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The Reaction of Lupane and Friedo-Oleanane Type Triterpenes with *m*-Chloroperbenzoic Acid[1)]

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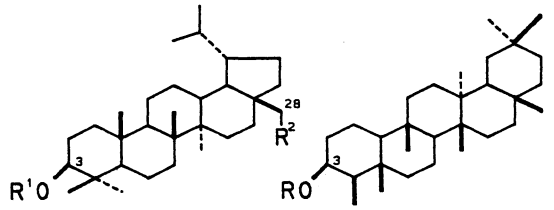
Lupane-3β,28-diol, lupan-3β-ol, and friedelan-3β-ol were treated with *m*-chloroperbenzoic acid (*m*CPBA) in refluxing chloroform to afford corresponding lactones in one step, while lupane-3β,28-diyl diacetate, lupan-3β-yl acetate, and friedelan-3β-yl acetate to give hydroxylated or keto derivatives. Similar reaction of dendropanoxide with *m*CPBA yielded 6β-, 7β-, 21α-, and 22β-hydroxylated compounds.

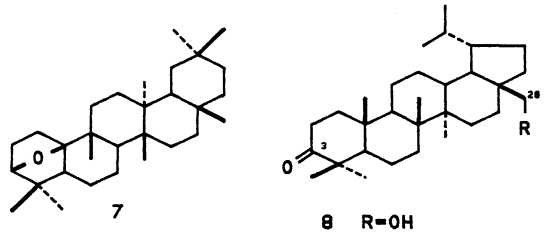
Recently, we reported the reaction of natural products, monoterpenes,[2)] sesquiterpenes,[3)] triterpenes,[4)] and other class of compounds,[5)] with *m*CPBA in chloroform under reflux to afford hydroxylated or carbonyl compounds as a result of functionalization at unactivated carbon atoms. These reactions are very similar to dry ozonization[6)] of natural products. Takahashi et al., in 1977, reported dry ozonization of friedelane and friedelin to yield the corresponding 15, 16, 19, and 21-keto derivatives as well as the 18,19-epoxide.[7)] In these cases ozone attacked the rings D and E, which were protruding. We expect that the reactions of this class of compounds with *m*CPBA might occur at these positions. In order to compare dry ozonization with *m*CPBA oxidation, lupane-3β,28-diol (**1**), lupan-3β-ol (**2**), friedelan-3β-ol (**3**), lupane-3β,28-diyl diacetate (**4**), lupan-3β-yl acetate (**5**), friedelan-3β-yl acetate (**6**), and dendropanoxide (**7**) were allowed to react with *m*CPBA in chloroform under reflux. We now report the details of these reactions.

Triterpene Alcohols. Dihydrobetulin (**1**) was allowed to react with *m*CPBA (2.2 equiv) in chloroform for 6 h under reflux. After the removal of acidic fractions of the product by means of chromatography over Sephadex LH-20 ($CHCl_3$-MeOH=1 : 1), the product was subjected to silica-gel column chromatography (PhH-EtOAc, gradient) [work up procedure A] to afford 28-hydroxylupan-3-one (**8**, 50.2%), methyl 4,28-dihydroxy-3,4-seco-lupan-3-oate (**9**, 4.7%), and methyl 28-hydroxy-3,4-seco-lup-4(23)-en-3-oate (**10**, 7.9%). The structure of **8** was easily assigned by the spectral data [*m/z* 442; 3450 and 1700 cm^{-1}; δ 3.32 and 3.78 (each d, *J*=11 Hz, H-28)]. The MS and IR spectra of compound **9** showed the peaks at *m/z* 472 $(M-H_2O)^+$, 385, and 373 and the absorptions at 3450 and 1730 cm^{-1}, respectively. The ^1H NMR spectrum indicated the presence of a methoxycarbonyl group [δ 3.67 (3H, s)] and the protons at C-28 (δ 3.31 and 3.77, each d, *J*=11 Hz). As the signals of the two methyl groups shifted downfield (δ 1.23 and 1.28, each 3H, s), this compound was found to be a 4-hydroxy-3,4-seco derivative. Compound **10** showed similar spectral data to those of **9**, including the methoxycarbonyl group [1730 cm^{-1}, δ 3.66 (3H, s)] and the C-28 hydroxyl group [3450 cm^{-1}, δ 3.31 and 3.77 (each d, *J*=11 Hz)], except for the exo-methylene group (890 cm^{-1}, δ 4.65 and 4.85) and the vinyl methyl group (δ 1.73). Thus, this compound was found to be derived from compound **9** by dehydration. These two compounds, **9** and **10**, were presumably formed by methanolysis of the initially produced lactone **11** catalyzed by *m*-chlorobenzoic acid present in the reaction mixture during column chromatography over Sephadex LH-20 ($CHCl_3$-MeOH=1 : 1). Indeed, when lactone **11** was exposed to similar conditions (*m*-chlorobenzoic acid/$CHCl_3$-MeOH), **9** and **10** were formed. Therefore, the reaction of **1** with *m*CPBA was worked up by washing with aq Na_2SO_3, aq. $NaHCO_3$, and brine, successively [work up procedure B] to afford **8** (50.2%) and **11** (20%). These results were presumably explained as follows: **1** was oxidized to ketone **8** which underwent Baeyer-Villiger oxidation to give **11**, the lactone ring of which opened by methanolysis to afford the hydroxy methyl ester **9**. **9** underwent dehydration to give the unsaturated methyl ester **10** under the conditions employed.



