



Four new sesquiterpene derivatives from *Dendrobium findlayanum*

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[ABSTRACT] Three new sesquiterpene glycosides with alloaromadendrane and ylangene-derived type aglycones, named dendrofindlayanosides A–C (**1–3**), one new cyclopacamphe type sesquiterpene named dendrofindlayanobilin A (**4**), together with five known compounds have been isolated from stems of *Dendrobium findlayanum*. Their structures were determined on the basis of spectroscopic and chemical methods.

[KEY WORDS] *Dendrobium findlayanum*; Sesquiterpene derivatives; Alloaromadendrane; Cyclopacamphe

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Introduction

The *Dendrobium* genus is one of the largest in Orchidaceae, containing more than 1500 species, and widely distributed in throughout Asia, Europe and Australia [1]. There are more than 100 *Dendrobium* species in China, and the fresh or dried stems of many species have been used both as medicine for the treatment of diabetes, fever, chronic atrophic gastritis, and skin aging diseases, as well as a high-quality health food now. The main chemical components of *Dendrobium* are alkaloids, phenolic compounds, sesquiterpenoids and polysaccharides with antioxidant, anti-inflammatory and anti-tumor effects etc. [2–7]. Our previous study on *D. findlayanum* which grown in the

southwest of China and used as one of the most common source for Shi-Hu, has led to the isolation of four new seco-dendrobines, findlayines A–D and four new phenolic compounds with anti-inflammatory, anti-tumor and antioxidant activities [8]. In order to supply more evidence to the efficacy and safety of *D. findlayanum* in clinical applications, we investigated chemical constituents of the stems of *D. findlayanum* and led to the isolation of four new sesquiterpene derivatives, dendrofindlayanosides A–C (**1–3**), dendrofindlayanobilin A (**4**), and five known compounds. This paper will describe the isolation, structural elucidation and the immunomodulatory bioassay *in vitro* of all isolates.

Results and Discussion

Compound **1** was obtained as colorless oil. A molecular formula of C₂₁H₃₄O₈ was established by the HRESI-MS [M + Na]⁺ *m/z* 437.2135 (Calcd. for 437.2146). The presence of hydroxyl (3426 cm^{−1}) was deduced from the IR spectrum. In the ¹³C NMR spectrum (Table 2), 21 carbon signals were observed, constituted by two methyls, seven methylenes, ten methines, and two quaternary carbons. On enzymatic hydrolysis of **1**, glucose was obtained as the only sugar component. The ¹H NMR spectrum of **1** revealed only one anomeric proton signal at δ_H 4.24 (1H, d, *J* = 7.8 Hz). Therefore, the glucose unit was assigned in

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Dedicated to Professor SUN Han-Dong on the Occasion of His 80th Birthday

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the β configuration. And acid hydrolysis of **1** furnished glc, which was detected by TLC comparison with authentic sample. Elucidation of ^1H - ^1H COSY, HSQC and HMBC spectra of **1** revealed the planar structure of its aglycone was similar to that of dendroside C^[9], except for the loss

of a hydroxy methyl group (δ_{C} 72.2, t), along with the appearance of aldehyde group (δ_{C} 205.7, d), which was evidenced by the aldehyde proton (δ_{H} 8.68, s) and the HMBC cross-peaks from H-6 (δ_{H} 1.18, d), H-7 (δ_{H} 1.70, d) and H-12 (δ_{H} 1.22, s) to C-13 (δ_{C} 205.7, d) (Fig. 2).

