New Peroxy Triterpenes from the Aerial Roots of *Ficus microcarpa*

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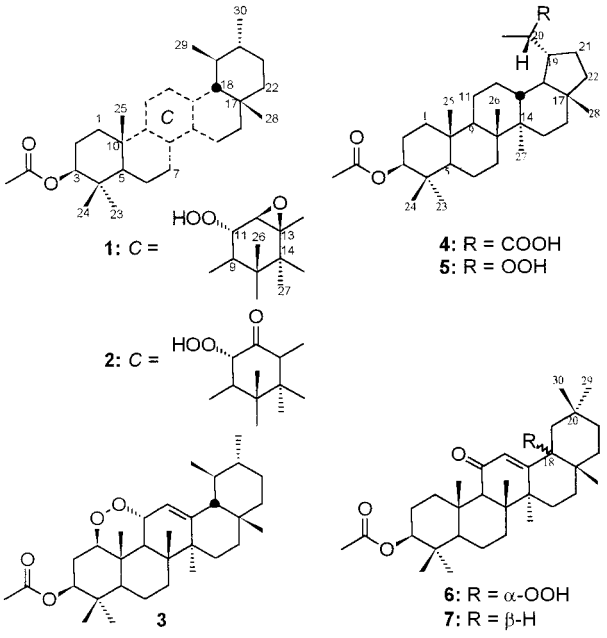
Six new triterpenes, 3β-acetoxy-12β,13β-epoxy-11α-hydroperoxyursane (**1**), 3β-acetoxy-11α-hydroperoxy-13α*H*-ursan-12-one (**2**), 3β-acetoxy-1β,11α-epidioxy-12-ursene (**3**), (20*S*)-3β-acetoxylupan-29-oic acid (**4**), (20*S*)-3β-acetoxy-20-hydroperoxy-30-norlupane (**5**), and 3β-acetoxy-18α-hydroperoxy-12-oleanen-11-one (**6**), together with 3β-acetoxy-12-oleanen-11-one (**7**), were isolated from the aerial roots of *Ficus microcarpa*. Compounds **1**−**3**, **5**, and **6** were characterized as new peroxytriterpenes. The structures of **3** and **6** were confirmed by X-ray crystallography, and their structures were elucidated by spectroscopic and chemical methods.

Ficus microcarpa L. f. (Moraceae) is a popular ornamental plant in Taiwan. Phytochemical studies of this species have led to the identification of six triterpenoids from the leaves.[1] Two isoflavones,[2] 28 known components,[3] and six new compounds (one monoterpenoid, two phenols, one apocarotenoid, and two γ-lactone derivatives) were previously isolated from its bark and heartwood.[4,5] Recently, new taraxastane-type triterpenes were isolated and elucidated from its aerial roots.[6,7] Reinvestigation of the aerial root extract has led to the isolation of six new ursene and oleanene derivatives including the cytotoxic constituent 3β-acetoxy-11α-hydroperoxy-12-ursene.[8] In the present study, we have isolated six new triterpenes (**1**−**6**) together with the known 3β-acetoxy-12-oleanen-11-one (**7**).[9] Compounds **1**−**3**, **5**, and **6** are unusual peroxytriterpenes. This paper deals with the isolation and structural determination of these metabolites.



