OLEANANE TRITERPENOIDS FUNCTIONALIZED AT C-25 AND C-26*

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Dedicated to Professor Jaroslav Podlaha on the occasion of his 60th birthday.

Reaction of 25-oximino-19β,28-epoxy-18α-oleanan-2β-ol (**4**) with nitrous acid afforded hemiacetal **22** ((25*S*)-2β,25;19β,28-diepoxy-18α-oleanan-25-ol). Functionalization of 19β,28-epoxy-18α-oleanan-2β-ol (**1**) with lead(IV) acetate gave 2β,25;19β,28-diepoxy-18α-oleanane (**31**). A series of derivatives with an oxygen functionality at position 25 has been prepared by modification of the functional groups in compounds **22** and **31**. 26-Oximino-19β,28-epoxy-18α-oleanan-2β-ol (**7**) on reaction with nitrous acid afforded the corresponding nitrimine **10** which could not be converted into derivatives with an oxygen group at C-26: all the attempted preparations led invariably to compounds containing a nitrile group in position 8β. The nitrile groups in positions 10β and 8β appeared to be extremely unreactive.

Key words: Triterpenoids; Oleanane; Functionalization; Oximes.

During our studies[2,3] we observed that photolysis of nitrite **2**, derived from 19β,28-epoxy-18α-oleanan-2β-ol (**1**), afforded two isomeric oximino derivatives **4** (40%) and **7** (40%) beside small amounts of alcohol **1** (10%) and the corresponding ketone **17** (5%). The functionalization of the remote methyl group in position 8β in the photolytic reaction (Barton reaction) was explained[2] by two consecutive hydrogen radical transfers: the first transfer of H$^{\bullet}$ is from the 10β-methyl group (C-25) to the oxygen radical in position 2β under formation of radical at C-25 which then gives the oxime **4**; the second H$^{\bullet}$ transfer is from the 8β-methyl group (C-26) to the radical at C-25; the arising radical at C-26 then recombinates with NO$^{\bullet}$ to give the 26-oxime **7**. In our previous paper[2] we further described the conversion of oximes **4** and **7** into 25-nitriles (**5**, **6**, and **12**) and 26-nitriles (**8**, **9**, and **13**), respectively. In the present study we tried to utilize

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

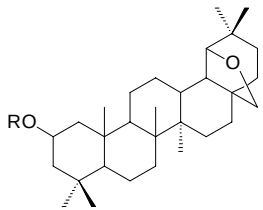
the mentioned oximino derivatives for the preparation of compounds containing an oxygen functionality at C-25 and C-26.

The nitrile groups in positions 10β and 8β are extremely unreactive: the 2β-hydroxy nitriles **5** and **8** did not change on boiling with 10% sodium hydroxide in ethylene glycol; in 2β-acetoxy nitriles **6** and **9** only the ester group was saponified under these conditions. The 2-oxonitriles **12** and **13** resisted boiling with 10% sulfuric acid in acetic acid. On reflux with 10% sodium hydroxide in ethylene glycol, the 2-oxo-25-nitrile **12** afforded a complex mixture of products (according to thin-layer chromatography); under the same conditions the nitrile group in the 2-oxo-26-nitrile **13** remained intact and the keto group was reduced with predominant formation of hydroxy nitrile **8**. For comparison, the keto group was reduced under the same conditions also in the 1-, 2-, and 3-oxo derivatives devoid of nitrile groups (ketones **14**, **15**, and **19**, respectively). This reaction gave mixtures of isomeric hydroxy derivatives in which isomers with axial hydroxyl predominated: 1-ketone **14** gave alcohols **15** and **16** in the ratio 8 : 1, 2-ketone **17** afforded alcohols **1** and **18** (3 : 1), and 3-ketone **19** was reduced to alcohols **20** and **21** (5 : 4). The reduction obviously proceeds at the expenses of ethylene glycol and its mechanism may be similar to that of the Meerwein–Ponndorf–Verley reduction. Reduction of ketones under comparable conditions (4% potassium hydroxide in boiling diethylene glycol) has recently been described[4] for some 3-oxotriterpenoids; however, the authors[4] observed predominant formation of the thermodynamically more stable equatorial isomers.

