A Novel Conversion of C_{19}-Diterpenoid Alkaloids into Aconane-Type Diterpenes with Eight-Membered Ring System *via* Skeletal Rearrangement of Corresponding Diazonium Derivatives

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A new and efficient approach toward the conversion of C_{19}-diterpenoid alkaloids into diterpenes with [6+8+5+6] ring system is reported. Treatment of imines 5, 14, and 24 derived from the C_{19}-diterpenoid alkaloids with $NaNO_2$–NaOAc–HOAc afforded a series of novel rearrangement diterpenes 6—8, 15—19, and 25—27, respectively. The lactone 11 was obtained in 41% yield by treating 5 with $NaNO_2$–HBr–Br_2. The formation of diazonium intermediate is postulated, which was subsequently subjected to skeletal rearrangement, leading to the enlargement of B ring. All the new compounds were isolated and fully characterized.

Key words C_{19}-diterpenoid alkaloid; imine; skeletal rearrangement; aconane-type diterpene; diazonium intermediate

The C_{19}-diterpenoid alkaloids (C_{19}-DAs) are isolated mainly from both *Aconitum* and *Delphinium* plants (Ranunculaceae)[1,2] that have been widely used in traditional herbal medicine. These compounds have stimulated considerable interest because of their complex structures, pharmacological activities,[3,4] interesting chemical reactions,[5] and economic importance.[6] In the course of further investigation of the chemistry of C_{19}-DAs, we synthesized a series of their derivatives for evaluation of their biological activities.[7—13] We also previously reported novel skeletal rearrangements involving A ring or C ring of C_{19}-DAs.[14—16] No chemical studies on synthesis of diterpenes with [6+8+5+6] cyclic system from C_{19}-DAs have been reported so far. Herein we wish to report in detail their skeletal conversion *via* both denitrogenation and enlargement of B ring.

Results and Discussion

Denitrogenation and enlargement of B ring are two of the most important stages in the structural modification of C_{19}-DAs. For construction of eight-membered ring, a wide variety of strategies have been attempted. Finally, we found effective access to denitrogenation and enlargement of B ring from the imine *via* one-pot step.

In 1962, Vorbrueggen and Djerassi[17] reported that immonium salt **1** reacts with $NaNO_2$–NaOAc–HOAc to afford hemiacetal **2**. Based on that, we designed a route to denitrogenation and assembly of eight-membered ring *via* five steps. As shown in Chart 1, reaction of imine with $NaNO_2$–NaOAc–HOAc was expected to provide ketal B, which was sequently subjected to decomposition with acid and Baeyer–Villiger oxidation, followed by the lactone ring-

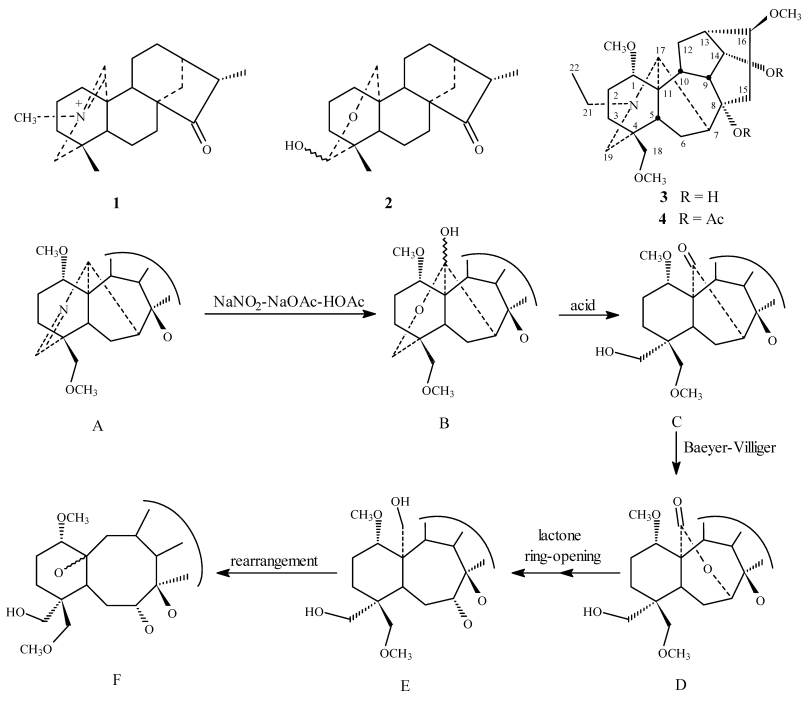

Chart 1

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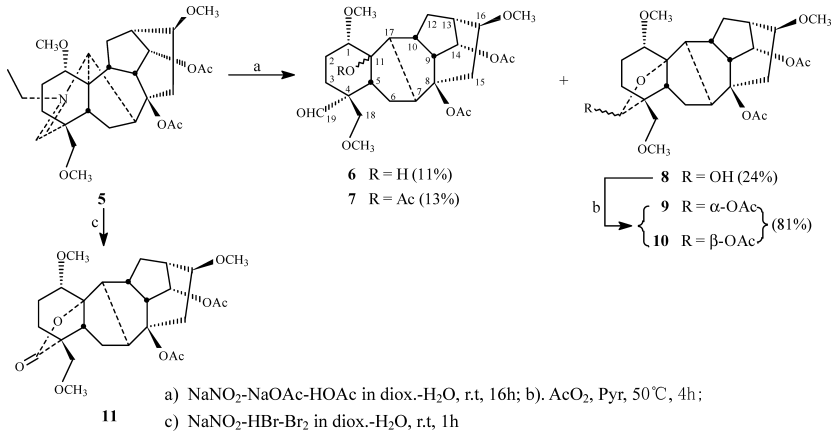


a) $NaNO_2$-NaOAc-HOAc in diox.-H_2O, r.t, 16h; b). AcO_2, Pyr, 50℃, 4h; c) $NaNO_2$-HBr-Br_2 in diox.-H_2O, r.t, 1h

Chart 2

Table 1. ^{1}H- and ^{13}C-NMR Data of Compounds **6** and **11** (400 MHz for ^{1}H, 100 MHz for ^{13}C)

