[Chem. Pharm. Bull.
29(8)2230—2236(1981)]

New Triterpenoids from the Leaves of *Bupleurum rotundifolium* L.

YOSHIMASA KOBAYASHI and YUKIO OGIHARA*

*Faculty of Pharmaceutical Sciences, Nagoya City University,
Tanabe-dori, Mizuhoku, Nagoya 467, Japan*

(Received January 26, 1981)

Two new triterpenoids, rotundiogenin C (**7**), and rotundiogenin F (**14**), isolated from the leaves of *Bupleurum rotundifolium* L. (Umbelliferae), were identified as oleana-11,13(18)-diene-3β,16α,21α,28-tetraol, and oleana-9,12-diene-3β,16α,21α,28-tetraol, respectively, on the basis of spectroscopic evidence and chemical correlations.

Keywords——oleanane triterpenoid; *Bupleurum rotundifolium* L.; Umbelliferae; rotundiogenin C; rotundiogenin F; Huang-Minlon reduction; selenium dioxide oxidation

In the preceding paper,[1] we described the isolation and the structural elucidation of rotundiosides E and F, isolated from the methanolic extracts of the leaves of *Bupleurum rotundifolium* L. This paper reports the isolation and structural identification of two new sapogenins, rotundiogenins C and F from the same source.

The crude saponin fraction was hydrolyzed under acidic conditions to afford four compounds, *viz.* the known 16-epi-saikogenin C (oleana-11,13(18)-diene-3β,16α,28-triol) (**1**) and saikogenin D,[2] and the newly designated rotundiogenin C (**7**) and rotundiogenin F (**14**).

Rotundiogenin C (**7**), $C_{30}H_{48}O_4$ (M^+ 472), exhibits strong ultraviolet (UV) absorptions at 242.5, 250.5, and 260.5 nm, characteristic of a heteroannular diene, and proton magnetic resonance (PMR) signals of two olefinic protons at δ 5.74 (d, J=11 Hz) and 6.78 (dd, J=11, 2 Hz) on a disubstituted double bond. Upon acetylation of rotundiogenin C (**7**), the triacetate (**7b**) and diacetate (**7c**) were formed immediately at room temperature, and warming on a water bath for 5 h provided a tetraacetate (**7a**) whose PMR spectrum showed four acetyl signals and the corresponding geminal protons at δ 3.90 and 4.34 (2H, ABq, J=11 Hz, $-C\underline{H}_2-OAc$), 4.54, 4.86 and 5.16. Thus, the presence of three secondary OH groups in the molecule was confirmed and one of these was found to be slightly hindered. These spectral data of **7a** and **7b** were very similar to those of 16-epi-saikogenin C triacetate (**1a**) and the only difference between the two compounds was observed in the PMR spectrum as an additional proton geminal to equatorial OAc at δ 4.86 (dd, J=10, 6 Hz). These results, together with biogenetic and structural considerations, suggest that rotundiogenin C (**7**) is oleana-11,13(18)-diene-3β,16α,21α,28-tetraol. The position of the newly introduced hydroxyl group was confirmed by the following results.

(1) Huang-Minlon Reduction of 16-Oxo-oleana-11,13(18)-diene Derivatives

As a model experiment, 16-oxo-oleana-11,13(18)-diene derivatives (**1e**)[2] and (**1f**), derived from 16-epi-saikogenin C diacetate (**1b**) and dimethyl ether (**1d**), were reduced by the Huang-Minlon method. The expected compounds (2) and (**2a**) were not obtained, but the formation of compound (3) from the former and the recovery of the starting material from the latter were observed. The structure of the compound (3) was deduced by analysis of the PMR spectrum [a single olefinic proton, δ 5.85 (t, J=4 Hz)] and from the UV peak at λ 301 nm (homoannular diene). Under the same conditions, the 16-keto-rotundiogenin C derivative (**7f**) afforded the compound (**10**). In these experiments, the elimination of 16-keto function by the Huang-Minlon method was successful, but the expected compounds (2) and (12) were not obtained. This interesting reaction was initiated by the elimination of formaldehyde from the hydroxyl methyl group on C-17 *via* retro-aldol condensation, followed by the possible