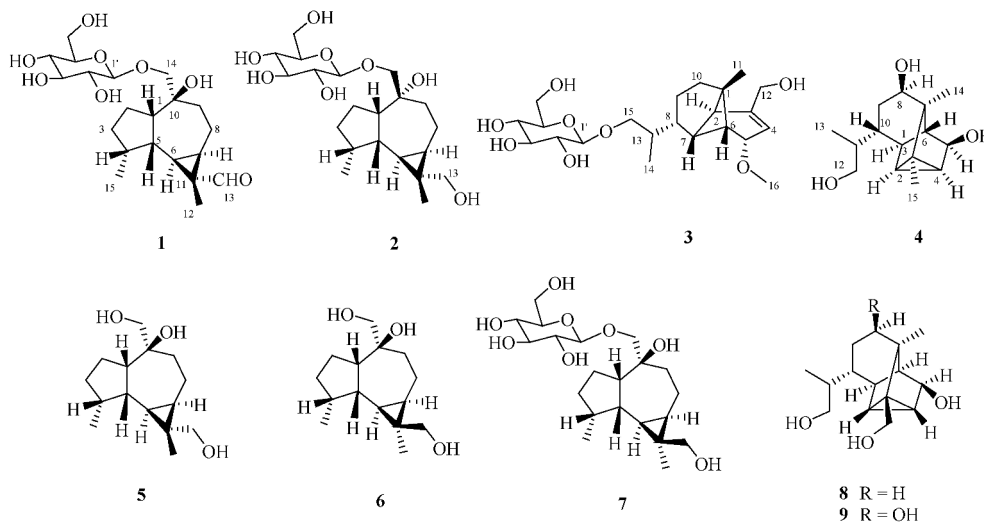


Fig. 1 Chemical structures of the compounds 1–9

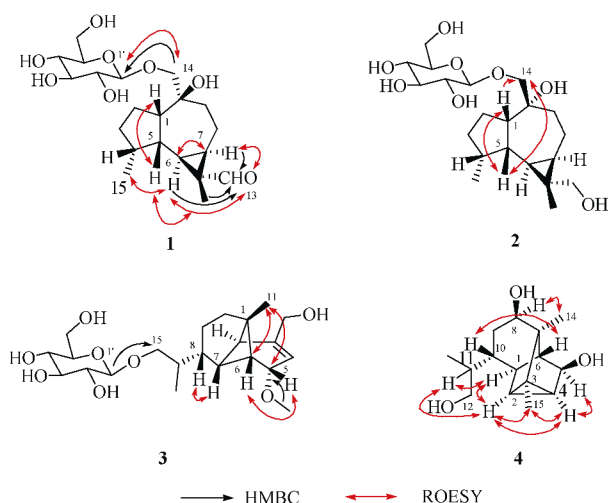


Fig. 2 Selected HMBC and ROESY correlations of compounds 1–4

Further analysis of ROESY correlation signals of H-6 and H-7, H-13, H-15; H-7 and H-13; H-5 and H-12; and H-1 and H-5, H-4 in the ROESY spectrum of **1** enabled establishment of the relative configuration of aglycone of **1**. The glucose unit was further determined to connect to C-14 according to the ROESY correlation of H-14 and $\text{H}_{\text{glc-1}}$, and also on the HMBC correlation from H-14 to $\text{C}_{\text{glc-1}}$ (Fig. 2). Thus, the structure of **1** was assigned as 13-aldehyde-10 β , 14-trihydroxyalloaromadendrane 14-*O*- β -D-glucopyranoside. Compound **1** is a new sesquiterpene glycoside and has been given the trivial name dendronobiloside A.

Compound **2** had molecular formula $\text{C}_{21}\text{H}_{36}\text{O}_8$, as deduced from HRESI-MS $[\text{M} + \text{Na}]^+ m/z$ 439.2302 (Calcd. for 439.2302) and NMR spectra (Tables 1 and 2), indicating four degrees of unsaturation. Its IR spectrum displayed the presence of hydroxyl group (3431 cm^{-1}). Enzymatic hydrolysis of **2** yielded glucose as its sugar component. In the ^1H NMR spectrum of **2**, one anomeric proton signal was found at δ_{H} 4.26 (1H, d, $J = 7.8\text{ Hz}$), so the glucose unit should link to the aglycone in the β configuration. And acid hydrolysis of **1** furnished glc, which was detected by TLC comparison with authentic sample. Comparing the NMR data (Tables 1 and 2) with those of dendroside C^[9] indicated that the aglycone of two compounds had the same planar structure. The difference was the β configuration of C-14 in compound **2** instead of the α configuration in dendroside C^[9], which was confirmed by the ROESY correlations from H-1 (δ_{H} 2.20, t) to H-5 (δ_{H} 1.68, m) and H-14 (δ_{H} 3.83, d; 3.50, d), and from H-5 to H-14 (Fig. 2). Accordingly, compound **2** was determined structurally as 10 α , 13, 14-trihydroxyalloaromadendrane 14-*O*- β -D-glucopyranoside. Since this is a new sesquiterpene glycoside, it has been assigned the trivial name dendrofindlayanoside B.