1 R^1=H, R^2=OH
2 R^1=H, R^2=H
4 R^1=Ac, R^2=OAc
5 R^1=Ac, R^2=H

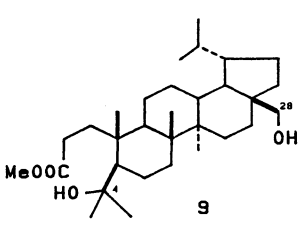
3 R=H
6 R=Ac

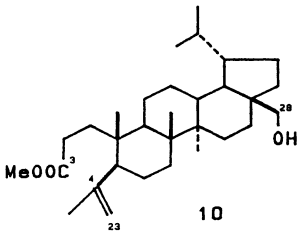


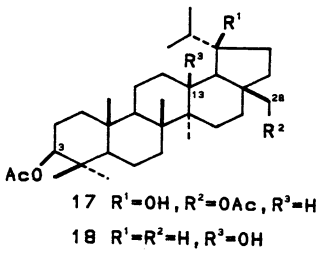
7

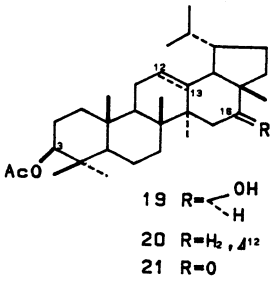
8 R=OH
12 R=H

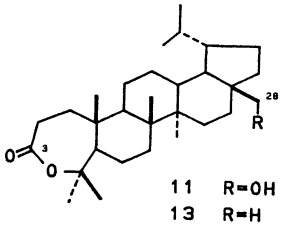
Lupan-3β-ol (**2**) was treated with *m*CPBA in refluxing chloroform for 6 h. The reaction mixture was

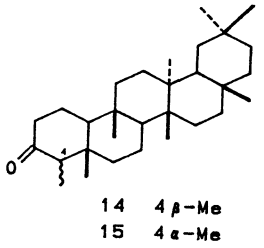


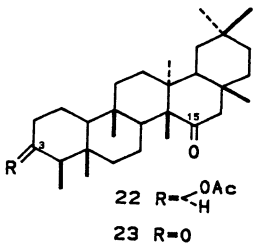


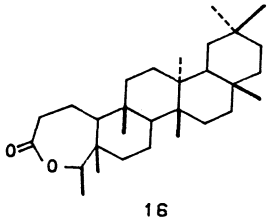












worked up [procedure B] and purified by column chromatography over silica gel to give lupan-3-one (**12**, 33.5%),[8] and 3,4-seco-lupan-4,3-olide (**13**, 4.3%). The IR spectrum of lactone **13** showed the absorption at 1710 cm^{-1} and the molecular ion peak at m/z 442 was observed in its mass spectrum. The ^1H NMR spectrum was very similar to those of **11**. It showed the signals of two tertiary methyl groups (δ 1.40 and 1.47), two secondary methyl groups (δ 0.75 and 0.84) and four tertiary methyl groups (δ 0.76, 0.93, 1.08, and 1.09). These data clearly indicated that compound **13** is a lactone.

Similar treatment of friedelan-3β-ol (**3**) with mCPBA gave friedelin (**14**, 42.7%),[9] 4-epi-friedelin (**15**, 9.5%),[9] and 3,4-seco-friedelan-4,3-olide (**16**, 20.3%)[10] after work up procedure B. The structure of compound **15** was determined to be 4-epi-friedelin, since the base treatment (KOH/EtOH) of **15** yielded **14** very easily. Compound **16** was identical with that of the Baeyer-Villiger oxidation product of **14**. 4-Epi-friedelin was presumably derived from the 3α,4α-epoxide by acid-catalyzed opening under the conditions employed. The epoxide was formed through friedel-3-ene, which was derived from **3** by acid-catalyzed dehydration.

The hydroxyl groups at C-3 position of these triterpenes were susceptible to this oxidation to give ketones and/or followed by further oxidation to afford lactones, but the hydroxyl groups at C-28 of the lupane triterpenes were not attacked under these conditions presumably due to the steric hindrance.

