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# Hyperacmosin N, new acylphloroglucinol derivative with complicated caged core from *Hypericum acmosepalum*

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ABSTRACT

*Three new polycyclic polyprenylated acylphloroglucinol derivatives, hyperacmosins N–P (**1**–**3**), were isolated from the air-dried aerial parts of Hypericum asmosepalum. Especially, compound **1** possessed a rare hexacyclic core, which was formed via oxidation and radical cyclization. Their structures were established by NMR, HRMS (ESI), and experimental electronic circular dichroism (ECD) spectra. The plausible biogenetic pathways of **1-3** were proposed, which gave an insight for future biomimetic synthesis of the novel compounds.*



## 1. Introduction

Polycyclic polyprenylated acylphloroglucinols (PPAPs), possessing highly oxygenated acylphloroglucinol-derived cores decorated with isoprenyl or geranyl side chains, are a group of structurally fascinating and synthetically challenging natural products that collectively exhibit a broad range of biological activities [1–10]. *Hypericum acmosepalum*, a member of the genus *Hypericum*, has been used for the treatment of hepatitis in China [11]. Previous chemical investigations on this plant revealed that a series of complex phloroglucinols have been isolated, which showed hepatoprotective and neuroprotective activities [12–14]. In our current study, three new PPAPs (**1**–**3**) (Fig. 1) were isolated from *H. acmosepalum*. Herein, we describe the isolation, structure and stereochemistry elucidation, as well as the plausible biosynthetic ways of the new compounds.

## 2. Result and discussion

Hyperacmosin N (**1**) was obtained as colorless oil. The molecular formula was established as $C_{35}H_{42}O_4$ according to its HRMS (ESI) data (*m/z* 527.3155, $[M+H]^+$, for $C_{35}H_{43}O_4$, calcd 527.3155), indicating 15 degrees of unsaturation. The IR spectrum displayed strong absorption bands due to carbonyls (1725 and 1696 $cm^{-1}$) and hydroxyl groups (3532 $cm^{-1}$). The $^1H$ NMR spectrum ($CDCl_3$) displayed signals for an *ortho*-disubstituted phenyl [$\delta_H$ 7.73 (1H, d, $J = 7.5$ Hz); 7.63 (1H, t, $J = 7.5$ Hz); 7.47 (1H, d, $J = 8.0$ Hz); 7.40 (1H, t, $J = 7.5$ Hz)], three olefinic protons [$\delta_H$ 5.41 (1H, br t, $J = 7.5$ Hz, H-23), 5.00 (1H, br t, $J = 5.0$ Hz, H-18), 4.99 (1H, t, $J = 5.0$ Hz, H-28), and six singlet methyls [$\delta_H$ 1.70 × 2, 1.69, 1.68, 1.60, 1.58]. The $^{13}C$ NMR spectrum of **1** indicated a total of 35 carbon signals, including three carbonyl carbons [$\delta_C$ 209.2 (C-4), 204.7 (C-2), 202.4 (C-10)], a phenyl group [$\delta_C$ 136.5 (C-11), 157.0 (C-12), 124.6 (C-13), 135.3 (C-14), 128.0 (C-15), 123.9 (C-16)], and six olefinic carbons [$\delta_C$ 118.5 (C-18), 134.6 (C-19), 119.2 (C-23), 137.2 (C-24), 123.1 (C-28), 132.6 (C-29)] (Table 1). In addition, the aforementioned functionalities accounted for 10 of 15 degrees of unsaturation, which implied the existence of five rings in the structure of **1**.

The polycyclic core structure of **1** was established by comprehensive analysis of 2D NMR spectral data. In the HMBC spectrum,

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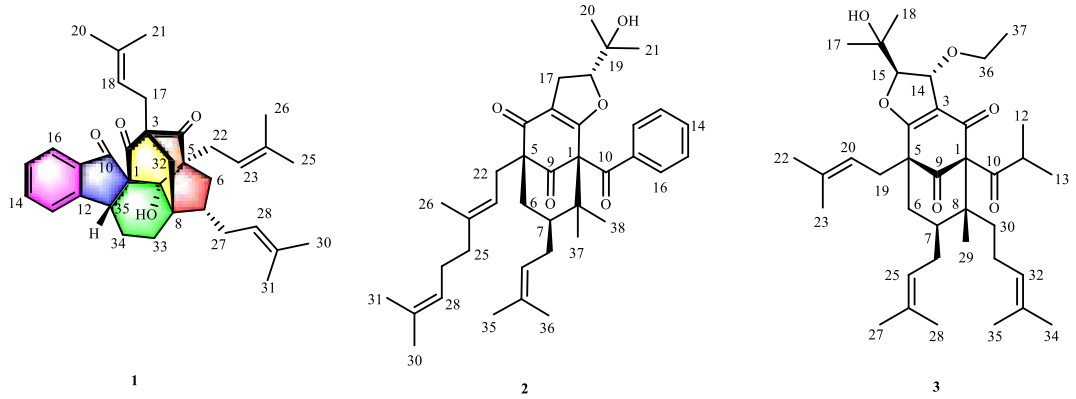


