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Belamcandanes A and B, two unprecedented tricyclic-iridal triterpenoids from *Belamcanda chinensis*

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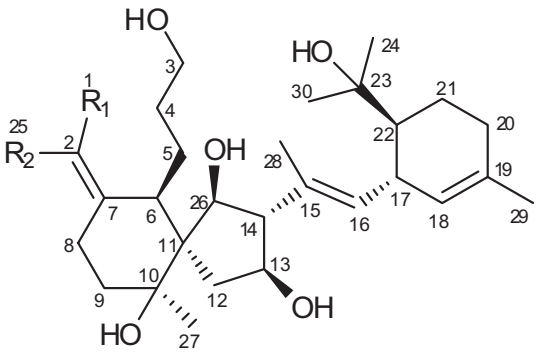
ABSTRACT

Two unprecedented tricyclic-iridal triterpenoids, belamcandanes A–B (**1**–**2**), have been isolated from the rhizomes of *Belamcanda chinensis*. The structures of **1** and **2** were assigned by interpretation of spectroscopic data including NMR and MS, and their absolute configurations were assigned by ECD calculation. Compounds **1**–**2** possess a spiro[4,5]decane core structure and a α-terpineol moiety, representing the first example of tricyclic-iridal triterpenoids. The plausible biogenetic pathway for **1** and **2** is also proposed.

The genus *Belamcanda*, belonging to the Iridaceae plant family, comprises only one species, namely *Belamcanda chinensis* (L.) DC.[1] *B. chinensis* is a perennial herb that is mainly distributed in South-East Asia. Its rhizome has been used for many centuries as Chinese traditional medicine for treatment of throat ailment such as asthma and tonsillitis. Previous chemical investigations of *B. chinensis* have revealed the presence of flavonoids,[2] benzoquinones,[3] and iridal-type triterpenoids.[4] Iridal-type triterpenoids are the characteristic constituents of the iridaceous plants. Based on the carbon skeleton, iridals may be divided into three classes: monocyclic iridals, bicyclic iridals, and spiroiridals.[4] Common features of most of iridals include a prenylated side chain and an α,β-unsaturated aldehyde. Iridal-type triterpenoids have provoked much interest because of their intriguing structures and attractive biological activities, including cytotoxicity,[5] PKC activation,[6] pesticidal activity,[7] neuroprotective activity,[8] and ichthyotoxicity.[4a] Furthermore, iridals have attracted attention to the total synthesis research. The enantioselective synthesis of iridal has been reported.[9]

During our continuing search for bioactive and structurally unique natural products, two unprecedented tricyclic-iridals, belamcandanes A–B (**1**–**2**), were isolated from the rhizomes of *Belamcanda chinensis*. Compounds **1**–**2** (Fig. 1) possess a spiro[4,5]decane core structure and a α-terpineol moiety, representing the first example of tricyclic-iridal triterpenoids. Furthermore, compounds **1** and **2** exhibited moderate hepatoprotective activities at a concentration of 10 μM. Herein, we described the isolation, structure elucidation, a plausible biogenetic pathway, and bioactivities of **1** and **2**.

Belamcandane A (**1**) was obtained as yellow solid. Its molecular formula $C_{30}H_{48}O_6$ was established from HRESIMS at 527.33374 [M+Na]$^+$. The ^{13}C NMR spectrum (Table 1) showed 30 carbon signals, which were resolved through DEPT experiment as six methyls, eight methylenes (one oxygenated), eight methines (two oxy-



1 R_1 = CHO, R_2 = CH_3
2 R_1 = CH_3, R_2 = CHO

Fig. 1. Structures of compounds **1** and **2**.

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genated and two olefinic), seven quaternary carbons (four olefinic and two oxygenated), and one aldehyde group. Further analysis of its ^{1}H, ^{13}C, and HMQC NMR data revealed the presence of an α,β-unsaturated aldehyde [δ_H 10.1 (1H, s, H-1); δ_C 133.3 (C-2), 162.0 (C-7), and 11.2 (C-25)]. This was consistent with the IR spectrum, which exhibited absorption bands at ν_{max} 1705, 1656, and 1612 cm^{-1}. In addition, the ^{1}H and ^{13}C NMR spectra showed the presence of two isolated trisubstituted double bonds [δ_H 5.46 (1H, d, J = 10.2 Hz, H-16), 5.18 (1H, br d, J = 4.8 Hz, H-18); δ_C 127.9 (C-15), 130.3 (C-16), 123.5 (C-18) and 133.8 (C-19)]. These data, together with the presence of one quaternary carbon at δ_C 51.2 (C-11), suggested that **1** was a spiroiridal derivative. The molecular formula indicated seven degrees of unsaturation. Since the one aldehyde and three double bonds accounted for four degrees of unsaturation, **1** was determined to be a tricyclic iridal-type triterpenoid.

Table 1
^{1}H and ^{13}C NMR Data for **1** and **2**.