No.	**6**		**11**	
	δ_C	δ_H mult (J=Hz)	δ_C	δ_H mult (J=Hz)
1	66.8 d	4.22 br s	76.8 d	3.56 dd (10.0, 6.0)
2	22.8 t	1.47 m (β)	24.6 t	1.47 m (β)
		1.94 m (α)		2.33 m (α)
3	22.8 t	2.06 m (α)	29.0 t	1.50 m (α)
		1.94 m (β)		1.73 d (3.2) (β)
4	50.9 s	—	53.1 s	—
5	43.7 d	2.39 m	49.9 d	2.18 m
6	28.1 t	1.88 m (α)	26.7 t	1.65 m (α)
		2.20 m (β)		1.83 m (β)
7	47.6 d	3.05 s	54.0 d	3.3 (hidden)
8	87.2 s	—	87.7 s	—
9	40.0 d	2.74 dd (9.6, 6.0)	56.0 d	2.61 dd (6.4, 5.2)
10	34.3 d	3.12 m	47.2 d	2.79 dd (8.4, 5.2)
11	86.3 s	—	99.2 s	—
12	35.5 t	1.88 m (β)	34.8 t	1.36 d (13.2) (β)
		1.15d (12.4) (α)		1.93 m (α)
13	48.1 d	3.26 d (2.8)	40.2 d	2.40 t (4.8)
14	76.0 d	4.80 t (4.6)	75.7 d	4.86 t (4.6)
15	38.9 t	2.85 dd (14.4, 8.0) (β)	38.6 t	2.03 d (5.6) (β)
		2.06 (hidden) (α)		2.87 dd (14.4, 8.0) (α)
16	80.4 d	3.33 (hidden)	79.8 d	3.36 t (7.6)
17	53.0 d	3.14 m	53.0 d	1.76 d (3.6)
18	76.8 t	3.22 ABq (9.2)	72.4 t	3.48 s
		3.40 ABq (9.2)		—
19	202.3 d	9.68 s	176.0 s	3.27 s
1′	55.1 q	3.27 s	55.1 q	3.33 s
16′	56.4 q	3.33 s	56.4 q	3.33 s
18′	59.4 q	3.33 s	59.4 q	—
8-OAc	170.9 s	—	170.9 s	1.99 s
	21.0 q	2.07 s	21.5 q	—
14-OAc	169.7 s	—	170.9 s	—
	21.6 q	2.01 s	21.0 q	2.07 s

opening, then a skeletal rearrangement would yield the target product F.

Acetyltalatisamine **4** was chosen as the starting material from acetylation of talatisamine **3**. Treatment of **4** with NBS[10,18,19] afforded imine **5** (25%). The NMR spectra of **5** showed absence of an *N*-ethyl group and the presence of characteristic signals at δ_H 7.20 s and δ_C 164.6 d for the imine group. Imine **5** reacted with $NaNO_2$–NaOAc–HOAc in attempt to prepare the corresponding ketal; however, the unexpected rearrangement products **6** (11%), **7** (13%), and **8** (24%) were obtained with no response to Dragendorff's reagent (Chart 2). The HR-ESI-MS of **6** and **7** exhibited the pseudomolecular ion at *m/z* 517.2400 (M^++Na) and 559.2496 (M^++Na) corresponding to the formula $C_{26}H_{38}O_9$ and $C_{28}H_{40}O_{10}$, respectively. The NMR spectra of **6** (Table 1) displayed absence of the imine group and quaternary carbon at δ_C 49.2 and presence of characteristic signals at δ_H 9.68 s and δ_C 202.3 d for a formyl group which was attributed to C-19 due to the presence of the multi-bond ^{1}H–^{13}C correlations between H-19 and C-3 in the heteronuclear multiple bonding connectivity (HMBC) spectrum (Fig. 1). In addition, a quaternary carbon at δ_C 86.3 was observed, attibuted to C-11 due to the multi-bond ^{1}H–^{13}C correlations between C-11 and H-2, H-6, and H-7 in the HMBC spectrum. Chemical shifts for many carbons attributed to A ring and B ring in the ^{13}C-NMR spectrum of **6** were changed greatly as compared with those of **5** besides distinctive upfield shift of C-1 from 82.1 to 66.8. These observations suggest that **5** was rearranged to **6**. As shown in Chart 3, we suppose that oxidation of imine **5** with HNO_2 produced diazonium intermediate G, followed by at least two possible skeletal rearrangements toward enlargement of A ring or B ring. Multi-bond ^{1}H–^{13}C correlations between C-11 and H-2, H-6, and H-7 (Fig. 1) indicated that the attack *via* path a led to enlargement of B ring. The structure of **6** was finally confirmed by its 2D NMR spectra (Table 1). The NMR spectra of **7** are very similar to those of **6**, except for an additional acetyl group. On the basis of comparison of the NMR spectra of **6** with **7**, the structure of **7** was determined. The molecular formula $C_{26}H_{38}O_9$ of **8** was inferred from its HR-MS. The NMR spectra suggested the presence of hemiacetal moiety (δ_H 5.07 d, J=2.4 Hz, δ_C 101.7 d) and a quaternary carbon at δ_C 100.6. The skeletal rearrangement

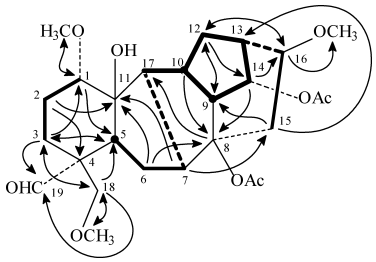


Fig. 1. Key (——) ^{1}H–^{1}H COSY and (⟶) HMBC Correlations of Compound **6**

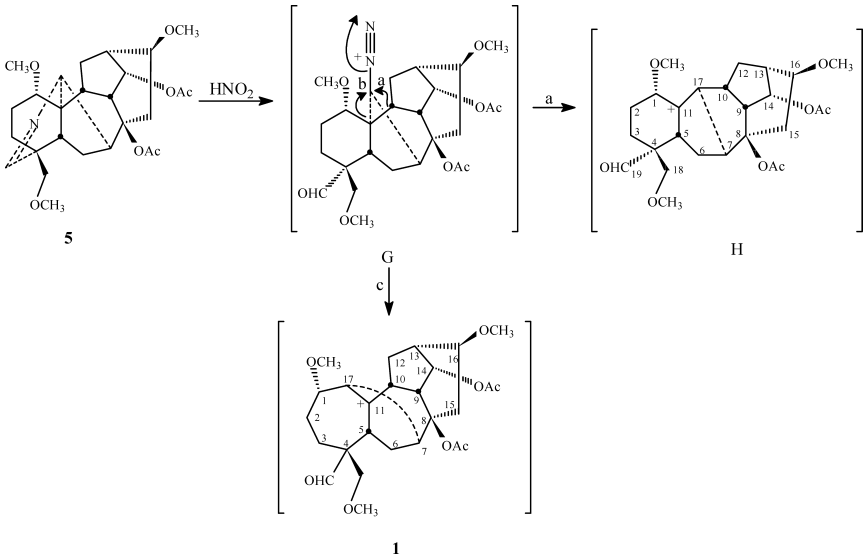


Chart 3. Plausible Mechanism for Rearrangement of Diazonium Derivatives from **5**

of diazonium intermediate produced **6**, followed by attack of 11α-OH to the aldehyde group at C-19, which presumably led to the formation of hemiacetal moiety. The structure of **8** was established by its NMR spectra. It is interesting that acetylation of **8** gave **9** and **10** in 81% yield as a pair of C-19 epimers, inseparable by repeated column chromatography. In comparison with the ^{1}H-NMR spectrum of compound **8**, that of **9** and **10** displayed an additional acetyl group and downfield shift of H-19 from 5.07 to 6.01 and 5.93 respectively. The ^{13}C-NMR spectra of **8**, **9**, and **10** are very similar except for C-11 and C-19, indicating the presence of an acetyl group at C-19. Furthermore, the spectral data of **9** are very similar to those of **10**. The δ value of C-11 of **9** was demonstrated higher by 2.9 ppm than that of **10**. Differences of chemical shifts for C-4, C-6, C-17 and C-18 were observed in the NMR data of **9** and **10**. These suggested that acetylation of compound **8** with Ac_2O probably resulted in epimerization at C-19, which could be explained by decomposition of hemiacetal moiety in acid condition and subsequent re-condensation.