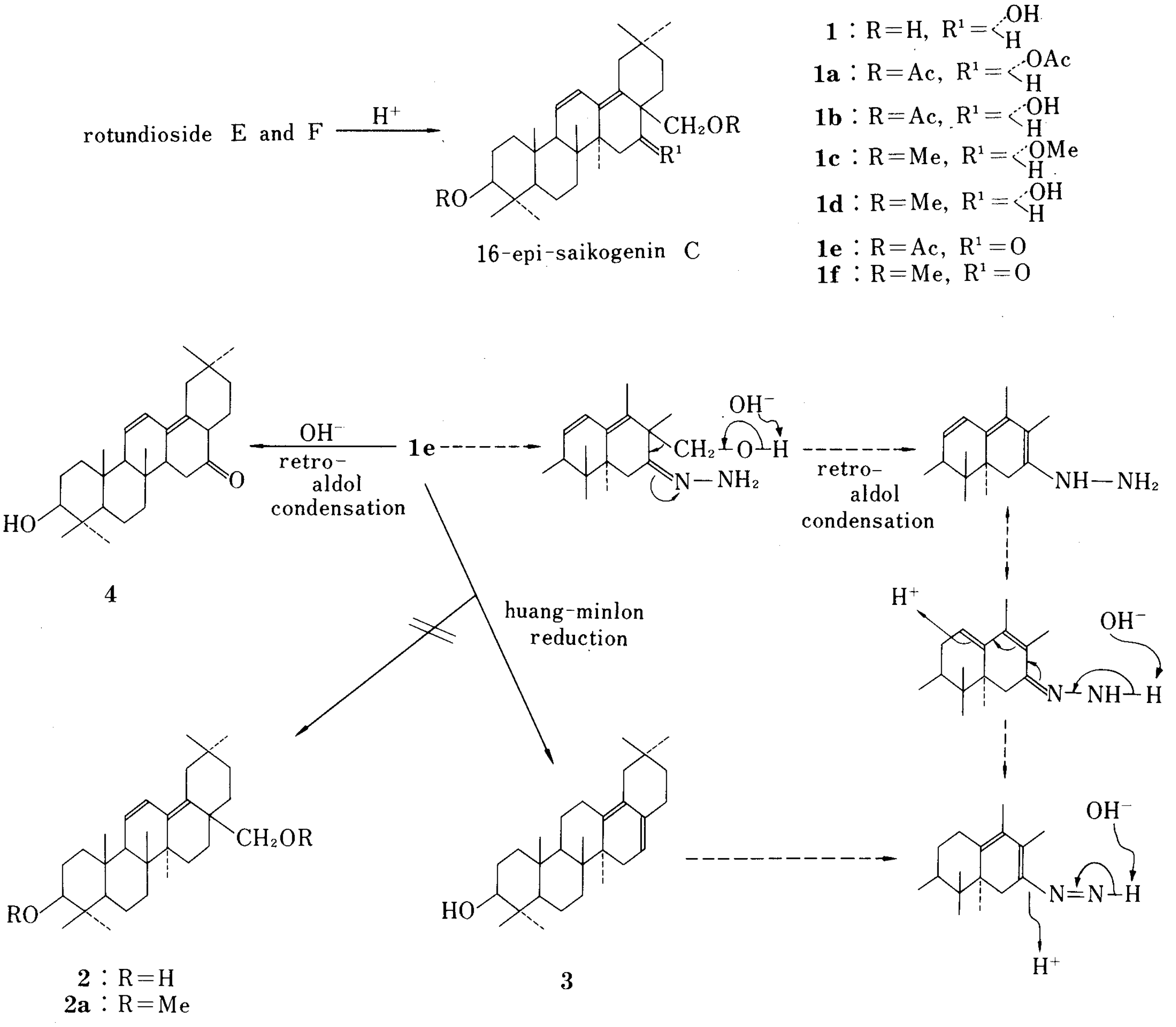


Chart 1

transformations shown in Chart 1 (dotted line). To obtain experimental support for this mechanism, compound (**1e**) was treated with 3% KOH-EtOH to afford compound (**4**), which exhibits strong UV absorptions at 245, 250.5, and 261 nm characteristic of a heteroannular diene, one carbonyl (1708 cm^{-1}) absorption in the infrared (IR) spectrum, and PMR signals of two olefinic protons at δ 5.74 (d, J=11 Hz) and 6.42 (dd, J=11, 3 Hz) on a disubstituted double bond and no hydroxyl methyl protons on C-17. Thus, compound (**1e**) was easily converted to 16-oxo-3β-hydroxy-28-noroleana-11,13(18)-diene *via* retro-aldol condensation.

(2) Dehydration and Hydrogenation of 16α-Hydroxy-oleana-11,13-(18)-diene Derivatives

As a model experiment, 16-epi-saikogenin C diacetate (**1b**) was treated with thionyl chloride in pyridine solution[3] to give the Δ^{15}-16-desoxy diacetate (**5**), $C_{34}H_{50}O_4$, which exhibits PMR signals of two newly introduced olefinic protons at δ 5.37 (d, J=10 Hz) and 5.70 (d, J=10 Hz). The compound (**5**) was hydrogenated with Adams catalyst in acetic acid to give the tetrahydro derivative (**6**), which exhibits no olefinic proton in the PMR spectrum or end absorption in the UV spectrum. The structures of the compounds (**5**) and (**6**) are shown in Chart 2. As described above, rotundiogenin C triacetate (**7b**) was treated to afford a single compound, the Δ^{15}-16-desoxy triacetate (**8**), $C_{36}H_{52}O_6$, [δ 5.35 (d, J=10 Hz) and 5.69 (d, J=