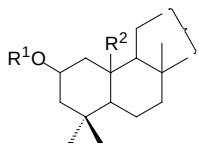
Because of the stability of the nitrile groups, we tried to prepare the oxygen derivatives directly from oximes **4** and **7** by treatment with nitrous acid according to an analogy[5,6]. The 26-oximino derivative **7** thus afforded nitrimine **10** which was acetylated to give acetate **11**. Both compounds exhibit characteristic IR bands due to a nitrimino group (1 604, 1 574, and 1 294 cm^{-1}). In ^1H NMR spectrum this group causes a marked upfield shift of the H-28 (endo) signal from the value δ 3.78, usual for 19β,28-epoxy-18α-oleanane and its common derivatives (see, e.g. ref.[7]), to δ 3.60. Nitrimines **10** and **11** changed neither on boiling in aqueous dioxane under conditions that should convert them into aldehydes[5,6] nor on reflux with pyridine. On boiling with aqueous ethylene glycol or with 1% sodium hydroxide solution in a mixture of benzene and ethanol, nitrimine **10** was converted into nitrile **8**, nitrimine **11** on treatment with boiling acetic acid gave nitrile **9**. Thus, neither of the described procedures afforded derivatives with an oxygen-containing group on C-26. This low reactivity of groups in the position 8β is undoubtedly due to a steric hindrance. A similar behaviour was observed by Ayer and coworkers[8] with lupane derivatives containing an 8β-carboxy or carbomethoxy group: these groups resisted reduction even under very vigorous conditions.

In the reaction of the 25-oximino derivative **4** with nitrous acid we did not isolate the nitrimine intermediate even when working at –20 °C. The only product obtained was hemiacetal **22**. This compound was acetylated to give acetate **23**; heating of **22** in

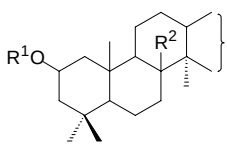
methanol or ethanol (or standing at room temperature) afforded the corresponding acetals **24** and **25**, respectively. The infrared spectrum of hemiacetal **22** exhibits a weak band at 1 698 cm^{-1} and its ^1H NMR spectrum displays a weak singlet at δ 10.31, indicating that in chloroform also the free aldehyde form **26** is present. Although the compounds **22**–**25** can exist in two isomers at C-25, in all cases we obtained only one isomer which probably has the OR group oriented toward C-11 (in the hemiacetal **22** configuration 25*S*). The other isomer (with the OR group oriented between the 4β- and 8β-methyl groups) is extremely improbable for steric reasons.



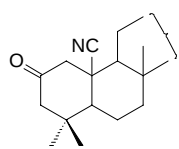
	R
1	H
2	NO
3	NO_2



	R^1	R^2
4	H	CH=NOH
5	H	CN
6	$COCH_3$	CN



	R^1	R^2
7	H	CH=NOH
8	H	CN
9	$COCH_3$	CN
10	H	$CH=NNO_2$
11	$COCH_3$	$CH=NNO_2$



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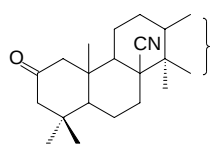

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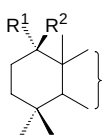
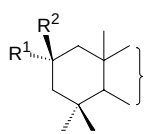
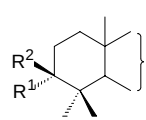


	R^1	R^2
14	O	
15	OH	H
16	H	OH

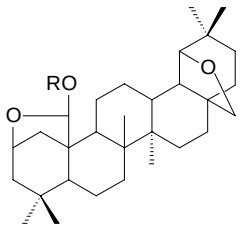


	R^1	R^2
17	O	
18	OH	H
1	H	OH

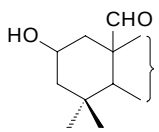


	R^1	R^2
19	O	
20	OH	H
21	H	OH

Oxidation of the hemiacetal **22** with sodium dichromate in acetic acid led to lactone **30**. This on further oxidation with chromium trioxide gave dilactone **32** (Scheme 1) which was also prepared as described below. Directed functionalization of 2β-hydroxy derivative **1** with lead tetraacetate afforded ether **31** in 70% yield: the radical attack thus took place at the 10β-methyl group, similarly as in steroidal 2β-alcohols[5,9]. In the reaction of the ether **31** with chromium trioxide in acetic acid both the groups –O–CH_2– were oxidized under formation of dilactone **32**. The structure of lactone **30** and ether **31** was confirmed (in addition to their ^{1}H NMR and IR spectra) also by ^{13}C NMR spectra (Table I); the assignment of the individual carbon signals was based on analogy with 19β,28-epoxy-18α-oleanane[10].