To optimize the reaction condition, other acids were tried instead of HOAc in the reaction. When **5** was treated with $NaNO_2$–HBr–Br_2, compound **11**, also with no response to Dragendorff's reagent, was obtained in moderate yield 41% (Chart 2). The formula $C_{26}H_{36}O_9$ of **11** was confirmed by its HR-ESI-MS and ^{13}C-NMR. The IR and ^{13}C-NMR spectra (Table 1) of **11** exhibited characteristic signals at 1772 cm^{-1} and δ_C 176.0 s for γ-lactone. The ^{1}H–^{13}C correlations between H-17 and C-1, C-5, C-6, C-8, and C-12 as well as the correlations between C-11 and H-2, H-6, and H-7 in the HMBC spectrum (Fig. 2) revealed that **11** possesses the same molecular skeleton as that of **6**, which was consistent with the ^{1}H–^{1}H COSY correlations between H-17 and H-7, and H-10. The structure of **11** was therefore identified by its 2D NMR (Fig. 2). The formation of **11** further supported the rearrangement mechanism mentioned above.

So as to avoid complexity of the reaction resulting from the forming aldehyde group, we synthesized imine **14** containing C_6-OCH_3 from 3,13-diacetylyunaconitine **13**. The 6-OCH_3 was expected to trap the aldehyde group at

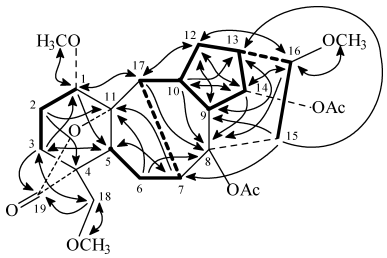


Fig. 2. Key (——) ^{1}H–^{1}H COSY and (⟶) HMBC correlations of compound **11**

C-19 to yield γ-lactone. The reaction of **14** with $NaNO_2$–NaOAc–HOAc was carried out in dioxane–H_2O, the products **15** (13%), **16** (11%), and **17** (21%) were obtained, together with a pair of C-11 epimers **18** (18%) and **19** (9%) (Chart 4). The molecular formular $C_{37}H_{46}O_{14}$ of compound **15** was inferred from its HR-MS. In the ^{1}H- and ^{13}C-NMR spectra of **15**, characteristic signals at δ_H 9.58 s and δ_C 198.9 d for an aldehyde group appeared. Besides, characteristic signals at δ_H 3.53 s and δ_C 141.2 s, 120.4 s, and 55.4 q in the NMR spectra showed that **15** contained a trisubstituted enol ether moiety. The double bond was located at C-1 and C-11, which was inferred from the δ value of C-2 (δ 28.5). In the ^{13}C-NMR spectra, the signal for C-2 of **15** shifted highfield by 5 ppm as compared with that of **14** due to the presence of double bond $\Delta^{1(11)}$. By a combination of its NMR data and the possible reaction process, the structure of **15** was identified. The molecular formula $C_{36}H_{44}O_{15}$ of compound **16** was deduced from HR-ESI-MS and ^{13}C-NMR data. Characteristic signals at δ_H 9.79 s and δ_C 200.9 d for an aldehyde group, and δ_C 205.3 for a ketone group were observed in the NMR spectra of **16**. In addition, its NMR spectra revealed the disappearance of one methoxyl group and the presence of an oxygen-substituted quarternary carbon at δ_C 113.6. Furthermore, chemical shifts of δ_C 40.5 and δ_C 113.6 for C-2 and C-11 shifted downfield greatly, compared with those in **18** or **19**, suggesting the presence of carbonyl group at C-1. The HR-ESI-MS of compound **17** displayed molecular ions (M^++Na) at *m*/*z* 755.2899 corresponding to the formula

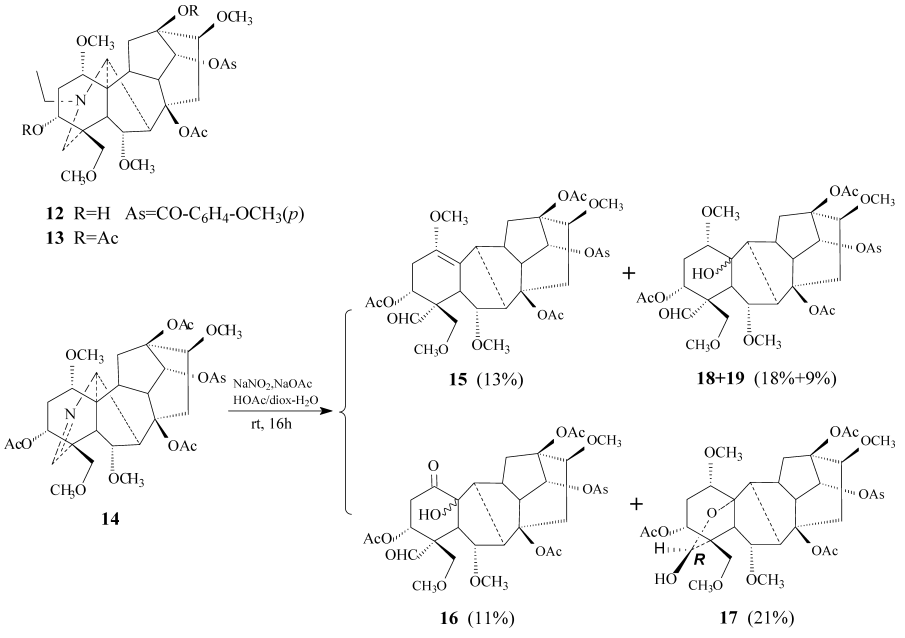
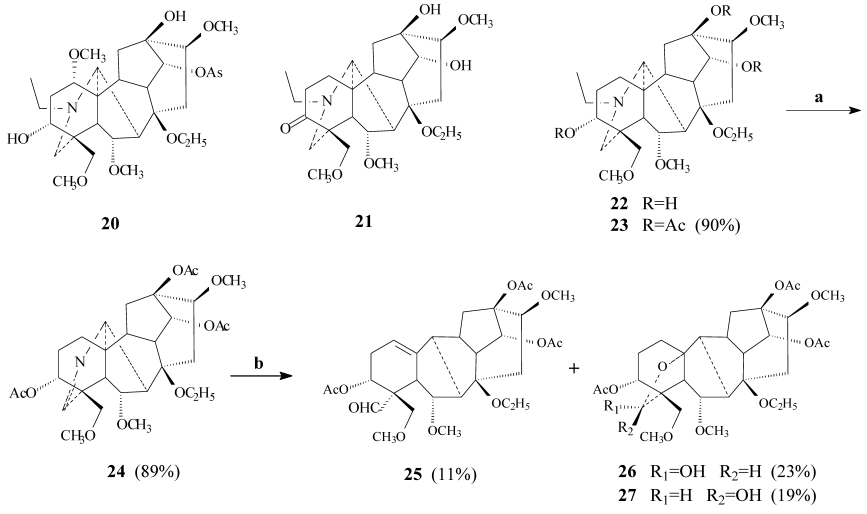


