

## Sesquiterpenes from the Root and Stem of *Aristolochia cucurbitafolia*

Tian-Shung Wu,\* Yu-Yi Chan, and Yann-Lii Leu

Department of Chemistry, National Cheng Kung University, Tainan, Taiwan, Republic of China

Received November 3, 1997

Investigation of the root and stem of *Aristolochia cucurbitafolia* Hayata resulted in the isolation of seven sesquiterpenes, five of which are new compounds, namely, madolins A (**1**), B (**2**), C (**3**), D (**4**), and E (**5**), together with two known sesquiterpenes, aristolactone and manshurolid. Their structures were elucidated by spectral methods.

The genus *Aristolochia* is distributed in a wide area from the tropics to temperate zones and consists of about 400 species. *Aristolochia cucurbitafolia* is native to Taiwan.<sup>1</sup> The fruits and roots of this plant are used in traditional Chinese medicine as anodynes, antiphlogistics, antitussives, expectorants, and antiasthmatic agents and also for the treatment of snakebite and lung inflammation.<sup>2</sup> Several aristolochic acids were isolated from the leaves and stems of *Aristolochia cucurbitafolia* Hayata.<sup>3</sup> In continuation of our chemical investigation of the genus *Aristolochia*,<sup>4</sup> we are interested in the constituents of this species. We report herein the isolation and structure elucidation of sesquiterpenoids.

The known compounds aristolactone<sup>5</sup> and manshurolid<sup>6</sup> were identified and characterized by comparison of their spectroscopic data with literature values. Madolin A (**1**) was isolated as optically active colorless needles, mp 67–69 °C. The HRMS of **1** indicated a molecular ion at  $m/z$  234.1618 in agreement with the molecular formula  $C_{15}H_{22}O_2$ . Considering the molecular formula and signals in the  $^{13}C$  NMR spectrum of **1** (Table 1), the existence of three quaternary carbons, five methines, four methylenes, and three methyls shown by DEPT spectra suggested a tricyclic sesquiterpene structure. The presence of a partial structure  $-CH=C-CHO$  in this molecule was inferred by the appearance of IR bands at 1674 and 1629  $cm^{-1}$ ; a UV absorption band at 263.2 nm, and  $^1H$  NMR signals at  $\delta$  9.30 (1H, s) and 6.42 (1H, d,  $J = 9.4$  Hz), together with  $^{13}C$  NMR signals at  $\delta$  193.7(d), 154.8(d), and 144.0(s). The NMR signals also showed the presence of a dimethylcyclopropane ring [ $\delta_H$  1.61 (1H, dd,  $J = 9.4, 9.4$  Hz), 1.07–1.01 (1H, m), 1.12, and 1.17 (each 3H, s);  $\delta_C$  23.8 (s)] and a long-range correlation of H-6 and H-7 to C-13 and C-12; a tertiary methyl [ $\delta_H$  0.79 (3H, s);  $\delta_C$  17.2 (q)] and an epoxide ring [ $\delta_H$  2.90 (1H, dd,  $J = 11.1, 3.0$  Hz);  $\delta_C$  62.8 (d) and 60.0 (s)]. This sesquiterpene was believed to have a germacrane skeleton. To confirm the structure of **1**, two-dimensional correlation spectroscopy (2D COSY) and the long-range  $^{13}C-^1H$  correlation in the HMBC experiment (Table 2) were conducted. The results showed the plane structure of madolin A as **1**. The stereochemistry of **1** was unambiguously determined by the NOESY experiment (Table 2) and was additionally confirmed by X-ray analysis

(Figure 1). On the basis of the above results, the structure of madolin A was assigned as **1**.

Madolin B (**2**) was obtained as an optically active colorless powder, and the MS established the molecular formula as  $C_{15}H_{22}O_3$ . The structure of **2** was similar to that of **1**, according to the  $^1H$  NMR and the  $^{13}C$  NMR spectral data (Table 1). In the  $^{13}C$  NMR spectrum, the carbonyl signal at 193.7 in **1** shifted to  $\delta$  177.3 in **2**, suggesting that the aldehyde group in **1** was oxidized to a carboxylic acid in **2**. To confirm this result, COSY, HMQC, and HMBC experiments were conducted, which definitely confirmed the proposed structure on the basis of the correlation peaks via  $^2J$  and  $^3J$  (Table 2). The relative stereochemistry of **2** was determined by the NOESY experiment (Table 2). Hence, structure **2** was established for madolin B.

