Two New Quinoline Alkaloid Mannopyranosides from *Solidago canadensis*

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Two novel quinoline alkaloid β-D-mannopyranosides, named dictamnine-7-β-D-mannopyranoside (**1**) and 8-methoxydictamnine-7-β-D-mannopyranoside (**2**), were isolated from the whole plant of *Solidago canadensis*. Their structures were identified on the basis of a spectroscopic analysis.

Introduction. – In most parts of the world, *i.e.*, Asia, America, and Europe, *ca.* 120 species 'goldenrod' (*Solidago* L. Compositae) grow wild or are cultivated, usually for decorative purposes. It is a very rugged and strong, healthy plant, a fact which may explain the wide distribution of goldenrod [1]. Four of these *Solidago* species occur in China: *Solidago virgaurea*, *Solidago decurrens*, *Solidago pacifica*, and *Solidago canadensis*. *Solidago canadensis*, a kind of perennial weed, was introduced into China as a horticultural plant from North America in the 1970s. It has caused damage to crops in dry fields, impeded the recovery of vegetation in abandoned fields, and was also recorded as one of the most common weeds on suburbs of east China [2].

Although the presence of flavonoids, leiocarposide, saponins, carotenoids, sesquiterpenes, and diterpenes has been reported previously in the genus of *Solidago* L. [3][4], the precise chemical composition of *S. canadensis* remains unknown. In many countries *S. canadensis* is also permitted to use for medical purposes [5]. It was reported that the antioxidant activity of the *S. canadensis* extract was greater than that of green tea and ascorbic acid [6]. Recent research on the title plant showed that the aerial parts can be used as an anti-inflammatory diuretic in bladder and kidney disorders, mainly due to the flavonoids and saponins in it [7]. This paper deals with the isolation and structural elucidation of the first novel two mannopyranosides of indole alkaloids from *S. canadensis* and its analgesic and anti-inflammatory activities.

Results and Discussion. – *Chemistry.* The BuOH fraction of the EtOH extract of *S. canadensis* was purified by repeated column chromatography to afford compounds **1** and **2**, which were characterized by their spectroscopic properties, including 2D-NMR techniques (HMQC, HMBC, NOESY). Their structures were identified as dictamnine-

7-β-D-mannopyranoside (**1**) and 8-methoxydictamnine-7-β-D-mannopyranoside (**2**) (*Figure*).

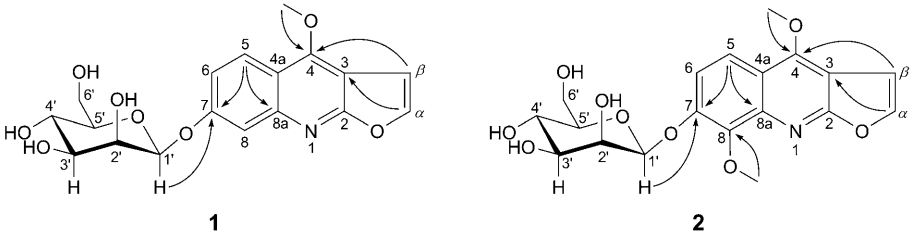

Figure. *The structures and key HMBC* (H → C) *of* **1** *and* **2**

Compound **1** was obtained as a white amorphous solid. The HR-ESI-MS (pos. ion-mode) showed a molecular-ion peak at *m*/*z* 378.1193 ($[M+H]^+$), in accordance with the molecular formula $C_{18}H_{19}NO_8$ (calc. 377.1111). Upon treatment with 5% H_2SO_4, compound **1** yielded mannose, identified by GC. The absolute configuration of the mannose moiety was determined as β-D by comparison of the chiroptical data with those reported in the literature ($[\alpha]_D^{22} = -138.0$ ($c = 0.2$, MeOH) [8]). The UV spectrum of **1** showed absorption maxima characteristic of a quinoline chromophore (227, 280, and 314 nm) [9]. The ^{1}H- and ^{13}C-NMR spectra (*Table*) showed the presence of a substituted quinoline ring. In addition, six aliphatic heterocyclic signals of the sugar unit were also visible in the spectra. Using the heterocyclic H-atoms H–C(α), H–C(β), and H–C(5)[1]) as a reference, H- and C-atom resonances were assigned on the basis of HMQC and HMBC data (*Figure*). The position of the sugar unit at C(7) was established by a correlation between both C(7) of quinoline and the anomeric H-atom, confirming that the mannose is directly linked to quinoline at this position. The identity of the sugar moiety was confirmed as β-D-mannopyranosyl by comparing C-atom chemical shifts with literature values [8]. On the basis of the above evidence, **1** was determined to be dictamnine-7-β-D-mannopyranoside (**1**).

