Isoprenylated Naphthoquinone Dimers Firmianones A, B, and C from *Firmiana platanifolia*

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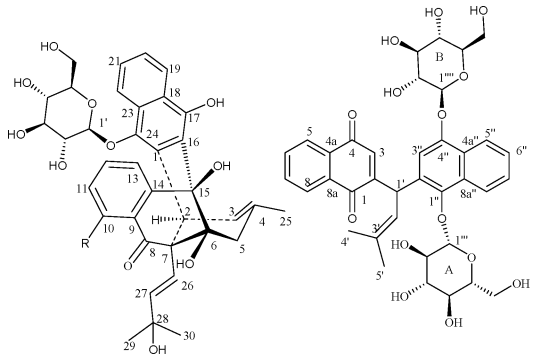
Three new compounds designated as firmianones A, B, and C (**1**−**3**), along with 13 known compounds, were isolated from the roots of *Firmiana platanifolia*. Their structures were elucidated by interpretation of HRESIMS, ^{1}H−^{1}H COSY, HMQC, HMBC, and NOESY. The absolute configurations of firmianones A and B with a rare hexacyclic skeleton were determined by CD exciton-coupling experiments. Firmianones A and B exhibited moderate cytotoxicity to the P388 cancer cell line.

The root bark of *Firmiana platanifolia* (L.f.) Marsili (Sterculiaceae) is a Chinese herbal medicine used in the treatment of numerous disorders such as rheumatism, asthma, fractures, and tumors.[1] Previous investigations of the leaves of *F. platanifolia* yielded several alkaloids[2] and flavonoids.[3] The seed oil yielded sterculic acid, malvalic acid,[4] and several alkaloids.[5] The stem bark afforded quercitrin.[6] The chemical study of the root has not been reported. In the course of our search for biologically active compounds[7] from medicinal plants, we have examined the EtOH extract of the root of the title plant and succeeded in isolating three new isoprenylated naphthoquinone dimers, along with 13 known compounds.



1 Firmianone A R=H
2 Firmianone B R=OH

3 Firmianone C

Results and Discussion

The dried plant material was extracted with 95% EtOH, and the concentrate was partitioned between H_2O and $CHCl_3$. The $CHCl_3$-soluble part was fractionated on a silica gel column, affording four groups of eluates, which yielded six known compounds after further chromatographic purification. The H_2O-soluble part was fractionated on a macroporous resin column, affording four groups of eluates, which yielded three new isoprenylated naphthoquinone dimers (**1**−**3**), six phenethyl alcohol glycosides, and one lignan glycoside after further chromatographic purification.

The known compounds were characterized by detailed NMR analyses as martynoside,[8] isomartynoside,[8] leucosceptoside A,[9] acteoside,[9] acteoside isomer,[9] forsythoside E,[10] (+)-syringaresinol-*O*-*β*-D-glucopyranoside,[11] α-lapachone,[12] 9-hydroxy-α-lapachone,[13] tectol,[14] paulownin,[15] sesamin,[16] and yangambin.[17]