Results and Discussion

Triterpene **1** was isolated as a colorless solid. The molecular formula $C_{32}H_{52}O_5$ was established by its ^{13}C NMR and MS data, representing seven indices of hydrogen deficiency (IHD). Compound **1** contained hydroxyl (or hydroperoxyl) and acetoxyl groups attributable to the IR absorption bands at 3395, 1733, and 1249 cm^{-1}. The ^1H NMR spectrum of **1** exhibited signals for a high-field methine proton [δ 0.57 (d, J = 10.8 Hz, H-18)], six singlet methyl groups (δ 0.83, 0.84, 1.00, 1.04, 1.11, 1.19), two doublet methyl groups [δ 0.90 (d, J = 6.4 Hz), 1.05 (d, J = 6.0 Hz)], an acetoxyl group [δ 2.02 (3H, s)], a methine proton attached with an acetoxyl group [δ 4.45 (dd, J = 10.8, 5.2 Hz)], and a low-field exchangeable hydroperoxy proton (δ 7.83)[8,10] connected to C-11 [δ 4.36 (d, J = 9.2 Hz) and δ_C 79.8]. Comparison of these data with 3β-acetoxy-11α-hydroperoxy-12-ursene[8] suggested that compound **1** is an ursane triterpene with an acetoxyl group at C-3 and a hydroperoxyl group at C-11. No olefinic signals between δ_C 110 and δ_C 160 were observed. Two remaining oxygenated carbons present at δ_C 64.7 and 57.1 [corresponding to the ^1H signal at δ 3.35 (s)] were consistent with the presence of an epoxide functionality. Comparison of the ^1H and ^{13}C NMR data of **1** with those of 3β-acetoxy-11α-hydroperoxy-12-ursene[8] indicated that an epoxide functionality was located at C-12 and C-13. The signal at δ 4.36 was assigned as H-11 due to the HMBC correlations with C-9 (δ_C 50.6), C-12 (δ_C 57.1), and C-13 (δ_C 64.7) and a NOESY correlation with H-12. This proton was assigned with a β-axial orientation because of the presence of a large coupling constant (J = 9.2 Hz) with H-9 (δ 1.35) and a NOESY correlation with H_3-25. The epoxide was also assigned with a β-orientation based on the fact that H-12 showed NOESY correlations with H-18 and H_3-29. Additionally, H-18 was present at an unusually high field (δ 0.57, d, J = 10.8 Hz) possibly due to a shielding effect from the same face of the epoxide ring system (see Figure 1). A chemical correlation between **1** and 3β-acetoxy-11α-hydroperoxy-12-ursene[8] was carried out by the oxidation of the latter compound with *m*-chloroperbenzoic acid (*m*-CPBA) in CH_2Cl_2 for 2 days, which yielded **1** (15%) and a trace of keto compound **2**. The slow reaction rate was attributed to the steric effects from CH_3-27, CH_3-28, and CH_3-29 and an inductive effect from the hydroperoxide group. The allylic hydroperoxide was in an equatorial orientation which could not direct the orientation of oxidation. The CH_3-29 group was positioned at the α-face since the double bond caused a strong steric effect from the α-face, and therefore the oxygen atom of the peracid attacked the less hindered β-face.

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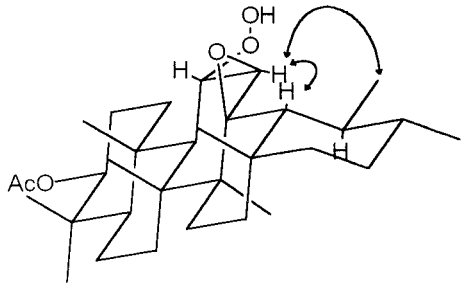

Figure 1. Key NOESY correlations for **1**.

Table 1. ^{13}C NMR Data (δ) for **1**−**7** (100 MHz in $CDCl_3$)

position	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	38.2	39.4	90.4	38.4	38.3	38.7	38.7
2	23.6	23.5	27.0	23.6	23.6	23.5	23.5
3	80.8	80.3	78.5	81.0	81.0	80.6	80.6
4	38.0[a]	38.0[a]	37.8	37.8	37.7	38.0	38.0
5	55.2	55.4	50.5	55.3	55.3	54.9	55.0
6	17.6	17.9	17.4	18.2	18.1	17.4	17.3
7	34.0	34.8	33.0	34.2	34.2	32.5	32.6
8	40.8	44.3	39.1	40.8	40.9	45.4	45.4
9	50.6	51.6	51.0	49.9	49.9	61.3	61.6
10	37.9[a]	37.9[a]	36.5	37.0	37.0	36.8	36.9
11	79.8	87.1	77.7	20.8	20.8	200.4	200.1
12	57.1	212.7	120.3	26.3	27.1	128.5	128.0
13	64.7	51.1	147.5	37.7	37.3	160.6	170.6
14	40.6	41.4	43.2	43.0	43.0	43.9	43.3
15	25.4	26.5	26.7	27.2	27.1	26.0	6.3[a]
16	28.2	28.9	27.9	35.4	40.4	30.3	6.4[a]
17	35.0	32.1	34.0	43.0	42.8	37.5	32.3
18	57.7	42.8	59.6	47.2	48.5	86.0	47.6
19	39.3[b]	41.2	39.5[a]	40.1	40.6	36.0	45.1
20	39.5[b]	39.1	39.6[a]	40.9	83.4	30.8	31.0
21	31.4	30.1	31.1	23.7	21.8	33.4	34.4
22	41.6	41.5	41.2	40.3	35.2	31.2	36.5
23	28.0	28.2	27.8	27.9	27.9	28.0	28.0
24	16.4	16.9	17.1	16.5	16.5	16.7	16.6
25	17.2	17.5	14.3	16.1	16.0	16.4	16.4
26	22.2	20.2	17.1	15.9	15.9	18.5	18.7
27	19.2	27.8	23.5	14.3	14.2	21.8	23.5
28	28.5	29.4	28.8	17.9	17.9	19.8	28.7
29	17.8	18.7	17.4	181.8	12.4	28.1	33.0
30	20.8	21.3	21.1	9.6		34.8	23.3
CH_3CO	171.2	170.9	170.4	171.1	171.2	171.0	170.9
CH_3CO	21.3	21.3	21.2	21.3	21.3	21.3	21.3