Triterpene Acetates. Lupane-3β,28-diyl diacetate (**4**) was subjected to the reaction with mCPBA. In this case only one compound was produced (83.2%) and its spectral data were identical with those of 19β-hydroxylupane-3β,28-diyl diacetate (**17**) reported in the literature.[11] It is interesting to note that **17** was the sole product of both dry ozonization and mCPBA oxidation. It is probably owing to the assistance of the acetoxyl group located at C-28.

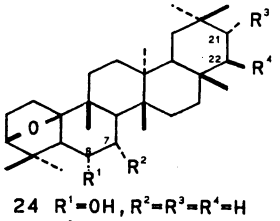
Lupan-3β-yl acetate (**5**) was next treated with mCPBA in $CHCl_3$ under reflux for 12 h to afford 13β-hydroxylupan-3β-yl acetate (**18**, 20.4%) and 16β-hydroxylupan-3β-yl acetate (**19**, 5.1%). Compound **18** showed molecular ion peak at m/z 486 and absorptions at 3500 and 1720 cm^{-1} in its MS and IR spectra, respectively, suggesting that a tertiary hydroxyl group was introduced in the skeleton. When **18** was subjected to dehydration with $POCl_3$ in pyridine, olefin **20** [δ 5.16, t, J=8 Hz; m/z 468 (M^+)] was formed. Since the MS spectrum of **20** indicated a fragment peak at m/z 218 due to retro-Diels-Alder fragmentation of the ring C, **20** must be formulated as lup-12-en-3β-yl acetate.[12] Hence, **18** was determined to be 13β-hydroxylupan-3β-yl acetate, providing that hydroxylation occurred with retention of configuration. The spectroscopic data of product **19** were identical with the literature data of 16β-hydroxylupan-3β-yl acetate.[12,13] The structure **19** was reconfirmed by Jones oxidation into known 16-oxolupan-3β-yl acetate (**21**)[13] and by measuring the solvent shift of the ^1H NMR data of **21**.

In the case of friedelan-3β-yl acetate (**6**), 15-oxofriedelan-3β-yl acetate (**22**, 12.9%) [m/z 484 (M^+), 1730 and 1695 cm^{-1}] was produced under similar conditions. The ^1H NMR spectrum of **22** showed the signals of two protons resonating at δ 2.16 and 2.50 (each d, J=18 Hz), suggesting the protons α to the carbonyl group. When compound **22** was hydrolyzed (KOH/EtOH) followed by Jones oxidation to afford diketone

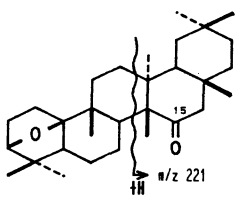
23, it was found that the spectral data of **23** were identical with those of authentic friedelane-3,15-dione.[7] Hence, product **22** should be formulated to be 15-oxofriedelan-3β-yl acetate.

When the hydroxyl groups were protected as acetates, unactivated carbon atoms at relatively unhindered positions were attacked to give a hydroxylated and/or a carbonyl compound. In these cases, the reaction products are quite similar to those of dry ozonization.

Triterpene Ether. Dendropanoxide (**7**) is a hexacyclic triterpene oxide isolated from *Dendropanax trifidus*.[14] Dendropanoxide (**7**) was treated with *m*CPBA in $CHCl_3$ under reflux to afford four alcoholic products **24—27** and ketone **28** after purification by column chromatography, prep. TLC, and HPLC. The first product **24**, $C_{30}H_{50}O_2$ (by HRMS), showed a signal at δ 4.10 (dt, J=11.8 and 7 Hz) due to the proton attached to the carbon bearing the hydroxyl group (3400 cm^{-1}) as well as a signal at δ 3.77 (d, J=7 Hz) due to H-3. These data indicated that **24** is a secondary alcohol and that the position of the hydroxyl group is at either C-6 or C-7, because there were three protons in the neighbor of the hydroxyl group judging from the coupling pattern. Irradiation of the proton at δ 4.10 (H-6β) induced NOE's into two methyl groups (δ 1.09 and 1.10). Since the 24-Me (δ 1.10) was assigned by observing NOE between the H-3 and the 24-Me and NOE's between the 24-Me (δ 1.10) and H-6β, and the 25-Me (δ 1.09) and the H-6β were expected, **24** should be formulated to be 6α-hydroxydendropanoxide. The ^{1}H NMR spectrum of the second compound **25** showed pattern of signals (δ 4.20, brt, J=5 Hz) very similar to that of **24**, indicating the presence of a secondary hydroxyl group probably at C-7. As actually only one methyl (δ 1.19, 25-Me) was observed in the NOE difference spectrum, when the proton at δ 4.20 (H-7β) was irradiated, **25** was determined to be 7α-hydroxydendropanoxide. These structures were in good agreement with the assignment of the ^{13}C NMR data (vide infra).