22, R = H
23, R = $COCH_3$
24, R = CH_3
25, R = C_2H_5



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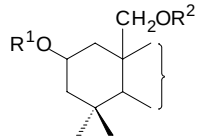
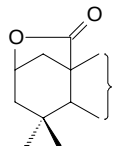


	R^1	R^2
27	H	H
28	$COCH_3$	$COCH_3$
29	H	NO_2



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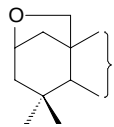

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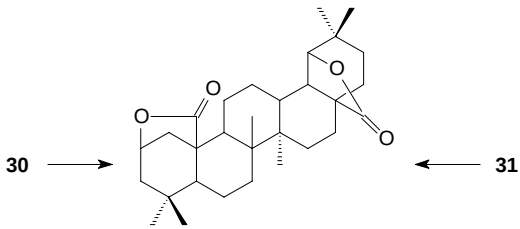
Attempted preparation of aldehydes by reaction of oximes with pyruvic acid in boiling acetic acid according to ref.[11] converted the 26-oxime **7** into nitrile **9**, the 25-oxime **4** gave a mixture of nitriles **5** and **6**, hemiacetal **22** and its acetate **23**. When the reaction



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SCHEME 1

was performed at 40 °C, the oxime **4** afforded a similar mixture, whereas oxime **7** did not react. Also in attempted preparation of oxime acetates by reaction with acetic anhydride in pyridine at room temperature both oximes **4** and **7** were dehydrated to give the respective 2-acetyl nitriles **6** and **9**.

In the preparation of the starting oximes **4** and **7** by photolysis of nitrite **2** (ref.[2]) we isolated in one case nitrate **29** (3%) along with the above-mentioned products **1**, **4**, **7**, and **17**. The nitrate **29** was hydrogenolyzed on a platinum catalyst to give diol **27**, characterized as diacetate **28**. The same diol **27** was obtained by reduction of hemiacetal **22** with lithium aluminium hydride (no reduction of **22** was observed with sodium borohydride). For comparison of the ^{1}H NMR spectra we prepared nitrate **3** from the 2β-hydroxy derivative **1**. The chemical shift of H-2α in the nitrate **29** (δ 4.12) is similar to that found for the 2α-hydroxy derivative **1** (δ 4.05, see ref.[12]) but it differs from the shift found for the nitrate **3** (δ 5.25); this confirms the presence of a free hydroxyl group at C-2 and a nitrate group at C-25. The formation of nitrates in the photolysis of nitrites was observed also in other cases and was explained by the action of air oxygen on the reaction intermediates[9,13].

TABLE I
Carbon-13 chemical shifts (δ) of compounds **30** and **31**

Carbon	**30**	**31**	Carbon	**30**	**31**
1	43.26[a]	43.51[a]	16	36.72	36.66
2	74.89	73.88	17	36.25	36.25
3	45.41[a]	47.27[a]	18	46.66	46.61
4	32.93	32.78	19	87.63	87.80
5	55.27	54.60	20	41.48	41.46
6	19.98	20.53	21	32.68	32.67
7	33.71	33.08	22	26.30	26.20
8	40.02	39.94	23	33.44	34.09
9	42.35	43.93	24	25.17	25.69
10	48.23	47.13	25	177.07	67.55
11	21.73	21.33	26	15.98	15.68
12	26.52	26.78	27	12.87	13.51
13	34.27	34.46	28	71.32	71.23
14	40.42	40.05	29	24.53	24.53
15	26.49	26.20	30	28.79	28.77

[a] The assignment of signals may be interchanged.

EXPERIMENTAL

The melting points were determined on a Kofler block and are uncorrected. Optical rotations were measured in chlorofom (unless stated otherwise) on an automatic polarimeter ETL-NPL (Bendix–Ericsson), accuracy ±2° (concentration 0.4–0.8). Infrared spectra were recorded in chloroform on a PE 684 (Perkin–Elmer) spectrometer; wavenumbers are given in cm^{-1}. Proton NMR spectra were measured on a Tesla BS 487A instrument (80 MHz, CW mode) in deuteriochloroform with hexamethyldisiloxane as internal standard (the chemical shifts were related to tetramethylsilane according to the relation δ(HMDS) = 0.063 and rounded to two decimals) or on a Varian XL-200 (at 200 MHz, FT mode) in deuteriochloroform with tetramethylsilane as internal standard. Chemical shifts and coupling constants were obtained by analysis of the first order. The coupling constants (*J*) and signal half-widths ($W_{1/2}$) are given in Hz, chemical shifts in the δ scale. ^{13}C NMR spectra were measured on a Varian XL-200 spectrometer (50.31 MHz, "attached proton test" technique) in deuteriochloroform. Chemical shifts were referenced to the solvent signal and calculated according to the relationship δ($CDCl_3$) = 77.00. Mass spectra were measured on a Varian MAT 311 spectrometer, ionizing electron energy 70 eV, direct inlet, 150–180 °C, data in *m*/*z* (%).