[a,b] Values bearing the same superscript may be interchanged.

Compound **2** was obtained as a colorless solid. The molecular formula of **2** was found to be $C_{32}H_{52}O_5$, similar to compound **1**, by HRFABMS. The IR absorption bands at 3339, 1731, 1717, and 1249 cm^{-1} indicated the presence of hydroxyl (or hydroperoxyl), acetoxyl, and carbonyl groups. The ^1H NMR signals at δ 0.84, 0.86, 0.87, 0.96, 1.13, 1.26, 2.03 (each 3 H, s), 0.82 (3H, d, J = 6.0 Hz), and 0.90 (3H, d, J = 6.4 Hz) were attributed to nine methyl groups. The pattern of the proton signals was similar to those of compound **1**, including a methine proton associated with a hydroperoxyl group [δ 4.22 (d, J = 8.8 Hz)], a methine proton associated with an acetoxyl group [δ 4.51 (dd, J = 10.0, 6.4 Hz)], and an exchangeable hydroperoxyl proton at δ 8.45.[8] However, a high-field proton signal at δ 0.57 was not observed as in the case of **1**, but a methine proton [δ 2.82 (s, H-13)] was present for **2**. The ^{13}C NMR data of **2** were similar to those of compound **1** except for the presence of a carbonyl carbon (δ_C 212.7) and a tertiary carbon (δ_C 51.1) instead of two epoxide carbons in **1** (Table 1). Thus, the structure of **2** was assigned as 3β-acetoxy-11α-hydroperoxy-13α*H*-ursan-12-one. This was also confirmed by HMQC, HMBC, and COSY NMR experiments, with the α-orientation of H-13 elucidated by an NOE

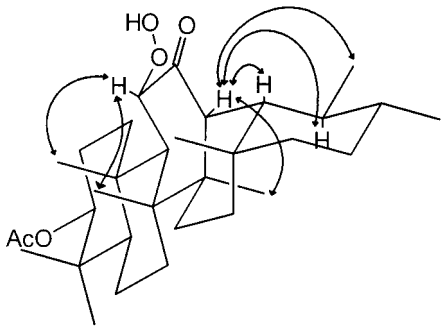

Figure 2. Key NOESY correlations for **2**.

experiment. Thus, H-13 exhibited NOE correlations with H-18, H-19, H_3-27, and H_3-29, so it was concluded that H-13 should be on the same face as H_3-27 (Figure 2). The oxidation of 3β-acetoxy-11α-hydroperoxy-12-ursene[8] with *m*-CPBA, as mentioned above, yielded two products, **1** and **2**. Compound **1** also gave **2**, after being dissolved in $CDCl_3$ for one week. By considering the reaction mechanism, H-13 was assigned in an α-orientation.