24 R^1=OH, R^2=R^3=R^4=H
25 R^2=OH, R^1=R^3=R^4=H
26 R^3=OH, R^1=R^2=R^4=H
27 R^4=OH, R^1=R^2=R^3=H



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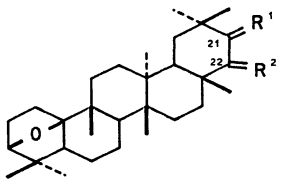

29 R^1=O, R^2=H_2
30 R^1=H_2, R^2=O

The spectral data of **26** (δ 3.70, dd, J=12 and 4 Hz) and **27** (δ 3.67, dd, J=12 and 5.6 Hz) only showed that these compounds had secondary hydroxyl groups having two protons in the neighbor. They would be located at C-11, 12, 15, 16, 21, or 22 position. It is difficult to assign by analysis of the ^{1}H NMR data or NOE experiments unless the ^{13}C NMR data of **7** are fully assigned. The ^{13}C NMR data of **7** were analyzed by the use of 2D NMR spectroscopy (COSY, ^{13}C-^{1}H correlation, long-range ^{13}C-^{1}H correlation, and H-H-C relayed correlation) and the results were shown in Table 1.[15] As the carbons of rings A—C of both compounds, **26** and **27**, have very similar chemical shifts to those of **7**, the positions of the hydroxyl groups are deduced to be at either C-21 or C-22. When **26** and **27** were subjected to Jones oxidation, they were converted to different ketones, namely, 21-oxodendropanoxide (**29**) and 22-oxodendropanoxide (**30**), respectively. Thus, **26** was determined to be 21α-hydroxydendropanoxide, because the irradiation of the proton at δ 3.70 (H-21β) induced NOE's into two methyl groups (28-Me and 29-Me). Only this position can give rise to

Table 1. ^{13}C NMR Data of Derivatives of Dendropanoxide (**7**)

Carbon	7	24	25	26	27	28
1	31.9	32.1	31.9	31.9	31.9	31.7
2	24.7	24.5	24.8	24.8	24.7	24.7
3	84.4	84.6	84.0	84.4	84.4	84.6
4	43.3	44.0	43.5	43.4	43.4	43.4
5	53.1	60.3	51.8	53.2	53.1	52.7
6	19.8*	67.5	31.5	19.8*	19.8*	19.8*
7	20.0*	32.5	68.4	20.3*	20.0*	21.7*
8	41.9	42.9	48.0	40.3	42.3	44.1
9	36.7	36.6	36.9	36.7	36.6	36.6
10	93.6	93.6	93.3	93.7	93.5	93.2
11	30.6	29.9	31.1*	29.7†	30.3†	30.1
12	30.0	29.9	30.0*	29.8†	30.9†	28.9
13	39.2	39.1*	39.3†	38.7#	38.9#	42.6
14	39.3	39.3*	40.4†	39.9#	39.4#	54.8
15	31.8	31.8	31.8	30.3	31.2	214.4
16	35.9	35.8	36.0	36.0	32.0	53.5
17	30.1	30.2	29.8	33.0	41.6	33.1
18	43.6	43.6	44.2	45.2	45.2	35.2
19	35.0	35.0	34.6	36.3	34.5	35.4
20	28.3	28.3	28.3	34.5	34.7	28.0
21	33.4	33.4	33.9	74.8	41.5	33.5
22	38.7	38.6	38.1	46.0	75.4	38.8
23	24.4	25.6	23.9	24.4	24.4	24.5
24	23.0	22.5	22.8	23.0	23.0	23.1
25	20.5	20.9	21.7	20.9	20.4	19.9
26	19.3	19.3	19.8	19.1	20.0	15.6
27	18.5	18.5	18.8	16.9	18.7	18.7
28	31.9	32.0	33.5	32.5	23.3	32.4†
29	32.8	32.9	32.4	33.0	31.9	32.7†
30	34.1	34.1	34.0	24.6	34.9	33.9

*,†,# Singles may be interchanged in each vertical column.

Table 2. Yields of the Products from **1**—**7**

Substrate	Work-up	Product (yield/%)[a]
1	A	**8** (50.2), **9** (4.7), **10** (7.9)
	B	**8** (50.2), **11** (20)
2	B	**12** (33.5),[8] **13** (4.3)
3	B	**14** (42.7),[9] **15** (9.5),[9] **16** (20.3)[10]
4	B	**17** (83.2)[11]
5	B	**18** (20.4), **19** (5.1)[12,13]
6	B	**22** (12.9)
7	B	**24** (1.6), **25** (1), **26** (0.4) **27** (0.2), **28** (0.3)

a) Yields shown indicate isolation yields based on consumed starting material.

NOE's into two methyl groups. However, the irradiation of the methine at δ 3.67 (H-22α) of **27** did not give any NOE into the methyl groups. If the hydroxyl group is located at 22α position, NOE into the 28-Me is expected upon irradiation of H-22β. Therefore, **27** was determined to be 22β-hydroxydendropanoxide.

