A NEW HYDROQUINONE DIGLUCOSIDE FROM *Lysimachia fordiana*

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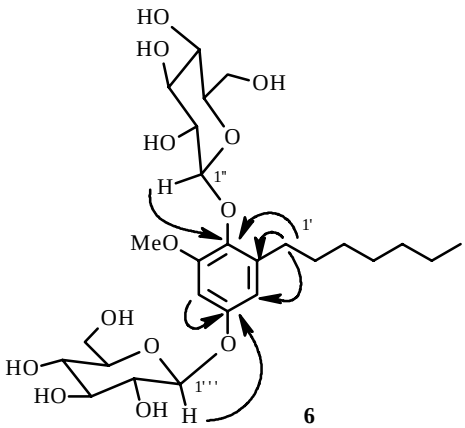
UDC 547.97

A new hydroquinone diglucoside along with five known compounds was isolated from the whole plant of Lysimachia fordiana *Oliv. The structure of the new compound was determined to be 2-heptyl-6-methoxy-1,4-hydroquinone-1,4-di-O-*β*-D-glucopyranoside (**6**). The five known compounds were identified as pentacosane (**1**), stigmasterol (**2**), 2-heptyl-6-methoxy-1,4-benzoquinone (**3**), palmitic acid (**4**), and rutin (**5**), respectively. This is the first report of the isolation of* Lysimachia fordiana *Oliv. in the family Primulaceae.*

Key words: Primulaceae, *Lysimachia fordiana,* 2-heptyl-6-methoxy-1,4-hydroquinone-1,4-di-O-*β*-*D*-glucopyranoside.

Lysimachia is one of the largest genera of Primulaceae, consisting of approximately 180 species. The center of diversity is southwestern China where there are 122 species, of which 110 are endemic to the region [1]. *Lysimachia fordiana* Oliv., a shrub species occurring in Yunnan, Guangxi, and Guangdong provinces [2], was commonly used in folk medicine for the treatment of wounds and scrofula and subcutaneous ulcer in China [3]. No phytochemical investigation had been carried out on this species previously. In order to investigate its natural products, we conducted the study on *L. fordiana* for the first time and obtained a new compound: 2-heptyl-6-methoxy-1,4-hydroquinone-1,4-di-O-*β*-D-glucopyranoside (**6**), along with pentacosane (**1**) [4], stigmasterol (**2**) [5], 2-heptyl-6-methoxy-1,4-benzoquinone (**3**) [7], palmitic acid (**4**) [7], and rutin (**5**) [8]. In this paper, we report the isolation and structure elucidation of these compounds.

Compound **6** was obtained as a white powder. Its IR spectrum showed absorptions at 3394 (OH), 1598, 1486 (aromatic ring) cm^{-1}. The ^1H NMR spectral data (Table 1) showed the presence of a 1,2,3,5-tetrasubstituted benzene ring (δ 7.01, d, J = 2.0 Hz and δ 7.12, d, J = 2.0 Hz), an aromatic methoxy (δ 4.03) and two monosaccharide residues (δ 5.54, d, J = 8.0 Hz and δ 5.43, d, J = 7.6 Hz), as well as an aliphatic chain.



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The observation of an aliphatic methyl and six aliphatic methylene resonances in the ^{13}C NMR spectrum (Table 1) as well as a triplet at δ 0.91 (3H, J = 7.2 Hz) and several multiplets between δ 1.24 and δ 3.17 in the ^1H NMR spectrum enabled the establishment of the aliphatic chain as an *n*-heptyl group. Combined analysis of the ^1H–^1H COSY, the HMQC, and the HMBC spectra led to the assignment of the carbon signals for monosaccharide residues and indicated the monosaccharide residues to be two separate *β*-D-glucopyranosyl moieties. Connectivities between the above partial structures were obtained from the HMBC spectrum (Fig. 1).