Compound **3** was isolated as colorless oil. The molecular formula, $\text{C}_{22}\text{H}_{36}\text{O}_8$, was established by HRESIMS $[\text{M} + \text{Na}]^+ m/z$ 451.2301 (Calcd. for 451.2302). The presence of hydroxyl groups (3450 cm^{-1}) was deduced from the IR spectrum. In the ^{13}C NMR spectrum, 21 carbon signals including three methyls, five methylenes, eleven methines, and two quaternary carbons were observed (Table 2). On enzymatic hydrolysis of **3**, glucose was obtained as the only sugar component. The ^1H NMR spectrum of **3** revealed only one anomeric

proton signal at δ_{H} 4.21 (1H, d, $J = 7.8$ Hz) (Table 1). Therefore, the glucose unit was assigned in the β configuration. And acid hydrolysis of **1** furnished glc, which was detected by TLC comparison with authentic sample.

Comparing the NMR data (Tables 1 and 2) with those of philippinlin B^[10] indicated the two compounds were similar, and the difference was the methoxy attaching to C-5 in compound **3** replaced the hydroxyl in philippinlin B^[10], and the additional glucose moiety attached to C-15 (δ_{C} 74.2, t) in compound **3**, which was confirmed by the HMBC cross-peaks from H-OMe (δ_{H} 3.38, s) to C-5 (δ_{C} 80.9, d), and from H-1' (δ_{H} 4.21, d) to C-15 (Fig. 2). Thus, the 2D structure of **3** was defined.

The relative configurations of the six chiral centers at C-1, C-2, C-5, C-6, C-7 and C-8 in **3** were similar with those in philippinlin B^[10], confirmed by the ROESY correlation signals of H-5 and H-6, H3-11; H-6 and H3-11; and H-7 and H-8 in the ROESY spectrum of **3** (Fig. 2). Assuming the β -orientation of H-5, both H-6 and H3-11 should be positioned on the β face. Thus, the relative structure of compound **3** was determined, named dendrofindlayanoside C.

Compound **4** was isolated as colorless oil. The molecular formula, $\text{C}_{15}\text{H}_{24}\text{O}_3$, was established by HRESI-MS $[\text{M} + \text{Na}]^+$ m/z 275.1615 (Calcd. for 275.1618). The absorption band at 3435 cm^{-1} in IR spectrum indicated the presence of hydroxyl groups. The ^{13}C NMR spectrum of **4** showed 15 carbon signals belonging to three methyls, two methylenes, eight methines and two quaternary carbons. A tetracyclic system skeleton was deduced to exist in the structure of **4** according to its unsaturation degree. Comparing the NMR data with those of dendrobane A^[9] indicated that the two compounds have the same planar structure, which was supported by the ^1H - ^1H COSY correlations of H-2/H-4, H-8/H-9/H-10, H-5/H-6/H-1, H-12/H-11/H-13, and was further established by the HMBC correlation signals at H₃-15/C-2, -4, -7; H-10/C-2, -6, -8, -13; C-3/H-1, -5, -6, -14; C-7/H-5, -9, -15 (Fig. 2).

Besides, the relative configuration of compound **4** was elucidated by a ROESY experiment and by comparison of the NMR data with those of dendrobane A^[9]. The relative configuration was similar with that of dendrobane A^[9], except for the β -orientation of H-6 in compound **4** instead of the α -orientation in dendrobane A^[9], which was supported by the upfield shift of C-6 (δ_{C} 47.0, d) in compound **4**, and the disappearance of the ROESY correlations of H-6 with H-8 and H-4. The relative configuration of compound **4** was further proved by the ROESY correlation signals between H-2 and H-1, H-4, H-11, H-15; H-4 and H-5, H-15; H-6 and H-10; H-1 and H-11, H-12; and H-8 and H-14 (Fig. 2). Thus, the relative structure of compound **4** was determined, named dendrofindlayanobilin A.