Chart 4



a) NBS/HOAc, rt, 30min; b) $NaNO_2$-NaOAc-HOAc in diox.-H_2O, rt, 4h

Chart 5

$C_{37}H_{48}O_{15}$. Its NMR spectra exhibited a hemiacetal moiety (δ_H 5.14 d, J=13.2 Hz, δ_C 98.1 d). The *R*-configuration of C-19 in **17** was confirmed by the NOEds between the OAc-3α (δ_H 2.05 or 2.08, s) and H-19 (δ_H 5.14, d, J=13.2 Hz). The ^{1}H- and ^{13}C-NMR spectra of **18** and **19** showed an aldehyde group (δ_H 10.10 s and δ_C 203.0 d for **18**, δ_H 9.60 s and δ_C 202.3 d for **19**) and an additional oxygen-substituted quaternary carbon (δ_C 86.0 s for **18**, δ_C 84.6 s for **19**). The ^{13}C-NMR spectrum of compound **18** was similar to that of **19** except for C-2, C-7, and C-11. In their ^{1}H-NMR spectra, significant differences of chemical shifts for H-3 and the aldehyde group were observed (δ_H 5.47, dd, J_1=13.0 Hz, J_2=4.8 Hz and δ_H 10.00 s for **18**; δ_H 5.34, dd, J_1=12.2 Hz, J_2=4.8 Hz and δ_H 9.60 s for **19**). These two compounds **18** and **19** were a pair of C-11 epimers as deduced on the basis of these spectral data.

The results showed that the expected γ-lactone was not easy to form from imine **14** in such condition, and the products might be complicated because of the presence of 1-OCH_3. To investigate further the effect of the A ring structure on the rearrangement, we prepared imine **24** without 1-OCH_3. Compound **24** was synthesized starting from 8-ethoxylyunnaconitine **20** *via* **21**→**23** in six steps in nearly quantitative overall yield. When the same reaction condition was applied to substrate **24**, compounds **26** (23%) and **27** (19%) were obtained as a pair of C-19 epimers, in addition to product **25** (11%) (Chart 5). Compound **25**, $C_{30}H_{42}O_{11}$ (HR-ESI-MS), was afforded as an amorphous powder. Its ^{1}H- and ^{13}C-NMR spectra showed the presence of an aldehyde group (δ_H 9.68, 1H, s; δ_C 200.4 d) and a trisubstituted double bond (δ_H 5.51, 1H, br s; δ_C 115.7 d, 144.5 s). The structure of **25** was determined by comparison with its analogue **15**. Both compounds **26** and **27** have the same molecular formula $C_{30}H_{44}O_{12}$ (HR-ESI-MS). Characteristic signals (δ_H 5.13,

1H, d, J=12.8 Hz; δ_C 98.4 d for **26** and δ_H 4.89, 1H, d, J=12.8 Hz; δ_C 99.4 d for **27**) for hemiacetal were observed in the NMR spectra of **26** and **27,** respectively. The stereochemistry of C-19 of **26** was *R*, based on the NOE relationship between the H-19 (δ_H 5.13, 1H, d) and the 3α-OAc (δ_H 2.05, s). The NOEds spectrum of **26** displayed enhancement of the signal at δ_H 2.05 for 3α-OAc when H-19 (δ_H 5.13, 1H, d, J=12.8 Hz) was irradiated. Its structure was established by spectral data and comparison with the analogs **8** and **17**. In the ^{1}H-NMR spectra of **26** and **27**, differences of δ value of H-3 and H-19 were observed. The ^{13}C-NMR spectrum of **27** is similar to that of **26** except for C-4, C-5, C-18, C-19. These data led us to deduce that the two compounds **26** and **27** are a pair of C-19 epimers.

In conclusion, different substituents on the A ring of C_{19}-DAs provide the same rearrangement combinations. This is the first novel and effective access to diterpenes with [6+8+5+6] cyclic system from C_{19}-DAs. More stable carbonium intermediate and rigid skeleton of the products are probably the main reason for enlargement of B ring toward path a, giving the more thermodynamically stable rearrangement products. This method should be convenient for us to construct similar skeletons, however, it is still necessary to study the stereochemistry of the rearrangement and promote the yield of the desired pruducts.

Experimental

General Melting points were determined on a Kofler block (uncorrected); IR spectra were recorded on a Nicolet FT-IR 200 SXV spectrometer; Optical rotations were measured in a 1.0-dm cell by a PE-314 polarimeter at 20±1 °C; ^{1}H- and ^{13}C-NMR spectra were acquired on a Varian INOVA 400/54 or a Bruker AC-E 200 spectrometer in $CDCl_3$ with TMS as internal standard; MS spectra were obtained on Finnigan LCQ and Micromass Auto Spec Ultima-Tof spectrometer; Silica gel GF_{254} and H (10—40 μm, Qingdao Sea Chemical Factory, China) were used for TLC, Chromatotron, and CC.

Compound 5 To a solution of compound **4** (2.4 g, 4.75 mmol) in HOAc (50 ml), NBS (5.07 g, 28.5 mmol) was added and the solution was stirred at room temperature for 1.5 h. After pouring into ice water (60 ml), the solution was basified with conc. NH_4OH to pH 10. Extraction ($CHCl_3$, 60 ml×3), drying (Na_2SO_4), and evaporation and column chromatography (silica gel H, petroleum ether–acetone 2 : 1) afforded the pure product **5** (white amorphous powder, 564 mg, 25%), mp 63—65 °C; $[\alpha]_D^{20}$ +18.2° (c=0.50, $CHCl_3$); IR (KBr) 2933, 1727, 1367, 1251, 1093 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.90, 2.01 (each 1H, s, 2×OAc), 3.18, 3.31, 3.31 (each 3H, s, 3×OMe), 4.81 (1H, t, J=4.6 Hz, H-14β), 7.20 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 82.1 (C-1), 23.1 (C-2), 24.2 (C-3), 48.2 (C-4), 40.8 (C-5), 26.1 (C-6), 43.9 (C-7), 84.9 (C-8), 40.5 (C-9), 38.5 (C-10), 49.2 (C-11), 28.6 (C-12), 48.0 (C-13), 75.1 (C-14), 36.9 (C-15), 82.2 (C-16), 61.1 (C-17), 75.3 (C-18), 164.6 (C-19), 56.0 (C-1′), 56.3 (C-16′), 59.3 (C-18′), 170.8, 169.1, 22.1, 21.1 (2×OAc); HR-ESI-MS m/z 476.2639 (M^++H), Calcd for $C_{26}H_{37}NO_7$H, 476.2643.

Compounds 6—8 Acetic acid (0.38 ml) was added dropwise to a solution of compound **5** (262 mg, 0.57 mmol), $NaNO_2$ (904 mg, 13.10 mmol), and NaOAc (444 mg, 5.40 mmol) in dioxane–H_2O (2 : 1, 12 ml). The mixture was stirred at room temperature for 16 h. The reaction was quenched with saturated Na_2SO_3 aqueous solution (5 ml), the solvent was extract with ethyl acetate (12 ml×3), the combined organic extract was dried ($NaSO_4$), and the solvent was removed under reduced pressure. Chromatography of the residue (235 mg) on silica gel (6 g) using cyclohexane–acetone (8 : 1) as eluent afforded compounds **6** (white amorphous powder, 32 mg, 11%), **7** (colorless crystalline needle, 40 mg, 13%), and **8** (white amorphous powder, 68 mg, 24%).