Firmianone A (**1**) (14 mg, 0.00014%) was isolated as an optically active yellow powder, $[\alpha]^{20}_D$ −255° (*c* 0.085, CH_3-OH). The ESIMS of firmianone A (**1**) exhibited quasi-molecular ions $[M + Na]^+$ at *m/z* 669.3 and $[M - H]^-$ at *m/z* 645.6. Its molecular formula was determined as $C_{36}H_{38}O_{11}$ by the HRESIMS, which showed a molecular ion peak at *m/z* 669.2328 ($[M + Na]^+$). The ^{1}H NMR, ^{13}C NMR, ^{1}H−^{1}H COSY, HMQC, and HMBC experiments revealed the presence of a 3-hydroxy-3-methylbut-1(*E*)-enyl side chain (C-26 to C-30) [*δ* 123.8 (CH, C-26), 144.2 (CH, C-27), 72.3 (C, C-28), 30.0 (CH_3, C-29), 30.6 (CH_3, C-30); *δ* 5.96 (1H, d, *J* = 16.2 Hz, H-26), 6.20 (1H, d, *J* = 16.2 Hz, H-27), 1.34 (6H, s, H-29 and H-30)], a *β*-glucosyl group (C-1′ to C-6′) [*δ* 108.0 (CH, C-1′), 76.1 (CH, C-2′), 78.5 (CH, C-3′), 72.2 (CH, C-4′), 78.4 (CH, C-5′), 63.2 (CH_2, C-6′); *δ* 4.54 (1H, d, *J* = 7.3 Hz, H-1′), 3.60 (4H, m, H-2′, H-3′ and H-6′), 3.48 (1H, t, *J* = 9.0 Hz, H-4′), 3.03 (1H, m, H-5′)], a −CH−CH=C(Me)CH_2− group (C-2 to C-5 and C-25) [*δ* 43.1 (CH, C-2),126.4 (CH, C-3), 132.6 (C, C-4), 40.1(CH_2, C-5), 22.4 (CH_3, C-25); *δ* 4.79 (1H, d, *J* = 5.7 Hz, H-2), 5.84 (1H, d, *J* = 5.7 Hz, H-3), 2.14 (1H, d, *J* = 8.7 Hz, H-5), 3.23 (1H, d, *J* = 8.7 Hz, H-5), 1.54 (3H, s, H-25)], a tetrasubstituted dihydroxynaphthalene (C_1 and C-16 to C-24) [*δ* 118.4 (C, C-1), 128.3 (C, C-16), 151.3 (C, C-17), 126.4 (C, C-18), 123.0 (CH, C-19), 126.2 (CH, C-20), 127.5 (CH, C-21), 125.0 (CH, C-22), 131.1 (C, C-23), 143.8 (C, C-24); *δ* 7.99 (1H, d, *J* = 8.1 Hz, H-19), 7.26 (1H, t, *J* = 8.2 Hz, H-20), 7.32 (1H, t, *J* = 7.9 Hz, H-21), 8.20 (1H, d, *J* = 8.5 Hz, H-22)], and an *ortho*-substituted benzoyl group (C-8 to C-14) [*δ* 203.3 (C, C-8), 133.0 (C, C-9), 128.4 (CH, C-10), 128.2 (CH, C-11), 135.2 (CH, C-12), 123.4 (CH, C-13), 150.9 (C, C-14); *δ* 7.70 (1H, d, *J* = 7.7 Hz, H-10), 7.22 (1H, t, *J* = 7.6 Hz, H-11), 7.52 (1H, t, *J* = 7.6 Hz, H-12), 7.89 (1H, d, *J* = 7.8 Hz, H-13)]. The functionalities above accounted for 15 of 18 degrees of unsaturation of **1**, which suggested that firmianone A contained another tricyclic structure. The structure of the tricyclic core was determined by tracing the connections shown in the HMBC spectrum (Table 1). The C-2 methine proton at *δ* 4.79 correlated with the quaternary carbon signals at *δ* 78.4 (C-6), 59.8 (C-7), and 203.3 (C-8), while one of the C-5 methylene protons at *δ* 3.23 correlated with the quaternary carbon signals at *δ* 78.4 (C-6) and 59.8 (C-7). Therefore, carbons 2, 3, 4, 5, 6, and 7 formed the first six-membered ring. The C-13 methine proton at *δ* 7.89 of the *ortho*-substituted benzoyl group

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Table 1. ^{1}H and ^{13}C NMR, HMBC, and NOESY Data of Firmianones A (**1**) and B (**2**)