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0009-3130/04/4005-0457

TABLE 1. ^{1}H (400 MHz) and ^{13}C (100 MHz) NMR Data of Compound **6** (C_5D_5N, TMS, δ, ppm)

No.	δ_H (J/Hz)	δ_C	No.	δ_H (J/Hz)	δ_C
1		139.7	Glu″		
2		140.5	1″	5.43 (1H, d, J = 7.6)	106.1
3	7.01 (1H, d, J = 2.0)	111.0	2″	4.44 (1H, m)	75.4
4		156.1	3″	4.23 (1H, m)	79.0
5	7.12 (1H, d, J = 2.0)	101.8	4″	4.33-4.26*	71.9
6		154.0	5″	4.46 (1H, m)	78.3
OCH_3	4.03 (3H, s)	57.4	6″	4.56 (1H, m), 4.37-4.26*	62.9
1′	2.98 (1H, m), 3.17 (1H, m)	31.6	Glu‴		
2′	1.74 (2H, m)	31.6	1‴	5.54 (1H, d, J = 8.0)	103.3
3′	1.39 (2H, m)	30.6	2‴	4.32 (1H, m)	76.4
4′	1.24 (2H, m)	23.8	3‴	3.87 (1H, m)	78.7
5′	1.24 (2H, m)	30.3	4‴	4.33-4.26*	72.0
6′	1.90 (2H, m)	32.9	5‴	4.39 (1H, m)	78.5
7′	0.91 (3H, t, J = 7.2)	15.2	6‴	4.37-4.26*	62.9

*Glucosyl proton signals unclear due to overlapping.

The HMBC correlations from the anomeric proton at δ 5.43 (H-1″) to the aromatic quaternary carbon at δ 139.7 (C-1), from the latter to both aromatic protons at δ 7.01 (H-3) and δ 7.12 (H-5), and the methylene protons at δ 2.98 and 3.17 (H_2-1′) of the *n*-heptyl group, and from H-3 to C-1′ indicated the attachment of the first glucose moiety at C-1 and the substitution of the *n*-heptyl group at C-2. In turn, the correlations from the anomeric proton at δ 5.54 (H-1‴) to the carbon at δ 156.1, from the latter to both H-3 and H-5, and from the carbon at δ 154.0 (C-6) to H-5 and the methoxy protons at δ 4.03 indicated the connection between the second glucose moiety and C-4 and the attachment of the methoxy group at C-6. Therefore, the structure of compound **2** was elucidated as 2-heptyl-6-methoxy-hydroquinone-1,4-di-O-*β*-D-glucopyranoside. The fragment ions at *m/z* 238 $[M–2Glu]^+$ (98) and 400 $[M–Glu]^+$ (**2**) in the EI-MS spectrum supported the structure.

EXPERIMENTAL

General Experimental Procedures. NMR spectra were measured on a Bruker DRX-400 (400 MHz for ^{1}H and 100 MHz for ^{13}C spectra) spectrometer. Chemical shifts were expressed in δ values with reference to TMS as internal standard, and coupling constants (J) were given in Hz. EI-MS and ESI-MS were recorded on a Micromass Platform and API2000 LC/MS/MS spectrometer respectively. IR spectra were obtained on an Analect RFX-65A spectrometer respectively.

Plant Material. *L. fordiana* were collected from the Wuzhishan Mountains of Guangdong province in July 2002. The voucher specimen (Gang Hao, 387) was deposited at the Herbarium of South China Institute of Botany, Chinese Academy of Sciences, and authenticated by Prof. Chi-ming Hu, South China Institute of Botany.