The spectral data of **28** [1690 cm^{-1}; m/z 440 (M^+) and 221], which were not identical with those of **29** or **30**, showed the presence of the ketone instead of the alcohol. The protons which showed absorptions at δ 2.17 and 2.44 (each d, J=17 Hz) indicated the partial structure ■-CO-CH_2-■, in the molecule. The predominant fragment ion (m/z 221) shown by the wave line in the structure **28** suggests that the position of the carbonyl group is at C-15. This ion has been proved to possess the composition of $C_{15}H_{25}O$ by HRMS. The ^{13}C NMR data supported this result (Table 1). Thus, ketone **28** was determined to be 15-oxodendropanoxide. As a result, dendropanoxide was attacked at methylene carbons in rings B, D, and E, which were protruded and unhindered.

The results obtained in this work (Table 2) clearly show that when the compound has a hydroxyl group in the ring A, oxidation to the corresponding ketone predominates. Sometimes further oxidation, Baeyer-Villiger oxidation, occurs. While in the case of the acetate, oxidation by this method occurs at an unactivated carbon atom of the sterically unhindered position to afford a secondary or tertiary alcohol or a ketone. Dendropanoxide has been attacked in its rings B, D, and E, which are unhindered. Although the reaction site is not easy to predict, it is quite interesting to note that the sites of the reaction are similar to those of dry ozonization. These reactions would be convenient for introduction of the oxygen functions at unactivated carbon atoms of various bioactive natural products.

Experimental

General Procedures. See Ref. 4b.

Reaction of Lupane-3β,28-diol (1) with *m*CPBA. Method A: The diol **1** (600 mg) was dissolved in chloroform (36 ml) and *m*CPBA (800 mg, 2.3 equiv) was added. The mixture was refluxed for 6 h. After removal of the solvent, the residue was chromatographed over Sephadex LH-20 using $CHCl_3$-MeOH (1 : 1) for elution. The mixture was further purified by silica-gel column chromatography (PhH-AcOEt) to give 28-hydroxylupan-3-one (**8**, 200 mg), **9** (35 mg), **10** (20 mg), and **1** (200 mg).

28-Hydroxylupan-3-one (8): mp 210 °C; IR ($CHCl_3$): 3450, and 1700 cm^{-1}; ^1H NMR: δ=0.77 (3H, d, J=7 Hz), 0.84 (3H, d, J=7 Hz), 0.94, 0.97, 1.03, 1.07, 1.08 (each 3H, s), 2.55 (2H, m, H-2), 3.32 and 3.78 (each 1H, d, J=11 Hz, H-28); MS m/z: 442 (M^+), 411 (base), 205, and 191; HRMS, Found: m/z 442.3807, Calcd for $C_{30}H_{50}O_2$: M, 442.3811.

Methyl 3,28-Dihydroxy-3,4-seco-lupan-3-oate (9): mp 155—158 °C; IR ($CHCl_3$): 3450 and 1730 cm^{-1}; ^1H NMR: δ=0.77 (3H, d, J=7 Hz), 0.84 (3H, d, J=7 Hz), 0.95, 1.00, 1.05, 1.23, 1.28 (each 3H, s), 2.21 (1H, m, H-2), 2.45 (1H, m, H-2), 3.31 (1H, d, J=11 Hz, H-28), 3.67 (3H, s, -OMe), and 3.77 (1H, d, J=11 Hz, H-28); MS m/z: 472 ($M-H_2O$)$^+$, 441, 385, 373, 361, 191, and 109 (base); HRMS, Found: m/z 472.3902, Calcd for $C_{31}H_{52}O_2$: $M-H_2O$, 472.3916.

Methyl 28-Hydroxy-3,4-seco-lup-4(23)-en-3-oate (10): mp 122 °C (EtOAc); IR ($CHCl_3$): 3450, 1730, and 890 cm^{-1}; ^1H NMR: δ=0.77 (3H, d, J=7 Hz), 0.84 (3H, s), 0.87 (3H, d, J=7 Hz), 0.97 (3H, s), 1.07 (3H, s), 1.73 (3H, s, vinyl Me), 2.18 (1H, m, H-2), 2.33 (1H, m, H-2), 3.31 (1H, d, J=11 Hz, H-28), 3.66 (3H, s, -OMe), 3.77 (1H, d, J=11 Hz, H-28), and 4.65 and 4.85 (each 1H, s, C=CH_2); MS m/z: 472 (M^+), 441, 373, and 81 (base); HRMS, Found: m/z 472.3902, Calcd for $C_{31}H_{52}O_3$: M, 472.3916.