	A (**1**)			B (**2**)		
position	^{1}H[a]	^{13}C[b]	HMBC[c]	NOESY	^{1}H[a]	^{13}C[b]
1		118.4				117.7
2	4.79 (d, 5.7)	43.1	1, 3, 4, 6, 7, 8, 16, 24, 26	3	4.80 (d, 5.7)	42.6
3	5.84 (d, 5.7)	126.4	2, 5, 7, 25	2, 25	5.85 (d, 5.7)	126.2
4		132.6				132.3
5	2.14 (d, 8.7)	40.1	3, 4, 6, 15	25	2.19 (d, 8.7)	39.7
	3.23 (d, 8.7)		3, 4, 6, 7, 15, 25		3.20 (d, 8.7)	
6		78.4				78.2
7		59.8				59.9
8		203.3				208.1
9		133.0				116.3
10	7.70 (d, 7.7)	128.4	8, 12, 14			163.5
11	7.22 (t, 7.6)	128.2	9, 13	12	6.65 (d, 8.3)	117.0
12	7.52 (t, 7.6)	135.2	10, 11, 14	11, 13	7.40 (t, 8.0)	137.9
13	7.89 (d, 7.8)	123.4	9, 11, 15	12	7.36 (d, 7.8)	113.8
14		150.9				151.6
15		83.0				82.9
16		128.3				127.9
17		151.3				151.3
18		126.4				126.3
19	7.99 (d, 8.1)	123.0	17, 21, 23	20	7.99 (d, 8.3)	122.9
20	7.26 (t, 8.2)	126.2	18, 22	19, 21	7.28 (t, 7.8)	126.1
21	7.32 (t, 7.9)	127.5	19, 23	20, 22	7.31 (t, 7.8)	127.4
22	8.20 (d, 8.5)	125.0	18, 20, 24	21	8.21 (d, 8.3)	124.7
23		131.1				130.8
24		143.8				143.7
25	1.54 s	22.4	3, 4, 5	3, 5	1.53	22.7
26	5.96 (d, 16.2)	123.8	6, 7, 8, 27	27, 29, 30	5.96 (d, 16.2)	123.1
27	6.20 (d, 16.2)	144.2	6, 7, 28, 29, 30	26, 29, 30	6.23 (d, 16.2)	144.4
28		72.3				72.1
29	1.34 s	30.0	26, 27, 28	26, 27	1.35	30.0
30	1.34 s	30.6	26, 27, 28	26, 27	1.35	30.4
1′	4.54 (d, 7.3)	108.0	24, 2′, 3′	4′, 5′	4.54 (d, 7.7)	108.1
2′	3.60 m	76.1	1′, 3′		3.60 m	75.8
3′	3.60 m	78.5	1′, 2′, 4′, 5′		3.51 (t, 9.0)	78.3
4′	3.48 (t, 9.0)	72.2	3′, 5′, 6′	1′, 5′	3.48 (t, 9.0)	71.9
5′	3.03 m	78.4	3′, 4′	1′, 4′	3.02 m	78.4
6′	3.60 m	63.2	4′		3.60 m	62.9

[a] Recorded in CD_3OD at 500 MHz. [b] Recorded in CD_3OD at 125 MHz. [c] Protons that correlate with carbons

correlated with the quaternary carbon signal at δ 83.0 (C-15), which established the second six-membered ring, containing carbons 6, 7, 8, 9, 14, and 15. The third six-membered ring, including carbons 1, 2, 7, 6, 15, and 16, was established from the cross-peaks in the HMBC experiment between (i) the C-2 methine proton at δ 4.79 and the quaternary carbon at δ 118.4 (C-1), 128.3 (C-16), and 143.8 (C-24) and (ii) the two C-5 methylene protons at δ 2.14 and 3.23 correlated with the quaternary carbon at δ 83.0 (C-15). Other correlations in the HMBC spectrum of **1**, the C-26 methine proton at δ 5.96 with the quaternary carbons at δ 78.4 (C-6), 59.8 (C-7), and 203.3 (C-8) and the C-1′ methine proton at δ 4.54 with the quaternary aromatic carbon at δ 143.8 (C-24), elucidated that the 3-hydroxy-3-methylbut-1(*E*)-enyl group was located at C-7 and the −*O*-pyranoglucosyl group at C-24. On the basis of its molecular formula, besides the identified residues above and the hexacyclic core, **1** contained three other hydroxyl groups. The ^{1}H NMR and ^{13}C NMR experiments revealed that two of them were located at the oxygenated quaternary carbons at δ 78.4 (C-6) and 83.0 (C-15), repectively, and the third hydroxyl group attached to the oxygenated quaternary aromatic carbon at δ 151.3 (C-17).

Acid hydrolysis[18] of **1** yielded D-glucose by GC analysis of its leucine derivative, compared with the derivative of the standard glucose. The chemical shift, the signal multiplicity, the absolute value of the coupling constant, its magnitude in the ^{1}H NMR spectrum, and the ^{13}C NMR data [δ 4.54 (1H, d, J = 7.3 Hz, H-1′), δ 108.0 (CH, C-1′ of glc)] indicated a β-configuration for the glucosyl unit.