Madolin C (**3**), optically active colorless needles, exhibited  $[M^+]$  at  $m/z$  206, corresponding to a molecular formula  $C_{14}H_{22}O$ . The  $^{13}C$  NMR spectrum contained 14 distinct signals attributable to three quaternary carbons, three tertiary carbons, five secondary carbons, and three methyls as deduced from DEPT experiments (Table 1). The spectral properties of **3** were similar to those of **1** and **2**, except for the signals of C-4 and C-5 at  $\delta$  130.6 (d) and 128.4 (d) [**1** at  $\delta$  144.0 (s) and 154.8 (d), respectively] and the absence of the  $^1H$  and  $^{13}C$  signals due to CHO. The plane structure of **3** was established from the  $^1H-^1H$  COSY, HMQC, and HMBC experiments. The coupling constant 9.6 Hz between H-4 and H-5 indicated the *Z*-configuration of the double bond. The stereochemistry of **3** was determined by the NOESY experiment (Table 2). Consequently, the above spectral data afforded the structure of madolin C as **3**.

Madolin D (**4**) was obtained as a colorless oil, and the molecular formula was determined as  $C_{17}H_{22}O_4$  by HRMS. The  $^{13}C$  NMR spectrum of **4** appeared as five quaternary carbons, four methines, six methylenes, and two methyls from DEPT experiments (Table 1). The  $^1H$  NMR spectrum displayed a trisubstituted- $\alpha,\beta$ -unsaturated aldehyde moiety at  $\delta$  9.32 and 6.28 (1H, d,  $J = 8.6$  Hz), which was confirmed by the IR bands at 1676 (C=O), 1629 (C=C)  $cm^{-1}$  and the UV absorption at 255.6 nm. A terminal methylene signal appeared at  $\delta$  5.73 (1H, s) and 5.69 (1H, s). One singlet signal at 2.07 (3H, s), together with methylene protons at  $\delta$  3.93 (1H,  $J = 11.4$  Hz) and 3.83 (1H,  $J = 11.4$  Hz), were attributed to  $-CH_2OCOCH_3$  moiety. The presence of a bicyclic skeleton in the molecule was determined by seven

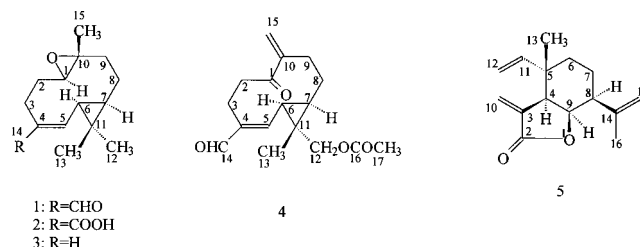
\* To whom correspondence should be addressed. Tel: 886-6-2747538. Fax: 886-6-2740552. E-mail: tswu@mail.ncku.edu.tw.