Method B: To a stirred solution of **1** (200 mg) in chloroform (12 ml) was added *m*CPBA (270 mg, 2.3 equiv). The mixture was refluxed for 6 h. More chloroform was added and the solution was washed successively with 5% Na_2SO_3 aq, 5% $NaHCO_3$ aq, and brine. The dried solution was evaporated in vacuo to give a residue (198 mg), which was separated by silica-gel column chromatography (PhH-EtOAc and PhH-Et_2O) to give **8** (60 mg), **1** (80 mg), and **11** (25 mg).

28-Hydroxy-3,4-seco-lupan-4,3-olide (11); mp 142 °C; IR ($CHCl_3$): 3450 and 1715 cm^{-1}; ^1H NMR: δ=0.77 (3H, d, J=7 Hz), 0.84 (3H, d, J=7 Hz), 0.96, 1.07, 1.08, 1.40, 1.48 (each 3H, s), 2.49 (1H, ddd, J=13, 6, and 3.5 Hz, H-2), 2.63 (1H, td, J=13 and 4 Hz, H-2), 3.32 and 3.77 (each 1H, d, J=11 Hz, H-28); MS m/z: 458 (M^+), 427, 369, 191, and 81 (base); HRMS, Found: m/z 458.3775, Calcd for $C_{30}H_{50}O_3$: M, 458.3760.

Methanolysis of Lactone 11. *m*-Chlorobenzoic acid (0.3 mg) was added to a solution of the lactone **11** (0.3 mg) in methanol (0.1 ml) and chloroform (2 drops) and the mixture stirred at rt for 1 h. TLC examination showed that there were three spots, one of which was **11**. Two new spots had the same R_f values (0.47 and 0.25: solvent system PhH-EtOAc (4:1)) as those of **10** and **9**, respectively.

Reaction of Lupan-3β-ol (2) with *m*CPBA. Lupan-3β-ol (**2**) (470 mg) was treated with *m*CPBA (250 mg, 2.2 equiv) in $CHCl_3$ (14 ml) under reflux for 6 h. After work up by method B, the solvent was evaporated to give a residue (253 mg), which was chromatographed over silica gel (EtOAc-PhH gradient as eluant) to give lupan-3-one **12** (30 mg),[8] **2** (110 mg) and **13** (4 mg). **3,4-Seco-lupan-4,3-olide (13);** mp 190 °C (EtOAc); IR: 1710 cm^{-1}; ^1H NMR: δ=0.75 (3H, d, J=7 Hz), 0.76 (3H, s), 0.84 (3H, d, J=7 Hz), 0.93, 1.08, 1.09, 1.40, 1.47 (each 3H, s), 2.49 (1H, ddd, J=14, 6.5, and 3.5 Hz, H-2),

2.63 (1H, td, J=14 and 4.5 Hz, H-2); MS m/z: 442 (M^+), 399, 369, 341, 291, 206, 191, and 81 (base); HRMS, Found: m/z 442.3792, Calcd for $C_{30}H_{50}O_2$: M, 442.3809.

Reaction of Friedelan-3β-ol (3) with *m*CPBA. Friedelan-3β-ol (**3**, 200 mg) was dissolved in $CHCl_3$ (20 ml) and *m*CPBA (260 mg, 2.2 equiv) was added. The mixture was refluxed for 12 h and worked up [procedure B] to give a residue (203 mg), which was chromatographed over silica gel using PhH-EtOAc and PhH-Et_2O solvent systems for elution to afford friedelin (**14**, 85 mg), 4-epi-friedelin (**15**, 8 mg), and lactone (**16**, 35 mg).

3,4-Seco-friedelan-4,3-olide (16); mp 273 °C (EtOAc); IR ($CHCl_3$): 1720 cm^{-1}; ^1H NMR: δ=0.83 (3H, s), 0.89 (3H, s), 0.95 (3H, s), 0.98 (3H, s), 0.99 (3H, s), 1.00 (3H, s), 1.17 (3H, s), 1.20 (3H, d, J=7 Hz), 2.52 (1H, t, J=13 Hz, H-2), 2.64 (1H, dd, J=13 and 6 Hz, H-2), and 4.21 (1H, q, J=7 Hz, H-4); MS m/z: 442 (M^+), 398, 205, and 95 (base); HRMS, Found: m/z 442.3815, Calcd for $C_{30}H_{50}O_2$: M, 442.3810.

Isomerization of 4-Epi-friedelin (15). 4-Epi-friedelin (**15**, 1.5 mg) was dissolved in 5% KOH-MeOH (5 ml) and the mixture was stirred at rt for 5 h. Work up as usual yielded friedelin (**14**, 1.0 mg).

Baeyer-Villiger Reaction of Friedelin (14). Friedelin (**14**, 50 mg) was treated with *m*CPBA (35 mg, 1.2 equiv) in $CHCl_3$ (60 ml) at rt for 2 days to afford the lactone **16** (40 mg) after chromatographic purification.

