ent-Pimarane Diterpenoids from *Siegesbeckia orientalis* and Structure Revision of a Related Compound

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Six new *ent*-pimarane diterpenoids, namely, *ent*-14β,16-epoxy-8-pimarene-3β,15α-diol (**1**), 7β-hydroxydarutigenol (**2**), 9β-hydroxydarutigenol (**3**), 16-*O*-acetyldarutigenol (**4**), 15,16-di-*O*-acetyldarutoside (**5**), and 16-*O*-acetyldarutoside (**6**), were isolated from the ethanol extract of *Siegesbeckia orientalis*. Their structures were elucidated on the basis of spectroscopic studies, and the absolute configuration of **1** was established by the modified Mosher's method. Furthermore, the structure of *ent*-12β,16-epoxy-8-pimarene-2α,15β,19-triol, recently isolated from the same plant, should be revised as *ent*-14β,16-epoxy-8-pimarene-2α,15α,19-triol (**10**).

Plants of the genus *Siegesbeckia* (Compositae) are annual herbs widely distributed in tropical, subtropical, and temperate parts of the world. Three species of this genus grow in China, and the aerial parts have been used as a traditional Chinese medicine, "Xi-Xian", to treat rheumatic arthritis, hypertension, malaria, and snakebite.[1] Extracts and some chemical constituents of *Siegebeckia* exhibit antioxidative,[2] antiallergic,[3] and antifertility[4] activities. Previous studies show the genus is a rich source of *ent*-pimarane diterpenoids.[5−15]

As part of our effort to assemble a natural compound library possessing thousands of structures originating from plants and micro-organisms,[16] further chemical investigation on *Siegebeckia orientalis* led to the isolation of six new *ent*-pimarane diterpenoids, *ent*-14β,16-epoxy-8-pimarene-3β,15α-diol (**1**), 7β-hydroxydarutigenol (**2**), 9β-hydroxydarutigenol (**3**), 16-*O*-acetyldarutigenol (**4**), 15,16-di-*O*-acetyldarutoside (**5**), and 16-*O*-acetyldarutoside (**6**), as well as three known *ent*-pimarenes, darutigenol (**7**),[7] darutoside (**8**),[7] and kirenol (**9**).[6] This paper describes the isolation and structural elucidation of these new compounds and structure revision of a recently published *ent*-pimarene.

Results and Disscussion

Compound **1**, obtained as an amorphous powder, has a molecular formula of $C_{20}H_{32}O_3$ on the basis of the positive HRESIMS, showing a quasi-molecular ion peak at *m*/*z* 343.2243 (calcd for $C_{20}H_{32}O_3Na$, 343.2249). The IR spectrum revealed absorption bands of hydroxy (3423 cm^{-1}) and double-bond (1630 cm^{-1}) groups. The ^{1}H NMR spectrum (Table 1) showed three oxygenated methine protons at δ_H 3.85 (1H, dd, J = 5.0, 2.3 Hz), 3.57 (1H, s), and 3.23 (1H, dd, J = 11.5, 4.6 Hz), two AB double doublets assignable to the protons of an oxygenated methylene at δ_H 4.24 (1H, dd, J = 10.1, 5.0 Hz) and 3.63 (1H, dd, J = 10.1, 2.3 Hz), and four quaternary methyl signals at δ_H 1.01, 0.99, 0.95, and 0.81 (each 3H, s). The ^{13}C NMR (DEPT) spectrum (Table 3) exhibited 20 carbon signals, including the carbons of a tetrasubstituted double bond at δ_C 141.2 (s) and 124.5 (s), four oxygen-bearing carbons at δ_C 82.5 (d), 80.1 (d), 78.8 (d), and 73.8 (t), and four methyl signals at δ_C 28.0, 19.3, 15.5, and 14.2 (each q). Considering the degree of unsaturation and its biological source, this compound should be an *ent*-pimarene diterpenoid containing an epoxy group.[14] The HMBC correlations (Figure 1) from the proton at δ_H 3.57 (1H, s, H-14) to the carbons at δ_C 30.7 (t, C-7), 124.5 (s, C-8), 141.2 (s, C-9), 29.2 (t, C-12), and 14.2 (q, C-17) and from the protons at δ_H 4.24 and 3.63 (each 1H, H-16) to the carbon at δ_C 82.5 (d, C-14) demonstrated that the epoxy group was embedded between C-14 and C-16. Accordingly, the gross structure of **1** was unambiguously determined to be *ent*-14,16-epoxy-8-pimarene-3,15-diol. The ROESY correlations (Figure 2) between H-3 and H-1β, H-5, and Me-18 as well as characteristic coupling constants of H-3 were indicative of the α-orientation of the C-3 hydroxy group. The proton at C-14 was deduced to be β-orientated on the basis of the ROESY correlations (Figure 2) between H-14 and Me-17, H-7β and H-5, and H-14 and 7β. Modified Mosher's method was applied to determine the absolute configuration of secondary alcohols.[17] According to the values of $\Delta\delta_{S-R}$ of the resultant diastereomeric α-methoxy-α-(trifluoromethyl)phenylacetic acid (MTPA) esters (Figure 3), both C-3 and C-15 possessed an *R* absolute configuration. The conclusion was in accordance with a previous study of the C-15 configuration of naturally occurring pimaren-15,16-diols.[18] Therefore, the structure of **1** was determined as *ent*-14β,16-epoxy-8-pimarene-3β,15α-diol.