Compound **3**, a colorless solid, had a molecular formula of $C_{32}H_{50}O_4$ on the basis of its HREIMS, ^{13}C NMR (Table 1), and DEPT data. Like **1** and **2**, it also contained an acetoxyl group due to the IR absorption bands at 1741 and 1245 cm^{-1}. The ^1H NMR data of compound **3** showed six singlet methyl groups (δ 0.77, 0.86, 0.86, 1.04, 1.17, 1.19), two doublet methyl groups [δ 0.76 (d, J = 6.4 Hz), 0.88 (d, J = 5.2 Hz)], four methine protons [δ 1.85 (d, J = 8.8 Hz, H-9), 4.03 (dd, J = 12.4, 3.6 Hz, H-1), 4.63 (dd, J = 11.2, 4.4 Hz, H-3), and 5.00 (H-11, overlapped with H-12)], and an olefinic proton [δ 5.02 (overlapped with H-11)]. The ^{13}C NMR and DEPT data showed an ester carbonyl (δ_C 170.4), a trisubstituted double bond (δ_C 147.5, 120.3), and three oxygenated carbons (δ_C 90.4, 78.5, 77.7). Comparison of the ^1H and ^{13}C NMR data of **3** and **1** indicated that **3** is a 3β-acetoxy-12-ursene derivative. On account of the molecular formula $C_{32}H_{50}O_4$, the IHD of **3** was eight, including one carbonyl and one olefinic functionality. Thus, the number of rings in **3** should be six. The absence of a hydroxyl absorption as well as the presence of three oxygenated carbons in **3** indicated that the remaining two oxygen atoms should be in an endoperoxide moiety. The evidence from $J_{9,11}$ = 8.8 Hz permitted the conclusion that H-9 (d 1.85) and H-11 are both axial. The other end of the endoperoxide unit was connected to C-1 in a β-orientation because H-1 exhibited a large coupling constant (J = 12.4, 3.6 Hz) to H-2. The signal at δ 4.03 (H-1) showed HMBC correlations with C-2 and C-25, and COSY correlations between H-1/H-2 and H-2/H-3 were observed. On the basis of the above evidence, the structure of **3** was assigned as 3β-acetoxy-1β,11α-epidioxy-12-ursene. This new structure was also confirmed by a single-crystal X-ray diffraction study (Figure 3).

Compound **4** was assigned the molecular formula $C_{32}H_{52}O_4$ (HRFABMS). Its IR and ^1H and ^{13}C NMR spectra indicated the presence of a methine proton attached to an acetoxyl group, a carboxylic acid, six singlet methyl groups, a doublet methyl group [δ 1.03 (d, J = 7.2 Hz, H_3-30)], one methine proton [δ 2.29 (m, H-19)], and a methine proton [δ 2.77 (m, H-20)]. The latter methine proton had COSY correlations with H_3-30 and H-19. On the basis of the above evidence and DEPT spectra, compound **4** was considered to be a lupane-type triterpene with C-29 and C-3 bearing a carboxylic acid and an acetoxyl group, respectively. The absolute configuration at C-20 was defined following the method of Corbett and his collaborators.[11] Thus, compound

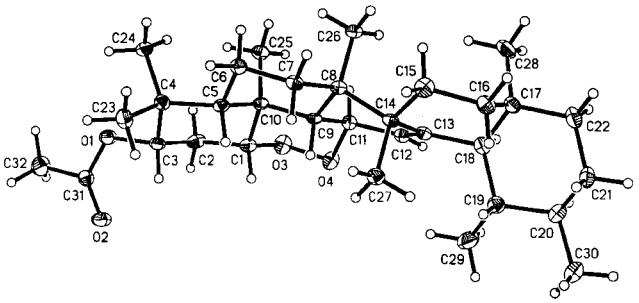

Figure 3. ORTEP drawing of **3**.

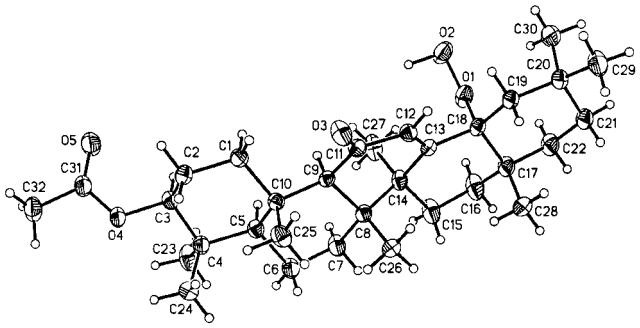

Figure 4. ORTEP drawing of **6**.