**Fig. 1.** Structures of compounds **1**–**3**.

**Table 1**
$^{1}$H NMR and $^{13}$C NMR data for compounds **1**–**3**[a].

| No | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| | $\delta_C$ | $\delta_H$ ($J$ in Hz) | $\delta_C$ | $\delta_H$ ($J$ in Hz) | $\delta_C$ | $\delta_H$ ($J$ in Hz) |
| 1 | 70.1 | | 69.2 | | 84.3 | |
| 2 | 204.7 | | 173.4 | | 187.5 | |
| 3 | 66.0 | | 118.7 | | 121.9 | |
| 4 | 209.2 | | 190.8 | | 178.8 | |
| 5 | 62.2 | | 63.6 | | 55.1 | |
| 6 | 39.4 | 2.02, dd (9.0, 13.5); 1.90, dd (6.0, 13.5) | 40.5 | 2.21 dd (14.4, 7.6); 2.11 dd (14.4, 1.2) | 39.1 | 1.47 m; 1.98 m |
| 7 | 49.3 | 1.72, m | 48.6 | 1.50 m | 41.6 | 1.95 m |
| 8 | 47.0 | | 48.9 | | 49.3 | |
| 9 | 83.9 | | 207.8 | | 206.5 | |
| 10 | 202.4 | | 193.3 | | 209.5 | |
| 11 | 136.5 | | 137.3 | | 42.7 | 2.06 m |
| 12 | 157.0 | | 128.3 | 7.57 m | 20.7 | 1.13 d (6.4) |
| 13 | 124.6 | 7.47, d | 128.6 | 7.34 m | 21.7 | 1.06 d (6.4) |
| 14 | 135.3 | 7.64, td | 132.9 | 7.49 m | 78.1 | 4.94 dd (3.4) |
| 15 | 128.0 | 7.40, br t | 128.6 | 7.34 m | 99.1 | 4.48 d (3.4) |
| 16 | 123.9 | 7.73, d | 128.3 | 7.57 m | 71.1 | |
| 17 | 25.3 | 2.49, dd (7.0,15.0); 2.35, dd (8.0, 15.0) | 27.0 27.0 | 2.95 dd (15.2, 9.2); 2.80 dd (14.8, 10.8) | 26.4 | 1.24 s |
| 18 | 118.5 | 5.00, br t (5.0) | 93.6 | 4.65 dd (10.4, 8.8) | 23.7 | 1.28 s |
| 19 | 134.6 | | 70.8 | | 29.4 | 2.51 m |
| 20 | 18.0 | 1.60, s | 23.8 | 0.89 s | 120.3 | 4.96 m |
| 21 | 26.0 | 1.68, s | 26.5 | 0.90 s | 135.2 | |
| 22 | 28.4 | 2.84, dd (8.0, 15.0); 2.67, dd (7.0, 15.5) | 29.8 | 2.62 dd (14.0, 6.4); 2.52 dd (14.4, 7.6) | 18.4 | 1.69 s |
| 23 | 119.2 | 5.41, t (7.5) | 119.2 | 5.13 m | 26.0 | 1.68 s |
| 24 | 137.2 | | 138.7 | | 27.6 | 1.78 m; 2.11 m |
| 25 | 18.5 | 1.70, s | 40.2 | 1.98 m | 122.4 | 4.99 m |
| 26 | 26.3 | 1.70, s | 16.7 | 1.72 s | 133.7 | |
| 27 | 33.1 | 2.22, m; 2.10, m | 29.8 | 2.01 m | 26.1 | 1.71 s |
| 28 | 123.1 | 4.99, br t (5.0) | 124.3 | 5.08 m | 18.1 | 1.57 s |
| 29 | 132.6 | | 131.5 | | 14.7 | 1.02 s |
| 30 | 18.0 | 1.58, s | 25.9 | 1.65 s | 36.6 | 1.75 m |
| 31 | 25.8 | 1.69, s | 17.9 | 1.57 s | 24.5 | 1.93 m; 2.06 m |
| 32 | 43.4 | 2.17, d (14.5); 1.46, d (14.5) | 29.8 | 2.25 m; 1.96 m | 124.8 | 5.02 m |
| 33 | 26.0 | 2.28, 1.64, m | 124.7 | 4.89 m | 131.2 | |
| 34 | 24.3 | 2.26, 2.18, m | 133 | | 17.8 | 1.58 s |
| 35 | 45.7 | 3.60, t (7.5) | 18.1 | 1.55 s | 25.8 | 1.64 s |
| 36 | | | 26 | 1.67 s | 66.3 | 3.89 dq (9.2, 6.8); 3.70 dq (9.2, 6.8) |
| 37 | | | 26.9 | 1.44 s | 15.7 | 1.17 t (6.8) |
| 38 | | | 23.7 | 1.48 s | | |