The identity of samples prepared by different procedures was checked by thin-layer chromatography and IR and ^1H NMR spectra. Thin-layer chromatography was carried out on plates of silica gel G (Merck), detection by spraying with 10% sulfuric acid and heating, or on Silufol foils (Kavalier, Votice, Czech Republic), detection with 5% ethanolic solution of phosphomolybdic acid and heating. Preparative thin-layer chromatography was performed on Kieselgel 60 G (Merck), column chromatography on silica gel Silpearl (Kavalier, Votice, Czech Republic). The usual work-up denotes the following operations: The reaction mixture was poured into water, the products were taken up in ether, the extract was washed successively with water, dilute (1 : 4) hydrochloric acid, water, saturated solution of sodium hydrogen carbonate and again water, dried over sodium sulfate, and the solvent was evaporated under diminished pressure. Alcohols were acetylated by treatment with an acetic anhydride–pyridine mixture (1 : 2) at room temperature for 15–20 h; the reaction mixtures were worked up in the usual manner. Analytical samples were dried in vacuo over phosphorus pentoxide at room temperature. Compounds **2**, **4**–**9**, **12**, and **13** are described in ref.[2], alcohol **1** in ref.[12]. The preparation of authentic samples of ketones and alcohols **14**–**19** is summarized in refs[3,14].

19β,28-Epoxy-18α-oleanan-2β-ol Nitrate (**3**)

Nitric acid (100%; 1 ml, 24 mmol) was added dropwise at –15 °C to acetic anhydride (10 ml). Into this mixture hydroxy derivative **1** (100 mg, 0.23 mmol) was added under stirring during 5 min. The mixture was then stirred at –15 °C for 30 min, poured onto ice and worked up in the usual manner. Crystallization of the residue from benzene–ethanol afforded 85 mg (77%) of nitrate **3**, m.p. 169–171 °C, $[\alpha]_D$ +51°. IR spectrum: 1 623, 1 280, 865 (ONO_2). ^1H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.92 s, 3 H, 0.93 s, 3 H, 0.97 s, 6 H, 0.98 s, 3 H and 1.06 s, 3 H (7 × CH_3); 3.51 s, 1 H (H-19); 3.44 d, 1 H and 3.79 d, 1 H, J = 8 (2 × H-28); 5.25 m, 1 H, ΣJ = 21 (H-2). For $C_{30}H_{49}NO_4$ (487.7) calculated: 73.88% C, 10.13% H, 2.87% N; found: 73.96% C, 10.02% H, 3.01% N.

19β,28-Epoxy-2β-hydroxy-18α-oleanane-25-nitrile (**5**)

Sodium hydroxide (200 mg, 5 mmol) was added to a suspension of acetate **6** (50 mg, 0.10 mmol) in ethylene glycol (2 ml). The mixture was boiled for 8 h and poured into water. The precipitate was collected and crystallized from chloroform–ethanol; yield 35 mg (76%) of compound **5**, m.p. 282–284 °C, identical with an authentic sample[2].

2β-Acetoxy-19β,28-epoxy-18α-oleanane-25-nitrile (**6**)

Oxime **4** was acetylated with acetic anhydride in pyridine at room temperature for 15 h. The usual work-up, filtration of the ethereal solution through a layer of aluminium oxide and crystallization from chloroform–methanol afforded nitrile **6** (83%), m.p. 253–256 °C, identical with an authentic sample[2].

19β,28-Epoxy-2β-hydroxy-18α-oleanane-26-nitrile (**8**)

A. A mixture of acetate **9** (50 mg, 0.10 mmol), sodium hydroxide (200 mg, 5 mmol) and ethylene glycol (2 ml) was refluxed for 16 h. After pouring into water, the separated product was collected and crystallized from methanol. Yield 30 mg (65%) of compound **8**, m.p. 316–318 °C, identical with an authentic sample[2].

B. A mixture of nitrimine **10** (50 mg, 0.10 mmol) and ethylene glycol (2 ml) was boiled for 20 min. The reaction mixture was worked up as described for method *A* to give 23 mg (51%) of compound **8**. The same product was obtained in 65% yield by boiling nitrimine **10** with 1% sodium hydroxide solution in benzene–ethanol (8 : 5) mixture.