The molecular model showed that the hexacyclic system itself set up the relative configurations at the chiral centers C-2, C-6, C-7, and C-15, which were confirmed from a 2D NOESY experiment. The two strongly absorbing benzophenone and naphthalene chromophores were spatially close and constitute a chiral system. Their electric transition moments interact spatially and the energy level of the excited states splits, as reflected in the CD spectra.[19] Consequently the CD spectrum of **1** (CH_3OH, Figure 1) displayed a strong negative CD minimum at λ 260 nm ($\Delta\epsilon$ −8.5) and maximum at λ 230 nm ($\Delta\epsilon$ +5.2). The large A value of Cotton effects observed for **1** was attributed to the dipole−dipole interaction between the electric transition moments of the benzophenone chromophore and the naphthalene chromophore. The long axis transitions of the two chromophores interacted as depicted in Figure 1. According to the "dibenzoate chirality rule"[20] and Harada's modified method,[21] the sign of the Cotton effects is negative, so we consequently established the absolute configurations of **1** at C-2, C-6, C-7, and C-15, which were 2*R*, 6*S*, 7*R*, and 15*S*, respectively.

The other minor constituent, firmianone B (**2**) (7.0 mg, 0.00007%), was isolated as a yellow powder, $[\alpha]^{20}_D$ −97.8° (*c* 0.00046, CH_3OH). Its molecular formula was determined as $C_{36}H_{38}O_{12}$ by the HRESIMS, in which a molecular ion peak was displayed at *m/z* 685.2276 ($[M + Na]^+$). Compound **2** had UV features similar to those of **1**. A comparison of the ^{1}H NMR and ^{13}C NMR data of **2** with those of **1** revealed that the only difference was that H-10 in **1** was replaced by a hydroxyl group. Its structure was confirmed

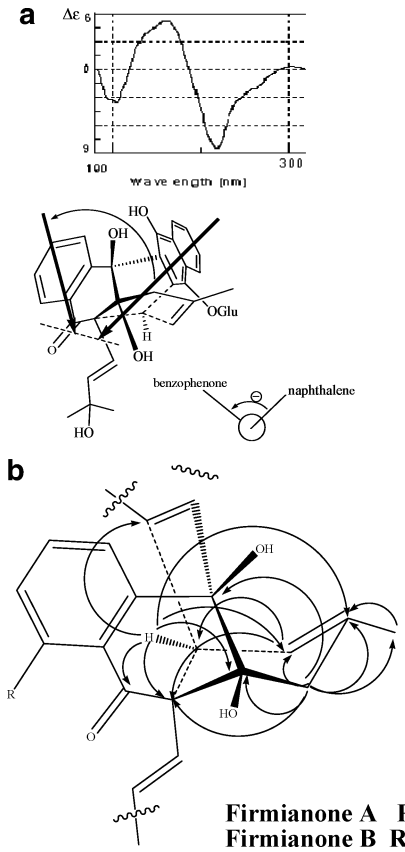


Figure 1. (a) CD spectrum and chiral analysis of firmianone A. (b) Key HMBC (H→C) correlations of firmianones A and B.

to be the 10-hydroxy derivative of firmianone A by ^{1}H−^{1}H COSY, HMQC, HMBC, and NOESY spectra.

Firmianones A and B had carbon skeletons similar to lippsidoquinone, previously isolated from *Lippia sidoides*.[22] Firmianones A and B were a pair of isoprenylated naphthoquinone dimers with a hexacyclo[14.8.0.0.^{2,7}0.^{6,15}0.^{9,14}0^{18,23}]-tetracosa-1(16),3,9(14),10,12,17,19,21,23-nonaen-8-one skeleton. They were presumably biosynthesized from 2-(3-hydroxy-3-methylbut-1-enyl)-[1,4]naphthoquinone **4**. Dehydration of **4** yielded 2-(3-methylbut-1,3-dienyl)-[1,4]naphthoquinone, which cyclized to a pentacyclonaphthoquinone dimer intermediate **5** by Diels−Alder reaction with **4**. Intramolecular cyclization, subsequent allylic hydroxylation, and *O*-glucosylation of **5** gave firmianones A and B finally (Scheme 1).