NII-Electronic Library Service

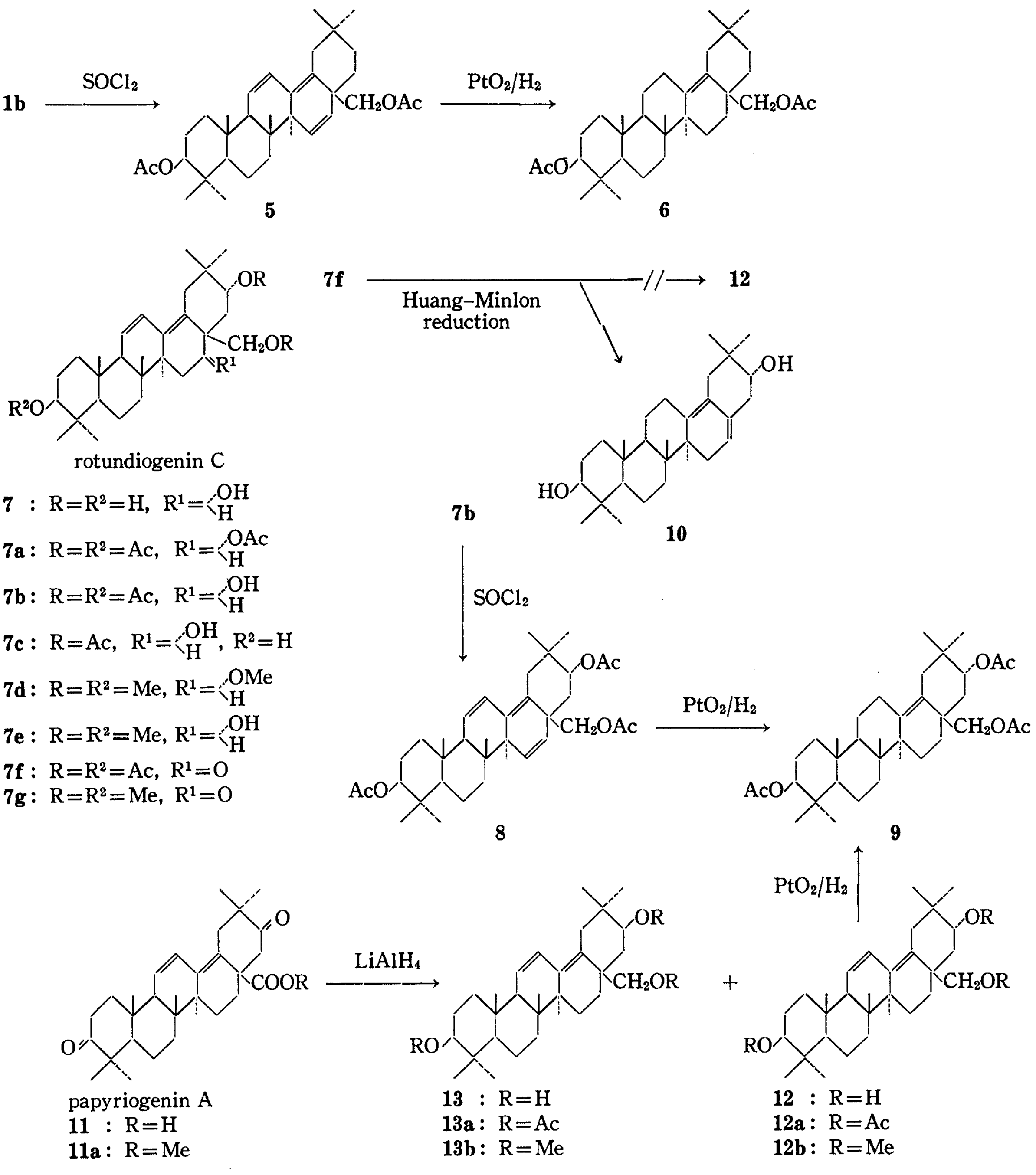


Chart 2

10 Hz)]. The hydrogenation of compound (**8**) gave (**9**), which was identical, as judged by spectral comparison, with an authentic sample derived from papyriogenin A (**11**)[4] by reduction with lithium aluminium hydride[5] and acetylation, followed by hydrogenation. Thus, the structure (7) was assigned on the basis of the chemical correlation. The structures of 16-epi-saikogenin C derivatives (**1e**) and (**1f**), the seven rotundiogenin C derivatives (**7a**—**g**), and the four reduced products (**12a**—**b**) and (**13a**—**b**) were deduced by analysis of the PMR spectra (see Table I).

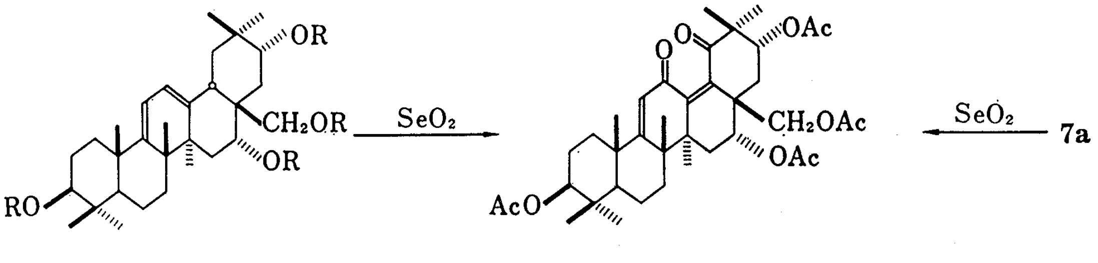
Rotundiogenin F (**14**), $C_{30}H_{48}O_4$ (M^+ 472), is isomeric with rotundiogenin C (7). Complete acetylation of **14** gave a tetraacetate (**14a**), which exhibits UV absorption at 284 nm, characteristic of a homoannular diene. Its PMR spectrum showed the signals of seven quaternary methyls in the region of δ 0.90—1.22, four acetyl signals and the corresponding geminal protons