2β-Acetoxy-19β,28-epoxy-18α-oleanane-26-nitrile (**9**)

A. The reaction of oxime **7** with acetic anhydride in pyridine, performed in the same manner as in the preparation of compound **6**, afforded nitrile **9** (92%), m.p. 280–283 °C, identical with an authentic sample[2].

B. A solution of nitrimine **11** (50 mg, 0.09 mmol) in acetic acid (10 ml) was heated at 100 °C for 3 h. After pouring into water, the deposited product was collected and crystallized from ethanol. Yield 35 mg (77%) of nitrile 9, m.p. 281–284 °C.

C. A mixture of nitrimine **11** (50 mg, 0.09 mmol) and ethylene glycol (5 ml) was refluxed for 30 min and then worked up in the usual manner. Crystallization from ethanol gave 40 mg (87%) of nitrile **9**.

19β,28-Epoxy-26-nitrimino-18α-oleanan-2β-ol (**10**)

To a stirred solution of oxime **7** (300 mg, 0.64 mmol) in acetic acid (25 ml), cooled to 0 °C, was added 15% aqueous sodium nitrite solution (3 ml, 6.5 mmol). After standing at 0 °C for 3 h and at room temperature for 15 h, the mixture was poured into water and the precipitate was collected and crystallized from chloroform–methanol. Yield 280 mg (88%) of nitrimine **10**, decomposing at about 330 °C (change of modification at 190–200 °C and 240–250 °C), $[\alpha]_D$ +10°. IR spectrum: 3 609 (OH); 1 604, 1 574, 1 294 (CH=NNO_2); 1 032, 1 007 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.92 s, 3 H, 0.935 s, 6 H, 0.97 s, 3 H and 1.06 s, 3 H (6 × CH_3); 2.26 bd, 1 H, J = 11; 3.52 s, 1 H (H-19); 3.45 d, 1 H and 3.58 d, 1 H, J = 8 (2 × H-28); 4.07 m, 1 H, $W_{1/2}$ = 14 (H-2); 8.91 bs, 1 H (H-26). Mass spectrum: 453 (100, $M^+ - 47$), 451 (31), 382 (34), 380 (21), 177 (35). For $C_{30}H_{48}N_2O_4$ (500.7) calculated: 71.96% C, 9.66% H, 5.60% N; found: 72.12% C, 9.53% H, 5.87% N.

Acetate **11** was prepared by acetylation of nitrimine **10** with acetic anhydride in pyridine; m.p. 283–285 °C (methanol), $[\alpha]_D$ +15°. IR spectrum: 1 728, 1 257 (OAc); 1 604, 1 578, 1 294 (CH=NNO_2); 1 062, 1 030, 1 008 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.92–0.94, 12 H and 1.07 s, 3 H (6 × CH_3); 2.00 s, 3 H (OAc); 2.30 bd, 1 H, J = 10; 3.52 s, 1 H (H-19); 3.44 d, 1 H and 3.60 d, 1 H, J = 8 (2 × H-28); 8.92 s, 1 H (H-26). For $C_{32}H_{50}N_2O_5$ (542.7) calculated: 70.81% C, 9.29% H, 5.16% N; found: 70.69% C, 9.41% H, 5.38% N.

Nitrimines **10** and **11** changed neither on boiling for 2 h in dioxane, containing 10% of water nor on reflux in pyridine for 6 h.

Reaction of Ketones **12–14**, **17**, and **19** with Sodium Hydroxide and Ethylene Glycol

A mixture of the ketone (100 mg, 0.22–0.23 mmol), sodium hydroxide (0.5 g, 12.5 mmol) and ethylene glycol (5 ml) was refluxed for 3 h, cooled and worked up in the usual manner. The obtained material was subjected to preparative thin-layer chromatography on silica gel (10 g) in light petroleum–ether (2 : 1). The products were crystallized from methanol and identified by comparison with authentic samples. The 2-oxo-25-nitrile **12** afforded a mixture of 5 products which could not be separated or identify, the 2-oxo-26-nitrile **13** gave 70 mg (70%) of hydroxy nitrile **8**, identical with an authentic sample. The 1-oxo derivative **14** furnished 73 mg (73%) of 1α-ol **15** and 9 mg of 1β-ol **16**. Reaction of the 2-oxo derivative **17** led to 65 mg (65%) of 2β-ol **1** and 20 mg (20%) of 2α-ol **18**, and the 3-oxo derivative **19** was converted into 50 mg (50%) of 3α-ol **20** and 40 mg (40%) of 3β-ol **21**.