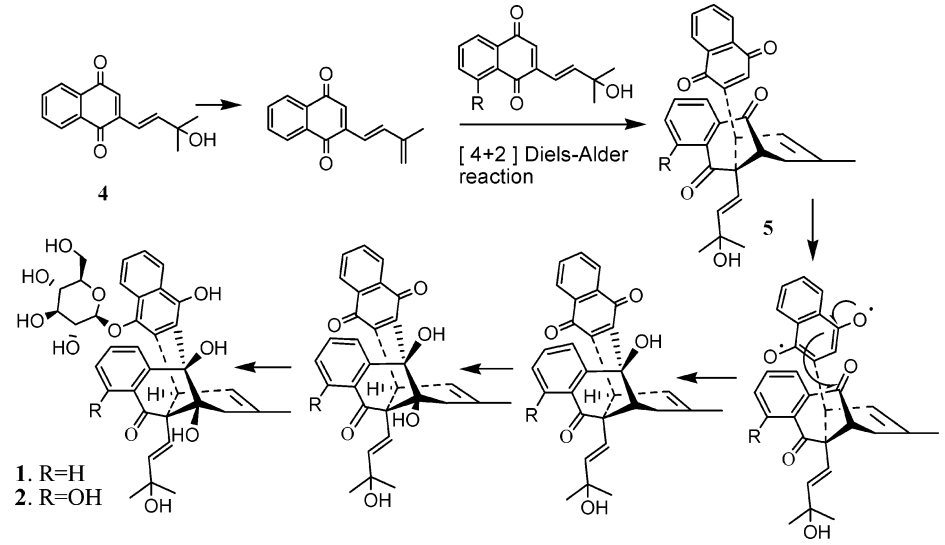
Table 2. ^{1}H and ^{13}C NMR and HMBC Data of Firmianone C (**3**)

position	^{1}H[a]	^{13}C[b]	HMBC[c]
1		186.3	
2		157.4	
3	6.55 s	136.2	1, 2, 4a
4		187.4	
5	8.02 (d, 8.9)	128.1	7
6	7.71 m	135.5	8
7	7.71 m	135.5	5
8	7.93 (d, 8.9)	127.3	6, 4a
4a		133.7	
8a		134.1	
1′	6.08 (d, 9.2)	40.4	1, 2, 3, 2′, 3′, 1″, 2″, 3″
2′	5.45 (d, 9.2)	125.4	4′, 5′
3′		138.6	
4′	1.86 s	26.6	2′, 3′, 5′
5′	1.86 s	19.5	2′, 3′, 4′
1″		145.7	
2″		134.2	
3″	7.31 s	111.3	1′, 1″, 4″, 4a″
4″		152.0	
5″	8.44 (d, 8.0)	124.1	7″, 8a″
6″	7.45 m	126.9	8″, 4a″
7″	7.42 m	128.0	5″, 8a″
8″	8.36 (d, 8.0)	124.1	
4a″		130.2	
8a″		128.0	
1‴	5.03 (d, 7.3)	106.7	1″, 3‴
2‴	3.40−3.65 m	76.2	5‴
3‴	3.40−3.65 m	78.6	
4‴	3.40−3.65 m	71.8	5‴
5‴	3.40−3.65 m	78.7	3‴
6‴	3.78 m	63.3	
1⁗	5.08 (d, 7.8)	103.5	4″, 3⁗
2⁗	3.40−3.65 m	75.4	
3⁗	3.40−3.65 m	78.4	4⁗
4⁗	3.40−3.65 m	71.6	5⁗
5⁗	3.40−3.65 m	78.7	3⁗
6⁗	3.80 m	62.8	

[a] Recorded in CD_3OD at 500 MHz. [b] Recorded in CD_3OD at 125 MHz. [c] Protons that correlate with carbons

Firmianones C (**3**) (17 mg, 0.00017%) was also isolated as an optically active yellow powder, $[\alpha]^{20}_D$ −28.5° (*c* 0.39, CH_3OH), with the following spectroscopic characteristics: UV (CH_3OH) λ_{max} (log ϵ) 252.8 (3.54) nm; ^{1}H and ^{13}C NMR (Table 2). The ESIMS of **3** exhibited a quasi-molecular ion $[M + HCOO^-]^-$ at *m/z* 753.5. Its molecular formula was