4 was deduced as (20*S*)-3β-acetoxylupan-29-oic acid by comparison of spectral data with those in the literature.[11]

Compound **5**, a colorless solid, showed an ion peak at *m/z* 470 ($M^+ - H_2O$). Analysis of its IR spectrum suggested it contained a hydroxyl (or a hydroperoxyl group) (3400 cm^{-1}) and an acetoxyl group (1735, 1248 cm^{-1}). The ^1H NMR spectrum of **5** was similar to those of (20*S*)-3β-acetoxylupan-29-oic acid (**4**).[11] The major difference between **4** and **5** was a hydroperoxyl group in **5** instead of a carboxylic acid in **4**. The lower field exchangeable hydroperoxyl proton present at δ 8.27 proved the existence of this functionality. A lower field ^{13}C NMR signal at δ_C 83.4 (resonating at δ 4.34) suggested a connection with a hydroperoxyl group. This signal (δ 4.34) was assigned as H-20 due to the COSY correlations with H_3-29 (δ 1.07, d) and H-19 (δ 2.27, m). Therefore, according to the molecular formula ($C_{31}H_{52}O_4$), the structure of **5** was elucidated as 3β-acetoxy-20-hydroperoxy-30-norlupane. The absolute configuration of C-20 was determined as having the *S*-configuration on the basis of the following observations. Corbett et al.[11] have synthesized two epimers of 3β,20-dihydroxy-30-norlupane and defined the C-29 ^{13}C NMR signals of 20*S* and 20*R* at δ_C 17.2 and 23.0, respectively. Reduction of **5** with lithium aluminum hydride gave 3β,-20-dihydroxy-30-norlupane with C-29 at δ_C 17.2. Therefore, the structure of **5** was elucidated as (20*S*)-3β-acetoxy-20-hydroperoxy-30-norlupane.

3β-Acetoxy-18α-hydroperoxy-12-oleanen-11-one (**6**) was isolated as a colorless solid. The molecular formula of $C_{32}H_{50}O_5$ was established from HREIMS and ^{13}C NMR data (Table 1). Compound **6** showed absorption bands at 1734, 1249 cm^{-1} (acetoxyl group) and 1669 cm^{-1} (conjugated carbonyl) in its IR spectrum. Eight singlet methyl groups and the splitting patterns in the ^1H NMR spectrum between δ 6.00 and 2.00 of **6** [δ 5.74 (1H, s, H-12), 4.49 (1H, dd, J = 11.2, 5.2 Hz, H-3; δ_C 80.6 for C-3), 2.71 (1H, dt, J = 13.6, 3.2 Hz, H-1β), 2.43 (1H, s, H-9), and 2.03 (3H, s, CH_3CO)] were similar to those of compound **7**,[9] which was also isolated from the same source. When the molecular formulas of **6** and **7** were compared, two additional oxygen atoms were found to occur in compound **6**. An exchangeable signal at δ 6.80 (s) and a ^{13}C signal at δ_C 86.0 (s) revealed that two oxygen atoms were attributable to a hydroperoxyl moiety. The carbon (δ_C 86.0) connected to the hydroperoxyl group had HMBC correlations with H-12, H-19, H-22, and H_3-28. Thus, the location of the hydroperoxide should be at C-18. The H_3-27 (δ 1.53) and H_3-29 (δ 1.13) signals were at a lower field than the corresponding protons in **7** (see Experimental Section) and were obviously deshielded by the hydroperoxide group. A NOESY correlation between $-$OOH and H_3-29 together with the above evidence confirmed the orientation of the hydroperoxyl group in the α-axial orientation, unambiguously. This structure was proved by a single-crystal X-ray diffraction study (Figure 4).

Experimental Section

General Experimental Procedures. Melting points were determined with a Yanagimoto micromelting point apparatus and are uncorrected. Optical rotations were measured on a JASCO DIP-1000 digital polarimeter. IR spectra were recorded on a Perkin-Elmer 983G spectrophotometer. ^1H and ^{13}C NMR spectra were run on a Varian Unity Plus 400 spectrometer. EIMS were obtained on a JEOL JMS-HX 300 mass spectrometer. The X-ray crystallographic data were collected on a Siemens Smart CCD diffractometer using graphic-monochromated Mo Kα radiation. Extracts were chromatographed over Si gel (Merck 70−230 mesh, 230−400 mesh, ASTM).

Plant Material. The aerial roots of *Ficus microcarpa* L. f. were collected on the campus of National Taiwan University, Taipei, Taiwan, in Auguest 1996. The plant was identified by Mr. Muh-Tsuen Gun, formerly of the Department of Botany, National Taiwan University. A voucher specimen (No. 038671) has been deposited at the Herbarium of the Department of Botany, National Taiwan University, Taipei, Taiwan.