Compound **2**, a white amorphous solid, exhibited a molecular-ion peak at *m*/*z* 408.1292 ($[M+H]^+$) in the HR-MS, which corresponded to the molecular formula $C_{19}H_{21}NO_9$ (calc. 407.1216). Upon treatment with 5% H_2SO_4, compound **2** furnished mannose, identified by GC. The absolute configuration of the mannose was determined as β-D by comparison of the chiroptical data with those reported in the literature ($[\alpha]_D^{22} = -138.0$ ($c = 0.2$, MeOH) [8]). The UV spectrum showed absorption maxima at 227, 280, and 314 nm indicating the presence of a quinoline chromophore. The ^{1}H- and ^{13}C-NMR spectra (*Table*) suggested that there was an additional MeO group in compound **2**. The downfield shifts observed for the C(8)[1]) resonances of the quinoline moiety suggested that the MeO group is linked to C(8), which was further supported by the HMBC spectrum (*Figure*). Correspondingly, the C-atom chemical shifts of C(8a) and C(6) were moved downfield to 152.6, and upfield to 112.6 ppm, respectively. Consequently, compound **2** was unambiguously determined as 8-methoxydictamnine-7-β-D-mannopyranoside (**2**).

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[1]) Arbitrary numbering. For systematic names, see *Exper. Part.*

Table. *^{1}H- and ^{13}C-NMR Data of Compounds* **1** *and* **2** (^{1}H at 500 MHz; ^{13}C at 125 MHz, in CD_3OD)[1])

	1		**2**	
	δ(H)	δ(C)	δ(H)	δ(C)
H–C(α)	7.58 (*d*, *J* = 3.0)	143.4	7.62 (*d*, *J* = 3.0)	143.1
H–C(β)	7.01 (*d*, *J* = 3.0)	104.7	7.07 (*d*, *J* = 3.0)	104.5
C(2)		163.8		164.6
C(3)		118.6		116.6
C(4)		156.7		157.3
C(4a)		112.4		102.4
H–C(5)	8.23 (*dd*, *J* = 8.6, 2.4)	118.3	8.03 (*d*, *J* = 8.6)	118.1
H–C(6)	7.67 (*dd*, *J* = 8.6, 2.4)	123.6	7.47 (*d*, *J* = 8.6)	112.6
C(7)		142.5		141.5
H–C(8)	8.00 (*d*, *J* = 2.4)	127.7	–	141.7
C(8a)		140.6		152.6
MeO–C(4)		56.9	3.64 (*s*)	56.7
MeO–C(5)	–	–	3.95 (*s*)	61.6
H–C(1′)	4.82 (*d*, *J*(1′,2′) = 1.4)	101.9	4.78 (*d*, *J*(1′,2′) = 1.4)	101.5
H–C(2′)	3.70 (*dd*, *J*(1′,2′) = 1.4, *J*(2′,3′) = 3.2)	72.1	3.71 (*dd*, *J*(1′,2′) = 1.4, *J*(2′,3′) = 3.2)	72.3
H–C(3′)	3.37 (*dd*, *J*(2′,3′) = 3.2, *J*(3′,4′) = 9.5)	73.3	3.34 (*dd*, *J*(2′,3′) = 3.2, *J*(3′,4′) = 9.5)	72.8
H–C(4′)	3.52 (*dd*, *J*(4′,5′) = 9.3, *J*(3′,4′) = 9.5)	69.9	3.53 (*dd*, *J*(4′,5′) = 9.3, *J*(3′,4′) = 9.5)	69.2
H–C(5′)	3.22 (*dt*, *J*(4′,5′) = 9.3, *J*(5′,6′) = 5.0)	77.3	3.21 (*dt*, *J*(4′,5′) = 9.3, *J*(5′,6′) = 5.0)	77.0
CH_2(6′)	3.75, 3.50 (2*dd*, *J*(5′,6″) = 5.0, *J*(6′,6′) = 12.2)	60.9	3.77, 3.49 (2*dd*, *J*(5′,6″) = 5.0, *J*(6′,6′) = 12.2)	61.2