Scheme 1. Biogenetic Pathway Proposed for Firmianones A and B



determined as $C_{37}H_{40}O_{14}$ by HRESIMS (753.2386 [M + $HCOO^-$]$^-$). The ^{1}H NMR, ^{13}C NMR, ^{1}H−^{1}H COSY, HMQC, and HMBC experiments revealed the presence of a 3-methylbut-2-enyl side chain (C-1′ to C-5′) [δ 40.4 (CH, C-1′), 125.4 (CH, C-2′), 138.6 (C, C-3′), 26.6 (CH_3, C-4′), 19.5 (CH_3, C-5′); δ 6.08 (1H, d, J = 9.2 Hz, H-1′), 5.45 (1H, d, J = 9.2 Hz, H-2′), 1.86 (3H,s, H-4′), 1.86 (3H, s, H-5′)], two β-glucosyl groups, A (C-1‴ to C-6‴) [δ 106.7 (CH, C-1‴), 76.2 (CH, C-2‴), 78.6 (CH, C-3‴), 71.8 (CH, C-4‴), 78.7 (CH, C-5‴), 63.3 (CH_2, C-6‴); δ 5.03 (1H, d, J = 7.3 Hz, H-1‴), 3.78 (2H, m, H-6‴), 3.40−3.65 (4H, m, H-2‴, H-3‴, H-4‴, and H-5‴)] and B (C-1⁗ to C-6⁗) [δ 103.5 (CH, C-1⁗), 75.4 (CH, C-2⁗), 78.4 (CH, C-3⁗), 71.6 (CH, C-4⁗), 78.7 (CH, C-5⁗), 62.8 (CH_2, C-6⁗); δ 5.08 (1H, d, J = 7.8 Hz, H-1⁗), 3.80 (2H, m, H-6⁗), 3.40−3.55 (4H, m, H-2⁗, H-3⁗, H-4⁗, and H-5⁗)], a trisubstituted dihydroxynaphthalene group (C-1″ to C-8a″) [δ 145.7 (C, C-1″), 134.2 (C, C-2″), 111.3 (CH, C-3″), 152.0 (C, C-4″), 124.1 (CH, C-5″), 126.9 (CH, C-6″), 128.0 (CH, C-7″), 124.1 (CH, C-8″), 130.2 (C, C-4a″), 128.0 (C, C-8a″); δ 7.31 (1H, s, H-3″), 8.44 (1H, d, J = 8.0 Hz, H-5″), 7.45 (1H, m, H-6″), 7.42 (1H, m, H-7″), 8.36 (1H,d, J = 8.0 Hz, H-8″)], and a monosubstituted naphthoquinone group (C-1 to C-8a) [δ 186.3 (C, C-1), 157.4 (C, C-2), 136.2 (CH, C-3), 187.4 (C, C-4), 128.1 (CH, C-5), 135.5 (CH, C-6), 135.5 (CH, C-7), 127.3 (CH, C-8), 133.7 (C, C-4a), 134.1 (C, C-8a); δ 6.55 (1H, s, H-3), 8.02 (1H, d, J = 8.90 Hz, H-5), 7.71 (2H, m, H-6 and H-7), 7.93 (1H, d, J = 8.90 Hz, H-8). Acid hydrolysis of **3** yielded D-glucose. The chemical shifts, the signal multiplicities, the absolute values of the coupling constants, and the ^{1}H, ^{13}C NMR data [δ 5.03 (1H, d, J = 7.3 Hz, H-1‴ of glc-A), δ 106.7 (CH, C-1‴of glc-A) and 5.08 (1H, d, J = 7.8 Hz, H-1⁗ of glc-B), δ 103.5 (CH, C-1⁗ of glc-B)] indicated a β-configuration for the two glucosyl units. The cross-peak between H-1‴/C-1″ in the HMBC spectrum established that the glucosyl group A was located at C-1″, the cross-peak between H-1⁗/C-4″ established that the glucosyl group B was located at C-4″, and the cross-peaks between H-1′/C-1, H-1′/C-3, H-1′/C-1″, and H-1′/C-3″ established the dihydroxynaphthalene group and the naphthoquinone group located at C-1′. Thus, **3** was determined as 2-{1-[1,4-bis-β-D-glucosylnaphthalen-2-yl]-3-methylbut-2-enyl}-[1,4]naphthoquinone.

Firmianones A and B were evaluated for their cytotoxicity against the P388 cell line and were found to be active, with ED_{50} values of 6.5 ± 0.5 and 8.1 ± 0.6 μM, respectively.

Experimental Section

General Experimental Procedures. Optical rotations were measured in MeOH with a Perkin-Elmer model 341 polarimeter. NMR spectra were obtained on a Bruker AMX-500 spectrometer in CD_3OD solution. ESIMS were run on a Bruker Esquire 3000 plus spectrometer in MeOH, and HRESMS measurements were carried out on a Bruker Atex III instrument in MeOH. Silica gel (200−300 mesh) and Sephadex LH-20 were used for column chromatography. Macroprous resin AB-8 (The Chemical Plant of Nankai University, Tianjin, China), MCI GEL CHP20P (75−150 μm) (Mitsubishi Chemical Industry LTD), and C-18 reversed-phase silica gel (ODS) (20−45 μm) (Fuji Silysia Chemical LTD) were also used for column chromatography.