Recently, Xiang et al.[14] reported two new *ent*-pimarane diterpenes with an unprecedented 12,16-epoxy group from the same plant. However, the authors proposed the wrong structure because of failure to comprehend the HMBC correlations (see **1** in ref 14; spectrum S5, Supporting Information, in ref 14). By reconsidering the original Supporting Information (SI), the structure *ent*-12β,16-epoxy-8-pimarene-2α,15β,19-triol (viz., **1** in ref 14) should be revised as *ent*-14β,16-epoxy-8-pimarene-2α,15α,19-triol (**10**) (Figure 4). This revision is based on the following evidence: (a) the HMBC correlations (spectrum S5, SI in ref 14) from the proton at δ_H 3.55 (1H, s, H-14) to the carbons at δ_C 32.1 (t, C-7), 125.5 (s, C-8), 142.9 (s, C-9), 30.4 (t, C-12), and 14.6 (q, C-17) were observed, as shown in Figure 4; (b) the ^{13}C NMR signals of rings C and D in **10** were in accord with those of **1** described herein by us. In conclusion, compounds **1** and **10** have been reported as the first examples of 14,16-epoxy *ent*-pimarenes. Their presence as markers may be helpful in chemotaxonomical classifications.

Compound **2** was also obtained as an amorphous powder. Its molecular formula was determined to be $C_{20}H_{34}O_4$ on the basis of the ^{13}C NMR (DEPT) spectrum and positive HRESIMS, showing a quasi-molecular ion peak at *m*/*z* 361.2347 (calcd for $C_{20}H_{34}O_4Na$, 361.2354). The NMR signals were similar to those of darutigenol (**7**),[7] suggesting that **2** was also an *ent*-pimarene derivative. However, a prominent difference was that a set of newly arisen oxygen-bearing methine signals at δ_C 73.8 (d) and δ_H 4.12 (br s) displaced an upfield methylene resonance of **7**, indicating that a methylene carbon was substituted by a hydroxy group. The positioning of the hydroxy group at C-7 was based on observation