Extraction and Isolation. The powder of the whole plant of *L. fordiana* was extracted with EtOH–H_2O (95:5,V/V). After concentration under reduced pressure, the aqueous residue was partitioned with petroleum ether, EtOAc, and *n*-BuOH, respectively. The petroleum ether-soluble portion (900 g) was chromatographed over silica gel (6 ≅ 98 cm, 40 ml/min, 250 ml) and eluted with petroleum ether-Me_2CO gradient solvent. Combination of similar fractions on the basis of TLC analysis afforded 6 fractions. Fraction 1 was chromatographed over silica gel with petroleum ether-acetone (98:2) to give pentacosane (**1**, 20 mg). Fraction 2 was chromatographed over silica gel with petroleum ether–$CHCl_3$ (80:20) to afford stigmasterol (**2**, 1 g) and 2-heptyl-6-methoxy-1,4-benzoquinone (**3**, 3 g). The EtOAc-soluble part was isolated by the same methods above to afford compound **1**–**3** and get palmitic acid (**4**, 15 mg, petroleum ether–Me_2CO, 95:5). The *n*-BuOH-soluble part was subjected to D101 resin column chromatography and eluted with H_2O, 20% MeOH, 50% MeOH, 70% MeOH and MeOH, respectively. The 50% MeOH eluted part was dissolved with MeOH, the soluble part was subjected to polyamide chromatography and eluted with $CHCl_3$–MeOH–$CH_3COC_2H_5$–*n*-BuOH (4:2:1:0.5) to obtain rutin (**5**, 1.1 g), and the insoluble part was recrystallized with MeOH–H_2O (1:1) to get 2-heptyl-6-methoxy-1,4-hydroquinone-1,4-di-O-*β*-D-glucopyranoside (**6**, 120 mg).

Pentacosane (1): White wax, mp 54–56 °C (Me_2CO); IR spectrum (KBr, ν, cm^{-1}): 2956, 2915, 2850, 1473, 1463, 1476 (C-H), 719 ([CH_2]n); EI-MS m/z: $[M]^+$ 352 (1), 99 (12), 85 (48), 71 (65), 57 (100); ^1H NMR ($CDCl_3$, δ ppm, J/Hz): 0.84 (6H, t, J = 6.4, CH_3-1, CH_3-25), 1.23 (46H, m, H-2~24); ^{13}C NMR ($CDCl_3$, δ, ppm): 31.9 (C-3, 23), 29.7 (C-5~21), 29.4 (C-4, 22), 22.7 (C-2, 24), 14.1 (C-1, 25).

Stigmasterol (2): White needles (EtOAc), ESI-MS (MeOH) *m/z*: 413.4 ($[M]^+$+1); mp 169–170 °C (EtOAc); IR spectrum (KBr, ν, cm^{-1}): 3345 (OH), 2920, 2860, 1450 (C-H), 1380 (2Me), 1055 (C-O); ^1H NMR ($CDCl_3$, δ, ppm, J/Hz): 5.32 (1H, d, J = 4.2, H-6), 5.13 (1H, dd, J_1 = 8.4, J_2 = 14.8, H-22), 5.00 (1H, dd, J_1 = 8.4, J_2 = 14.8, H-23), 3.50 (1H, m, H-3); ^{13}C NMR ($CDCl_3$) δ ppm: 37.2 (C-1), 31.6 (C-2), 71.7 (C-3), 42.3 (C-4), 140.7 (C-5), 121.7 (C-6), 31.9 (C-7), 31.9 (C-8), 50.1 (C-9), 36.5 (C-10), 21.1 (C-11), 39.7 (C-12), 42.3 (C-13), 56.8 (C-14), 24.3 (C-15), 28.9 (C-16), 55.9 (C-17), 12.0 (C-18), 19.4 (C-19), 40.5 (C-20), 21.1 (C-21), 138.3 (C-22), 129.3 (C-23), 51.2 (C-24), 31.9 (C-25), 19.0 (C-26), 21.2 (C-27), 25.4 (C-28), 12.2 (C-29).

