3.95, in cyclohexane), λ_{max} 336 nm (log ε 1.80, in tetrahydrofuran). ^{1}H NMR spectrum (80 MHz): 0.76 s, 3 H; 0.76 d, 3 H, J = 7; 0.83 d, 3 H, J = 7; 0.97 s, 3 H; 1.05 s, 3 H; 1.08 s, 3 H; 1.12 s, 3 H and 1.20 s, 3 H (8 × CH_3); 5.63 d, 1 H, J = 10.3 and 6.25 d, 1 H, J = 10.3 (H-2 and H-3).

Fraction 7 (120 mg) was dissolved in ether (5 ml), lithium aluminium hydride (50 mg) was added, and the mixture was refluxed for 1 h. Subsequently, ethyl acetate was added dropwise, the whole was poured onto ice with hydrochloric acid, and following conventional treatment, the evaporation residue was chromatographed on a silica gel plate (10 g) using a 6 : 1 mixture of light petroleum and ether. Crystallization of the most abundant (most polar) zone from methanol gave lupan-16α-ol (**4**) (35 mg, 0.7%), m.p. 215–217 °C, $[\alpha]_D$ –35°. IR spectrum: 3 612 (OH), 1 027 (C–O–C). ^{1}H NMR spectrum (200 MHz): 0.792 s, 3 H, 0.799 s, 3 H, 0.797 d, 3 H, J = 6.8, 0.836 s, 3 H, 0.845 s, 3 H, 0.853 d, 3 H, J = 6.8, 1.017 s, 3 H and 1.171 d, 3 H, J = 1.0 (8 × CH_3); 1.26 dd, 1 H, J(15α,15β) = 14.9, J(15α,16β) = 2.1 (H-15α); 1.95 ddq, 1 H (H-15β); 3.80 dd, 1 H, J(15α,16β) = 2.1, J(15β,16β) = 4.2 (H-16β), J(15β,27) = 1.0. ^{13}C NMR spectrum: 74.44 (C-16), 56.36 (C-5), 49.21 (C-9), 47.52 (C-17), 43.88 (C-19), 43.26 (C-14), 42.10 (C-3), 41.26 (C-8), 40.47 (C-18), 40.29 (C-1), 38.07 (C-13), 37.44 (C-10), 34.50 (C-7), 34.21 (C-15), 33.36 (C-23), 33.26 (C-4), 33.26 (C-22), 29.69 (C-20), 26.73 (C-12), 23.00 (C-29), 21.57 (C-24), 21.33 (C-21), 20.88 (C-11), 19.12 (C-28), 18.70 (C-2), 18.59 (C-6), 17.35 (C-27), 16.22 (C-26), 16.07 (C-25), 15.22 (C-30). Mass spectrum; 428 (M^+, 25), 413 (13), 410 (20), 395 (6), 385 (6), 367 (10), 290 (3), 275 (3), 272 (3), 257 (4), 247 (8), 229 (8), 204 (34), 191 (100).

Fraction 9 gave lup-18-en-21-one (**5**) (43 mg, 0.9%), m.p. 251–254 °C (chloroform, methanol), $[\alpha]_D$ –88°. IR spectrum: 1 680 (C=O), 1 597 (C=C), 969. ^{1}H NMR spectrum (200 MHz): 0.806 s, 3 H, 0.855 s, 3 H, 0.901 s, 3 H, 0.920 s, 3 H, 1.162 s, 3 H, 1.172 d, 3 H, J = 7.0; 1.195 d, 3 H, J = 7.0 and 1.189 s, 3 H (8 × CH_3); 2.06 d, 1 H and 2.15 d, 1 H, J(gem) = 18.6 (2 × H-22); 2.87 m, 1 H, ΣJ = 16; 3.14 sep, 1 H, J = 7.0 (H-20). Mass spectrum: 424 (M^+, 14), 409 (8), 381 (10), 325 (8), 279 (13), 243 (13), 219 (61), 205 (24), 191 (25), 167 (35), 149 (100).