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Chart 1

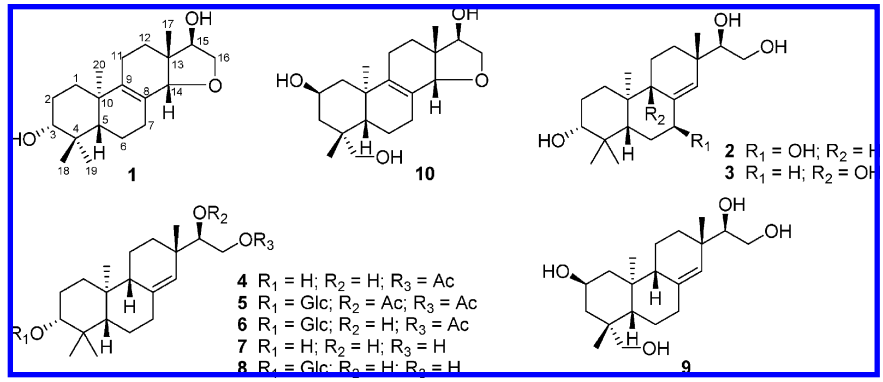

Table 1. ^{1}H NMR Data of Compounds **1**−**3**

no.	**1**[a]	**2**[b]	**3**[b]
1	1.17 (ddd, 13.3, 13.3, 3.7)	1.22 (m)	1.40 (m)
	1.78 (ddd, 13.3, 3.7, 3.2)	1.71 (ddd, 13.2, 3.5, 3.1)	1.77 (m)
2	1.61 (m)	1.60 (m)	1.60 (m)
	1.70 (m)		
3	3.23 (dd, 11.5, 4.6)	3.22 (dd, 9.0, 7.0)	3.19 (dd, 9.0, 6.6)
5	1.09 (dd, 12.4, 1.4)	1.56 (m)	1.90 (m)
6	1.51 (m)	1.60 (m)	1.37 (m)
	1.74 (m)	1.77 (br d, 11.4)	1.57 (m)
7	1.92 (m)	4.12 (br s)	2.08 (br d, 14.2)
	2.44 (br dd, 17.4, 5.5)		2.43 (m)
9		2.09 (dd, 8.1, 8.1)	
11	1.97 (m)	1.54 (m)	1.41 (m)
			1.95 (td, 14.4, 3.4)
12	1.24−1.35 (m)	0.97 (m)	1.25 (m)
		1.96 (ddd, 12.8, 3.5, 3.1)	1.89 (m)
14	3.57 (s)	5.45 (s)	5.23 (s)
15	3.85 (dd, 5.0, 2.3)	3.54 (dd, 9.1, 2.0)	3.54 (dd, 9.0, 2.0)
16	3.63 (dd, 10.1, 2.3)	3.45 (dd, 10.8, 9.1)	3.47 (dd, 10.8, 9.0)
	4.24 (dd, 10.1, 5.0)	3.64 (dd, 10.8, 2.0)	3.66 (dd, 10.8, 2.0)
17	0.95 (s)	0.89 (s)	0.87 (s)
18	1.01 (s)	0.98 (s)	1.00 (s)
19	0.81 (s)	0.80 (s)	0.82 (s)
20	0.99 (s)	0.79 (s)	0.92 (s)

[a] Measured in $CDCl_3$ (7.26 ppm). [b] Measured in methanol-d_4 (3.30 ppm).

of the HMBC correlations (Figure 1) of the proton at δ_H 4.12 (1H, br s, H-7) and the carbons at δ_C 47.8 (d, C-5), 141.2 (s, C-8), 47.3 (d, C-9), and 134.3 (d, C-14). In the ROESY spectrum, the correlation between δ_H 4.12 (1H, br s, H-7) and 2.09 (1H, dd, 8.1, 8.1, H-9β) was not detected. The multiplicity of H-7 and downfield shift of H-5β allowed definition of the β-orientation of the C-7 hydroxy group. Thus, the structure of **2** was determined as *ent*-8(14)-pimarene-3β,7α,15*S*,16-tetrol, named 7β-hydroxydarutigenol.

By analysis of the ^{13}C NMR and DEPT spectra and positive HRESIMS, compound **3** possessed the same molecular formula ($C_{20}H_{34}O_4$) as **2**. The NMR characteristics were similar to those of darutigenol (**7**)[7] and 7β-hydroxydarutigenol (**2**), suggesting that **3** was another tetrahydroxy-*ent*-pimarene. Owing to the presence of an oxygenated quaternary carbon at δ_C 75.7 (s), the additional hydroxy group should be located at C-5 or C-9 in **7**. In the HMBC spectrum, the correlations from the Me-18, Me-19, and Me-20 protons to the carbon at δ_C 45.7 (d, C-5) and from Me-20 to the carbon at δ_C 75.7 (s) were observed, which allowed us to locate the hydroxy group at C-9. In the ^{1}H NMR spectrum, the H-5β signal at δ_H 1.90 (1H, m) showed a remarkable downfield chemical shift ($\Delta \approx 0.8$ ppm) in comparison with that of **4** or **7**, indicative of the β-orientation of the C-9 hydroxy group. Accordingly, the structure of **3** was established as *ent*-8(14)-pimarene-3β,9α,15*S*,16-tetrol, named 9β-hydroxydarutigenol.