Acetylation of Diol 1. A solution of diol **1** (350 mg) in pyridine (15 ml) and acetic anhydride (2 ml) was stirred at 50° overnight. The mixture was worked up as usual to yield diacetate **4** (365 mg).

Reaction of Lupane-3β,28-diyl Diacetate (4) with *m*CPBA. *m*CPBA (168 mg, 1.2 equiv) was added to a solution of diacetate **4** (270 mg) in $CHCl_3$ (16 ml) in one portion and the mixture was refluxed for 6 h. The reaction mixture was worked up by method A to give a residue (273 mg). The mixture was purified by silica-gel column chromatography (PhH-Et_2O) to give **4** (235 mg) and 19β-hydroxylupane-3β,28-diyl diacetate (**17**) (30 mg).[11]

Reaction of Lupan-3β-yl Acetate (5) with *m*CPBA. Lupan-3β-yl acetate (**5**, 470 mg) was treated with *m*CPBA (280 mg, 1.2 equiv) in $CHCl_3$ (25 ml) under reflux for 12 h to afford a residue (490 mg) after work up by method A. The residue was subjected to column chromatography over silica gel. Elution with hexane-EtOAc solvent system afforded **5** (375 mg), **18** (20 mg), and **19** (5 mg).[12,13]

13β-Hydroxylupan-3β-yl Acetate (18); mp 250 °C; IR ($CHCl_3$): 3500 and 1720 cm^{-1}; ^1H NMR: δ=0.84 (3H, s), 0.85 (3H, s), 0.86 (3H, d, J=7 Hz), 0.87 (3H, s), 0.93 (3H, d, J=7 Hz), 0.96 (3H, s), 1.02 (3H, s), 1.07 (3H, s), 2.04 (3H, s, Ac), 4.48 (1H, dd, J=12 and 4.5 Hz, H-3α); ^{13}C NMR: δ=14.6 (q), 16.1 (q×2), 16.5 (q), 17.4 (q), 18.3 (t), 18.7 (q), 19.2 (q), 20.8 (t), 21.3 (q), 23.7 (t), 25.8 (t), 27.3 (t), 28.0 (q), 34.1 (t), 34.4 (t), 34.5 (d), 37.1 (t), 37.1 (d), 37.1 (s), 37.8 (s), 38.4 (t), 40.4 (t), 41.1 (s), 42.9 (s), 43.3 (s), 49.5 (d), 50.1 (d), 55.4 (d), 81.0 (d, H-3), 85.8 (s, H-13), and 171.0 (s, Ac); MS m/z: 486 (M^+), 426, 383, 365, 189, and 43 (base); HRMS, Found: m/z 486.4051, Calcd for $C_{32}H_{54}O_3$: M, 486.4073.

Dehydration of 18. The alcohol **18** (10 mg) was treated with $POCl_3$ (4 drops) in pyridine (3 ml) at 90 ° for 1 h. The usual work up and prep. TLC gave lup-12-en-3β-yl acetate (**20**, 6 mg).[12,13]

Oxidation of the Alcohol 19. To a stirred solution of **19** (3 mg) in acetone (1.5 ml) was added Jones reagent (3 drops) at rt. The mixture was stirred for 1 h and usual work up afforded 16-oxolupan-3β-yl acetate (**21**, 1.5 mg).[13]

Reaction of Friedelan-3β-yl Acetate (6) with *m*CPBA. Friedelan-3β-yl acetate (**6**, 100 mg) was treated with *m*CPBA (60 mg, 1.2 equiv) in $CHCl_3$ (10 ml) under reflux for 12 h. Work up by method B afforded a residue (104 mg), which was subjected to column chromatography over silica gel (hexane-Et_2O as eluant) and HPLC (μ-PORASIL, hexane-Et_2O 9 : 1, 2 ml min^{-1}) to give **6** (85 mg) and the ketone **22** (2 mg).

15-Oxofriedelan-3β-yl Acetate (22); mp 245 °C; IR ($CHCl_3$): 1730 and 1695 cm^{-1}; ^1H NMR: δ=0.82 (3H, d, J=7 Hz), 0.88, 0.89, 0.95, 1.01, 1.21, 1.32 (each 3H, s), 2.04 (3H, s, Ac), 2.16 and 2.50 (each 1H, d, J=18 Hz, H-16), and 4.89 (1H, m, H-3α).