No.	**1**		**2**	
	δ_H[a] (J in Hz)	δ_C[b]	δ_H[a] (J in Hz)	δ_C[b]
1	10.1 s	190.2	1.79 s	11.6
2		133.3		132.5
3	3.64 m	62.5	3.64 m	62.7
4	1.30 m	32.4	1.33 m	32.4
	1.49 m		1.48 m	
5	2.11	26.9	2.09 m	27.3
			2.22 m	
6	3.03 br d (9.6)	49.7	2.47 br d (10.8)	54.0
7		162.0		162.8
8	2.47 m	23.7	2.69 m	19.8
	2.71 dt (4.8, 13.8)		3.17 dt (3.6, 13.8)	
9	1.49 m	37.6	1.51 m	38.8
	1.66 m		1.69 m	
10		75.2		75.4
11		51.2		51.7
12	1.51 m	43.5	1.49 m	43.3
	1.81 m		1.68 m	
13	3.77 m	69.6	3.79 m	69.8
14	2.56 t (10.2)	63.9	2.55 t (10.2)	63.8
15		127.9		127.9
16	5.46 d (10.2)	130.3	5.47 d (10.2)	130.5
17	3.27 dt (4.8, 10.2)	35.5	3.28 dt (4.8, 10.2)	35.5
18	5.18 br d (4.8)	123.5	5.18 d (4.8)	123.5
19		133.8		133.8
20	2.06 m	31.3	2.06 m	31.3
21	1.69 m	18.9	1.69 m	18.9
	1.79 m		1.79 m	
22	1.54 m	47.3	1.55 m	47.3
23		73.1		73.1
24	1.24[c] s	29.9 or 27.7	1.24 or 1.22 s	29.9 or 27.8
25	1.83 s	11.2	10.2 s	190.8
26	3.96 dd (1.8, 11.4)	81.5	3.99 d (10.8)	81.1
27	1.48 s	28.3	1.46 s	28.1
28	1.78 s	14.6	1.79 s	14.2
29	1.67 s	23.4	1.67 s	23.4
30	1.21[c] s	27.7 or 29.9	1.22 or 1.24 s	27.8 or 29.9

[a] In $CDCl_3$ (600 MHz).
[b] In $CDCl_3$ (150 MHz).
[c] Assignment may be interchanged in each group.

Interpretation of the ^{1}H-^{1}H COSY spectrum indicated the presence of four spin systems (**a**–**d**) within **1** (Fig. 2). The correlations between H-3 and H-4, H-4 and H-5, and H-5 and H-6 helped to generate the first spin system **a**. The second spin system **b** included only two complex methylene signals, H_2-8 (δ_H 2.47 and 2.71) and H_2-9 (δ_H 1.49 and 1.66). The correlations of H-12/H-13, H-13/H-14, and H-14/H-26 defined the third spin system **c**. The last spin system started with the olefinic signal (δ_H 5.46 (1H, d, J = 10.2 Hz, H-16), which coupled with H-17 [δ_H 3.27 (1H, dt, J = 4.8, 10.2 Hz)]. The latter in turn showed cross-peaks with another olefinic proton at δ_H 5.18 (1H, br d, J = 4.8 Hz, H-18) and with a methine proton at δ_H 1.54 (1H, m, H-22). H-22 showed correlation with a pair of methylene protons H_2-21 [δ_H 1.69 and 1.79], which in turn coupled with H_2-20 [δ_H 2.06], thereby completing the fourth spin system **d**. Above subunit and nonprotonated carbons were connected to each other on the basis of HMBC correlations. In the HMBC spectrum, the C-25 methyl group showed the long-range correlations with the aldehyde, C-2 and C-7, indicating the presence of an α-methyl-acryl aldehyde group. The C-27 methyl singlet exhibited the HMBC correlations with C-9, C-10, and C-11, indicating the linkages from C-9 to C-11. The HMBC correlations from H-6 to C-7, C-8, C-10, C-11, C-12 and C-26, from H-13 and H-14 to C-11 and C-12, from H-26 to C-6, C-10, C-11, and C-12 allowed us to construct a spirobicyclic moiety containing a hydroxypropane side chain at C-6 and an α-methyl-acryl aldehyde group at C-7. In addition, the HMBC correlations from H_3-29 to C-18, C-19, and C-20 and from H_3-24 and H_3-30 to C-22 and C-23, together with COSY correlations of H-18/H-17/H-22/H_2-21/H_2-20, indicated the pres-

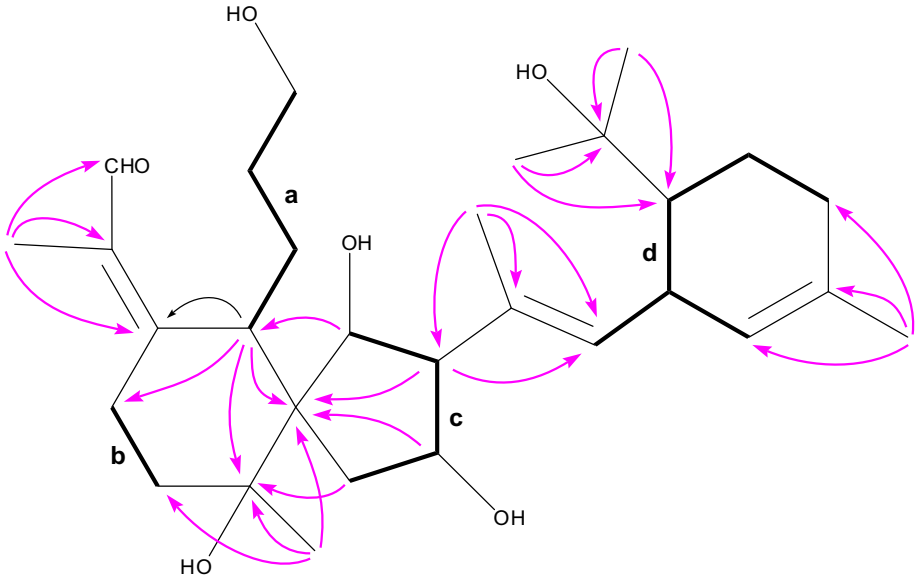

Fig. 2. Selected COSY (bold bonds) and HMBC (H → C) correlations of **1**.