Five known sesquiterpenes including, 10 β , 12, 14-tridroxaromadendrane (**5**)^[11], 10 β , 13, 14-tridroxaromadendrane (**6**)^[12], dendroside A (**7**)^[12], dendronobilin I (**8**)^[13] and dendronobilin N (**9**)^[14] were identified by comparison of their

NMR data with those in the literatures. The immunomodulatory bioassay *in vitro* of isolates was evaluated, but all compounds were inactive. Compound **3**, one ylangene-derived sesquiterpene, was reported for the first time from the genus *Dendrobium*. From the results of our experiment, it could be dedicated that just like *D. nobile*, the main compositions of *D. findlayanum* are sesquiterpenes or its alkaloids.

Experimental

General

Optical rotations were obtained on a Jasco P-1020 digital polarimeter (Horiba, Tokyo, Japan). UV spectra were taken on a Shimadzu UV-2401 PC spectrophotometer (Shimadzu, Kyoto, Japan). IR spectra were obtained on a Bruker Tensor 27 infrared spectrophotometer (Bruker Optics GmbH, Ettlingen, Germany) with KBr pellets. NMR spectra were recorded on Bruker AM-400, DRX-500 or Av III-600 instruments with TMS as the internal standard (Bruker, Bremen, Germany). The chemical shifts were given in δ (ppm) scale with reference to the solvent signal. Mass spectra were recorded on an API QSTAR time-of-flight spectrometer (MDS Sciex, Concord, Ontario, Canada) or LCMS-IT-TOF (Shimadzu, Kyoto, Japan) spectrometer. Semi-preparative HPLC was performed on Agilent 1100 liquid chromatography with a ZORBAX SB-C₁₈ (5 μm , 9.4 mm $\times$ 250 mm) column (Agilent, USA) at a flow rate of 3.0 mL·min⁻¹. Column chromatography was performed on silica gel (200–300 mesh, Qingdao Marine Chemical Inc., Qingdao, China). Lichroprep RP-18 gel (40–63 μm , Merck, Darmstadt, Germany), MCI gel CHP-20P (75–150 μm , Mitsubishi Chemical Corp., Tokyo, Japan), Sephadex LH-20 (20–150 μm , Amersham Biosciences, Uppsala, Sweden). Fractions were monitored by TLC, and spots were visualized by UV light (254 nm) and sprayed with 5% H₂SO₄ in ethanol, followed by heating.

Plant material

The stems of *Dendrobium findlayanum* Par. et Rehb. f. were collected in April 2013 from the Wenshan County, Yunnan Province, China, and identified by Prof. YU Hong, Yunnan University, Yunnan Province, China. A voucher specimen (KIB Zsh-13) has been deposited at the State Key Laboratory of Phytochemistry and Plant Resource in West China, Kunming Institute of Botany, Chinese Academy of Sciences.

Extraction and isolation

The dried and powdered stems of *D. findlayanum* (5.0 kg) were extracted with 95% aqueous EtOH (4 $\times$ 15 L, 2 days each) at room temperature and filtered. The filtrate was evaporated under reduced pressure and further fractionated between EtOAc and H₂O and between *n*-BuOH and H₂O, successively.

The *n*-BuOH part (100 g) was chromatographed on Si CC (1000 g), eluted with CHCl₃-MeOH (95 : 5, 90 : 10, 80 : 20, 60 : 40), to afford four sub-fractions (A–D). Fraction A (15 g) was separated by repeated Si CC (CHCl₃-MeOH, 60 : 1, 40 : 1, 20 : 1) and Sephadex LH-20 column (MeOH) to yield compounds **4** (10 mg) and **8** (4 mg). Fraction B (8 g)

was performed on a MCI CHP-20P gel CC (160 g) and eluted with MeOH–H₂O (10 : 90, 30 : 70, 60 : 40, 80 : 20) to give four fractions (B1–B3). Fraction B2 (0.5 g) was performed on Si CC (5 g), eluted with CHCl₃–MeOH (29 : 1), and further purified on a Sephadex LH-20 column (CHCl₃–MeOH, 1 : 1) to yield compounds **5** (6 mg), **6** (5 mg) and **9** (5 mg).