Friedelane-3,15-dione (23). To a solution of 15-oxofriedelan-3β-yl acetate (**22**, 1 mg) in MeOH (0.5 ml) was added 5% KOH-MeOH (5 drops) and the mixture was stirred at 75 °C for 10 h. The reaction mixture was worked up as usual and chromatographed on silica gel (hexane-EtOAc) to give 3β-hydroxyfriedelan-15-one (0.5 mg). The alcohol in acetone (0.2 ml) was oxidized with Jones reagent (2 drops) at rt for 1 h to afford friedelane-3,15-dione (**23**, 0.3 mg).[7]

Reaction of Dendropanoxide (7) with *m*CPBA. To a stirred solution of dendropanoxide (**7**) (1.6 g) in chloroform (70 ml) was added *m*CPBA (0.98 g) and the mixture was refluxed for 12 h. More chloroform was added and the mixture was worked up by method B to give a residue (2.5 g), which was purified by silica-gel column chromatography (PhH-EtOAc, gradient), prep. TLC, and HPLC (Finepak SIL, hexane-EtOAc, gradient) to afford **24** (27 mg, 1.6%), **25** (17 mg, 1%), **26** (7 mg, 0.4%), **27** (3 mg, 0.2%), and **28** (4 mg, 0.3%) as well as **7**.

6α-Hydroxydendropanoxide (24); IR ($CHCl_3$): 3400 cm^{-1}; ^1H NMR: δ=0.95, 0.97, 0.99, 1.09, 1.10, 1.14, 1.14, and 1.17 (each 3H, s, Me), 3.76 (1H, d, J=5.8 Hz, H-3α), and 4.10 (1H, dt, J=11.8 and 7 Hz, H-6β); MS m/z: 442 (M^+), 427; HRMS, Found: m/z 442.3794, Calcd for $C_{30}H_{50}O_2$: M, 442.3811.

7α-Hydroxydendropanoxide (25); IR ($CHCl_3$): 3400 cm^{-1}; ^1H NMR: δ=0.90, 0.96, 0.96, 1.05, 1.05, 1.14, 1.19, and 1.19 (each 3H, s, Me), 3.77 (1H, d, J=5.6 Hz, H-3α), and 4.19 (1H, brt, J=5 Hz, H-7β); MS m/z: 442 (M^+), 427; HRMS, Found: m/z 442.3803, Calcd for $C_{30}H_{50}O_2$: M, 442.3811.

21α-Hydroxydendropanoxide (26); IR ($CHCl_3$): 3400 cm^{-1}; ^1H NMR: δ=0.90, 0.98, 1.01, 1.04, 1.04, 1.06, 1.15, and 1.19 (each 3H, s), 3.70 (1H, dd, J=12 and 4 Hz, H-21β), and 3.76 (1H, d, J=5.6 Hz, H-3α); MS m/z: 442 (M^+), 427; HRMS, Found: m/z 442.3794, Calcd for $C_{30}H_{50}O_2$: M, 442.3810.

22β-Hydroxydendropanoxide (27); IR ($CHCl_3$): 3400 cm^{-1}; ^1H NMR: δ= 0.90, 0.99, 1.01, 1.01, 1.03, 1.13, 1.18, and 1.21 (each 3H, s), 3.67 (1H, dd, J=12 and 5.6 Hz, H-22α), and 3.75 (1H, d, J=5.7 Hz, H-3α); MS m/z: 442 (M^+), 427; HRMS: Found: m/z 442.3816, Calcd for $C_{30}H_{50}O_2$: M, 442.3811.

15-Oxodendropanoxide (28); IR ($CHCl_3$): 1690 cm^{-1}; ^1H NMR: δ=0.86, 0.91, 0.96, 1.02, 1.02, 1.19, 1.31, and 1.38 (each 3H, s, Me), 2.17 and 2.44 (each 1H, d, J=17 Hz, H_2-16), and 3.76 (1H, d, J=5 Hz, H-3α); MS m/z 440 (M^+) and 221; HRMS, Found: m/z 440.3644, Calcd for $C_{30}H_{48}O_2$: M, 440.3655, Found: m/z 221.1893, Calcd for $C_{15}H_{25}O$: M, 221.1905.

Oxidation of 21α-Hydroxydendropanoxide (26). 21α-Hydroxydendropanoxide (**26**, 2 mg) was treated with Jones reagent (1 drop) in acetone (2 ml) at rt for 15 min. Work up as usual gave 21-oxodendropanoxide (**29**, 1.5 mg); ^1H NMR:

δ=3.77 (1H, d, J=5.6 Hz), 1.80 and 2.62 (each 1H, d, J=12.4 Hz); MS m/z: 440 (M^+); HRMS, Found: m/z 440.3649, Calcd for $C_{30}H_{48}O_2$: M, 440.3654.

Oxidation of 22β-Hydroxydendropanoxide (27). 22β-Hydroxydendropanoxide (**27**, 2 mg) was oxidized with Jones reagent (1 drop) in acetone (2 ml) at rt for 15 min. Work up as usual afforded 22-oxodendropanoxide (**30**, 1 mg); ^{1}H NMR: δ=3.75 (1H, d, J=5.4 Hz), 2.55 and 2.16 (each 1H, d, J=17 HZ); MS m/z: 440 (M^+); HRMS, Found: m/z 440.3659, Calcd for $C_{30}H_{48}O_2$: M, 440.3654.

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