By analysis of the ^{13}C NMR (DEPT) spectrum and positive ESIMS, the molecular formula of compound **4** was determined to be $C_{22}H_{36}O_4$. The NMR data were very similar to those of darutigenol (**7**)[7] except for a set of resonances due to an acetoxy group. The H-16 proton signals were shifted downfield, and the HMBC correlation from the protons at δ_H 4.04 and 4.24 (each 1H, H-16) to the *O*-acetyl carbonyl carbon at δ_C 171.5 (s) confirmed that the acetoxy group was located at C-16. Consequently, the structure of **4** was elucidated as *ent*-16-acetoxy-8(14)-pimarene-3β,15*S*-diol, named 16-*O*-acetyldarutigenol.

Table 2. ^{1}H NMR Data of Compounds **4**−**6**

no.	**4**[a]	**5**[a]	**6**[b]
1	1.16 (ddd, 13.8, 12.7, 3.7)	1.07 (m)	1.15 (m)
	1.68 (m)	1.74 (m)	1.74 (m)
2	1.54 (m)	1.54 (m)	1.57 (m)
	1.65 (m)	1.73 (m)	1.79 (m)
3	3.25 (br d, 11.2)	3.24 (dd, 12.1, 2.9)	3.37 (dd, 11.5, 3.5)
5	1.03 (dd, 12.7, 1.8)	1.03 (m)	1.11 (dd, 12.3, 2.0)
6	1.35 (qd, 13.0, 4.6)	1.37 (qd, 13.0, 4.2)	1.39 (m)
	1.61 (m)	1.61 (m)	1.63 (m)
7	2.02 (ddd, 14.2, 13.7, 5.7)	2.00 (m)	2.04 (m)
	2.26 (br d, 14.2)	2.26 (br d, 12.5)	2.28 (br d, 13.7)
9	1.68 (m)	1.64 (m)	1.71 (m)
11	1.45−1.56 (m)	1.45−1.57 (m)	1.46−1.58 (m)
12	0.99 (ddd, 13.4, 12.0, 4.2)	0.99 (m)	0.93 (m)
	1.94 (ddd, 13.4, 4.0, 3.5)	1.56 (m)	1.99 (br. d, 13.1)
14	5.12 (s)	5.11 (s)	5.18 (s)
15	3.71 (ddd, 9.4, 3.7, 1.3)	5.12 (dd, 9.4, 2.0)	3.71 (dd, 9.0, 2.3)
16	4.04 (dd, 11.2, 9.4)	4.07 (dd, 11.3, 9.4)	4.00 (dd, 11.3, 9.0)
	4.24 (dd, 11.2, 1.3)	4.34 (dd, 11.3, 2.0)	4.21 (dd, 11.3, 2.3)
17	0.91 (s)	0.95 (s)	0.87 (s)
18	0.99 (s)	1.00 (s)	1.04 (s)
19	0.80 (s)	0.82 (s)	0.85 (s)
20	0.74 (s)	0.82 (s)	0.81 (s)
$CH_3CO_{(15)}$		2.07 (s)	
$CH_3CO_{(16)}$	2.08 (s)	2.01 (s)	2.04 (s)
1′		4.33 (d, 7.6)	4.32 (d, 7.8)
2′		3.36 (dd, 9.2, 7.6)	3.15 (dd, 9.0, 7.8)
3′		3.55 (t, 9.2)	3.35 (t, 9.0)
4′		3.60 (t, 9.2)	3.29 (t, 9.0)
5′		3.28 (m)	3.22 (m)
6′		3.83 (2H, m)	3.66 (dd, 11.7, 5.5)
			3.85 (dd, 11.7, 2.2)
15-OH	2.11 (1H, d, 3.7)		

[a] Measured in $CDCl_3$ (7.26 ppm). [b] Measured in methanol-d_4 (3.30 ppm).