Table 1. <sup>1</sup>H NMR and <sup>13</sup>C NMR Spectral Data of Compounds 1–5

compound	1		2		3		4		5	
	δ <sub>C</sub>	δ <sub>H</sub>	δ <sub>C</sub>	δ <sub>H</sub>	δ <sub>C</sub>	δ <sub>H</sub>	δ <sub>C</sub>	δ <sub>H</sub>	δ <sub>C</sub>	δ <sub>H</sub>
1	62.8	2.90 dd (11.1, 3.0, α)	65.2	3.10 dd (11.1, 3.1, α)	62.6	2.75 dd (8.0, 3.0, α)	203.6		29.7	
2	27.7	2.16 dq (14.0, 3.2, α)	29.7	2.15 m (α)	28.8	2.00 dd (13.5, 3.2, α)	37.2	2.80 m	166.5	
3	20.5	1.20 m (β)	24.6	1.48 m (β)	24.2	1.12 m (β)	23.7	2.89 td (14.4, 3.8)	139.0	
4	144.0	2.69 dt (13.3, 4.0, β)	138.5	2.55 td (13.3, 2.9, α)	130.6	2.20 dddd (13.5, 13.5, 9.6, 3.2, α)		2.69 td (14.4, 3.8)		
5	154.8	2.31 td (13.3, 3.2, α)	138.8	6.70 d (9.4)	128.4	5.40 ddd (9.6, 9.6, 3.2)	149.3		47.9	2.73 d (4.6)
6	28.8	6.42 d (9.4)	138.8	1.49 dd (9.4, 9.4, α)	128.4	5.21 dd (9.6, 9.6)	156.0	6.28 d (8.6)	38.3	
7	38.6	1.61 dd (9.4, 9.4, α)	29.2	1.49 dd (9.4, 9.4, α)	26.1	1.20 dd (9.6, 9.6, α)	25.4	1.66 t (8.6)	36.3	1.70–1.40
8	22.0	1.07–1.01 m (α)	37.2	0.86 ddd (9.4, 9.4, 1.8, α)	34.0	0.32 dd (10.8, 9.6, α)	35.9	1.06 t (8.6)	20.0	1.70–1.40
9	39.9	1.85 m (β)	22.8	1.82 dd (14.2, 6.8, α)	21.5	1.47 dd (13.4, 6.6, α)	24.9	1.89 m (a)	44.9	2.28 dd (14.0, 4.6)
10	60.0	1.07–1.01 m (α)	41.5	1.16 m (β)	40.9	0.78 ddd (13.4, 13.4, 10.8, β)	30.8	0.87 m (b)	78.5	4.54 dd (4.6, 4.6)
11	23.8		62.9	2.11 dd (14.4, 14.2, β)	59.7	2.04 dd (13.4, 6.6, β)	149.9	2.51 m,	121.1	6.15 s (a)
12	28.4	1.12 s	22.8	1.09 m (α)	19.9	1.04 m (α)	26.1		5.49 s (b)	
13	15.5	1.17 s	29.0	1.13 s	28.7	0.94 s	72.9	3.93 d (11.4, a)	146.6	5.73 dd (17.4, 10.8)
14	193.7	9.30 s	15.9	1.19 s	15.4	0.90 s	11.6	3.83 d (11.4, b)	112.3	5.05 dd (10.8, 0.8, a)
15	17.2	0.79 s	17.9	1.07 s	18.3	1.09 s	130.6	1.19s	19.1	4.98 dd (17.4, 0.8, b)
16							171.9	5.73 s	112.0	4.92 q (1.2, a)
17							20.9	5.69 s	21.6	4.87 br s (b)
								2.07 s		1.88 s

degrees of unsaturation to reduce the five accounted for the  $-\text{CH}=\text{CCHO}$ ,  $-\text{CH}_2\text{OCOCH}_3$ ,  $\text{CH}_2=\text{C}-$ , and one carbonyl signal at  $\delta$  203.6 in the <sup>13</sup>C NMR spectrum. The COSY and HMQC spectra readily established the presence of one  $>\text{CH}-\text{CH}-\text{CH}=\text{C}-\text{CHO}$  and two  $-\text{CH}_2-\text{CH}_2-$  partial structures. The above fragments could be arranged as shown in formula 4 on the basis of the HMBC experiment (Table 2). The 8.6 Hz coupling constant and NOE between H-6 and H-7 indicated a cis configuration of cyclopropane moiety.<sup>7,8</sup> The stereochemistry of madolin D was determined by the NOESY experiment (Table 2). Based on the above analyses, madolin D thus has structure 4.

Madolin E (5) was isolated as an optically active oil and was determined to have the molecular formula C<sub>15</sub>H<sub>20</sub>O<sub>2</sub>. The presence of an  $\alpha$ -methylene- $\gamma$ -lactone unit was confirmed by the IR bands at 1775, 1652 cm<sup>-1</sup>, <sup>13</sup>C NMR spectrum at  $\delta$  166.5 (s), 139.0 (s), and 121.1 (t), and <sup>1</sup>H NMR spectrum at  $\delta$  5.49, 6.15 (each 1H, s). Moreover, the presence of the following four partial structures  $\text{CH}_2=\text{C}-\text{CH}-\text{CH}-\text{CH}-$ ,  $\text{CH}_2=\text{CH}-$ ,  $\text{CH}_2=\text{C}-\text{CH}_3$ , and  $-\text{CH}_2-\text{CH}_2-$  in 5 was solved by COSY and HMQC experiments. The connection between the above partial structures to form structure 5 was established by the HMBC experiment (Table 2). The relative stereochemistries of H-4, H-8, and H-9 were deduced as having axial, axial, and equatorial orientations from the 4.6 and 4.6 Hz coupling constant between H-4 and H-9, H-8 and H-9, respectively. On the other hand, the configuration of H-4 and the vinylic group at C-5 were determined as *cis*-form due to the appearance of a crosspeak between H-4 (2.73) and H-11 (5.73) in the NOESY experiment (Table 2). Based on the above analyses, the structure 5 was assigned for madolin E.