2-Heptyl-6-methoxy-1,4-benzoquinone (3): Yellow needles, IR spectrum (KBr, ν, cm^{-1}): 3073 (C=C-H), 2965, 2911, 2850 (C-H), 1679, 1652, 1629 (C=O), 1602 (Ar), 1240 (C-O); ^1H NMR ($CDCl_3$, δ ppm, J/Hz): 0.86 (3H, t, J = 6.8, H-7′), 1.28 (8H, m, H-3′~6′), 1.47 (2H, m, H-2′), 2.39 (2H, t, J = 7.6, H-1′), 3.78 (3H, s, 6-OCH_3), 5.84 (1H, d, J = 2.4, H-3), 6.45 (1H, d, J = 0.8, H-5); ^{13}C NMR ($CDCl_3$) δ ppm: 187.6 (C-4), 182.1 (C-1), 158.8 (C-2), 147.5 (C-6), 132.8 (C-5), 107.0 (C-3), 56.2 (6-OCH_3), 28.7 (C-1′), 27.7 (C-2′), 28.9 (C-3′), 29.1 (C-4′), 31.6 (C-5′), 22.5 (C-6′), 14.0 (C-7′).

Palmitic acid (4): White powder, mp 56–58°C (Me_2CO); EI-MS *m/z*: 256 $[M]^+$, 213 (10), 129 (30), 73 (90), 43 (100); ^1H NMR ($CDCl_3$, δ, ppm, J/Hz): 0.86 (3H, t, J = 6.8, H-16), 1.23 (24H, m, H-4~15), 1.60 (2H, m, H-3), 2.32 (2H, t, J = 7.2, H-2); ^{13}C NMR ($CDCl_3$) δ ppm: 180.1 (C-1), 34.0 (C-2), 24.7 (C-3), 29 (C-4), 29.2 (C-5), 29.4 (C-6), 29.7 (C-7~12), 29.3 (C-13), 31.9 (C-14), 22.7 (C-15), 14.1 (C-16).

Rutin (5): Yellow powder; mp 179–181 °C (MeOH); ^1H NMR (CD_3OD, δ, ppm, J/Hz): 1.11 (3H, d, J = 6.0, H-6‴), 4.51 (1H, d, J = 1.2, H-1‴), 5.11 (1H, d, J = 7.6, H-1″), 6.20 (1H, d, J = 2.0, H-6), 6.39 (1H, d, J = 2.0, H-8), 6.86 (1H, d, J = 8.4, H-5′), 7.62 (1H, dd, J_1 = 8.4, J_2 = 2.0, H-6′), 7.65 (1H, d, J = 2.0, H-2′); ^{13}C NMR (CD_3OD) δ ppm: 158.5 (C-2), 135.6 (C-3), 179.4 (C-4), 163.0 (C-5), 99.9 (C-6), 166.0 (C-7), 94.9 (C-8), 159.3 (C-9), 105.6 (C-10), 123.1 (C-1′), 116.1 (C-2′), 149.8 (C-3′), 145.8 (C-4′), 117.7 (C-5′), 123.5 (C-6′), 102.4 (C-1″), 75.7 (C-2″), 78.2 (C-3″), 71.4 (C-4″), 77.2 (C-5″), 68.5 (C-6″), 104.7 (C-1‴), 72.1 (C-2‴), 72.2 (C-3‴), 73.9 (C-4‴), 69.7 (C-5‴), 17.9 (C-6‴).

2-Heptyl-6-methoxy-1,4-hydroquinone-1,4-di-O-β-D-glucopyranoside (6): White powder, mp 238–239 °C (MeOH), [α] + 110 (*c* 0.5; Pyridine); IR (KBr, ν, cm^{-1}): 3394 (OH), 2927, 2856 (C-H), 1598, 1486 (Ar), 1074 (C-O); EI-MS *m/z*: 238 $[M–2Glu]^+$ (98), 400 $[M–Glu]^+$ (2), 154 (95), 104 (35), 91 (40), 73 (50), 69 (49); ^1H NMR and ^{13}C NMR were listed in Table 1.

ACKNOWLEDGMENT

We are grateful to Prof. Gang Hao of South China Institute of Botany, Chinese Academy of Sciences, for help in obtaining the plant material.

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