Table I. ^{1}H NMR Spectra (δ Values) in $CDCl_3$

Compound	3-H (J/Hz)	16-H (J/Hz)	21-H (J/Hz)	28-H_2 (J/Hz)
7a	4.54(dd, 9, 7)	5.16 br (s, 6)	4.86(dd, 10, 6)	3.90(d, 11), 4.34(d, 11)
7b	4.55(dd, 8, 7)	4.00 br (s, 6)	4.87(dd, 11, 6)	3.90(d, 12), 4.32(d, 12)
7c	3.15(dd, 8, 7)	3.96 br (s, 6)	4.83(dd, 11, 5)	3.86(d, 12), 4.28(d, 12)
7d	2.69(dd, 11, 4)	3.44 br (s, 4)	3.09(dd, 9, 7)	3.10(d, 10), 3.45(d, 10)
7e	2.72(dd, 10, 5)	4.09 br (s, 6)	3.18(dd, 9, 6)	3.14(d, 11), 3.58(d, 11)
7f	4.49(dd, 9, 7)		4.85(dd, 11, 5)	4.00(d, 12), 4.66(d, 12)
7g	2.63(dd, 10, 7)		3.10(dd, 10, 5)	3.36(d, 10), 3.74(d, 10)
1e	4.54(dd, 9, 8)			3.94(d, 11), 4.70(d, 11)
1f	2.71(dd, 11, 4)			3.33(d, 10), 3.79(d, 10)
12a	4.51(dd, 9, 7)		4.81(dd, 12, 5)	3.99(d, 11), 4.17(d, 11)
13a	4.51(dd, 8, 7)		4.64 br (s, 5)	3.98(d, 11), 4.31(d, 11)
12b	2.69(dd, 11, 4)		3.05(dd, 11, 4)	3.17(d, 10), 3.37(d, 10)
13b	2.68(dd, 11, 5)		2.82 br (s, 6)	3.17(d, 9), 3.62(d, 9)

For broad signals, numbers in parentheses are $W_{1/2}$ values.

at δ 3.87 and 4.04 (ABq, J=11 Hz, $-C\underline{H}_2OAc$), 4.52, 4.80, and 5.09, respectively, and two protons on a conjugated double bond as a singlet at δ 5.63. These spectral data are very similar to those of rotundiogenin C tetraacetate (**7a**) except for two protons as a singlet at at δ 5.63. The structure of rotundiogenin F (**14**) was confirmed by the following experiments. The SeO_2 oxidation$^{6)}$ of rotundiogenin F tetraacetate (**14a**) yielded a dienedione derivative (**15**), showing IR absorption at 1694, 1655, and 1624 cm^{-1}, and this product was identical with an authentic sample derived from rotundiogenin C tetraacetate (**7a**) by SeO_2 oxidation. On the basis of these data, the structure of rotundiogenin F (**14**) was elucidated as olean-9,12-diene-3β,16α,21α,28-tetraol. So far only five triterpenes with such a homoannular diene system, saikogenin B,$^{6)}$ echinatic acid,$^{7,8)}$ isomacedonic acid,$^{9)}$ and castanopsin$^{10)}$ are known in nature.



rotundiogenin F

14 : R=H
14a : R=Ac

15

Chart 3

Finally, it is interesting that all the naturally occurring triterpenoids described here have an α-hydroxyl group at C-16.

Experimental

Mps were measured with a Yanagimoto microapparatus, UV spectra were taken for solutions in methanol, IR spectra for KBr discs, optical rotations for solutions in chloroform, and PMR spectra for solutions in deuteriochloroform.

Isolation of Rotundiogenins C (7) and F (14)——The dried leaves of *Bupleurum rotundifolium* L. (2.2 kg) were extracted with methanol. The extracts were diluted with water and then extracted with ether. The aqueous layer was extracted with *n*-butanol. The *n*-butanolic extract was evaporated to dryness and the residue was dissolved in a minimal amount of methanol and poured into ether with stirring. The precipitate (crude saponins) was collected by filtration (164 g). The products obtained by acidic hydrolysis of the crude saponins (6 g) were chromatographed on silica gel [$CHCl_3$–MeOH (30: 1)] to afford a minor sapogenin (**7**, 235 mg) and **14** (105 mg).

Rotundiogenin C (**7**) was obtained from $CHCl_3$–MeOH as colorless prisms, mp 287—289°C. $[\alpha]^{22}_{D}$ −30° (c=0.20, in methanol). UV λ_{max} nm (ε): 242.5 (24800), 250.5 (28300), 260.5 (18600). MS m/e: 472 (M^+), 454, 441, 423, 405. PMR (C_5D_5N) δ: 0.91 (3H, s), 1.01 (3H, s), 1.03 (3H, s), 1.22 (3H, s), 1.25 (3H, s), 1.31 (3H, s), 1.71 (3H, s), 3.44 (1H, dd, J=10, 6 Hz), 3.80 (1H, d, J=11 Hz), 4.24 (1H, d, J=11 Hz), 4.23 (1H, dd, J=10, 6 Hz), 5.74 (1H, d, J=11 Hz), 6.78 (1H, dd, J=11, 2 Hz). *Anal.* Calcd for $C_{30}H_{48}O_4$: C, 76.23; H, 10.24. Found: C, 75.76; H, 10.17.