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Experimental Part

General. Column chromatography (CC): *Sephadex LH-20* (*Pharmacia Fine Chemicals*, Piscataway, NJ, USA); *ODS* (25–40 μ, *Merck*); *XAD-7 HP* (*Rohm and Haas*, USA). M.p.: *RY-2* apparatus (*Analytical instruments Co.*, Tianjin, China); uncorrected. IR: *Bruker Vector-22* spectrophotometer; KBr pellets, in cm^{-1}. NMR Spectra: *DRX-500* spectrometer (500/125 MHz); in CD_3OD; δ in ppm rel. to Me_4Si, *J* in Hz. HR-ESI-MS: *Q-Tof* micro mass spectrometer.

Plant Material. Above ground parts of *S. canadensis* were collected in the suburb of Shanghai, P. R. China, in August of 2006 and identified by Prof. *Han-Chen Zheng* of Department of Pharmacognosy of this college. A voucher specimen (2006031) has been deposited at the Herbarium of School of Pharmacy, Second Military Medical University, Shanghai, P. R. China.

Extraction and Isolation. The air-dried aerial part (25 kg) of *S. canadensis* was soaked in 80% EtOH (25 l) for 5 d. After removal of EtOH under reduced pressure, the aq. brownish syrup (6 l) was partitioned successively with petroleum ether (PE), $CHCl_3$, and MeOH. Concentration of the solutions afforded a PE extract (312 g), a $CHCl_3$ extract (465 g), and a MeOH extract (512 g). The MeOH extract (200 g) was chromatographed over SiO_2, eluting with a $CHCl_3$/MeOH gradient to afford six fractions (*Fr. A1–A6*). *Fr. A2* (3.2g) was subjected to *ODS* CC to afford crude crystals (1.2 g), and then purified by *Sephadex LH-20* (MeOH) to yield compounds **1** (89 mg) and **2** (69 mg).

Compound Characterization. *Dictamnine-7-β-*D*-mannopyranoside* (=*4-Methoxyfuro[2,3-*b*]quinolin-7-yl β-*D*-Mannopyranoside*; **1**). White amorphous solid. M.p. 162–178°. UV (EtOH): 227 (4.55), 280 (3.57), 314 (3.57). IR: 2922, 2855, 1741, 1579, 1371, 1327, 1244, 1093, 1017. ^{1}H- and ^{13}C-NMR: see the *Table*. EI-MS: 377 (8, M^+), 198 (7), 125 (5), 97 (23), 63 (9), 50 (17). ESI-MS: 377.1 (M^+). HR-EI-MS: 378.1193 ($[M+H]^+$, $C_{18}H_{20}NO_8^+$; calc. 378.1189).

*8-Methoxydictamnine-7-β-*D*-mannopyranoside* (=*4,8-Dimethoxyfuro[2,3-*b*]quinolin-7-yl β-*D*-Mannopyranoside*; **2**). White amorphous solid. M.p. 115–126°. UV (EtOH): 227 (4.53), 280 (3.53), 314 (3.58). IR: 2922, 2855, 1741, 1579, 1371, 1327, 1244, 1093, 1017. ^{1}H- and ^{13}C-NMR: see the *Table*. ESI-MS: 407.1 (M^+). HR-EI-MS: 408.1292 ($[M+H]^+$, $C_{19}H_{22}NO_9^+$; calc. 408.1295).

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