Extraction and Isolation. The dried aerial roots of *F. microcarpa* were crushed to give 18 kg of raw material, which was extracted with MeOH (150 L) at room temperature (7 days × 2). The extract was evaporated in vacuo to yield a residue, which was suspended in H_2O (1 L), and this was then partitioned with ethyl acetate (1 L × 3). The combined ethyl acetate layer afforded a black syrup (250 g), which was subsequently chromatographed over Si gel with a hexane/EtOAc gradient solvent system. The crude compounds **7**, **1**, **2**, **3**, **5**, **6**, and **4** were eluted in turn with 20% EtOAc in hexane. Further purification by HPLC [Merck LichroCART 250-10 Cat. 1.50179 Lichrosorb Si 60 (7 μm)] gave **7** (46 mg), **1** (8 mg), **2** (10 mg), **3** (13 mg), **5** (45 mg), **6** (9 mg), and **4** (8 mg) using 10% EtOAc/hexane, 20% EtOAc/hexane, 20% EtOAc/hexane, 20% EtOAc/hexane, 20% EtOAc/hexane, 20% EtOAc/hexane, and 30% EtOAc/hexane, respectively.

3β-Acetoxy-12β,13β-epoxy-11α-hydroperoxyursane (1): colorless solid (CH_2Cl_2); mp 187−193 °C; $[\alpha]^{25}_D$ +14.4° (*c* 0.2, $CHCl_3$); IR (KBr) ν_{max} 3395, 1734, 1456, 1381, 1268, 1249, 1031, 986, 740 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.57 (1H, d, J = 10.8 Hz, H-18), 0.83, 0.84, 1.00, 1.04, 1.11, 1.19, 2.02 (each 3H, s), 0.90 (3H, d, J = 6.4 Hz, H-30), 1.05 (3H, d, J = 6.0 Hz, H-29), 4.36 (1H, d, J = 9.2 Hz, H-11), 4.45 (1H, dd, J = 10.8, 5.2 Hz, H-3), 7.83 (1H, s, exchangeable with D_2O, OOH); ^{13}C NMR data, see Table 1; EIMS *m/z* 516 [M^+] (1), 498 (64), 483 (70), 277 (28), 221 (100), 123 (56); HREIMS *m/z* 498.3706 [$M^+ - H_2O$] (calcd for $C_{32}H_{50}O_4$, 498.3711).

3β-Acetoxy-11α-hydroperoxyursan-12-one (2): amorphous solid; $[\alpha]^{25}_D$ +63.9° (*c* 0.4, $CHCl_3$); IR (KBr) ν_{max} 3339, 1731, 1717, 1458, 1387, 1268, 1249, 1031, 975, 739 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.84, 0.86, 0.87, 0.96, 1.13, 1.26, 2.03 (each 3H, s), 0.82 (3H, d, J = 6.0 Hz, H-29), 0.90 (3H, d, J = 6.4 Hz, H-30), 1.78 (1H, d, J = 8.8 Hz, H-9), 1.94 (1H, dt, J = 14.0, 3.2 Hz, H-1β), 2.82 (1H, s, H-13), 4.22 (1H, d, J = 8.8 Hz, H-11), 4.51 (1H, dd, J = 10.0, 6.4 Hz, H-3), 8.45 (1H, s, OOH); ^{13}C NMR data, see Table 1; FABMS *m/z* 517 [M^+ + 1] (33), 515 (55), 499 (100), 483 (27), 439 (50), 289 (45), 219 (78); HRFABMS *m/z* 517.3878 [M^+ + 1] (calcd for $C_{32}H_{53}O_5$, 517.3895).

3β-Acetoxy-1β,11α-epidioxy-12-ursene (3): colorless solid (CH_2Cl_2); mp 250−253 °C; $[\alpha]^{29}_D$ +29.4° (*c* 0.9, $CHCl_3$); IR (KBr) ν_{max} 3032, 1741, 1465, 1370, 1245, 1028, 990, 972 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.77, 0.86, 0.86, 1.04, 1.17, 1.19, 2.02 (each 3H, s), 0.76 (3H, d, J = 6.4 Hz, H-29), 0.88 (3H, d, J = 5.2 Hz, H-30), 1.85 (1H, d, J = 8.8 Hz, H-9), 4.03 (1H, dd, J = 12.4, 3.6 Hz, H-1), 4.63 (1H, dd, J = 11.2, 4.4 Hz, H-3), 5.00 (1H, H-11, overlapped with H-12), 5.02 (1H, H-12, overlapped with H-11); ^{13}C NMR data, see Table 1; EIMS *m/z* 498 [M^+] (1), 482 (5), 466 (4), 420 (100), 405 (28), 267 (23); HREIMS *m/z* 498.3730 [M^+] (calcd for $C_{32}H_{50}O_4$, 498.3711).