## Experimental Section

**General Experimental Procedures.** Melting points (uncorrected) were determined with a Yanagimoto MP-S3 apparatus. Optical rotations were recorded on a JASCO DIP-370 polarimeter. IR and UV spectra were measured on Shimadzu FTIR-8501 and Hitachi UV-3210 spectrophotometers, respectively. EIMS was recorded on a VG-70-250S mass spectrometer. The <sup>1</sup>H and <sup>13</sup>C NMR, DEPT, COSY, HMQC, NOESY, and HMBC experiments were recorded on Bruker AMX-400 spectrometer.

**Plant Material.** *Aristolochia cucurbitifolia* Hayata was collected from Kaohsiung Hsien, Taiwan, in April 1992, and verified by Prof. C.-S. Kuoh. A voucher specimen is deposited in the Herbarium of Cheng Kung University, Taiwan.

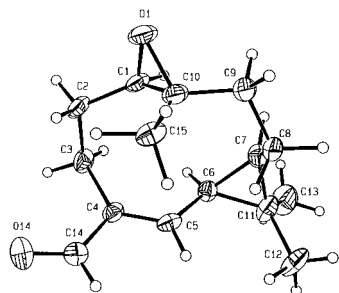
**Extraction and Separation.** The fresh stems and roots of *A. cucurbitifolia* (3.1 kg) were extracted with MeOH ( $\times 10$ ) at room temperature and concentrated to give a deep brown syrup. The syrup was partitioned

Table 2. NOE Correlations and <sup>2</sup>J,<sup>3</sup>J-Correlations of HMBC of Madolins, A–E (1–5)

1			2			3		
H	NOESY cross peaks	HMBC correlated carbons	H	NOESY cross peaks	HMBC correlated carbons	H	NOESY cross peaks	HMBC correlated carbons
1 α	H-3 α, H-2 α, H-6 α, H-9 α	C-2	1 α	H-3 α, H-2 α, H-6 α, H-7 α, H-9 α		1	H-3 α, H-2 α, H-6 α, H-7 α, H-9 α	C-2
2 α	H-2 β, H-3 α, H-3 β, H-1 α	C-3, C-4	2 α	H-2 β, H-1 α		2 α	H-2 β, H-1 α, H-3 α, H-3 β	C-1, C-10
2 β	H-2 α, H-3 β		2 β	H-2 α, H-5		2 β	H-2 α, H-3 β	C-10
3 α	H-3 β, H-2 α, H-6 α, H-1 α	C-1, C-2, C-4, C-14	3 α	H-3 β, H-6 α, H-1 α	C-4	3 α	H-3 β, H-6 α, H-1 α, H-2 α	C-2
3 β	H-3 α, H-2 α, H-2 β	C-1, C-2, C-4, C-14	3 β	H-3 α	C-14	3 β	H-2 α, H-3 α, H-4, H-2 β	
5	H-8 β, H-13, H-14, H-15	C-3, C-11, C-14	5	H-2 β, H-13	C-3, C-4, C-14	4	H-3 β, H-5, H-14	C-3, C-6
6 α	H-1 α, H-3 α, H-7 α, H-12	C-7, C-8, C-12	6 α	H-1 α, H-3 α, H-7 α, H-12	C-4, C-5, C-7, C-8, C-12	5	H-13, H-4	C-3, C-4, C-11
7 α	H-6 α	C-8, C-13	7 α	H-1 α, H-6 α, H-12	C-6, C-12	6 α	H-1 α, H-3 α, H-7 α	C-8, C-13
8 α	H-8 β	C-7, C-9	8 α	H-8 β	C-6	7 α	H-1 α, H-6 α, H-8 α, H-12	C-13
8 β	H-8 α, H-9 β, H-5	C-6, C-7, C-9	8 β	H-8 α		8 α	H-7 α, H-8 β, H-9 β	C-6, C-7, C-9, C-10
9 α	H-9 β, H-1 α	C-7, C-8	9 α	H-9 β, H-1 α		8 β	H-8 α, H-9 β	C-7
9 β	H-8 β, H-9 α, H-15	C-1, C-7, C-8, C-10, C-15	9 β	H-9 α	C-8, C-10	9 α	H-9 β, H-1 α	C-1, C-10
12	H-6 α	C-6, C-7, C-11, C-13	12	H-6 α, H-7 α	C-6, C-7, C-11, C-13	9 β	H-9 α, H-8 α, H-8 β	C-1, C-7, C-8, C-10
13	H-5	C-6, C-7, C-11, C-12	13	H-5, H-15	C-6, C-7, C-11, C-12	12	H-7 α	C-6, C-7, C-11, C-13
14	H-5, H-15	C-3, C-4	15	H-13	C-9, C-10	13	H-5	C-6, C-7, C-11, C-12
15	H-9 β, H-5, H-14	C-1, C-9, C-10				14	H-4	C-1, C-9, C-10
4								
2	H-3 α, H-15		4 α	H-9 α, H-10b, H-11	C-3			
3 α	H-2, H-6 α		6 α	H-8 α				
3 β	H-15		6 β	H-13				
5	H-13, H-14	C-3, C-6, C-14	7 α	H-8 α				
6 α	H-3 α, H-7 α, H-12a, H-12b		8 α	H-6 α, H-7 α, H-9 α				
7 α	H-6 α, H-9, H-12a, H-12b		9 α	H-4 α, H-8 α, H-16, H-15b				
8a	H-8b, H-9, H-17		10a	H-10b				
8b	H-8a		10b	H-10a, H-4 α				C-2, C-3, C-4
9	H-8a, H-7 α, H-15		11	H-12a, H-12b, H-4 α				C-2, C-4
12a	H-6 α, H-7 α	C-6, C-7, C-11, C-13	12a	H-12a, H-11				C-5
12b	H-6 α, H-7 α	C-6, C-7, C-11, C-13	12b	H-12a, H-13, H-11				C-5
13	H-5	C-6, C-7, C-11, C-12	13	H-12b, H-6 β				C-4, C-5, C-6, C-11
14	H-5	C-4	15a	H-16				C-8, C-16
15	H-3 β, H-2, H-9	C-1, C-9	15b	H-9 α, H-16,				C-8, C-16
17	H-8a	C-16	16	H-9 α, H-15a, H-15b				C-8, C-15, C-14