Similarly, by observation of the effects of esterification and glycosylation shifts (see Tables 2 and 3, respectively), in combination with their HMBC spectra (spectra S23 and S27, SI), the structures of **5** and **6** were determined as *ent*-15*S*,16-diacetoxy-8(14)-pimaren-3β-ol 3-*O*-β-D-glucopyranoside and *ent*-16-acetoxy-8(14)-pimaren-3β,15*S*-diol 3-*O*-β-D-glucopyranoside, respectively, named 15,16-di-*O*-acetyldarutoside and 16-*O*-acetyldarutoside. Full assignment of the NMR signals was achieved and summarized in Tables 2 and 3.

Experimental Section

General Experimental Procedures. Optical rotations were measured on a Jasco P-1020 polarimeter. IR spectra were obtained using a Bruker Tensor 27 FT-IR spectrometer with KBr pellets. NMR spectra were

Table 3. ^{13}C NMR Data of Compounds **1**−**6**

no.	**1**[a]	**2**[b]	**3**[b]	**4**[a]	**5**[a]	**6**[b]
1	34.3 (t)	38.3 (t)	31.3 (t)	37.0 (t)	36.7 (t)	38.1 (t)
2	27.5 (t)	28.3 (t)	28.0 (t)	27.5 (t)	23.6 (t)	24.4 (t)
3	78.8 (d)	79.8 (d)	79.5 (d)	79.0 (d)	85.7 (d)	86.0 (d)
4	38.8 (s)	39.6 (s)	39.9 (s)	38.9 (s)	38.3 (s)	39.4 (s)
5	50.5 (d)	47.8 (d)	45.7 (d)	54.1 (d)	54.8 (d)	56.2 (d)
6	18.5 (t)	30.6 (t)	23.2 (t)	22.1 (t)	22.2 (t)	23.4 (t)
7	30.7 (t)	73.8 (d)	33.3 (t)	35.9 (t)	35.9 (t)	37.1 (t)
8	124.5 (s)	141.2 (s)	140.2 (s)	140.0 (s)	140.4 (s)	140.4 (s)
9	141.2 (s)	47.3 (d)	75.7 (s)	50.4 (d)	50.4 (d)	52.0 (d)
10	37.5 (s)	39.3 (s)	42.7 (s)	37.9 (s)	37.9 (s)	39.0 (s)
11	20.7 (t)	18.9 (t)	27.4 (t)	18.2 (t)	18.3 (t)	19.3 (t)
12	29.2 (t)	32.8 (t)	29.8 (t)	31.5 (t)	32.1 (t)	33.1 (t)
13	42.9 (s)	38.7 (s)	39.1 (s)	37.4 (s)	36.9 (s)	38.6 (s)
14	82.5 (d)	134.3 (d)	132.1 (d)	127.1 (d)	126.1 (d)	129.0 (d)
15	80.1 (d)	77.4 (d)	75.9 (d)	73.7 (d)	74.3 (d)	74.1 (d)
16	73.8 (t)	64.2 (t)	64.5 (t)	66.6 (t)	63.8 (t)	67.5 (t)
17	14.2 (q)	22.7 (q)	22.6 (q)	22.7 (q)	23.2 (q)	22.8 (q)
18	28.0 (q)	28.8 (q)	29.3 (q)	28.4 (q)	28.6 (q)	29.2 (q)
19	15.5 (q)	16.4 (q)	16.4 (q)	15.7 (q)	16.8 (q)	17.4 (q)
20	19.3 (q)	14.6 (q)	18.8 (q)	14.7 (q)	14.6 (q)	15.2 (q)
$CH_3CO_{(15)}$					21.0 (q)	
$CH_3CO_{(15)}$					170.6 (s)	
$CH_3CO_{(16)}$				21.0 (q)	20.9 (q)	20.9 (q)
$CH_3CO_{(16)}$				171.5 (s)	171.0 (s)	173.1 (s)
1′					100.5 (d)	101.9 (d)
2′					73.4 (d)	75.1 (d)
3′					76.3 (d)	78.2 (d)
4′					69.9 (d)	71.8 (d)
5′					75.2 (d)	77.7 (d)
6′					62.0 (t)	63.0 (t)

[a] Measured in $CDCl_3$ (77.0 ppm). [b] Measured in methanol-d_4 (49.0 ppm).