Rotundiogenin F (**14**) was obtained from MeOH–H_2O as a white powder, mp 299—302°C. MS m/e: 472 (M^+), 454, 423, 405 (100%). *Anal.* Calcd for $C_{30}H_{48}O_4$: C, 76.23; H, 10.24. Found: C, 75.98; H, 10.09. Tetraacetate (**14a**) (acetylated with acetic anhydride–pyridine), amorphous, $[\alpha]^{21}_{D}$ +75.1° (c=0.73). UV λ_{max} nm (ε): 284 (7700). PMR δ: 0.90 (6H, s), 0.96 (3H, s), 1.04 (3H, s), 1.08 (3H, s), 1.16 (3H, s), 1.22 (3H, s), 2.06 (3H, s), 2.07 (3H, s), 2.09 (3H, s), 2.10 (3H, s), 3.87 (1H, d, J=11 Hz), 4.04 (1H, d, J=11 Hz), 4.52 (1H, dd, J=9, 7 Hz), 4.80 (1H, dd, J=10, 4 Hz), 5.09 (1H, t, J=5 Hz), 5.63 (2H, s).

Rotundiogenin C 21,28-Diacetate (7c), 3,21,28-Triacetate (7b), and 3,16,21,28-Tetraacetate (7a)——Rotundiogenin C (**7**) (100 mg) was treated with an excess of pyridine and acetic anhydride at room temperature. After 1 h the reaction mixture was worked up in the usual way and the products (110 mg) were chromatographed on silica gel to afford the triacetate (43 mg) and diacetate (20 mg). The triacetate (**7b**) was recrystallized from methanol as colorless needles, mp 240—242°C. PMR: see Table I. *Anal.* Calcd for $C_{36}H_{54}O_7$: C, 72.21; H, 9.09. Found: C, 71.91; H, 9.29. Diacetate (**7c**), PMR: see Table I. The tetraacetate (**7a**) (acetylated with acetic anhydride–pyridine, by warming on a water bath for 5 h) was obtained from aqueous methanol as colorless needles, mp 221—222°C. PMR spectrum: see Table I. *Anal.* Calcd for $C_{38}H_{56}O_8$: C, 71.22; H, 8.81. Found: C, 71.26; H, 8.81.

Methylation of Rotundiogenin C (7)——(a) Dimsyl Carbanion: Prepared by adding NaH (6 g, washed with dry *n*-hexane 3 times beforehand) to DMSO (60 ml) and stirring the mixture under an argon atmosphere at 55°C for 2 h.

(b) The above prepared dimsyl carbanion (4 ml) was added to a solution of **7** (150 mg) in DMSO (3 ml), and the mixture was stirred under an argon atmosphere at room temperature for 2 h. Methyl iodide (4 ml) was then added and the reaction was continued for 20 h. The reaction mixture was poured into ice-water and extracted with ether. The combined ether extract was washed with water and dried over $MgSO_4$. The products obtained by evaporation of the solvent were chromatographed on silica gel [$CHCl_3$–MeOH (100: 1)] to give rotundiogenin C 3,16,21,28-tetramethyl ether (**7d**) (110 mg) and 3,21,28-trimethyl ether (**7e**) (20 mg). The tetramethyl ether (**7d**) was recrystallized from methanol, mp 164—166°C. MS m/e: 528 (M^+), 484, 483, 451, 419, 387. PMR spectrum: see Table I. *Anal.* Calcd for $C_{34}H_{56}O_4$: C, 77.22; H, 10.67. Found: C, 76.91; H, 10.86. The trimethyl ether (**7e**) was recrystallized from methanol, mp 236—238°C. PMR spectrum: see Table I.

Oxidation of Compounds (1b), (1d), (7b), and (7e) with Chromium (III) Oxide-Pyridine——(a) A solution of compound (**1b**) (340 mg) in pyridine (3 ml) was added to a stirred solution of chromium (III) oxide (500 mg) in pyridine (10 ml). The mixture was stirred for 2 h at room temperature. Water was added and the mixture was extracted with ether. The organic layer was washed with water, dried over Na_2SO_4, and evaporated to dryness. The residue (335 mg) was crystallized from methanol to afford 16-oxo-oleana-11,13(18)-diene-3β,28-diacetate (**1e**) (300 mg), mp 254—256°C (lit.[2] 247—250°C). $[\alpha]^{20}_{D}$ −105° (c=0.41). IR ν^{KBr}_{max} cm^{-1}: 1739, 1724, 1708, 1245, 1033. PMR spectrum: see Table I. *Anal.* Calcd for $C_{34}H_{50}O_5$: C, 75.80; H, 9.35. Found: C, 75.68; H, 9.63.