(25*S*)-2β,25;19β,28-Diepoxy-18α-oleanan-25-ol (**22**)

To a solution of oxime **4** (250 mg, 0.53 mmol) in acetic acid (15 ml) was added dropwise 15% aqueous solution of sodium nitrite (2 ml, 4.3 mmol) at 0 °C. After standing at 0 °C for 30 min and then at room temperature for 6 h, the reaction mixture was poured into water. The precipitate was collected and crystallized from acetone to give 210 mg (84%) of dimorphous hemiacetal **22**, m.p. 229–232 °C (plates) or 238–240 °C (needles); $[\alpha]_D$ +81°. IR spectrum: 3 599, 3 388 (OH); 1 698 w (C=O); 1 029, 1 005 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.93 s, 9 H, 0.99 s, 3 H and 1.05 s, 3 H (6 × CH_3); 2.56 bd, 1 H, J = 12; 3.55 s, 1 H (H-19); 3.45 d, 1 H and 3.82 d, 1 H, J = 8 (2 × H-28); 4.36 m, 1 H, $W_{1/2}$ = 13 Hz (H-2); 5.44 bs, 1 H (H-25). For $C_{30}H_{48}O_3$ (456.7) calculated: 78.89% C, 10.59% H; found: 79.05% C, 10.41% H. Hemiacetal **22** was obtained as the sole product also when the reaction was carried out at –20 °C and the mixture was worked up without crystallization.

Acetate **23** was prepared by acetylation of hemiacetal **22** with acetic anhydride in pyridine; m.p. 238–240 °C (chloroform–methanol), $[\alpha]_D$ +54°. IR spectrum: 1 735, 1 242 (OAc); 1 030 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.81 s, 3 H, 0.85 s, 3 H, 0.93 s, 3 H, 0.94 s, 3 H, 0.95 s, 3 H and 1.06 s, 3 H (6 × CH_3); 2.05 s, 3 H (OAc); 2.56 dd, 1 H, J = 10 and 6.5; 3.56 s, 1 H (H-19); 3.44 d, 1 H and 3.80 d, 1 H, J = 8 (2 × H-28); 4.39 m, 1 H, $W_{1/2}$ = 15 (H-2); 6.30 s, 1 H (H-25). For $C_{32}H_{50}O_4$ (498.7) calculated: 77.06% C, 10.11% H; found: 77.23% C, 9.93% H.

(25*S*)-2β,25;19β,28-Diepoxy-25-methoxy-18α-oleanane (**24**)
and (25*S*)-2β,25;19β,28-Diepoxy-25-ethoxy-18α-oleanane (**25**)

A solution of hemiacetal **22** (80 mg, 0.18 mmol) in methanol (10 ml) was refluxed for 20 min and then concentrated to crystallization to give 75 mg (90%) of acetal **24**, m.p. 220–221 °C, $[\alpha]_D$ +81°. IR spectrum: 1 026 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.91 s, 3 H, 0.93 s, 9 H and 0.99 s, 3 H (6 × CH_3); 2.51 dd, 1 H, J = 11 and 7; 3.29 s, 3 H (OCH_3); 3.55 s, 1 H (H-19); 3.45 d, 1 H and 3.81 d, 1 H, J = 8 (2 × H-28); 4.30 m, 1 H (H-2); 4.87 s, 1 H (H-25). For $C_{31}H_{50}O_3$ (470.7) calculated: 79.10% C, 10.71% H; found: 78.88% C, 10.46% H. The acetal **24** was not hydrolyzed on treatment with hydrochloric acid in aqueous acetone at room temperature.

Acetal **25** was prepared in the same manner as described above, using ethanol instead of methanol; m.p. 228–232 °C, $[\alpha]_D$ +82°. IR spectrum: 1 107, 1 029, 1 005, 995 (C–O–C). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.91 s, 3 H, 0.93 s, 9 H and 0.99 s, 3 H (6 × CH_3); 1.21 t, 3 H and 3.46 q, 2 H, J = 7 (OC_2H_5); 3.55 s, 1 H (H-19); 3.45 d, 1 H and 3.81 d, 1 H, J = 8 (2 × H-28); 4.33 m (H-2); 5.00 s, 1 H (H-25). For $C_{32}H_{52}O_3$ (484.7) calculated: 79.28% C, 10.81% H; found: 79.05% C, 10.79% H.