4

5



**Figure 1.** Structure and solid-state conformation of madolin A (**1**); small circles represent hydrogen atoms.

successively between  $\text{H}_2\text{O}$  and  $\text{CHCl}_3$ , and then *n*-BuOH. The  $\text{CHCl}_3$  layer was filtered to obtain a precipitate and filtrate solution. The filtrate was dried over  $\text{Na}_2\text{SO}_4$  and then concentrated under reducing pressure to leave a brown syrup that was chromatographed directly on Si gel and eluted with a gradient of  $\text{CHCl}_3$  and MeOH to afford three fractions. Fraction 1 was rechromatographed on Si gel and eluted with *n*-hexane–EtOAc (15:1) to give madolins A (**1**) (15 mg), B (**2**) (5 mg), C (**3**) (13 mg), D (**4**) (3 mg), and E (**5**) (1 mg); aristolactone (683 mg), and manshurolide (23 mg), successively.

**Madolin A (1):** colorless needles; mp 67–69 °C;  $[\alpha]_{\text{D}} +156.74^\circ$  (*c* 0.038,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 264.0 (4.02) nm; IR (KBr)  $\nu_{\text{max}}$  1674, 1629, 1377, 1251, 1207, 1186, 1066  $\text{cm}^{-1}$ ; EIMS  $m/z$  234  $[\text{M}]^+$  (32), 219 (59), 206 (21), 191 (77), 163 (84), 149 (82), 135 (54), 121 (67), 109 (65), 107 (100); HREIMS  $m/z$  234.1618 (anal. calcd for  $\text{C}_{15}\text{H}_{22}\text{O}_2$ , 234.1619); crystal data monoclinic, space group  $P2_12_12_1$   $a = 11.3372$  (18),  $b = 9.1153$  (20),  $c = 13.3167$  (13) Å,  $U = 1376.2$  (4) Å<sup>3</sup>,  $Z = 2$ ,  $D_c = 1.078$   $\text{mg m}^{-3}$ , (Mo  $K\alpha$  radiation,  $\lambda = 0.70930$  Å), crystal dimensions  $0.06 \times 0.13 \times 0.50$  mm. Intensity data ( $+h$ ,  $+k$ ,  $+l$ ,  $2\theta_{\text{max}} = 49.8^\circ$ ) were recorded on a Nonius diffractometer. The crystal structure was solved by a direct method. Full-matrix least-squares refinement of atomic parameters (anisotropic C, O; isotopic H) converged at  $R = 0.053$  ( $R_w = 0.048$ ) over 2581 reflections with  $I > 2.5\sigma(I)$ .