(b) Compound (**1d**) (30 mg) was worked up as in (a) and the product was recrystallized from methanol to afford 16-oxo-oleana-11,13(18)-diene-3,28-dimethyl ether (**1f**) (22 mg), mp 206—208°C. $[\alpha]^{20}_{D}$ −43.1° (c=0.42). IR ν^{KBr}_{max} cm^{-1}: 1705, 1106, 1097. PMR spectrum: see Table I. *Anal.* Calcd for $C_{32}H_{50}O_3$: C, 79.62; H, 10.44. Found: C, 79.76; H, 10.47.

(c) Compound (**7b**) (40 mg) was worked up as in (a) and the product was recrystallized from methanol to afford 16-oxo-oleana-11,13(18)-diene-3,21,28-triacetate (**7f**) as plates, mp 240—241°C. $[\alpha]^{21}_{D}$ −111° (c=0.34). IR ν^{KBr}_{max} cm^{-1}: 1745, 1736, 1732, 1707. PMR: see Table I. *Anal.* Calcd for $C_{36}H_{52}O_7$: C, 72.45; H, 8.78. Found: C, 72.48; H, 8.90.

(d) Compound (**7e**) (7 mg) was worked up as in (a) to afford 16-oxo-oleana-11,13(18)-diene-3,21,28-trimethyl ether (**7g**) (5 mg). IR ν^{KBr}_{max} cm^{-1}: 1703, 1458, 1106. PMR: see Table I.

Huang-Minlon Reduction of the Oxidation Products (1e), (1f), (7f), and (7g)——(a) The oxidation product (**1e**) (50 mg) and 100% hydrazine hydrate (0.7 ml) in a mixture of ethylene glycol (4 ml) and ethanol (4 ml) were heated under reflux for 1 h under an argon atmosphere. After addition of potassium hydroxide pellets (400 mg) and heating under reflux for an additional 0.5 h, the condenser was removed and the mixture was warmed slowly until an internal temperature of 195°C was attained. The condenser was replaced and the mixture was maintained at 195—205°C for 4 h, under an argon atmosphere. After cooling to room tempera-

NII-Electronic Library Service

ture, the solution was poured into water and extracted with *n*-butanol-saturated water. The extract was evaporated to dryness and the residue was separated by preparative TLC to give compound (**3**) (30 mg) as a white powder. IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: no absorption of C=O. UV $\lambda_{\max}$ nm (ε): 301 (14600). PMR δ: 0.81 (3H, s), 0.96 (9H, s), 0.98 (3H, s), 1.01 (3H, s), 1.03 (3H, s), 3.24 (1H, dd, J=9, 7 Hz), 5.85 (1H, t, J=4 Hz). *Anal.* Calcd for $C_{29}H_{46}O \cdot H_2O$: C, 81.25; H, 11.29. Found: C, 80.97; H, 11.48.

(b) Compound (**1f**) (20 mg) was worked up as in (a). The product was identical with the starting material.

(c) Compound (**7f**) (40 mg) was worked up as in (a) and the reaction mixture was purified by preparative TLC to afford compound (**10**) (12 mg) as a white powder. IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: no absorption of C=O. UV $\lambda_{\max}$ nm (ε): 298 (12800). PMR δ: 0.82 (3H, s), 0.92 (3H, s), 0.98 (9H, s), 1.01 (3H, s), 1.06 (3H, s), 3.20 (1H, dd, J=9, 7 Hz), 3.59 (1H, dd, J=8, 5 Hz), 5.79 (1H, t, J=3 Hz). *Anal.* Calcd for $C_{29}H_{46}O_2 \cdot 2H_2O$: C, 75.28; H, 10.90. Found: C, 74.96; H, 10.98.

(d) Compound (**7g**) (4 mg) was worked up as in (a) and the product was identical with the starting material.

Alkaline Treatment of Compound (**1e**)——Compound (**1e**) (42 mg) was treated with 3% KOH–EtOH (4 ml) under reflux for 4 h. The solvent was evaporated off and the reaction mixture was extracted with ether. The extract was evaporated to dryness and the residue was separated by preparative TLC to give compound (**4**) (11 mg) as a white powder. IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: 1708. UV $\lambda_{\max}$ nm (ε): 245 (23400), 250.5 (25200), 261 (sh). PMR δ: 0.75 (3H, s), 0.79 (3H, s), 0.90 (6H, s), 0.94 (3H, s), 1.00 (3H, s), 1.02 (3H, s), 3.23 (1H, t, J=7 Hz), 5.74 (1H, d, J=11 Hz), 6.42 (1H, dd, J=11, 3 Hz). *Anal.* Calcd for $C_{29}H_{44}O_2 \cdot 2H_2O$: C, 75.61; H, 10.50. Found: C, 75.38; H, 10.67.