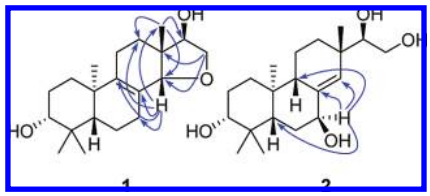

Figure 1. Significant HMBC correlations of **1** and **2**.

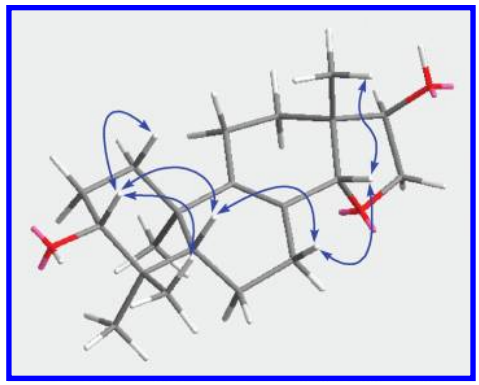

Figure 2. Minimum energy conformations and key ROESY correlations of **1**.

acquired with a Bruker DRX-500 or Bruker AV-400 instrument at room temperature. ESIMS (including HRESIMS) and FABMS were measured on API QSTAR Pulsar i and VG Autospec-3000 mass spectrometers, respectively. Silica gel (200−300 mesh, Qingdao Marine Chemical Inc., China) and Sephadex LH-20 (Amersham Biosciences, Sweden) were used for column chromatography. MPLC was performed on a Büchi Sepacore System including pump manager C-615, pump modules C-605, and fraction collector C-660 (Büchi Labortechnik AG, Switzerland) and columns packed with Chromatorex C-18 (40−75 μm, Fuji Silysia Chemical Ltd., Japan). Fractions were monitored by TLC (Qingdao Marine Chemical Inc., China) and spots visualized by heating silica gel plates immersed in vanillin−H_2SO_4 in EtOH.

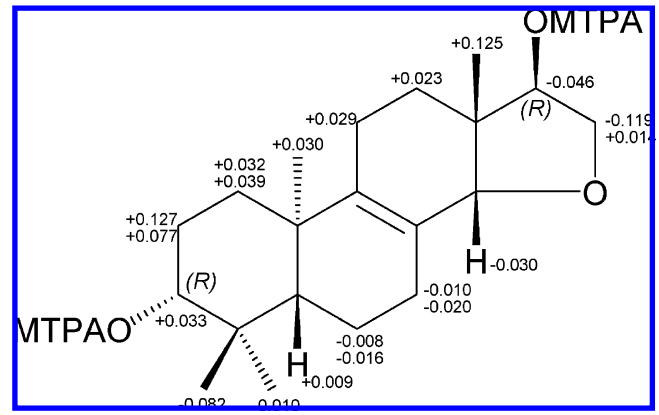

Figure 3. Values of $\delta_S - \delta_R$ of the MTPA esters of **1**.

Plant Material. The aerial parts of *S. orientalis* were collected in Xinping County of Yunnan Province, China, March 2008, and identified by Yu Chen of Kunming Institute of Botany, Chinese Academy of Sciences. The voucher specimen (BBP2009006SO) was deposited at BioBioPha Co., Ltd.

Extraction and Isolation. The air-dried, powdered aerial parts of *S. orientalis* (11.0 kg) were extracted with 95% EtOH at room temperature. The EtOH extract was concentrated to give a residue (∼900 g), which was fractionalized by silica gel column chromatography eluted with a solvent system of petroleum ether (PE)−acetone and then MeOH to yield fractions A−N. Fraction F, eluted by 5% acetone, was separated on silica gel to give two subfractions (PE−acetone, 20:1, 10:1), which were further isolated and purified by Sephadex LH-20, silica gel ($CHCl_3$−acetone, 300:1, 80:1), and recrystallization from acetone to afford **4** (24 mg) and **1** (112 mg), respectively. Fraction J, eluted by 15% acetone, was further isolated and purified by silica gel ($CHCl_3$−MeOH, 80:1), Sephadex LH-20, and MPLC (MeOH−H_2O, 20%) to afford **3** (51 mg). Fraction L, eluted by 50% acetone, was further isolated and purified by silica gel ($CHCl_3$−MeOH, 25:1), Sephadex LH-20, and recrystallization from $CHCl_3$−MeOH (6:1) to afford **2** (401 mg). Fraction N, eluted by 100% methanol, was separated on silica gel to give two subfractions ($CHCl_3$−MeOH, 30:1, 15:1),