Plant Material. *Firmiana platanifolia* (L.f.) Marsili was collected in Shandong Province, People's Republic of China, in May 2001. A voucher specimen of the plant (No. PA0501) was identified by Mr. Jin-Gui Shen and deposited at the herbarium of Chinese National Center for Drug Screening, Shanghai, People's Republic of China.

Extraction and Isolation. The dried and powdered root of *F. platanifolia* (10.0 kg) was extracted with 95% EtOH (3 × 35 L × 7 days) at room temperature, and the extract was concentrated in vacuo. The concentrate was partitioned between $CHCl_3$ (1200 mL) and H_2O (2000 mL). The H_2O-soluble portion (100 g) was then separated into four fractions by macroprous resin column chromatography, eluting with different proportions of EtOH−H_2O [15% × 5 L (fraction 1, 20 g), 30% × 10 L (fraction 2, 20 g), 60% × 10 L (fraction 3, 30 g), and 100% × 2 L (fraction 4, 1.2 g)]. Fraction 1 (10 g) was subjected to CC on silica gel (L-30 cm × D-5 cm), eluted with $CHCl_3$−MeOH (2:1) × 2 L, to give fraction 1-1 (3 g). Fraction 1-1 (700 mg) was further subjected to CC on Sephadex LH-20 (L-1 m × D-2 cm), eluted with MeOH−50% H_2O × 200 mL, to give forsythoside E (15 mg). Fraction 2 (20 g) was subjected to CC on MCI ((L-30 cm × D-5 cm), eluted with different proportions of MeOH−H_2O [25% × 3 L (fraction 2-1, 4 g), 35% × 2 L (fraction 2-2, 8 g), 45% × 2 L (fraction 2-3, 3 g), and 70% × 1 L (fraction 2-4, 560 mg)]. Fraction 2-1 (500 mg) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with MeOH−20% H_2O × 2 L, to give acteoside (43 mg) and acteoside isomer (16 mg). Fraction 2-2 (1 g) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with MeOH−25% H_2O × 3 L, to give isomartynoside (560 mg) and leucosceptoside A (89 mg). Fraction 2-3 (500 mg) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with MeOH−30% H_2O × 2 L, to give martynoside (13 mg). Fraction 2-4 (560 mg) was further subjected to CC on silica gel (L-15 cm × D-3 cm), eluted with $CHCl_3$−MeOH (20:1) × 1 L, to give (+)-syringaresinol-*O*-β-D-glucopyranoside (15 mg). Fraction 3 (10 g) was subjected to CC on MCI (L-30 cm × D-5 cm), eluted with different proportions of MeOH−H_2O [50% × 2 L (fraction 3-1, 5 g), 60% × 2 L (fraction 3-2, 120 mg), and 70% × 2 L (fraction 3-3, 1 g)]. Fraction 3-1 (500 mg) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with methanol−55% water × 2 L, to give compound **3** (firmianone C 14 mg) and martynoside (47 mg). Fraction 3-2 (12 mg) was further subjected to CC on Sephadex LH-20 (L-1 m × D-2 cm), eluted with MeOH−50% H_2O × 2 L, to give compound **1** (firmianone A, 14 mg) and **2** (firmianone B, 7 mg). The $CHCl_3$-soluble portion (20 g) was fractionated on a silica gel column (L-30 cm × D-5 cm), eluting with different proportions of $CHCl_3$−MeOH [100:0 × 2 L (fraction A, 300 mg), 100:2 × 1 L (fraction B, 2 g), 100:5 × 1 L (fraction C, 3 g), and 100:10 × 1 L (fraction D, 500 mg)]. Fraction A (300 mg) was subjected to CC on silica gel (L-15 cm × D-3 cm), eluted with petroleum ether−EtOAc (50:1), to give tectol (34 mg). Fraction B (2 g) was subjected to CC on silica gel (L-30 cm × D-4.5 cm), eluted using different proportions of petroleum ether−acetone [20:1 × 1 L (fraction A-1, 76 mg) and 10:1 × 1 L (fraction A-2, 1 g)]. Fraction A-1 (70 mg) was further subjected to CC on Sephadex LH-20 (L-1 m × D-2 cm), eluted with $CHCl_3$−50% MeOH, to give α-lapachone (11 mg). Fraction A-2 (150 mg) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with MeOH−55% H_2O × 2 L, to give 9-hydroxy-α-lapachone (29 mg). Fraction C (3 g) was subjected to CC on silica gel (L-25 cm × D-4 cm), eluted using different proportions of $CHCl_3$−MeOH [100:0 × 1 L (fraction C-1, 940 mg) and 100:5 × 1 L (fraction C-2, 1.3 g)]. Fraction C-1 (100 mg) was further subjected to CC on Sephadex LH-20 (L-1 m × D-2 cm), eluted with $CHCl_3$−50% MeOH × 500 mL, to give yangambin (24 mg). Fraction C-2 (560 mg) was further subjected to CC on ODS (L-15 cm × D-4.5 cm), eluted with MeOH−50% H_2O, to give paulownin (29 mg) and sesamin (32 mg).