Oxidation of Lup-18-ene (**6**) with Chromium Oxide

A solution of lup-18-ene[4] (100 mg, 0.24 mmol) in acetic acid (30 ml) was mixed with a solution of chromium oxide (50 mg, 0.5 mmol) in water (2 ml), allowed to stand at room temperature for 16 h, and treated conventionally. Chromatography of the evaporation residue on a silica gel plate (10 g) using a 10 : 1 mixture of light petroleum and ether gave 35 mg (34%) of the more polar ketone **5**, identical with the compound obtained from the preceding experiment, and 40 mg (39%) of the less polar 18β,19β-epoxylupane (**7**), identical with the compound described in ref.[4].

Lupan-3β,28-diol Dinitrate (**9**)

Nitric acid 100% (3 ml, 67 mmol) was added dropwise to stirred acetic anhydride (20 ml, 212 mmol) at 0 °C, and lupan-3β,28-diol (**8**) (0.30 g, 0.68 mmol) was added portionwise to this mixture within 30 min at the same temperature. The mixture was stirred for another 3 h at 0 °C and poured onto ice. The separated product was filtered out, dried, and crystallized from a chloroform–methanol mixture. Yield 310 mg (86%) of the dinitrate **9**, m.p. 182–184 °C (decomp.), $[\alpha]_D$ –4°. IR spectrum: 1 624, 1 276, 872, 862 (ONO_2). ^{1}H NMR spectrum (80 MHz): 0.78 d, 3 H, J = 7, 0.86 d, 3 H, J = 7, 0.88 s, 6 H, 0.97 s, 3 H, 1.00 s, 3 H and 1.06 s, 3 H (7 × CH_3); 4.19 d, 1 H and 4.63 d, 1 H, J(gem) = 10.5 (2 × H-28); 4.66 m, 1 H, ΣJ = 16 (H-3α). For $C_{30}H_{50}N_2O_6$ (534.7) calculated: 67.38% C, 9.43% H, 5.24% N; found: 67.31% C, 9.40% H, 5.31% N.

3β,28-Dimethoxylupane (**11**)

A solution of 3β,28-dimethoxy-20(29)-lupene[12] (**10**) (1 g, 2.13 mmol) in ether (50 ml) was hydrogenated at room temperature under atmospheric pressure of hydrogen for 3 h until hydrogen (50 ml, 2.23 mmol) was used up. Platinum(IV) oxide after Adams served as the catalyst. After filtering the catalyst off and distilling ether off, the evaporation residue was crystallized from a chloroform–methanol mixture to obtain 930 mg (93%) of the dimethyl ether **11**, m.p. 200–202 °C, $[\alpha]_D$ –11°. IR spectrum: 1 096 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.75 s, 3 H, 0.76 d, 3 H, J = 7; 0.83 d, 3 H, J = 7, 0.84 s, 3 H, 0.95 s, 6 H and 1.04 s, 3 H (7 × CH_3); 3.33 s, 3 H and 3.35 s, 3 H (2 × OCH_3); 2.64 m, 1 H, ΣJ = 16 (H-3α); 3.01 d, 1 H and 3.47 d, 1 H, J(gem) = 9.4 (2 × H-28). For $C_{32}H_{56}O_2$ (472.8) calculated: 81.29% C, 11.94% H; found: 81.07% C, 11.81% H.

Oxidation of 3β,28-Dimethoxylupane (**11**) with Chromium Oxide

A solution of the dimethyl ether **11** (1.2 g, 2.54 mmol) and chromium oxide (1.0 g, 10 mmol) in acetic acid (40 ml) was heated to boil under a reflux condenser for 30 min, poured into water, the crystalline precipitate was extracted into ether, and the ether layer was treated conventionally. Chromatography of the evaporation residue (0.95 g) on a silica gel column (70 g) using a 20 : 1 mixture of light petroleum and ether gave consecutively the starting dimethyl ether **11** (540 mg, 45%) and the following compounds:

*28-Methoxylupan-3*β*-ol formate* (**12**). Crystallization of the crude product (180 mg) from methanol gave 60 mg (5%) of the substance, m.p. 227–230 °C, $[\alpha]_D$ –16°. IR spectrum: 1 712 (OCHO); 1 187, 1 101 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.76 d, 3 H, J = 7, 0.84 d, 3 H, J = 7, 0.88 s, 9 H, 0.95 s, 3 H and 1.05 s, 3 H (7 × CH_3); 3.33 s, 3 H (OCH_3); 3.02 d, 1 H and 3.46 d, 1 H, J(gem) = 10.5 (2 × H-28); 4.60 m, 1 H, ΣJ = 16 (H-3α); 8.09 s, 1 H (OCHO). For $C_{32}H_{54}O_3$ (486.7) calculated: 78.96% C, 11.18% H; found: 79.05% C, 11.23% H.