Fraction C (18 g) was loaded on a RP-18 column (MeOH–H₂O gradient system: 10%–80%) to obtain fractions C1–C4. After repeated CC on silica gel (200–300 mesh), eluting with CHCl₃–MeOH (gradient system: 29 : 1–5 : 1), compounds **1** (5 mg), **2** (6 mg) and **7** (8 mg) precipitated from fraction C1. Fraction C2 (2 g) was performed on a MCI CHP-20P gel CC (40 g) and eluted with MeOH–H₂O (10 : 90, 30 : 70, 60 : 40, 80 : 20) to afford three sub-fractions (C2-1–C2-3). Fraction C2-2 was performed on Si CC, eluted with CHCl₃–MeOH (9 : 1), and further purified by preparative HPLC MeOH–H₂O (60 : 40) to afford compound **3** (4 mg, *t_R* = 56 min).

Spectroscopic data

Dendrofindlayanoside A: White amorphous powder,

C₂₁H₃₄O₈; [α]_D²⁰ –16.7 (*c* 0.20, MeOH); UV (MeOH) $\lambda_{\max}$ (log ϵ) 205 (2.01) nm; IR (KBr) $\nu_{\max}$ 3426, 2924, 2872, 1684, 1631, 1451, 1419, 1384, 1078, 595, 473 cm^{–1}; ¹H and ¹³C NMR data, see Tables 1 and 2; positive-ion ESI-MS: *m/z* 437 [M + Na]⁺; positive-ion HRESI-MS [M + Na]⁺ *m/z* 437.2135 (Calcd. for 437.2146).

Dendrofindlayanoside B: White amorphous powder, C₂₁H₃₆O₈; [α]_D²⁰ –22.8 (*c* 0.16, MeOH); UV (MeOH) $\lambda_{\max}$ (log ϵ) 203 (2.06) nm; IR (KBr) $\nu_{\max}$ 3431, 2926, 2872, 1631, 1384, 1287, 1078, 1044, 879, 712, 581, 471 cm^{–1}; ¹H and ¹³C NMR data, see Tables 1 and 2; positive-ion ESI-MS: *m/z* 439 [M + Na]⁺; positive-ion HRESI-MS [M + Na]⁺ *m/z* 439.2302 (Calcd. for 439.2302).

Dendrofindlayanoside C: White amorphous powder, C₂₂H₃₆O₈; [α]_D²¹ –28.2 (*c* 0.17, MeOH); UV (MeOH) $\lambda_{\max}$ (log ϵ) 203.8 (1.97) nm; IR (KBr) $\nu_{\max}$ 3450, 2920, 2850, 1640, 1384, 1079, 470 cm^{–1}; ¹H and ¹³C NMR data, see Tables 1 and 2; positive-ion ESI-MS *m/z* 451 [M + Na]⁺; positive-ion HRESI-MS [M + Na]⁺ *m/z* 451.2301 (Calcd. for 451.2302).

Table 1 ¹H NMR spectroscopic data (methanol-*d*₄, 600 MHz) for 1–4 (δ in ppm, *J* in Hz)