[a] Recorde in $CDCl_3$ ($^{1}$H NMR 400 MHz,$^{13}$C NMR 125 MHz).

the correlations from $H_2$-6 ($\delta_H$ 2.02/1.90) to C-4/C-5/C-7/C-8/C-9, from $H_2$-32 ($\delta_H$ 2.17/1.46) to C-2/C-3/C-4/C-7/C-8/C-9/C-33, from $H_2$-33 ($\delta_H$ 2.28/1.64) to C-8/C-9/C-32/C-34/C-35, from $H_2$-34 ($\delta_H$ 2.26/2.18) to C-1/C-8/C-33/C-35, and from H-35 ($\delta_H$ 3.60) to C-1/C-2/C-9/C-34 implied the presence of the tetracyclic skeleton (rings A-D) as shown in Fig. 2. Moreover, the HMBC correlation from H-16 ($\delta_H$ 7.73) to C-10, from H-35 ($\delta_H$ 3.60) to C-11/C-12/C-13, and from H-13 ($\delta_H$ 7.47) to C-35 deduced the linkage of C-12/C-35 and the formation of the ring E. The locations of isopentenyls of **1** were determined by the HMBC cross-peaks of $H_2$-17 ($\delta_H$ 2.49/2.35) with C-2/C-3/C-4/C-32, of $H_2$-22 ($\delta_H$ 2.84/2.67) with C-4/C-5/C-6/C-9, and of $H_2$-27 ($\delta_H$ 2.22/2.10) with C-6/C-7/C-8. Thus, the planar structure of **1** with an unprecedented hexacyclic skeleton was confirmed.

The relative configuration of **1** was fixed by its rigid skeleton, NOESY data in $CDCl_3$, as well as ROESY data in DMSO-$d_6$. The

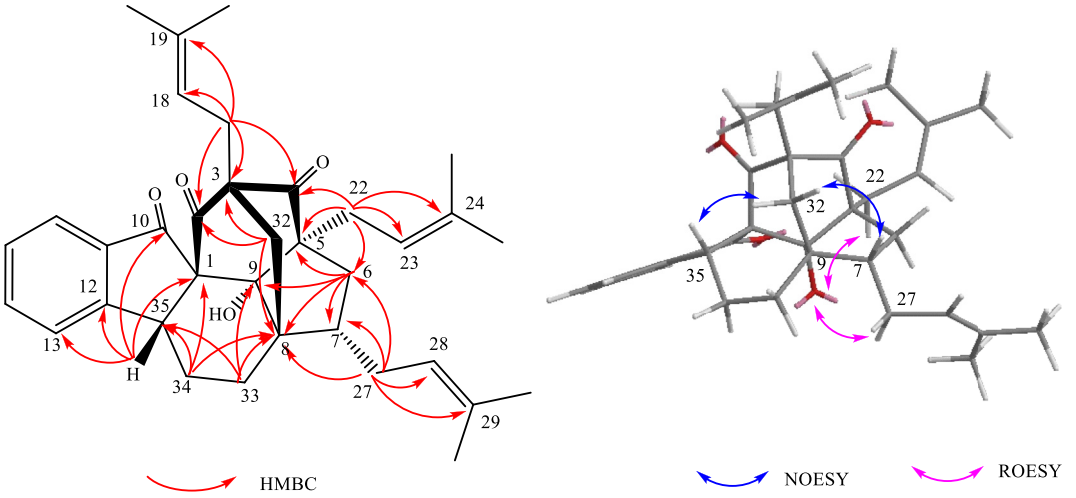



**Fig. 2.** Key HMBC, NOESY, and ROESY correlations of **1**.

correlations of H-35/H-32a, and H-7/H-32b in the NOESY spectrum ($CDCl_3$) showed they were on the same side with $\beta$-orientation (Fig. 2). In addition, the correlations of OH-9/$H_2$-22, and OH-9/$H_2$-27 in the ROESY spectrum (DMSO-$d_6$) supported the configuration of C-5, C-7, and C-9.