28-Methoxylupan-3-one (**14**), yield 95 mg (8%), m.p. 232–234 °C (methanol, at 210 °C sublimation from needles to prisms), $[\alpha]_D$ +1°. IR spectrum: 1 700 (C=O); 1 112, 1 099 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.76 d, 3 H, J = 7, 0.85 d, 3 H, J = 7, 0.95 s, 3 H, 0.96 s, 3 H, 1.03 s, 3 H and 1.08 s, 6 H (7 × CH_3); 2.43 m, 2 H (2 × H-2); 3.34 s, 3 H (OCH_3); 3.02 d, 1 H and 3.46 d, 1 H, J(gem) = 9.6 (2 × H-28). For $C_{31}H_{52}O_2$ (456.7) calculated: 81.52% C, 11.48% H; found: 81.64% C, 11.23% H.

28-Methoxy-2-norlupan-1,3-dioic anhydride (**13**), 110 mg (9%), m.p. 267–270 °C (chloroform–methanol), $[\alpha]_D$ +33°. IR spectrum: 1 797 and 1 753 (anhydride); 1 098 and 1 006 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.78 d, 3 H, J = 6.5, 0.85 d, 3 H, J = 7, 1.01 s, 3 H, 1.12 s, 3 H, 1.17 s, 3 H and 1.33 s, 6 H (7 × CH_3); 3.34 s, 3 H (OCH_3); 3.03 d, 1 H and 3.46 d, 1 H, J(gem) = 10 (2 × H-28).

Mass spectrum: 472 (M^+, 3), 457 (1), 440 (15), 427 (74), 426 (72), 399 (100), 191 (62). For $C_{30}H_{48}O_4$ (472.7) calculated: 76.22% C, 10.24% H; found: 76.00% C, 10.31% H.

If the reaction time is extended to 2 h and the amount of chromium oxide is increased to 3 g, the evaporation residue (0.3 g) involves, by TLC, largely very polar compounds and mere traces of the compounds **13** and **14**.

28-Methoxylupan-3β-ol (**15**)

a) To a solution of the ketone **14** (45 mg, 0.1 mmol) in a mixture of methanol (2 ml) and benzene (1 ml) was added sodium tetrahydroborate (80 mg, 2.1 mmol), and the mixture was allowed to stand overnight at room temperature. Subsequently, the mixture was diluted with water and extracted with ether, and the ether layer was treated conventionally. Crystallization of the evaporation residue from a chloroform–methanol mixture gave the alcohol **15** (32 mg, 71%), m.p. 233–234 °C (sublimation at about 200 °C), $[\alpha]_D$ –29°. IR spectrum: 3 611 (OH), 1 099 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.76 d, 3 H, J = 6.5, 0.77 s, 3 H, 0.84 d, 3 H, J = 6.5, 0.84 s, 3 H, 0.95 s, 3 H, 0.97 s, 3 H and 1.04 s, 3 H (7 × CH_3); 3.03 d, 1 H and 3.46 d, 1 H, J(gem) = 9.5 (2 × H-28); 3.18 m, 1 H, ΣJ = 16 (H-3α); 3.33 s, 3 H (OCH_3). For $C_{31}H_{54}O_2$ (458.7) calculated: 81.16% C, 11.87% H; found: 81.25% C, 11.69% H.

b) Formate **12** (20 mg, 0.04 mmol) was hydrolyzed by boiling in 1% sodium hydroxide solution in methanol (1 ml) for 2 h. Conventional treatment followed by crystallization from methanol gave 15 mg (80%) of the alcohol **15**, identical with that prepared by route *a*).

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