Reduction of Papyriogenin A (**11**) **with Lithium Aluminium Hydride**——Papyriogenin A (**11**) (1.0 g) was methylated with diazomethane and a mixture of the methyl ester (**11a**) and $LiAlH_4$ (500 mg) in THF (80 ml) was left to stand overnight. The excess reagent was decomposed with water and the mixture was extracted with ether. The extract was dried (Na_2SO_4) and evaporated to dryness. The residue was chromatographed on silica gel [solvent, $CHCl_3$–MeOH (30: 1)] to afford 3β,21β,28-trihydroxyoleana-11,13(18)-diene (**13**) (270 mg) and 3β,21α,28-trihydroxyoleana-11,13(18)-diene (**12**) (130 mg). The 3β,21β,28-triacetate (**13a**) (acetylated with acetic anhydride–pyridine) was obtained as prisms from methanol, mp 265—267°C. $[\alpha]_D^{22}$ $-32.7°$ (c=0.28). PMR: see Table I. *Anal.* Calcd for $C_{36}H_{54}O_6$: C, 74.19; H, 9.34. Found: C, 74.04; H, 9.13. The 3β,21α,28-triacetate (**12a**) (acetylated with acetic anhydride–pyridine) was obtained as prisms from methanol, mp 218—220°C. $[\alpha]_D^{22}$ $-107°$ (c=1.0). PMR: see Table I. *Anal.* Calcd for $C_{36}H_{54}O_6$: C, 74.19; H, 9.34. Found: C, 73.75; H, 9.04. The 3β,21β,28-trimethyl ether (**13b**) (methylated by Hakomori's method) was obtained as colorless needles from methanol, mp 205—206°C. $[\alpha]_D^{21}$ $-15°$ (c=0.2). PMR: see Table I. *Anal.* Calcd for $C_{33}H_{54}O_3$: C, 79.46; H, 10.91. Found: C, 79.46; H, 11.10. The 3β,21α,28-trimethyl ether (**12b**) (methylated by Hakomori's method) was obtained as prisms from methanol, mp 236—238°C. $[\alpha]_D^{21}$ $-74°$ (c=0.58). PMR: see Table I. *Anal.* Calcd for $C_{33}H_{54}O_3$: C, 79.46; H, 10.91. Found: C, 79.49; H, 10.93.

Catalytic Reduction of Compound (**12a**)——A solution of compound (**12a**) (66 mg) in AcOH (2 ml) was shaken with PtO_2 (32 mg) in an H_2 atmosphere for 6 h at room temperature. The catalyst was filtered off and the filtrate was evaporated to dryness under reduced pressure. Recrystallization of the residue from methanol afforded colorless needles (50 mg) of the dihydro–derivative (**9**), olean-13(18)-en-3β,21α,28-triacetate, mp 184—186°C. $[\alpha]_D^{22}$ $-69.0°$ (c=0.12). IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: 1742, 1736, 1732, 1250, 1033. PMR δ: 0.77 (3H, s), 0.84 (3H, s), 0.86 (6H, s), 0.88 (3H, s), 0.93 (3H, s), 1.17 (3H, s), 2.01 (3H, s), 2.04 (3H, s), 2.08 (3H, s), 4.03 (1H, d, J=11 Hz), 4.21 (1H, d, J=11 Hz), 4.51 (1H, dd, J=8, 7 Hz), 4.79 (1H, dd, J=12, 7 Hz). *Anal.* Calcd for $C_{36}H_{56}O_6$: C, 73.93; H, 9.65. Found: C, 73.75; H, 9.88.

Dehydration of 16-Epi-saikogenin C Diacetate (**1b**) **and Rotundiogenin C triacetate** (**7b**)——(a) A solution of 16-epi-saikogenin C diacetate (**1b**) (100 mg) in pyridine (5 ml) was treated at 0°C with thionyl chloride (1 ml). The mixture was allowed to stand at 0°C for 24 h, and then at room temperature for 24 h, Finally the reaction mixture was poured into ice-water. The mixture was extracted with ether, and the extract was washed with water, dried and evaporated to dryness under reduced pressure. The residue (97 mg) was chromatographed on silica gel to afford compound (**5**) (60 mg), colorless needles from methanol, mp 235—237°C. $[\alpha]_D^{22}$ $+89.2°$ (c=0.37). MS m/e: 522 (M^+), 449, 389 (100%), 253, 227. PMR δ: 0.85 (6H, s), 0.87 (3H, s), 0.89 (3H, s), 0.92 (3H, s), 1.02 (3H, s), 1.09 (3H, s), 1.97 (3H, s), 2.06 (3H, s), 3.95 (1H, d, J=11 Hz), 4.42 (1H, d, J=11 Hz), 4.53 (1H, dd, J=9, 8 Hz), 5.37 (1H, d, J=10 Hz), 5.70 (1H, d, J=10 Hz), 5.59 (1H, d, J=10 Hz), 6.52 (1H, dd, J=10, 3 Hz). *Anal.* Calcd for $C_{34}H_{50}O_4$: C, 78.12; H, 9.70. Found: C, 78.09; H, 9.70.