Position	1	2	3	4
1	2.03 (m)	2.20 (t, 4.8)		1.78 (br s)
2	1.73 (m) 1.61 (m)	1.79 (m) 1.85 (m)	1.71 (d, 7.7)	0.86 (d, 5.4)
3	1.89 (m) 1.29 (m)	1.31 (m) 1.79 (m)		
4	2.05 (m)	2.04 (m)	5.61 (s)	1.06 (m)
5	2.05 (m)	1.68 (m)	3.96 (m)	3.76 (br s)
6	1.18 (m)	0.42 (t, 9.0)	2.39 (t, 3.0)	1.65 (br s)
7	1.70 (m)	0.88–0.92 (m)	1.93 (m)	
8	1.67–1.71 (m)	1.06 (m) 1.85 (m)	1.95 (m)	3.64 (br s)
9	1.84 (m) 1.78 (m)	1.83 (m)	1.69 (m)	1.56 (dd, 10.2, 3.0)
10			1.81 (m) 1.65 (m)	1.67 (d, 8.4)
11			0.83 (s)	1.44 (m)
12	1.22 (s)	1.07 (s)	3.96 (m) 3.91 (m)	3.57 (dd, 10.8, 4.2) 3.50 (dd, 10.8, 7.2)
13	8.68 (s)	3.53 (d, 10.8) 3.07 (d, 11.4)	1.72 (m)	0.92 (d, 6.6)
14	3.81 (m) 3.72 (m)	3.83 (d, 10.4) 3.50 (d, 10.4)	0.94 (d, 7.2)	1.27 (s)
15	0.85 (d, 6.6)	0.96 (d, 7.2)	3.76 (d, 7.2) 3.52 (d, 7.2)	1.08 (s)
1'	4.24 (d, 7.8)	4.26 (d, 7.8)	4.20 (d, 7.8)	
2'	3.22 (m)	3.15–3.22 (m)	3.14 (m)	
3'	3.27 (m)	3.26 (m)	3.33 (m)	
4'	3.27 (m)	3.27 (m)	3.27 (m)	
5'	3.35 (m)	3.34 (m)	3.23 (m)	
6'	3.87 (dd, 12.0, 1.8) 3.66 (dd, 12.0, 6.0)	3.86 (dd, 12.0, 1.8) 3.66 (dd, 12.0, 6.0)	3.83 (dd, 12.0, 1.8) 3.66 (dd, 12.0, 6.0)	
16			3.38(s)	

Table 2 ^{13}C NMR spectroscopic data (methanol- d_4 , 150 MHz) for 1–4 (δ in ppm)

Position	1	2	3	4
1	54.2, CH	51.6, CH	49.1, C	42.5, CH
2	25.4, CH ₂	24.9, CH ₂	52.1, CH	22.2, CH
3	30.1, CH ₂	30.3, CH ₂	152.7, C	26.9, C
4	39.5, CH	40.3, CH	116.7, CH ₂	27.5, CH
5	39.6, CH	40.4, CH	80.9, CH	79.4, CH
6	24.9, CH	20.4, CH	41.5, CH	47.0, CH
7	29.8, CH	25.3, CH	42.1, CH	49.7, C
8	17.9, CH ₂	20.2, CH ₂	40.9, CH	75.5, CH
9	31.7, CH ₂	34.4, CH ₂	23.5, CH ₂	32.5, CH ₂
10	76.4, C	76.8, C	37.5, CH ₂	34.3, CH
11	37.6, C	25.7, C	19.5, CH ₃	39.8, CH
12	8.2, CH ₃	12.1, CH ₃	65.5, CH ₂	66.5, CH ₂
13	205.7, CH	73.2, CH ₂	38.8, CH	15.3, CH ₃
14	79.3, CH ₂	78.2, CH ₂	14.1, CH ₃	18.6, CH ₃
15	16.3, CH ₃	16.7, CH ₃	74.2, CH ₂	10.5, CH ₃
1'	105.2, CH	105.2, CH	104.4, CH	
2'	75.2, CH	75.1, CH	75.0, CH	
3'	77.9, CH	77.9, CH	78.0, CH	
4'	71.6, CH	71.6, CH	71.6, CH	
5'	78.0, CH	78.0, CH	78.2, CH	
6'	62.7, CH ₂	62.7, CH ₂	62.7, CH ₂	
16			56.6, CH ₃	

Dendrofindlayanobilin A: colorless oil, $\text{C}_{15}\text{H}_{24}\text{O}_3$; $[\alpha]_{\text{D}}^{21} +0.50$ (c 0.17, MeOH); UV (MeOH) λ_{max} (log ϵ) 201.6 (1.58) nm; IR (KBr) ν_{max} 3435, 2925, 2875, 1733, 1632, 1454, 1382, 1082, 1037, 565 cm^{-1} ; ^1H and ^{13}C NMR data, see Tables 1 and 2; positive-ion ESI-MS m/z 275 $[\text{M} + \text{Na}]^+$; positive-ion HRESI-MS $[\text{M} + \text{Na}]^+ m/z$ 275.1615 (Calcd. for 275.1618).