The absolute configurations of **1** was elucidated by ECD calculation using time-dependent density functional theory (TD-DFT). A pair of enantiomers, (1*R*, 3*S*, 5*S*, 7*S*, 8*R*, 9*S*, 35*R*)-**1a** and (1*S*, 3*R*, 5*R*, 7*R*, 8*S*, 9*R*, 35*S*)-**1b** were calculated for ECD spectra based on the known relative configuration of **1**. The ECD spectrum of **1** was in sufficient agreement with **1a** (Fig. 5). Therefore, the absolute configuration of **1** was determined to be 1*R*, 3*S*, 5*S*, 7*S*, 8*R*, 9*S*, 35*R*.

Hyperacmosin O (**2**) was obtained as colorless oil. The molecular formula was established as $C_{38}H_{50}O_5$ according to its HRMS (ESI) data (*m/z* 587.3722, $[M+H]^+$, for $C_{38}H_{51}O_5$, calcd 587.3731), indicating 14 degrees of unsaturation. The IR spectrum displayed strong absorption bands due to carbonyls (1723 and 1701 $cm^{-1}$) and hydroxyl groups (3574 and 3475 $cm^{-1}$). The $^1H$ NMR spectrum ($CDCl_3$) showed characteristic signals assignable to a benzoyl [$\delta_H$ 7.57 (2H, m); 7.49 (1H, m); 7.34 (2H, m)], three olefinic protons [$\delta_H$ 5.13 (1H, m, H-23), 5.08 (1H, m, H-28), 4.89 (1H, m, H-33), and nine singlet methyls [$\delta_H$ 0.89, 0.90, 1.72, 1.65, 1.57, 1.55, 1.67, 1.44, 1.48]. The $^{13}C$ NMR spectrum of **2** indicated a total of 38 carbon signals, including three carbonyl carbons [$\delta_C$ 190.8 (C-4), 207.8 (C-9), 193.3 (C-10)], eight olefinic carbons [$\delta_C$ 173.4 (C-2), 118.7 (C-3), 119.2 (C-23), 138.7 (C-24), 124.3 (C-28), 131.5 (C-29), 124.7 (C-33), 133.0 (C-34)], one benzoyl group [$\delta_C$ 137.3 (C-11), 128.3 (C-12 and C-16), 128.6 (C-13 and C-15), 132.9 (C-14)] (Table 1). In addition, the aforementioned function groups accounted for 11 of 14 degrees of unsaturation, which implied the existence of three rings in the structure of **2** (Fig. 1).

The structure of compound **2** was subsequently supported by inspecting its 2D NMR spectra. The HMBC correlations from $H_2$-17 ($\delta_H$ 2.80/2.95) to C-2/C-3/C-4/C-18/C-19, from $H_2$-22 ($\delta_H$ 2.52/2.62) to C-4/C-5/C-6/C-9/C-23/C-24, and from $H_2$-32 ($\delta_H$ 2.01/2.24) to C-6/C-7/C-8/C-33/C-34, suggested that **2** shared same planar structure with sampsonione M [15]. Moreover, the NMR data of **2** was very close to that of sampsonione M except for few slight shifts (**2**: $\delta_H$ 4.65, dd, $J$ = 10.4, 8.8 Hz, H-18; 0.89, s, $H_3$-20; 0.90, s, $H_3$-21; sampsonione M: $\delta_H$ 4.02, dd, $J$ = 11.2, 10.2 Hz, H-18; 1.14, s, $H_3$-20; 1.18, s, $H_3$-21), which revealed that **2** was likely a C-18 epimer of sampsonione M. According to the ROESY correlation from H-18 ($\delta_H$ 4.65) to $H_2$-32 and $H_3$-38, the isopentenyl group at C-7 and the proton at C-18 were both determined to be $\alpha$-orientation. Therefore, the relative configuration of **2** was elucidated as shown in Fig. 3.