Compound **6**: mp 156—157 °C; $[\alpha]_D^{20}$ −12.3° (c=0.26, $CHCl_3$); IR (KBr) 3455, 2948, 1730, 1369, 1251, 1101 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$) and ^{13}C-NMR (100 MHz, $CDCl_3$): see Table 1; ESI-MS m/z (%) 517 (M^++Na, 21); HR-ESI-MS m/z 517.2400 (M^++Na), Calcd for $C_{26}H_{38}O_9$Na, 517.2408.

Compound **7**: mp 96—97 °C; $[\alpha]_D^{20}$ −6.0° (c=0.25, $CHCl_3$); IR (KBr) 2951, 1734, 1460, 1368, 1247, 1095 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) 1.99, 2.04, 2.06 (each 1H, s, 3×OAc), 3.09, 3.26, 3.29 (each 3H, s, 3×OMe), 4.81 (1H, t, J=4.8 Hz, H-14β), 9.66 (1H, s, H-19). ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 67.8 (C-1), 22.5 (C-2), 23.7 (C-3), 50.5 (C-4), 44.7 (C-5), 24.5 (C-6), 47.5 (C-7), 86.7 (C-8), 40.1 (C-9), 34.9 (C-10), 84.9 (C-11), 35.2 (C-12), 48.4 (C-13), 75.7 (C-14), 38.8 (C-15), 80.0 (C-16), 52.7 (C-17), 76.6 (C-18), 201.8 (C-19), 54.4 (C-1′), 56.4 (C-16′), 59.4 (C-18′), 170.9, 169.7, 169.5, 21.5, 21.3, 21.0 (3×OAc); ESI-MS m/z (%): 559 (M^++Na, 100), HR-ESI-MS m/z: 559.2496 (M^++Na), Calcd for $C_{28}H_{40}O_{10}$Na, 559.2514.

Compound **8**: mp 102—103 °C; $[\alpha]_D^{20}$ +12.5° (c=0.28, $CHCl_3$); IR (KBr) 3447, 2947, 1736, 1370, 1252, 1099 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.94, 2.04 (each 1H, s, 2×OAc), 3.26, 3.28, 3.30 (each 3H, s, 3×OMe), 4.82 (1H, t, J=4.6 Hz, H-14β), 5.07 (1H, d, J=2.4 Hz, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 79.4 (78.8) (C-1), 24.7 (25.0) (C-2), 26.7 (26.0) (C-3), 51.9 (51.3) (C-4), 47.2 (47.1) (C-5), 30.6 (28.2) (C-6), 54.4 (54.4) (C-7), 87.9 (88.0) (C-8), 57.3 (57.5) (C-9), 40.4 (40.3) (C-10), 100.6 (100.6) (C-11), 34.8 (34.8) (C-12), 35.6 (35.0) (C-13), 76.0 (76.0) (C-14), 38.7 (38.7) (C-15), 80.0 (80.0) (C-16), 50.2 (50.3) (C-17), 73.4 (74.4) (C-18), 101.7 (101.3) (C-19), 56.1 (55.9) (C-1′), 56.4 (56.4) (C-16′), 59.3 (59.3) (C-18′), 170.8 (170.8), 169.4 (169.4), 21.5 (21.6), 21.0 (21.0) (2×OAc); ESI-MS m/z (%): 517 (M^++Na, 100), HR-ESI-MS m/z: 517.2399 (M^++Na), Calcd for $C_{26}H_{38}O_9$Na, 517.2408.

Compounds 9 and 10 To a mixed solution of acetic anhydride (0.3 ml, 3.18 mmol) and pyridine (3 ml), compound **8** (50 mg, 0.10 mmol) was added and the solution was kept at 50 °C for 4 h. Evaporation of the reaction solution *in vacuo* gave a residue that was chromatographed on silica gel (1 g) column eluting with cyclohexane–acetone (7 : 1) to give compounds **9** and **10** as a mixture (white amorphous powder, 44 mg, 81%). Compounds **9** and **10**, $[\alpha]_D^{20}$ +14.2° (c=0.62, $CHCl_3$); IR (KBr) 3503, 1735, 1247, 1104 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.99, 2.06, 2.06, 2.07, 2.07, 2.07 (each 3H, s, 6×OAc), 3.31, 3.30, 3.30, 3.30, 3.28, 3.28 (each 3H, s, 6×OMe), 4.84 (2H, t, J=4.8 Hz, 2×H-14β), 6.01 (1H, s, H-19), 5.93 (1H, s, H-19); for compound **9**, ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 78.9 (C-1), 24.7 (C-2), 26.5 (C-3), 52.0 (C-4), 47.1 (C-5), 30.5 (C-6), 54.4 (C-7), 87.8 (C-8), 57.3 (C-9), 40.5 (C-10), 102.0 (C-11), 34.8 (C-12), 35.3 (C-13), 75.9 (C-14), 38.6 (C-15), 79.9 (C-16), 51.2 (C-17), 73.7 (C-18), 99.7 (C-19), 56.0 (C-1′), 56.4 (C-16′), 59.3 (C-18′), 170.6, 169.7, 169.3, 21.5, 21.0, 20.9 (3×OAc); for compound **10**, ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 78.5 (C-1), 24.6 (C-2), 25.9 (C-3), 50.3 (C-4), 47.1 (C-5), 29.0 (C-6), 54.2 (C-7), 87.7 (C-8), 57.0 (C-9), 40.4 (C-10), 99.1 (C-11), 34.8 (C-12), 35.0 (C-13), 75.9 (C-14), 38.5 (C-15), 79.8 (C-16), 50.0 (C-17), 72.5 (C-18), 99.6 (C-19), 56.0 (C-1′), 56.4 (C-16′), 59.3 (C-18′), 170.6, 169.7, 169.3, 21.5, 21.0, 20.9 (3×OAc); HR-ESI-MS m/z: 559.2497 (M^++Na), Calcd for $C_{28}H_{40}O_{10}$Na, 559.2514.

Compound 11 Forty percent HBr (0.15 ml) and Br_2 (0.01 ml) was added dropwise to a solution of compound **5** (100 mg, 0.22 mmol) and $NaNO_2$ (345 mg, 5.01 mmol) in dioxane–H_2O (2 : 1, 6 ml). The mixture was stirred at room temperature for 1 h. The reaction was quenched with saturated Na_2SO_3 aqueous solution (3 ml); the solvent was extracted with ethyl acetate (6 ml×3), the combined organic extract was dried ($NaSO_4$), and the solvent was removed under reduced pressure. Chromatography of the residue (94 mg) on silica gel (3 g) using cyclohexane–acetone (6 : 1) as eluent afforded compound **11** (white amorphous powder, 44 mg, 41%). Compound **11**, mp 107—108 °C; $[\alpha]_D^{20}$ +40.3° (c=0.30, $CHCl_3$); IR (KBr) 2946, 1772, 1734, 1458, 1368, 1247, 1102 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$) and ^{13}C-NMR (100 MHz, $CDCl_3$): see Table 2; ESI-MS m/z (%): 515 (M^++Na, 100); HR-ESI-MS m/z: 515.2229 (M^++Na), Calcd for $C_{26}H_{36}O_9$Na, 515.2252.