(20*S*)-3β-Acetoxylupan-29-oic acid (4): colorless solid; mp 287−290 °C; $[\alpha]^{29}_D$ +18.9° (*c* 0.7, $CHCl_3$) ($[\alpha]^{20}_D$ +22.66°; lit.[11]); IR (KBr) ν_{max} 3200−2500, 1734, 1712, 1389, 1251, 1030, 983 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.75, 0.82, 0.83, 0.84, 0.90, 1.01, 2.02 (each 3H, s), 1.03 (3H, d, J = 7.2 Hz, H-30), 2.29 (1H, m, H-19), 2.77 (1H, m, H-20), 4.45 (1H, dd, J = 10.4, 6.8 Hz, H-3); ^{13}C NMR data, see Table 1; FABMS *m/z* 501 [M^+ + 1] (3), 441 (5), 307 (25), 289 (15), 154 (100), 136 (64); HRFABMS *m/z* 501.3930 [M^+ + 1] (calcd for $C_{32}H_{53}O_4$, 501.3946).

(20*S*)-3β-Acetoxy-20-hydroperoxy-30-norlupane (5): colorless solid (CH_2Cl_2); mp 159−162 °C; $[\alpha]^{29}_D$ +6.8° (*c* 3.9, $CHCl_3$); IR (KBr) ν_{max} 3400, 1735, 1458, 1383, 1248, 1030, 981, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.74, 0.80, 0.81, 0.83, 0.86, 1.00, 2.01 (each 3H, s), 1.07 (3H, d, J = 8.8 Hz, H-29), 2.27 (1H, m, H-19), 4.34 (1H, m, H-20), 4.44 (1H, dd, J = 9.6, 6.4 Hz, H-3), 8.27 (1H, s, OOH); ^{13}C NMR data, see Table 1; EIMS *m/z* 470 ($M^+ - H_2O$, 1), 410 (16), 394 (16), 367 (36), 351 (30), 323 (26), 189 (80), 95 (88), 71 (92), 57 (100), 55 (92); HREIMS *m/z* 470.3771 [$M^+ - H_2O$] (calcd for $C_{31}H_{50}O_3$, 470.3762).

3β-Acetoxy-18α-hydroperoxy-12-oleanen-11-one (6): colorless solid (CH_2Cl_2); mp 205−207 °C; $[\alpha]^{25}_D$ +23.7° (*c* 0.7, $CHCl_3$); UV λ_{max} (log ϵ) (MeOH) 242.0 (3.91) nm; IR (KBr) ν_{max} 3414, 3062, 1734, 1669, 1466, 1367, 1249, 1032, 987, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.79 (1H, br d, J = 10.0 Hz, H-5), 0.83, 0.86, 0.86, 0.94, 1.10, 1.13, 1.15, 1.53, 2.03 (each 3H, s), 2.43 (1H, s, H-9), 2.71 (1H, dt, J = 13.6, 3.2 Hz, H-1β), 4.49 (1H, dd, J = 11.2, 5.2 Hz, H-3), 5.74 (1H, s, H-12), 6.80 (1H, s, OOH); ^{13}C NMR data, see Table 1; EIMS *m/z* 514 [M^+] (3), 496 (100), 480 (40), 465 (48), 436 (26), 421 (24), 289 (32), 271 (68), 189 (38), 135 (37); HREIMS *m/z* 514.3660 [M^+] (calcd for $C_{32}H_{50}O_5$, 514.3660).

3β-Acetoxy-12-oleanen-11-one (7): colorless solid (CH_2Cl_2); mp 283−286 °C; IR (KBr) ν_{max} 1734, 1663, 1622, 1466, 1637, 1247, 1030, 987, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.76 (1H, dd, J = 9.6, 2.8 Hz, H-5), 0.82, 0.84, 0.84, 0.85, 0.87 (H_3-29), 1.09, 1.12, 1.32 (H_3-27), 2.01 (each 3H, s), 2.32 (1H, s, H-9), 2.76 (1H, dt, J = 13.6, 3.2 Hz, H-1β), 4.48 (1H, dd, J = 11.6, 4.8 Hz, H-3), 5.55 (1H, s, H-12); ^{13}C NMR data, see Table 1; EIMS *m/z* 482 [M^+] (21), 467 (8), 422 (40), 407 (36), 379 (16), 273 (88), 232 (100), 175 (38), 135 (72).