Hyperacmosin P (**3**) was isolated as colorless oil, and its molecular formula was established as $C_{37}H_{56}O_6$ according to the HRMS (ESI) data (*m/z* 597.4150 $[M+H]^+$, calcd 597.4150), indicating 10 degrees of unsaturation. The IR spectrum displayed strong absorption bands due to carbonyls (1725 $cm^{-1}$) and hydroxyl group (3491 $cm^{-1}$). Examination of its $^1H$ NMR spectrum revealed the presence of three olefinic protons ($\delta_H$ 4.96 (1H, m, H-20), 4.99 (1H, m, H-25), 5.03 (1H, m, H-32); one isopropyl group ($\delta_H$ 2.06, 1H, m; 1.06, 3H, d, $J$ = 6.4 Hz; 1.13, 3H, d, $J$ = 6.4 Hz); eight singlet methyls [$\delta_H$ 1.24, 1.28, 1.57, 1.58, 1.64, 1.68, 1.69, 1.71]; one ethoxy group ($\delta_H$ 3.89, 1H, dq, $J$ = 9.2, 6.8 Hz; 3.70, 1H, dq, $J$ = 9.2, 6.8 Hz; 1.17, 3H, t, $J$ = 6.8 Hz). The $^{13}C$ NMR spectrum of **2** indicated a total of 37 carbon signals, including three carbonyl carbons [$\delta_C$ 187.5 (C-2), 206.5 (C-9), 209.5 (C-10)], and eight olefinic carbons [$\delta_C$ 121.9 (C-3), 178.8 (C-4), 120.3 (C-20), 135.2 (C-21), 122.4 (C-25), 133.7 (C-26), 124.8 (C-32), 131.2 (C-33)] (Table 1). In addition, the aforementioned function groups accounted for 7 of 10 degrees of unsaturation, which implied the existence of three rings in the structure of **3** (Fig. 1).

The planar structure of **3** was deduced by the key HMBC correlations from H-14 ($\delta_H$ 4.94) to C-3/C-4/C-15/C-16/C-36, from H-15 ($\delta_H$ 4.48) to C-4/C-14/C-17/C-18, from $H_2$-19 ($\delta_H$ 2.51) to C-4/C-5/C-6/C-9/C-20/C-21, from $H_2$-24 ($\delta_H$ 1.78/2.11) to C-6/C-7/C-8/C-25/C-26, and from $H_2$-30 ($\delta_H$ 1.75) to C-1/C-7/C-8/C-29/C-31/C-32. The ROESY cross-peaks of H-6$\beta$ ($\delta_H$ 1.47) with H-19, of $H_3$-29 ($\delta_H$ 1.02) with H-6$\beta$, and of H-24 ($\delta_H$ 1.78) with $H_3$-29, of $H_3$-17 ($\delta_H$ 1.24) with H-20, and of H-14 ($\delta_H$ 4.94) with Me-18 indicated that the relative configuration of **3** was consistent with that of 27-Epifurohyperforin isomer 1 [16] as shown in Fig. 4.

The absolute configuration of Hyperacmosins O–P (**2**–**3**) were elucidated by the comparison of their CD spectra with other compounds. The CD spectrum of compound **2** is similar to that of hypersampsone T [17] (Fig. 5) while compound **3** matched well with hyperforatin K [3] (Fig. 5), on account of them, the absolute configuration of **2** was determined as 1*R*, 5*S*, 7*S*, 18*R* and **3** was determined as 1*R*, 5*R*, 7*S*, 8*R*, 14*R*, 15*R*.

The biogenetic pathway for **1**–**3** were proposed to be biosynthesized from the common precursor 2,4,6-trihydroxybenzophenone, which was further reacted with dimethylallyl diphosphate (DMAPP) followed by different ways of cyclization to yield the intermediate **i**, **ii**, and **iii**. Compound **1** could