Compound 14 To a solution of compound **13** (220 mg, 0.30 mmol) in HOAc (7 ml), NBS (422 mg, 2.37 mmol) was added and the solution was stirred at room temperature for 1.5 h. After pouring into ice water (9 ml), the solution was basified with conc. NH_4OH to pH 10. Extraction ($CHCl_3$, 12 ml×3), drying (Na_2SO_4), and evaporation afforded the pure product **14** (white amorphous powder, 210 mg, 100%). The structure of **14** was identified by comparison of ^{1}H-NMR and TLC (cyclohexane–acetone/1 : 1; $CHCl_3$–CH_3OH/9 : 1) with an authentic sample.

Compounds 15—19 Acetic acid (0.37 ml) was added dropwise to a solution of compound **14** (400 mg, 0.56 mmol), $NaNO_2$ (888 mg, 12.88 mmol) and NaOAc (436 mg, 5.32 mmol) in dioxane–H_2O (2 : 1, 21 ml). The mixture was stirred at room temperature for 16 h. The reaction was quenched with saturated Na_2SO_3 aqueous solution (5 ml), the solvent was extracted with ethyl acetate (15 ml×3), the combined organic extract was dried ($NaSO_4$), and the solvent was removed under reduced pressure. Chromatography of the residue (378 mg) on silica gel (11 g) using cyclohexane–acetone (7 : 1) as eluent afforded compounds **15** (white amorphous powder, 52 mg, 13%), **16** (white amorphous powder, 44 mg, 11%), **17** (colorless crystalline needle,

86 mg, 21%), **18** (colorless crystalline needle, 74 mg, 18%), and **19** (white amorphous powder, 36 mg, 9%).

Compound **15**: mp 116—118 °C; $[\alpha]_D^{20}$ +57.2° (c=0.29, $CHCl_3$); IR (KBr) 2943, 1730, 1659, 1371, 1250, 1100 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.64 (3H, s, 8-OAc), 2.02 (6H, s, 2×OAc), 3.07, 3.19, 3.36, 3.53, 3.84 (each 3H, s, 5×OMe), 5.27 (1H, dd, J_1=9.4 Hz, J_2=5.2 Hz, H-3β), 5.29 (1H, d, J=5.2 Hz, H-14β), 3.97 (1H, t, J=4.8 Hz, H-6β), 6.90, 8.00 (each 2H, AA′BB′, J=8.8 Hz, Ar-H), 9.58 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 141.2 (C-1), 28.5 (C-2), 70.8 (C-3), 51.4 (C-4), 50.1 (C-5), 78.9 (C-6), 51.7 (C-7), 89.0 (C-8), 47.6 (C-9), 39.3 (C-10), 120.4 (C-11), 40.5 (C-12), 82.4 (C-13), 77.4 (C-14), 41.4 (C-15), 84.4 (C-16), 59.7 (C-17), 69.4 (C-18), 198.9 (C-19), 55.4 (C-1′), 56.4 (C-6′), 58.2 (C-16′), 59.3 (C-18′), 165.7 (COAr), 122.3 (C-1″), 131.8 (C-2″, C-6″), 113.6 (C-3″, C-5″), 163.4 (C-4″), 55.3 (4″-OCH_3), 170.6, 170.2, 169.9, 21.2, 21.1, 20.7 (3×OAc); ESI-MS m/z (%): 737 (M^++Na, 100); HR-ESI-MS m/z: 737.7453 (M^++Na), Calcd for $C_{37}H_{46}O_{14}Na$ 737.7464.

Compound **16**: mp 156—157 °C; $[\alpha]_D^{20}$ +58.3° (c=0.30, $CHCl_3$); IR (KBr) 3454, 2934, 1736, 1606, 1370, 1254, 1102 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.50 (3H, s, 8-OAc), 2.05, 2.11 (each 3H, s, 2×OAc), 2.86, 3.35, 3.35, 3.84 (each 3H, s, 4×OMe), 3.95 (1H, t, J=6.8 Hz, H-6β), 5.17 (1H, d, J=5.4 Hz, H-14β), 5.59 (1H, dd, J_1=9.4 Hz, J_2=5.2 Hz, H-3β), 6.91, 8.02 (each 2H, AA′BB′, J=8.8 Hz, Ar-H), 9.79 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 205.3 (C-1), 40.5 (C-2), 67.0 (C-3), 51.3 (C-4), 49.7 (C-5), 78.3 (C-6), 50.6 (C-7), 88.1 (C-8), 48.0 (C-9), 38.5 (C-10), 113.6 (C-11), 40.6 (C-12), 81.8 (C-13), 77.2 (C-14), 41.0 (C-15), 82.4 (C-16), 59.1 (C-17), 79.3 (C-18), 200.9 (C-19), 55.4 (C-6′), 58.4 (C-16′), 59.5 (C-18′), 165.9 (COAr), 122.2 (C-1″), 131.9 (C-2″, C-6″), 113.7 (C-3″, C-5″), 163.5 (C-4″), 55.2 (4″-OCH_3), 170.4, 169.6, 169.6, 21.2, 21.0, 20.7 (3×OAc); ESI-MS m/z (%): 735 (M^++Na, 100); HR-ESI-MS m/z: 735.7194 (M^++Na), Calcd for $C_{36}H_{44}O_{15}Na$ 735.7186.

Compound **17**: mp 161—162 °C; $[\alpha]_D^{20}$ +37.1° (c=0.28, $CHCl_3$); IR (KBr) 3409, 2940, 1736, 1606, 1371, 1254, 1099 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.47 (3H, s, 8-OAc), 2.05, 2.08 (each 3H, s, 2×OAc), 3.24, 3.25, 3.29, 3.37, 3.87 (each 3H, s, 5×OMe), 5.11 (1H, d, J=4.8 Hz, H-14β), 3.97 (1H, t, J=4.8 Hz, H-6β), 4.88 (1H, dd, J_1=11.2 Hz, J_2=8.0 Hz, H-3β), 5.47 (1H, d, J=13.2 Hz, 19-OH), 5.14 (1H, d, J=13.2 Hz, H-19), 6.94, 8.05 (each 2H, AA′BB′, J=8.8 Hz, Ar-H); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 76.2 (C-1), 30.0 (C-2), 70.1 (C-3), 57.7 (C-4), 49.5 (C-5), 78.1 (C-6), 53.2 (C-7), 86.2 (C-8), 46.1 (C-9), 31.6 (C-10), 96.0 (C-11), 39.0 (C-12), 81.7 (C-13), 77.1 (C-14), 40.6 (C-15), 85.5 (C-16), 63.7 (C-17), 66.6 (C-18), 98.1 (C-19), 56.1 (C-1′), 58.3 (C-6′), 58.8 (C-16′), 59.2 (C-18′), 165.7 (COAr), 122.1 (C-1″), 131.7 (C-2″, C-6″), 113.6 (C-3″, C-5″), 163.4 (C-4″), 55.3 (4″-OCH_3), 170.3, 169.7, 169.0, 21.1, 21.1, 20.7 (3×OAc); NOEds: irradiation of the H-19 (δ_H 5.14, d) led to the enhancement of signal at δ_H 2.05 and 2.08 (each s, OAc-3α or OAc-13). ESI-MS m/z (%): 755 (M^++Na, 100); HR-ESI-MS m/z: 755.2885 (M^++Na), Calcd for $C_{37}H_{48}O_{15}$, 755.2899.