(b) Rotundiogenin C triacetate (**7b**) (40 mg) was worked up as in (a) and purified by preparative TLC to afford compound (**8**) (24 mg), colorless needles from methanol, mp 236—238°C. $[\alpha]_D^{22}$ $+42.9°$ (c=0.23). MS m/e: 580 (M^+), 520, 507, 447 (100%), 387. PMR δ: 0.82 (3H, s), 0.86 (6H, s), 0.88 (3H, s), 0.90 (3H, s), 1.00 (3H, s), 1.08 (3H, s), 1.98 (3H, s), 2.02 (3H, s), 3.99 (1H, d, J=11 Hz), 4.39 (1H, d, J=11 Hz), 4.50 (1H, dd, J=9, 7 Hz), 4.88 (1H, dd, J=12, 5 Hz), 5.35 (1H, d, J=10 Hz), 5.69 (1H, d, J=10 Hz), 5.63 (1H, d, J=11 Hz), 6.50 (1H, dd, J=11, 3 Hz). *Anal.* Calcd for $C_{36}H_{52}O_6$: C, 74.45; H, 9.02. Found: C, 74.42; H, 9.10.

Catalytic Hydrogenation of Compounds (5) and (8)——(a) A solution of compound (5) (37 mg) in AcOH (1 ml) was shaken with PtO_2 (40 mg) in an H_2 atmosphere for 5 h at room temperature. The catalyst was filtered off and the filtrate was evaporated to dryness under reduced pressure. Recrystallization of the residue from methanol afforded colorless needles (25 mg) of the tetrahydro derivative (6), olean-13(18)-en-3β,28-diacetate, mp 169—171°C. PMR δ: 0.73 (3H, s), 0.81 (3H, s), 0.84 (3H, s), 0.88 (6H, s), 0.93 (3H, s), 1.17 (3H, s), 2.05 (6H, s), 3.99 (1H, d, $J=11$ Hz), 4.21 (1H, d, $J=11$ Hz), 4.51 (1H, dd, $J=9$, 7 Hz). *Anal.* Calcd for $C_{34}H_{54}O_4$: C, 77.52; H, 10.33. Found: C, 77.66; H, 10.21.

(b) Compound (8) (15 mg) was worked up as in (a) and the residue was recrystallized from methanol to afford the tetrahydro derivative (9) (10 mg), mp 183—186°C; this product was identical with an authentic specimen (9) derived from papyriogenin A (mixed mp, thin-layer chromatogram (TLC), IR and PMR spectra).

SeO_2 Oxidation of Rotundiogenin C Tetraacetate (7a) and Rotundiogenin F Tetraacetate (14a)——(a) A mixture of **7a** (35 mg), SeO_2 (35 mg), and glacial AcOH (3 ml) was refluxed for 3 days. The filtered solution was extracted with ether, washed with water, dried and concentrated. The residue (31 mg) was chromatographed on silica gel, and elution with benzene–acetone (25: 1) gave a dienedione derivative (15) (15 mg), prisms from aqueous methanol, mp 164—166°C. IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: 1735, 1711, 1694, 1655, 1624, 1460, 1380, 1365, 1240, 1030. PMR δ: 0.92 (6H, s), 1.14 (3H, s), 1.27 (3H, s), 1.29 (3H, s), 1.39 (6H, s), 2.06 (3H, s), 2.09 (9H, s), 3.97 (2H, s), 4.51 (1H, t, $J=7$ Hz), 4.92 (1H, t, $J=8$ Hz), 5.14 (1H, t, $J=3$ Hz), 5.99 (1H, s). *Anal.* Calcd for $C_{38}H_{52}O_{10}\cdot H_2O$: C, 66.45; H, 7.92. Found: C, 66.59; H, 7.79.

(b) Rotundiogenin F tetraacetate (**14a**) (30 mg) was worked up as in (a) and the residue (29 mg) was chromatographed on silica gel. Elution with benzene–acetone (25: 1) gave a dienedione derivative (17 mg) prisms from aqueous methanol, mp 163—165°C; this product was identical with an authentic sample (**15**) derived from rotundiogenin C tetraacetate (**7a**) (mixed mp, TLC, and IR and PMR spectra).

Acknowledgement We thank Professor S. Nishibe and Mr. A. Sakushima, Higashi Nihon University, for measurement of mass spectra.

References and Notes

1) Y. Kobayashi, T. Takeda, and Y. Ogihara, *Chem. Pharm. Bull.*, **29**, 2222 (1981).
2) T. Kubota, F. Tonami, and H. Hinoh, *Tetrahedron*, **23**, 3333 (1967).
3) W.S. Allen and S. Bernsteine, *J. Am. Chem. Soc.*, **77**, 1028 (1955).
4) M. Takai, S. Amagaya, and Y. Ogihara, *J. Chem. Soc. Perkin I*, **1977**, 1801.
5) M. Asada, S. Amagaya, M. Takai, and Y. Ogihara, *J. Chem. Soc. Perkin I*, **1980**, 325.
6) T. Kubota and F. Tonami, *Tetrahedron*, **23**, 3353 (1967).
7) N.P. Kiryalov and T.N. Naugolnaya, *Zh. Obshch. Khim.*, **33**, 700 (1963).
8) N.P. Kiryalov and V.H. Bogatkina, *Khim. Prir. Soedin.*, **5**, 447 (1969).
9) A.D. Zorina, L.G. Matyukhina, I.A. Saltykova, and A.G. Shavva, *Zh. Org. Chim.*, **9**, 1673 (1973).
10) P. Pant and R.P. Rastogi, *Phytochemistry*, **17**, 575 (1978).

NII-Electronic Library Service