Oxidation of 3β-Acetoxy-11α-hydroperoxy-12-ursene with *m*-CPBA. 3β-Acetoxy-11α-hydroperoxy-12-ursene (33 mg) and *m*-CPBA (55 mg) were dissolved in CH_2Cl_2 (3 mL), and the mixture was stirred at room temperature for 48 h. The mixture was diluted with CH_2Cl_2 (5 mL), washed with 1 N sodium hydroxide (10 mL) and water (10 mL), and dried ($MgSO_4$). The CH_2Cl_2 was removed under reduced pressure to yield 30 mg of crude product, which was separated by HPLC (20% EtOAc/hexane) to yield **7** (5.2 mg, t_R = 9.7 min), starting material (15.0 mg, t_R = 11.0 min), **1** (4.8 mg, t_R = 12.4 min), and **2** (1.6 mg, t_R = 14.5 min).

Reduction of 5 with Lithium Aluminum Hydride. To a solution of compound **5** (5 mg) in 1 mL of dry THF was added an excess of $LiAlH_4$, and the suspension was stirred for 2 h at room temperature. The reaction mixture was carefully hydrolyzed by dropwise addition of wet THF (2 mL). After removal of THF, the mixture was extracted with ether (5 mL) and dried ($MgSO_4$) to afford (20*S*)-3β,20-dihydroxy-30-norlupane.[11]

X-ray Crystal Structure Analysis of 3. A colorless crystal of **3** with dimensions 0.40 × 0.20 × 0.02 mm was selected for X-ray analysis. Structure analysis was performed using the SHELXTL program on a PC.[12] Data were collected over a hemisphere of reciprocal space, by a combination of three sets of exposures. The compound crystallized in the monoclinic space group $P2_1$, with a = 8.1726(2) Å, b = 11.1238(3) Å, c = 15.5734(4) Å, β = 98.2750(10)°, V = 1401.04(6) $Å^3$, Z = 2, D_{calc} = 1.182 g/cm^3, λ = 0.71073 Å, μ(Mo Kα) = 0.076 mm^{-1}, F(000) = 548, and T = 150(2) K. The SMART program was used to make data corrections. A total of 16 217 reflections, collected in the range 1.32° ≤ θ ≤ 27.50°, yielded 6400 unique reflections. The structure was solved using direct methods and refined by full-matrix least-squares on F^2 values for 5804 reflections with $I > 2\sigma(I)$. Non-hydrogen atoms were refined anisotropically. Hydrogen atoms were fixed at calculated positions and refined using a riding mode. The final indices were R = 0.0630, R_w = 0.1228 with goodness-of-fit = 1.001. Scattering factors were taken from the *International Tables for X-ray Crystallography*.[13]

X-ray Crystal Structure Analysis of 6. A colorless crystal of **6** with dimensions 0.30 × 0.25 × 0.25 mm was selected for X-ray analysis. Structure analysis was performed using the SHELXTL program on a PC.[12] Data were collected over a hemisphere of reciprocal space, by a combination of three sets of exposures. The compound crystallized in the monoclinic space group $P2_12_12_1$, with a = 25.1203(6) Å, b = 8.0928(2) Å, c = 14.2733(3) Å, β = 90°, V = 2901.67(12) $Å^3$, Z = 4, D_{calc} = 1.178 g/cm^3, λ = 0.71073 Å, μ(Mo Kα) = 0.077 mm^{-1}, F(000) = 1128, and T = 295(2) K. The SMART program was used to make data corrections. A total of 28 786 reflections, collected in the range 1.62° ≤ θ ≤ 27.50°, yielded 6674 unique reflections. The structure was solved using direct methods and refined by full-matrix least-squares on F^2 values for 6470 reflections with $I > 2\sigma(I)$. Non-hydrogen atoms were refined anisotropically. Hydrogen atoms were fixed at calculated positions and refined using ariding mode. The final indices were R = 0.0468, R_w = 0.1268 with goodness-of-fit = 1.048. Scattering factors were taken from the *International Tables for X-ray Crystallography*.[13]

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Supporting Information Available: X-ray crystallographic data for compounds **3** and **6**. This material is available free of charge via the Internet at http://pubs.acs.org.

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