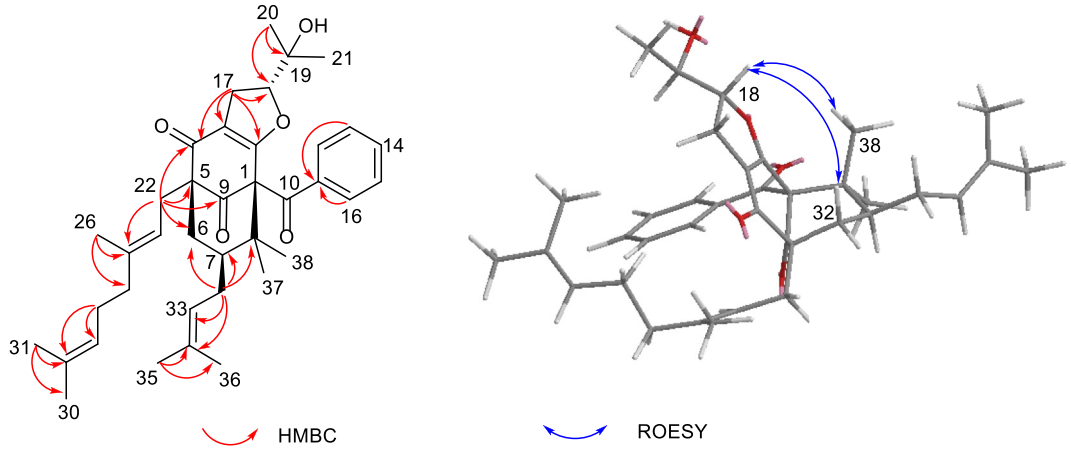



**Fig. 3.** Key HMBC and ROESY correlations of **2**.

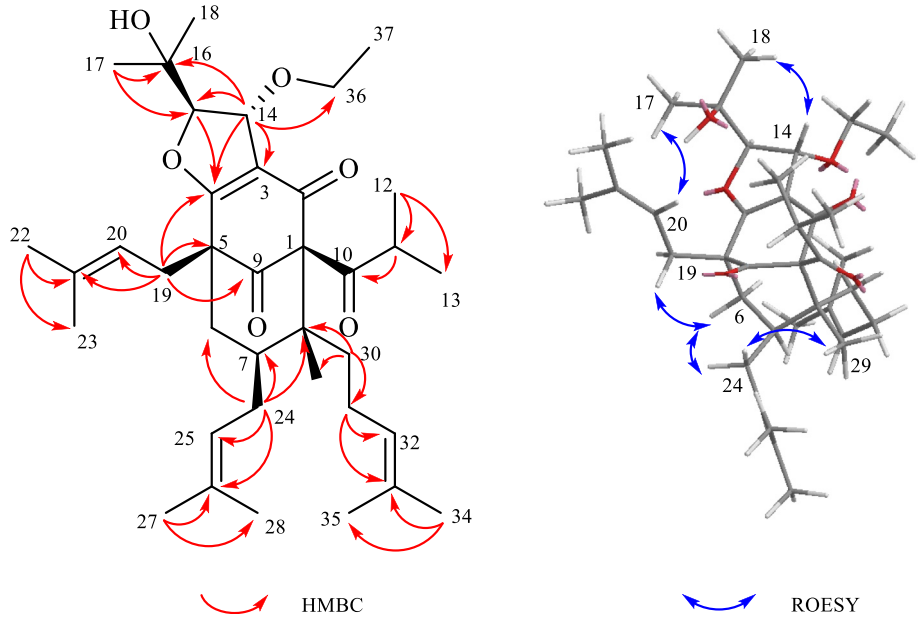
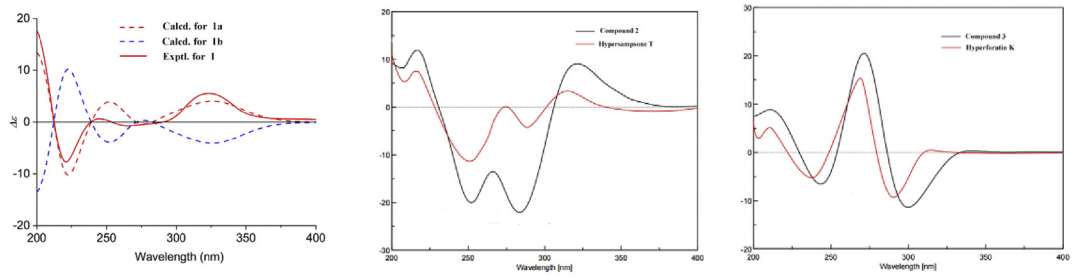