19β,28-Epoxy-18α-oleanane-2β,25-diol (**27**)

A. Lithium aluminium hydride (50 mg, 1.4 mmol) was added to a solution of hemiacetal **22** (80 mg, 0.18 mmol) in ether (10 ml) and the mixture was refluxed for 3 h. Ethyl acetate, water and dilute hydrochloric acid (1 : 4) were addded successively and the mixture was worked up in the usual manner. Yield 70 mg (88%) of diol **27**, m.p. 287–290 °C (methanol), $[\alpha]_D$ +47°. IR spectrum: 3 621, 3 385 (OH); 1 030 (C–O–C); ν(O–H) in tetrachloromethane (*c* 2 . 10^{-3} mol l^{-1}): 3 633, 3 526, and 3 468. For $C_{30}H_{50}O_3$ (458.7) calculated: 78.55% C, 10.99% H; found: 78.47% C, 11.02% H.

Diacetate **28** was prepared by acetylation of diol **27** with acetic anhydride in pyridine; m.p. 140–143 °C (methanol), $[\alpha]_D$ +52°. IR spectrum: 1 730, 1 258 (OAc); 1 028 (C–O–C). For $C_{34}H_{54}O_5$ (542.8) calculated: 75.23% C, 10.03% H; found: 75.00% C, 10.11% H.

B. Nitrate **29** (12 mg, 0.02 mmol) was hydrogenated in a mixture of ether (5 ml) and acetic acid (1 ml) over Adams catalyst (50 mg) for 3 h. The platinum was filtered off and the filtrate was worked up in the usual manner. Crystallization from methanol afforded 5 mg (46%) of diol **27**, identical with the compound prepared according to method *A*.

19β,28-Epoxy-18α-oleanane-2β,25-diol 25-Nitrate (**29**)

In one of the photolysis experiments, carried out according to ref.[2], in addition to compounds **1**, **4**, **7**, and **17**, column chromatography gave 3% of nitrate **29**, m.p. 224–225 °C (decomp.), $[\alpha]_D$ +38°. IR spectrum: 3 605 (OH); 1 626, 1 280 (ONO_2). ^{1}H NMR spectrum (80 MHz): 0.80 s, 3 H, 0.93 s, 6 H, 0.95 s, 3 H, 1.05 s, 3 H and 1.06 s, 3 H (6 × CH_3); 2.24 dd, 1 H, *J* = 15 and 4.5; 3.52 s, 1 H (H-19); 3.46 d, 1 H and 3.80 d, 1 H, *J* = 8 (2 × H-28); 4.12 m, 1 H (H-2); 4.81 d, 1 H and 5.30 d, 1 H, *J* = 10.5 (2 × H-25). Mass spectrum: 503 (0.5, M^+), 456 (16), 454 (7), 426 (23), 410 (18), 385 (11), 369 (14), 245 (13), 154 (100). For $C_{30}H_{49}NO_5$ (503.7) calculated: 71.53% C, 9.81% H, 2.78% N; found: 71.71% C, 9.88% H, 3.01% N.

19β,28-Epoxy-18α-oleanan-25,2β-olide (**30**)

A mixture of hemiacetal **22** (70 mg, 0.15 mmol), sodium dichromate dihydrate (100 mg, 0.34 mmol), sodium acetate (30 mg, 0.37 mmol), and acetic acid (3 ml) was stirred at room temperature for 30 min and then set aside for 15 h. The deposited crystals were collected and recrystallized from chloroform–methanol to give 55 mg (78%) of lactone **30**, m.p. 365–368 °C, $[\alpha]_D$ +95°. IR spectrum: 1 765 (C=O); 1 032 (C–O–C). ^{1}H NMR spectrum (200 MHz): 0.79 s, 3 H, 0.90 s, 3 H, 0.93 s, 3 H, 0.99 s, 3 H, 1.05 s, 3 H and 1.38 s, 3 H (6 × CH_3); 1.97 ddd, 1 H, *J* = 14.4, 4.3 and 1.9 (H-3β); 2.74 ddd, 1 H, *J* = 11.2, 6.4 and 1.9 (H-1β); 3.45 d, 1 H, *J* = 7.9 (H-28a); 3.55 s, 1 H (H-19); 3.80 dd, 1 H, *J* = 7.9 and 0.9 (H-28b); 4.62 ddd, 1 H, *J* = 6.4, 4.3 and 1.2 (H-2). Mass spectrum: 454 (100, M^+), 424 (43), 409 (12), 383 (81), 191 (98). For $C_{30}H_{46}O_3$ (454.7) calculated: 79.24% C, 10.20% H; found: 79.36% C, 10.01% H.