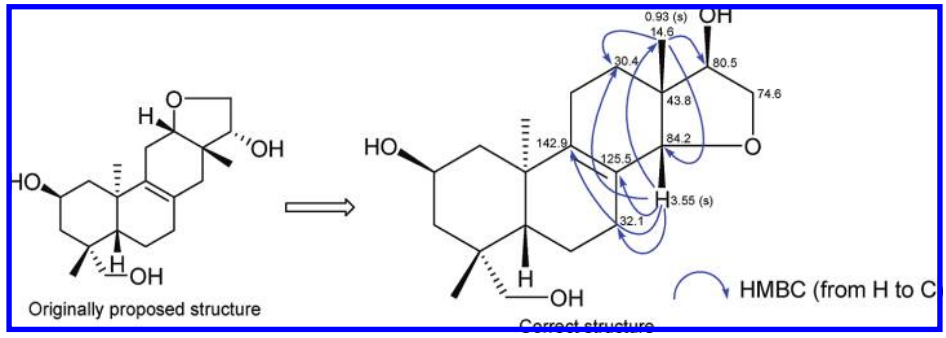

Figure 4. Structure revision of **10**.

which were further isolated and purified by silica gel ($CHCl_3$−MeOH, 70:1, 35:1) and Sephadex LH-20 to afford **5** (35 mg) and **6** (110 mg), respectively.

***ent*-14*β*,16-Epoxy-8-pimarene-3*β*,15α-diol (1):** amorphous powder, $[\alpha]^{28}_D$ +5.4 (*c* 0.40, MeOH); IR (KBr) ν_{max} 3423, 2933, 2876, 1630, 1458, 1380, 1090, 1036, 1002 cm^{-1}; ^1H NMR data (Table 1); ^{13}C NMR data (Table 3); ESIMS (pos.) *m*/*z* 343 $[M + Na]^+$; HRESIMS (pos.) *m*/*z* 343.2243 (calcd for $C_{20}H_{32}O_3Na$, 343.2249).

7*β*-Hydroxydarutigenol (2): amorphous powder, $[\alpha]^{23}_D$ +35.4 (*c* 0.56, MeOH); IR (KBr) ν_{max} 3451, 2955, 2871, 1637, 1456, 1382, 1091, 1034, 889 cm^{-1}; ^1H NMR data (Table 1); ^{13}C NMR data (Table 3); ESIMS (pos.) *m*/*z* 361 $[M + Na]^+$; HRESIMS (pos.) *m*/*z* 361.2347 (calcd for $C_{20}H_{34}O_4Na$, 361.2354).

9*β*-Hydroxydarutigenol (3): oil, $[\alpha]^{23}_D$ −42.3 (*c* 0.54, MeOH); IR (KBr) ν_{max} 3418, 2941, 2873, 1637, 1458, 1382, 1083, 1014, 914 cm^{-1}; ^1H NMR data (Table 1); ^{13}C NMR data (Table 3); ESIMS (pos.) *m*/*z* 361 $[M + Na]^+$; HRESIMS (pos.) *m*/*z* 361.2354 (calcd for $C_{20}H_{34}O_4Na$, 361.2354).

16-*O*-Acetyldarutigenol (4): amorphous powder, $[\alpha]^{28}_D$ −36.9 (*c* 0.41, MeOH); IR (KBr) ν_{max} 3438, 2940, 2873, 1723, 1642, 1455, 1368, 1248, 1088, 1034 cm^{-1}; ^1H NMR data (Table 2); ^{13}C NMR data (Table 3); ESIMS (pos.) *m*/*z* 387 $[M + Na]^+$.

15,16-Di-*O*-acetyldarutoside (5): oil, $[\alpha]^{20}_D$ −38.5 (*c* 0.29, MeOH); IR (KBr) ν_{max} 3424, 2941, 2876, 1744, 1638, 1456, 1370, 1246, 1077, 1043 cm^{-1}; ^1H NMR data (Table 2); ^{13}C NMR data (Table 3); ESIMS (pos.) *m*/*z* 591 $[M + Na]^+$, 509 $[M - CH_3COOH + H]^+$.