Firmianone A (1): yellow powder; $[\alpha]^{20}_D$ −255° (*c* 0.085, MeOH); UV (MeOH) λ_{max} (log ϵ) 252.8 (3.54); CD (*c* 7 × 10^{-4} M, MeOH) λ_{max} ($\Delta\epsilon$) 205 ($\Delta\epsilon$ −3.2), 230 ($\Delta\epsilon$ +5.2), 260 nm (−8.5), 340 ($\Delta\epsilon$ −5.2); IR (film) ν_{max} 3419, 2970, 2927, 1664, 1594, 1454, 1292, 1076, 1034, 742, 596 cm^{-1}; HRESIMS *m/z* 669.2328 (calcd for $C_{36}H_{38}O_{11}Na$ 669.2312); ^{1}H NMR (500 MHz, CD_3OD) and ^{13}C NMR (125 MHz, CD_3OD) data, see Table 1.

Firmianone B (2): yellow solid; $[\alpha]^{20}_D$ −97.8° (*c* 0.00046, MeOH); UV (MeOH) λ_{max} (log ϵ) 252.8 (3.54); CD (*c* 7 × 10^{-4} M, MeOH) λ_{max} ($\Delta\epsilon$) 202 ($\Delta\epsilon$ −3.0), 232 ($\Delta\epsilon$ +5.0), 260 nm (−8.3), 340 ($\Delta\epsilon$ −5.0); IR (film) ν_{max} 3419 (OH); IR (film) ν_{max} 3351, 2924, 1714, 1635, 1451, 1404, 1288, 1028, 758 cm^{-1}; HRESIMS *m/z* 685.2276 (calcd for $C_{36}H_{38}O_{12}Na$ 685.2261); ^{1}H

NMR (500 MHz, CD_3OD) and ^{13}C NMR (125 MHz, CD_3OD) data, see Table 1.

Firmianone C (3): yellow powder; $[\alpha]^{20}_D$ −28.5° (*c* 0.39, CH_3OH); IR (film) ν_{max} 3405, 2918, 2881, 1658, 1593, 1458, 1369, 1303, 1273, 1070, 1037, 777, 578 cm^{-1}; HRESIMS *m/z* 753.2386 {calcd for $C_{38}H_{41}O_{16}$ 753.2394 ($[M + HCOO^-]^-$)}; ^1H NMR (500 MHz, CD_3OD) and ^{13}C NMR (125 MHz, CD_3OD) data, see Table 2.

Acid Hydrolysis[18,23] of Compounds 1−3. Compounds **1**−**3** (4 mg each) in 10% HCl−dioxane (1:1, 1 mL) were heated at 80 °C for 4 h in a water bath. Each of the reaction mixtures was neutralized with Ag_2CO_3, filtered, and then extracted with $CHCl_3$ (1 mL × 3). After concentration, each H_2O layer (monosaccharide portion) was examined by TLC with $CHCl_3$−MeOH−H_2O (55:45:10) and compared with authentic samples. The sugar residue was then dissolved in 1 mL of anhydrous pyridine under Ar, 2 mg of L-leucine methyl ester hydrochloride was added, and the mixture was warmed at 60 °C for 1 h. $NaBH_4$ (2 mg) was added, and the mixture was stirred for 1 h at ambient temperature. Then 0.2 mL of Me_3SiCl (Shengyu Chemical Ltd., Shanghai, China) was added, and warming at 60 °C was continued for another 30 min. The leucine derivatives were subjected to GC analysis, column temperature 200 °C; injection temperature 250 °C; carrier gas N_2 at flow rate of 32.2 mL/min; derivative of d-glucose with a t_R of 13.95 min.[18]

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Supporting Information Available: NMR spectra of firmianones A−C. This material is available free of charge via the Internet at http://pubs.acs.org.

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