**Fig. 4.** Key HMBC and ROESY correlations of **3**.

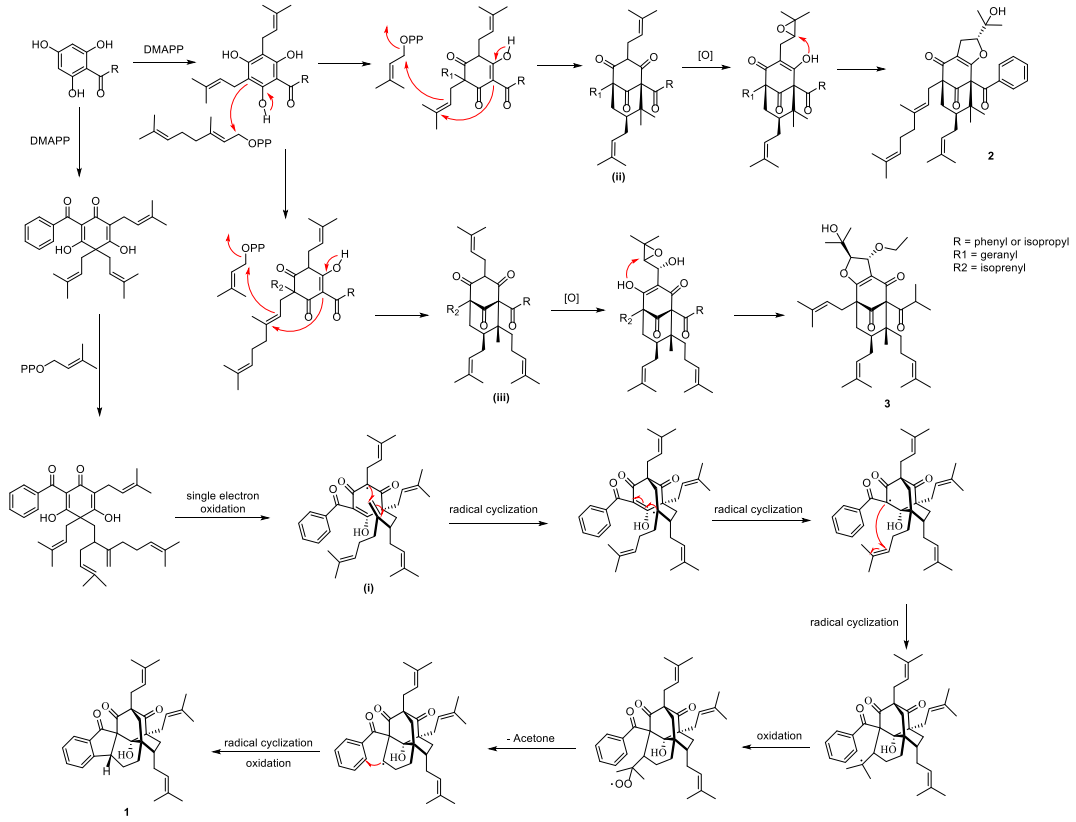



(a) (b) (c)

**Fig. 5.** (a) Calculated and Experimental ECD spectra of **1**. (b) The comparison of the CD spectra of 2 and hypersampsone T. (c) The comparison of the CD spectra of 3 and hyperforatin K.

be formed from the intermediate **i** via radical cyclization and oxidation to build the polycyclic rings system [18–20], while **2** or **3** was generated from the intermediate **ii** or **iii** through oxidation and intramolecular cyclization successively (Scheme 1).

Compounds **1**–**3** were evaluated for their hepatoprotective activitity against paracetamol-induced HepG2 cell damage, but none of them exhibited evident hepatoprotective activity at 10 μM. Furthermore, the type of ethers like compond **3** are rare in PPAPs, so




**Scheme 1.** Plausible biosynthetic pathways of **1**–**3**.

we suppose compound **3** might be an artifact because ethanol was used in the process of extraction, and we will validate our supposition in the following works.

## 3. Conclusion

In conclusion, hyperacmosins N–P (**1**–**3**), three new polycyclic polyprenylated acylphloroglucinol derivatives were isolated from the air-dried aerial parts of *H. asmosepalum*. Particularly, compound **1** possessed a rare hexacyclic core, which was formed via oxidation and radical cyclization. Their structures were established by NMR, HRMS (ESI), and experimental electronic circular dichroism (ECD) spectra. Biological assays showed compounds **1**–**3** had no evident hepatoprotective activity against paracetamol-induced HepG2 cell damage. Our study may provide the basis for further phytochemical investigation on the medicinal plant *H. asmosepalum*.

## 4. Experimental section

### 4.1. General experimental procedures

Melting points were measured on an XT5B melting instrument and uncorrected. Optical rotations were measured on a JASCO P-2000 polarimeter UV spectra were measured on a JASCO V650 spectrophotometer. The CD spectra were measured on a JASCO J-815 CD spectrometer (JASCO). IR spectra were recorded on a Nicolet 5700 FT-IR microscope instrument (FT-IR microscope transmission). IR (KBr pellet) spectra were conducted by Nicolet IS5 instrument (ThermoS2 Scientific, Waltham, MA, USA). NMR spectra were acquired with VNS-400 spectrometers and VNS-500 spectrometers. HRESI–MS spectra were collected on an Agilent 1100 series LC/MSD ion trap mass spectrometer. Preparative HPLC was performed on a Shimadzu LC-6AD instrument with a SPD-20A detector, using an YMC-Pack ODS-A column (2 × 25 cm, 5 μm). Column chromatography was performed with silica gel (200–300 mesh, Qingdao Marine Chemical Inc., Qingdao, People's Republic of China) and ODS (50 μm, YMC, Japan). Chiral AD-H column (4.6 mm × 250 mm, 5 μm, Daicel, Japan); TLC was carried out on glass precoated silica gel GF254 plates. Spots were visualized under UV light or by sprayingwith 10% sulfuric acid in EtOH followed by heating.