16-*O*-Acetyldarutoside (6): oil, $[\alpha]^{28}_D$ −50.6 (*c* 0.40, MeOH); IR (KBr) ν_{max} 3430, 2941, 2875, 1724, 1640, 1456, 1370, 1250, 1077, 1035 cm^{-1}; ^1H NMR data (Table 2); ^{13}C NMR data (Table 3); FABMS (pos.) *m*/*z* 527 $[M + H]^+$, 509 $[M - H_2O + H]^+$, 467 $[M - CH_3COOH + H]^+$, 347 $[M - Glc + H]^+$.

Preparation of the (*S*)- and (*R*)-MTPA Esters of 1. A mixture of **1** (9.0 mg), (*R*)-MTPA (40.6 mg), DMAP (3.7 mg), and DCC (41.4 mg) was dissolved in 6 mL of dry CH_2Cl_2 and stirred at room temperature for 16 h. The reaction mixture was filtered, and the concentrated filtrate was chromatographed over a silica gel column eluted with $CHCl_3$ to yield purified (*R*)-MTPA ester (13.0 mg). (*S*)-MTPA ester was prepared in the same manner. Complete assignment of ^1H NMR spectra (500 MHz, $CDCl_3$, 7.260 ppm) of the MTPA ester derivatives was achieved by ^{13}C NMR, HSQC, and HMBC experiments.

Bis[(*S*)-MTPA] Ester of 1. ^1H NMR data: δ 1.288 (1H, m, H-1*β*), 1.840 (1H, m, H-1α), 1.783 (1H, m, H-2α), 1.899 (1H, m, H-2*β*), 4.725 (1H, dd, *J* = 11.7, 4.5 Hz, H-3*β*), 1.189 (1H, dd, *J* = 12.4, 1.7 Hz, H-5*β*), 1.516 (1H, m, H-6α), 1.718 (1H, m, H-6*β*), 1.921 (1H, m, H-7*β*), 2.403 (1H, br dd, *J* = 17.7, 5.6 Hz, H-7α), 2.021 (2H, m, H-11), 1.379−1.493 (2H, m, H-12), 3.523 (1H, s, H-14*β*), 5.028 (1H, dd, *J* = 5.6, 2.3 Hz, H-15α), 3.629 (1H, dd, *J* = 11.1, 2.3 Hz, H-16a), 4.389 (1H, dd, *J* = 11.1, 5.6 Hz, H-16b), 0.899 (3H, s, Me-17), 0.846 (3H, s, Me-18), 0.826 (3H, s, Me-19), 1.031 (3H, s, Me-20).

Bis[(*R*)-MTPA] Ester of 1. ^1H NMR data: δ 1.256 (1H, m, H-1*β*), 1.801 (1H, m, H-1α), 1.656 (1H, m, H-2α), 1.822 (1H, m, H-2*β*), 4.692 (1H, dd, *J* = 11.9, 4.2 Hz, H-3*β*), 1.180 (1H, dd, *J* = 12.1, 1.1 Hz, H-5*β*), 1.524 (1H, m, H-6α), 1.734 (1H, m, H-6*β*), 1.931 (1H, m, H-7*β*), 2.423 (1H, br. dd, *J* = 17.2, 5.5 Hz, H-7α), 1.992 (2H, m, H-11), 1.338−1.488 (2H, m, H-12), 3.553 (1H, s, H-14*β*), 5.074 (1H, dd, *J* = 5.1, 2.2 Hz, H-15α), 3.748 (1H, dd, *J* = 11.0, 2.2 Hz, H-16a), 4.375 (1H, dd, *J* = 11.0, 5.1 Hz, H-16b), 0.774 (3H, s, Me-17), 0.928 (3H, s, Me-18), 0.836 (3H, s, Me-19), 1.001 (3H, s, Me-20).

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Supporting Information Available: NMR spectra of **1**−**6** and the MTPA esters of **1**. This material is available free of charge via the Internet at http://pubs.acs.org.

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