**Madolin B (2):** colorless powder; mp 83–85 °C;  $[\alpha]_{\text{D}} +7.07^\circ$  (*c* 0.10,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 248.6

(3.62) nm; IR (KBr)  $\nu_{\text{max}}$  1710, 1641, 1527, 1429  $\text{cm}^{-1}$ ; EIMS  $m/z$  250  $[\text{M}]^+$  (92), 209 (14), 208 (100), 166 (30), 165 (61), 153 (14), 152 (13), 132 (13), 129 (10), 89 (11), 77 (10), 63 (10); HREIMS  $m/z$  250.1566 (anal. calcd for  $\text{C}_{15}\text{H}_{22}\text{O}_3$ , 250.1569).

**Madolin C (3):** colorless needles; mp 59–60 °C;  $[\alpha]_{\text{D}} -18.56^\circ$  (*c* 0.10,  $\text{CHCl}_3$ ); IR (KBr)  $\nu_{\text{max}}$  1724, 1643, 1454, 1382, 1236, 1139  $\text{cm}^{-1}$ ; EIMS  $m/z$  206  $[\text{M}]^+$  (8), 162 (21), 148 (11), 144 (17), 134 (24), 132 (12), 125 (10), 122 (14), 120 (32), 108 (25), 106 (61), 104 (36), 94 (100); HREIMS  $m/z$  206.1670 (anal. calcd for  $\text{C}_{14}\text{H}_{22}\text{O}$ , 206.1671).

**Madolin D (4):** colorless oil;  $[\alpha]_{\text{D}} +188.41^\circ$  (*c* 0.028,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ): 225.4 (3.86), 255.6 (3.72) nm; IR (KBr)  $\nu_{\text{max}}$  1737, 1676, 1629, 1371, 1236, 1151  $\text{cm}^{-1}$ ; EIMS  $m/z$  290  $[\text{M}]^+$  (9), 231 (11), 217 (28), 215 (12), 202 (33), 201 (44), 189 (15), 187 (24); HREIMS  $m/z$  290.1518 (anal. calcd for  $\text{C}_{17}\text{H}_{22}\text{O}_4$ , 290.1519).

**Madolin E (5):** colorless oil;  $[\alpha]_{\text{D}} +9.20^\circ$  (*c* 0.44,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 237.4 (3.66) nm; IR (KBr)  $\nu_{\text{max}}$  1775, 1652, 1527, 1139  $\text{cm}^{-1}$ ; EIMS  $m/z$  232  $[\text{M}]^+$  (4), 136 (70), 121 (73), 107 (59), 105 (32), 93 (96), 81 (90), 68 (100); HREIMS  $m/z$  232.1460 (anal. calcd for  $\text{C}_{15}\text{H}_{20}\text{O}_2$ , 232.1463).

**Acknowledgment.** The authors are grateful for financial support from National Science Council of the Republic of China grant (NSC 84-2331-B006-074).

## References and Notes

- (1) Liu, T. S.; Lai, M. J. In *Flora of Taiwan*; Epoch: Taiwan, 1976; Vol. 2, p 572.
- (2) Jiangsu New Medicine College, in *Encyclopedia of Chinese Materia Medica*; Shanghai Science and Technology Press: Shanghai, 1977; Vol. 1, p 294.
- (3) Pakrashi, S. C.; Partha P. G.; Chakrabarty, S.; Achari, B. *J. Org. Chem.* **1980**, *45*, 4765–4767.
- (4) Wu, T. S.; Ou, L. F.; Teng, C. M. *Phytochemistry* **1994**, *36*, 1063–1068.
- (5) Ding L. S.; Lou, F. C. *Chung Ts'ao Yao* **1980**, *11*, 484–486.
- (6) Ruecker, G.; Chen, W.; Mayer, R.; Will, G.; Guellmann, A. *Phytochemistry* **1990**, *29*, 983–985.
- (7) Jackman, L. M.; Sternhell, S. In *Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry*, 2nd ed.; Pergamon Press: New York, 1969; p 286.
- (8) Zheng, G. C.; Ichikawa, A.; Ishitsuka, M. O.; Kusumi, T.; Yamamoto, H.; Kakisawa, H. *J. Org. Chem.* **1990**, *55*, 3677–3679.

NP970491+