Compound **18**: mp 168—169 °C; $[\alpha]_D^{20}$ +49.7° (c=0.60, $CHCl_3$); IR (KBr) 3445, 1719, 1256 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.44 (3H, s, 8-OAc), 2.02, 2.14 (each 3H, s, 3×OAc), 2.95, 3.23, 3.33, 3.36, 3.83 (each 3H, s, 5×OMe), 3.98 (1H, t, J=6.8 Hz, H-6β), 5.11 (1H, d, J=5.4 Hz, H-14β), 5.47 (1H, dd, J_1=13.0 Hz, J_2=4.8 Hz, H-3β), 6.90, 8.02 (each 2H, AA′BB′, J=8.6 Hz, Ar-H), 10.00 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 68.6 (C-1), 33.5 (C-2), 66.7 (C-3), 55.5 (C-4), 46.9 (C-5), 78.5 (C-6), 48.7 (C-7), 85.8 (C-8), 46.8 (C-9), 30.4 (C-10), 86.0 (C-11), 39.9 (C-12), 82.2 (C-13), 77.3 (C-14), 41.0 (C-15), 81.3 (C-16), 64.8 (C-17), 69.3 (C-18), 203.0 (C-19), 55.3 (C-1′), 58.2 (C-6′), 58.7 (C-16′), 59.6 (C-18′), 165.8 (COAr), 122.4 (C-1″), 131.8 (C-2″, C-6″), 113.6 (C-3″, C-5″), 163.4 (C-4″), 53.4 (4″-OCH_3), 170.8, 170.5, 169.9, 21.3, 21.2, 20.9 (3×OAc); ESI-MS m/z (%): 755 (M^++Na, 100); HR-ESI-MS m/z: 755.2862 (M^++Na), Calcd for $C_{37}H_{48}O_{15}Na$, 755.2885.

Compound **19**: mp 146—148 °C; $[\alpha]_D^{20}$ +38.3° (c=0.40, $CHCl_3$); IR (KBr) 1739, 1249 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.44 (3H, s, 8-OAc), 2.04, 2.13 (each 3H, s, 3×OAc), 2.96, 3.30, 3.34, 3.36, 3.85 (each 3H, s, 5×OMe), 5.11 (1H, d, J=5.6 Hz, H-14β), 3.95 (1H, t, J=7.4 Hz, H-6β), 5.34 (1H, dd, J_1=12.2 Hz, J_2=4.8 Hz, H-3β), 6.92, 8.03 (each 2H, AA′BB′, J=8.6 Hz, Ar-H), 9.60 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 68.0 (C-1), 30.2 (C-2), 67.5 (C-3), 55.1 (C-4), 47.7 (C-5), 78.0 (C-6), 52.9 (C-7), 85.4 (C-8), 46.8 (C-9), 30.8 (C-10), 84.6 (C-11), 39.5 (C-12), 81.6 (C-13), 77.0 (C-14), 41.1 (C-15), 80.7 (C-16), 64.6 (C-17), 69.0 (C-18), 202.3 (C-19), 55.3 (C-1′), 58.2 (C-6′), 58.7 (C-16′), 59.5 (C-18′), 165.9 (COAr), 122.0 (C-1″), 131.8 (C-2″, C-6″), 113.7 (C-3″, C-5″), 163.5 (C-4″), 55.3 (4″-OCH_3), 170.5, 169.7, 169.9, 21.2, 21.2, 20.7 (3×OAc); ESI-MS m/z (%): 755 (M^++Na, 100); HR-ESI-MS m/z: 755.2897 (M^++Na), Calcd for $C_{37}H_{48}O_{15}Na$, 755.2885.

Compounds 21—24 To a solution of 8-ethoxylyunnaconitine **20** (1.52 g, 2.35 mmol) in acetone (10 ml), Jone's reagent (3 ml, 8.22 mmol) was added dropwise under ice-water bath and the solution was stirred at room temperature for 30 min. Diluting (H_2O, 30 ml), basifying (conc. NH_4OH, pH 11), extraction ($CHCl_3$, 15 ml×4), drying (Na_2SO_4), and evaporation afforded white amorphous powder, which was dissolved in 5% methanolic NaOH (15 ml) and heated at 50 °C for 30 min. Removal of solvent, diluting (H_2O, 30 ml), extraction ($CHCl_3$, 15 ml×3), drying (Na_2SO_4) and evaporation afforded white amorphous powder (1.12 g, 100%). This residue (1.12 g, 2.35 mmol) was dissolved in 95% EtOH (40 ml), 10% Pd–C (90 mg) was added and the solution was stirred under hydrogen steam at room temperature for 1 h. Filtration was evaporated under reduced pressure to give the pure product **21** (white amorphous powder, 1.12 mg, 100%). To a solution of compound **21** (1.12 g, 2.35 mmol) in MeOH (30 ml), $NaBH_4$ (500 mg, 13.15 mmol) was added and the solution was stirred at room temperature for 3 h. Removal of solvent, diluting (H_2O, 50 ml), extraction ($CHCl_3$, 15 ml×3), drying (Na_2SO_4), and evaporation afforded the pure product **22** (white amorphous powder, 1.02 g, 90%). To a solution of compound **22** (1.02 g, 2.12 mmol) in Ac_2O (15 ml), *p*-TsOH (400 mg) was added and the solution was stirred at room temperature for 12 h. Diluting (ice water), basifying (conc. NH_4OH, pH 10), extraction ($CHCl_3$, 40 ml×3), drying (Na_2SO_4) and evaporation afforded the pure product **23** (white amorphous powder, 1.16 g, 90%). Compounds **21**, **22**, and **23** were identified by comparison with authentic sample (TLC: silica gel GF 254, cyclohexane–acetone/3 : 1; $CHCl_3$–CH_3OH/95 : 5). To a solution of compound **23** (2.11 g, 3.48 mmol) in HOAc (50 ml), NBS (3.71 g, 20.8 mmol) was added and the solution was stirred at room temperature for 30 min. After pouring into ice water (50 ml), the solution was basified with conc. NH_4OH to pH 10. Extraction ($CHCl_3$, 80 ml×3), drying (Na_2SO_4), and evaporation and column chromatography (silica gel H, petroleum ether–acetone 4 : 1) afforded the pure product **24** (white amorphous powder, 1.78 g, 89%).

Compound **24**: mp 97—99 °C; $[\alpha]_D^{20}$ +35.9° (c=0.29, $CHCl_3$); IR (KBr) 2939, 1737, 1714, 1369, 1239, 1106 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.10 (3H, t, J=6.8 Hz, $OCH_2\underline{CH_3}$), 2.05, 2.06, 2.08 (each 3H, s, 3×OAc), 3.28, 3.29, 3.33 (each 3H, s, 3×OMe), 3.87 (1H, t, J=8.0 Hz, H-16α), 4.02 (1H, d, J=4.2 Hz, H-6β), 4.83 (1H, d, J=5.0 Hz, H-14β), 5.00 (1H, dd, J_1=10.4 Hz, J_2=4.8 Hz, H-3β), 7.42 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 26.3 (C-1), 28.5 (C-2), 73.3 (C-3), 46.0 (C-4), 42.4 (C-5), 77.4 (C-6), 58.0 (C-7), 76.8 (C-8), 45.0 (C-9), 41.7 (C-10), 50.4 (C-11), 36.4 (C-12), 81.4 (C-13), 79.9 (C-14), 37.3 (C-15), 83.9 (C-16), 62.8 (C-17), 70.1 (C-18), 164.5 (C-19), 58.1 (C-6′), 58.8 (C-16′), 59.0 (C-18′), 170.9, 170.5, 169.9, 21.2, 21.0, 20.9 (3×OAc), 56.1 ($O\underline{CH_2}CH_3$), 15.9 ($OCH_2\underline{CH_3}$); ESI-MS m/z (%): 600 (M^++1, 100); HR-ESI-MS m/z: 600.2767 (M^++Na), Calcd for $C_{30}H_{43}O_{10}NNa$, 600.2779.