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Appendix A. Supplementary data

1D and 2D NMR, HRESIMS, IR, UV and $[\alpha]_{\text{D}}$ spectra of compounds 1–4 are available as Supporting Information, which can be requested by sending E-mails to the corresponding author.

References

- JIN XH, HUANG LQ. Investigation of original of Chinese medicine "Shihu" and "Tiepishihu" [J]. *Chin J Chin Mater Med*, 2015, **40**(13): 2475-2479.
- Jaime A, Teixeira S, Tzi BN. The medicinal and pharmaceutical importance of *Dendrobium* species [J]. *Appl Microbiol Bio-technol*, 2017, **101**(6): 2227-2239.
- Veronika C, Frederic B, Annelise L. *Dendrobium*: sources of active ingredients to treat age-related pathologies [J]. *Aging Dis*, 2017, **8**(6): 827-849.
- Lam Y, Ng TB, Yao RM, et al. Evaluation of chemical constituents and important mechanism of pharmacological biology in *Dendrobium* plants [J]. *Evid-Based Compl Alt Med*, 2015, **2015**: 1-25.
- Xu J, Han QB, Li SL, et al. Chemistry, bioactivity and quality control of *Dendrobium*, a commonly used tonic herb in traditional Chinese medicine [J]. *Phytochem Rev*, 2013, **12**(2): 341-367.
- Ng TB, Liu J, Wong JH, et al. Review of research on *Dendrobium*, a prized folk medicine [J]. *Appl Microbiol Biotechnol*, 2012, **93**(5): 1795-1803.
- Zhang GN, Bi ZM, Wang ZT, et al. Advances in studies on chemical constituents from plants of *Dendrobium* Sw [J]. *Chin Tradit Herb Drugs*, 2003, **6**: 102-105.
- Yang D, Cheng ZQ, Yang L, et al. Seco-dendrobine-type alkaloids and bioactive phenolics from *Dendrobium findlayanum* [J]. *J Nat Prod*, 2018, **81**(2): 227-235.
- Ye QH, Zhao WM. New alloaromadendrane, cadinene and cyclocopacamphane type sesquiterpene derivatives and bibenzyls from *Dendrobium nobile* [J]. *Planta Med*, 2002, **68**: 723-729.
- Xio YJ, Su JH, Chen BW, et al. Oxygenated ylangene-derived sesquiterpenoids from the soft coral *Lemnalia philippinensis* [J]. *Mar Drugs*, 2013, **11**: 3735-3741.
- Lima DPD, Carnell AJ, Roberts SM. Microbial transformation

- of (+)-10 β , 14-dihydroxy-*allo*-aromadendrane and (–)-*allo*-aromadendrone [J]. *Cheminform*, 1999, **30**(42): 396-397.
- [12] Zhao WM, Ye QH, Tan XJ, *et al.* Three new sesquiterpene glycosides from *Dendrobium nobile* with immunomodulatory activity [J]. *J Nat Prod*, 2001, **64**: 1196-1200.
- [13] Fan WW, Xu FQ, Dong FW, *et al.* Dendrowardol C, a novel sesquiterpenoid from *Dendrobium wardianum* Warner [J]. *Nat Prod Bioprospect*, 2013, **3**(3): 89-92.
- [14] Zhang X, Tu FJ, Yu HY, *et al.* ChemInform abstract: copacamphane, picrotoxane and cyclocopacamphane sesquiterpenes from *Dendrobium nobile* [J]. *Cheminform*, 2008, **39**(46): 47-48.

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Dr. HU Jiang-Miao's major is natural medicines and mainly focused on pharmaceutical research of herbal medicine from Orchidaceae. Structural modification and activity exploration of some large components from natural source have also been carried out by his group. More than 50 manuscripts on SCI indexed journals have been published by him as first or (co)corresponding author. H-index: 14.