2β,25;19β,28-Diepoxy-18α-oleanane (**31**)

A solution of hydroxy derivative **1** (100 mg, 0.23 mmol), lead(IV) acetate (200 mg, 0.45 mmol), and dibenzoyl peroxide (10 mg, 0.04 mmol) in benzene (10 ml) was refluxed for 4 h. After addition of the same amounts of lead(IV) acetate and dibenzoyl peroxide as above, the mixture was refluxed for another 4 h. The mixture was diluted with ether, filtered through a small column of alumina (2 g) and worked up in the usual manner. Crystallization from benzene–ethanol afforded 70 mg (70%) of diether **31**, m.p. 262–265 °C, $[\alpha]_D$ +66°. IR spectrum: 1 009, 1 030 (C–O–C). ^{1}H NMR spectrum (200 MHz): 0.78 s, 3 H, 0.80 s, 3 H, 0.92 s, 3 H, 0.93 s, 3 H, 0.94 s, 3 H and 1.02 s, 3 H (6 × CH_3); 2.25 ddd, 1 H, *J* = 10.9, 6.7 and 1.9 (H-1β); 3.45 dd, 1 H, *J* = 8.2 and 1.1 (H-25a); 3.54 s, 1 H

(H-19); 3.44 d, 1 H and 3.77 bd, 1 H, J = 7.8 (2 × H-28); 3.94 d, 1 H, J = 8.2 (H-25b); 4.19 ddd, 1 H, J = 6.4, 4.4 and 1.0 (H-2). Mass spectrum: 440 (90, M^+), 422 (12), 410 (24), 391 (9), 369 (100), 339 (5). For $C_{30}H_{48}O_2$ (440.7) calculated: 81.76% C, 10.98% H; found: 81.53% C, 10.86% H.

18α-Oleanane-25,2β;28,19β-diolide (**32**)

A. A solution of lactone **30** (40 mg, 0.09 mmol) and chromium(VI) oxide (50 mg, 0.5 mmol) in acetic acid (20 ml) was set aside at room temperature for 48 h. The excess chromium oxide was decomposed with methanol (5 ml) and the mixture was worked up in the usual manner. Crystallization from chloroform gave 22 mg (53%) of dilactone **32** which did not melt up to 360 °C, $[\alpha]_D$ +43° (pyridine). IR spectrum: 1 765 (C=O); 1 120, 1 094, 1 066 (C–O–C). Mass spectrum: 468 (36, M^+), 422 (64), 407 (37), 235 (36), 190 (100). For $C_{30}H_{44}O_4$ (468.6) calculated: 76.88% C, 9.46% H; found: 76.81% C, 9.55% H.

B. A solution of diether **31** (60 mg, 0.14 mmol) and chromium(VI) oxide (0.5 g, 5 mmol) in acetic acid (10 ml) was set aside at room temperature for 4 days and then the reaction mixture was worked up as described under *A*. Two crystallizations from chloroform afforded 23 mg (36%) of dilactone **32**, identical with the sample prepared by procedure *A*.

Reaction of Oximes **4** and **7** with Pyruvic Acid

A mixture of oxime **4** (50 mg, 0.11 mmol), acetic acid (5 ml), water (0.5 ml) and pyruvic acid (0.5 g, 5.7 mmol) was refluxed for 2 h, and then partitioned between water and ether. The ethereal layer was washed successively with water, 5% sodium hydroxide solution, and water, dried over sodium sulfate and the solvent was evaporated. According to thin-layer chromatography and ^{1}H NMR spectrum, the product mixture contained nitriles **5** and **6**, hemiacetal **22** and acetate **23** in the ratio of about 4 : 6 : 3 : 2. A similar mixture was also obtained when the reaction was performed at 40 °C for 48 h. Acetylation of the mixture (acetic anhydride, pyridine) and chromatography on a plate of silica gel (5 g, light petroleum–ether 3 : 2) afforded 22 mg (42%) of nitrile **6** and 12 mg (23%) of acetate **23**.

Reaction of oxime **7** (50 mg, 0.11 mmol) with pyruvic acid, carried out as described for the oxime **4**, afforded the nitrile **9** as the sole product (thin-layer chromatography) in 63% isolated yield. At 40 °C (48 h) the oxime **7** did not react.

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