### 4.2. Plant material

The air-dried aerial parts of *H. acmosepalum* were collected from Li jiang, Yunnan Province (100°11′ E; 26°11′ N), People's Republic of China, in July 2016. Associate Prof. Lin Ma was responsible for the identification of the plant. A voucher specimen (No. ID-S-2764) was deposited in the Institute of Materia Medica, Chinese Academy of Medical Sciences.

### 4.3. Extraction and isolation

The air-dried aerial parts of *H. acmosepalum* (15.0 kg) were extracted by 95% ethanol (150 L × 3 times) under reflux. The crude extract was suspended in $H_2O$ and partitioned with petroleum ether. The petroleum ether extract (562.0 g) was separated on a silica gel column (petroleum ether/EtOAc, 100:0 to 0:100) to gain five fractions (Fr.1-5). Fr.3 (95.2 g) was further purified by chromatography on a diol column, eluting with petroleum ether/EtOAc (100:0 to 0:100) to yield fourteen fractions (Fr.3.1-Fr.3.14). Fr.3.5 (6.1 g) was fractionated using a Sephadex LH-20 column with MeOH–CH2Cl2 (v/v 1:1) as eluent to give 8 fractions (Fr.3.5.1-Fr.3.5.8), Fr.3.5.6 was purified by semi-preparative HPLC (MeOH/

$H_2O$ 90:10, 3 ml/min, 254 nm) to yield **2** (5.3 mg, $t_R = 25.8$ min). Fr.3.6 (9.9 g) was fractionated using a Sephadex LH-20 column with MeOH−CH2Cl2 (v/v 1:1) as eluent to give 9 fractions (Fr.3.6.1-Fr.3.6.9), Fr.3.6.7 was purified by semi-preparative HPLC (MeOH/$H_2O$ 93:7, 3 ml/min, 254 nm) to yield **1** (6.2 mg, $t_R = 32.3$ min). Fr.3.10 (11.5 g) was purified over ODS (MeOH/$H_2O$, 70:30 to 100:0) to yield seven fractions (Fr.3.10.1-Fr.3.10.7). Fr.3.10.2 (249.0 mg) was also purified by semi-preparative HPLC (MeOH/$H_2O$ 93:7, 3 ml/min, 254 nm) to yield **3** (7.3 mg, $t_R = 35.5$ min).

Hyperacmosin N (**1**): colorless oil; $[\alpha]^{20}_D$ +47.3 (*c* 0.1, MeOH); UV (MeOH) $\lambda_{max}$ (log $\varepsilon$) 204 (4.48), 247 (4.19), 282 (4.11) nm; ECD (MeOH) $\lambda$ ($\Delta\varepsilon$) 221 (−7.64), 245 (0.61), 265 (−0.72), 324 (5.56) nm; IR $\upsilon_{max}$ 3532, 2976, 2928, 1725, 1696, 1451, 1382 $cm^{-1}$; HRESIMS *m/z* 527.3156 $[M + H]^+$ (calcd for $C_{35}H_{43}O_4$, 527.3156).

Hyperacmosin P**:** colorless oil; $[\alpha]^{20}_D$ −1.5 (*c* 0.1, MeOH); UV (MeOH) $\lambda_{max}$ (log $\varepsilon$) 203 (4.13), 248 (3.73), 282 (3.63) nm; CD (MeOH) $\lambda$ ($\Delta\varepsilon$) 217 (11.85), 252 (−20.05), 266 (−13.53), 284 (−22.08), 322 (8.99) nm; IR $\upsilon_{max}$ 3574, 3475, 2975, 2924, 1723, 1700, 1656, 1632, 1446, 1391, 1240 $cm^{-1}$; HRESIMS *m/z* 587.3733 $[M + H]^+$ (calcd for $C_{38}H_{51}O_5$, 587.3731).

Hyperacmosin Q**:** colorless oil; $[\alpha]^{20}_D$ −19.2 (*c* 0.1, MeOH); UV (MeOH) $\lambda_{max}$ (log $\varepsilon$) 203 (4.23), 274 (4.10) nm; CD (MeOH) $\lambda_{max}$ ($\Delta\varepsilon$) 211 (8.79), 244 (−6.57), 272 (20.51), 300 (−11.39) nm; IR $\upsilon_{max}$ 3491, 2972, 2924, 1725, 1647, 1623, 1447, 1405, 1380 $cm^{-1}$; HRESIMS *m/z* 597.4150 $[M + H]^+$ (calcd for $C_{37}H_{57}O_6$, 597.4150).

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tet.2021.132286.

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