Compounds 25—27 Acetic acid (1.43 ml) was added dropwise to a solution of compound **24** (1.25 g, 2.16 mmol), $NaNO_2$ (3.42 g, 49.7 mmol), and NaOAc (1.68 g, 20.52 mmol) in dioxane–H_2O (2 : 1, 45 ml). The mixture was stirred at room temperature for 4 h. The reaction was quenched with saturated Na_2SO_3 aqueous solution (10 ml), the solvent was extract with ethyl acetate (50 ml×3), the combined organic extract was dried ($NaSO_4$), and the solvent was removed under reduced pressure. Chromatography of the residue (1.65 g) on silica gel (30 g) using petroleum ether–acetone (6 : 1) as eluent afforded compounds **25** (white amorphous powder, 137 mg, 11%), **26** (white amorphous powder, 296 mg, 23%), and **27** (white amorphous powder, 244 mg, 19%).

Compound **25**: mp 103—105 °C; $[\alpha]_D^{20}$ +90.0° (c=0.27, $CHCl_3$); IR (KBr) 2932, 1740, 1369, 1243, 1099 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.09 (3H, t, J=6.8 Hz, $OCH_2\underline{CH_3}$), 2.02, 2.04, 2.09 (each 3H, s, 3×OAc), 3.12, 3.27, 3.32 (each 3H, s, 3×OMe), 3.84 (1H, t, J=8.6 Hz, H-16α), 3.93 (1H, d, J=3.8 Hz, H-6β), 5.15 (1H, d, J=4.2 Hz, H-14β), 5.31 (1H, dd, J_1=9.6 Hz, J_2=6.4 Hz, H-3β), 5.51 (1H, br s, H-1), 9.68 (1H, s, H-19); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 115.7 (C-1), 29.6 (C-2), 70.7 (C-3), 51.5 (C-4), 49.2 (C-5), 77.5 (C-6), 60.0 (C-7), 82.3 (C-8), 50.1 (C-9), 42.2 (C-10), 144.5 (C-11), 35.8 (C-12), 83.6 (C-13), 78.9 (C-14), 40.8 (C-15), 83.4 (C-16), 52.7 (C-17), 69.1 (C-18), 200.4 (C-19), 56.2 (C-6′), 57.9 (C-16′), 59.1 (C-18′), 170.5, 170.2, 170.0, 21.3, 21.0, 20.8 (3×OAc), 57.7 ($O\underline{CH_2}CH_3$), 15.9 ($OCH_2\underline{CH_3}$); ESI-MS m/z (%): 601 (M^++Na, 100), HR-ESI-MS m/z: 601.2649 (M^++Na), Calcd for $C_{30}H_{42}O_{11}Na$, 601.2619.

Compound **26**: mp 112—114 °C; $[\alpha]_D^{20}$ +19.3° (c=0.29, $CHCl_3$); IR (KBr) 3386, 2933, 1739, 1369, 1242, 1097 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.13 (3H, t, J=6.6 Hz, $OCH_2\underline{CH_3}$), 2.04, 2.04, 2.09 (each 3H, s, 3×OAc), 3.26, 3.31, 3.49 (each 3H, s, 3×OMe), 3.84 (1H, t, J=7.8 Hz, H-6β), 4.08 (1H, dd, J_1=7.4 Hz, J_2=3.4 Hz, H-16α), 4.90 (1H, dd, J_1=10.0 Hz, J_2=6.2 Hz, H-3β), 4.96 (1H, d, J=5.2 Hz, H-14β), 5.13 (1H, d,

J=12.8 Hz, exchangeable into singlet in D_2O, H-19), 5.72 (1H, d, J=12.8 Hz, exchangeable in D_2O, OH); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 24.7 (C-1), 29.3 (C-2), 72.0 (C-3), 57.3 (C-4), 54.5 (C-5), 77.6 (C-6), 56.3 (C-7), 81.6 (C-8), 47.7 (C-9), 34.4 (C-10), 93.8 (C-11), 37.4 (C-12), 83.1 (C-13), 78.6 (C-14), 40.3 (C-15), 84.7 (C-16), 64.1 (C-17), 67.6 (C-18), 98.4 (C-19), 58.1 (C-6′), 58.3 (C-16′), 59.1 (C-18′), 170.5, 170.5, 169.9, 21.2, 21.2, 20.9 (3×OAc), 58.2 ($O\underline{CH_2}CH_3$), 15.9 ($OCH_2\underline{CH_3}$); ESI-MS m/z (%): 619 (M^++Na, 100), HR-ESI-MS m/z: 619.2703 (M^++Na), Calcd for $C_{30}H_{44}O_{12}Na$, 619.2725.

Compound **27**: mp 104—106 °C; $[\alpha]_D^{20}$ +18.3° (c=0.18, $CHCl_3$); IR (KBr) 3330, 2931, 1734, 1371, 1244, 1097 cm^{-1}; ^{1}H-NMR (200 MHz, $CDCl_3$) δ: 1.14 (3H, t, J=7.0 Hz, $OCH_2\underline{CH_3}$), 2.05, 2.07, 2.10 (each 3H, s, 3×OAc), 3.24, 3.32, 3.40 (each 3H, s, 3×OMe), 3.86 (1H, t, J=7.8 Hz, H-6β), 4.01 (1H, dd, J_1=7.4 Hz, J_2=3.0 Hz, H-16α), 4.89 (1H, d, J=12.8 Hz, exchangeable into singlet in D_2O, H-19), 4.99 (1H, d, J=4.8 Hz, H-14β), 5.34 (1H, dd, J_1=10.0 Hz, J_2=6.2 Hz, H-3β), 5.84 (1H, d, J=12.8 Hz, exchangeable in D_2O, OH); ^{13}C-NMR (50 MHz, $CDCl_3$) δ: 25.1 (C-1), 28.5 (C-2), 71.4 (C-3), 58.5 (C-4), 51.5 (C-5), 77.7 (C-6), 56.9 (C-7), 81.7 (C-8), 48.1 (C-9), 34.5 (C-10), 93.9 (C-11), 37.1 (C-12), 83.2 (C-13), 78.7 (C-14), 40.4 (C-15), 84.8 (C-16), 63.9 (C-17), 69.8 (C-18), 99.4 (C-19), 58.2 (C-6′), 58.3 (C-16′), 59.2 (C-18′), 170.6, 170.5, 169.9, 21.3, 21.2, 21.1 (3×OAc), 58.0 ($O\underline{CH_2}CH_3$), 16.0 ($OCH_2\underline{CH_3}$); ESI-MS m/z (%): 619 (M^++Na, 100), HR-ESI-MS m/z: 619.2710 (M^++Na), Calcd for $C_{30}H_{44}O_{12}Na$, 619.2725.

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