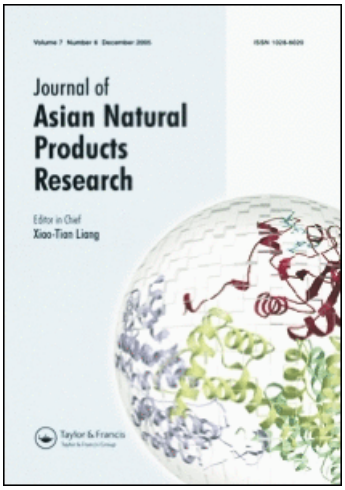


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# Urceolatol, a tetracyclic bromobenzaldehyde dimer from *Polysiphonia urceolata*

Q. -W. Liu[a]; C. -H. Tan[b]; T. Zhang[c]; S. -J. Zhang[b]; L. -J. Han[d]; X. Fan[d]; D. -Y. Zhu[b]
[a] Graduate School of the Chinese Academy of Sciences, Beijing, China [b] State Key Laboratory of Drug Research, Shanghai Institute of Materia Medica, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai, China [c] Shandong Engineering Research Center for Natural Drugs, Yantai, China [d] Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China

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*Note*

# Urceolatol, a tetracyclic bromobenzaldehyde dimer from *Polysiphonia urceolata*

Q.-W. LIU†‡¶, C.-H. TAN‡, T. ZHANG§, S.-J. ZHANG‡, L.-J. HAN†, X. FAN† and D.-Y. ZHU‡*

†Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China
‡State Key Laboratory of Drug Research, Shanghai Institute of Materia Medica, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai 201203, China
¶Graduate School of the Chinese Academy of Sciences, Beijing 100039, China
§Shandong Engineering Research Center for Natural Drugs, Yantai 264003, China

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Urceolatol (**1**), a novel bromobenzaldehyde dimer, together with one known bromophenol, 3-bromo-4,5-dihydroxy-benzaldehyde (**2**), were isolated from the red alga *Polysiphonia urceolata.* The structure and absolute stereochemistry of **1** were elucidated to be (5*R*,10*R*)-2,7-dibromo-3,8-dihydroxy-5,10-dimethoxyl-5,10-dihydrochromeno[5,4,3-cde]chromene, on the basis of spectroscopic techniques and X-ray diffraction analysis.

*Keywords*: Urceolatol; *Polysiphonia urceolata*; Rhodomelaceae; Red alga

## 1. Introduction

*Polysiphonia urceolata* is a red alga belonging to the family Rhodomelaceae. Previous studies indicated that bromophenols were the main components in plants of the family Rhodomelaceae. [1–15]. Phytochemical investigation on the EtOH extract of the title plant, yielded urceolatol (**1**), a novel bromobenzaldhyde dimer, whose structure was determined to be (5*R*,10*R*)-2,7-dibromo-3,8-dihydroxy-5,10-dimethoxyl-5,10-dihydrochromeno[5,4,3-cde]chromene. Herein, we describe the isolation and structural elucidation of urceolatol.

*Corresponding author. E-mail: dyzhu@mail.shcnc.ac.cn

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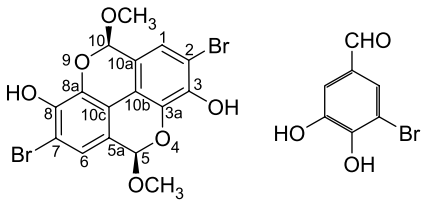


1 2

## 2. Results and discussion

Compound **1** was obtained as colourless prisms. Its IR absorptions suggested the existence of hydroxyl groups (3491 $cm^{-1}$) and aromatic rings (1618 and 1479 $cm^{-1}$). In the EI-MS spectrum, the molecular ion peak cluster at *m/z* 456/458/460 with a ratio of abundances 1:2:1 revealed the presence of two bromine atoms in the molecule. A high-resolution measurement on the peak at *m/z* 457.9003 indicated the molecular formula $C_{16}H_{12}Br_2O_6$.

The $^1$H NMR spectrum showed four singlets due to a methoxyl ($\delta$ 3.55, 3H), a phenolic hydroxyl group ($\delta$9.10, 1H), an aromatic proton ($\delta$7.32, 1H), and an acetal proton ($\delta$6.22, 1H). In the $^{13}$C NMR spectrum (table 1), 8 carbon signals were observed, which were resolved into one methoxyl, one acetal carbon, and a penta-substituted benzene ring carbon by the DEPT experiment. Under the consideration of the molecular formula $C_{16}H_{12}Br_2O_6$, **1** was suggested to be a symmetrical bromobenzaldehyde dimer.

By comparing the NMR data of **1** with those of **2** [6], the planar structure of **1** was tentatively assigned as a dimer of **2**. Two molecules of **2** were dimerised through a carbon–carbon bond between two molecules of **2**, and two acetal groups formed between the aldehyde functions and a hydroxyl group of the other benzene ring. Consequently, the carbon bond of the biphenyl was appointed at the common *ortho*-position of the aldehyde of **2**. This postulated structure was confirmed by 2D NMR (HMQC and HMBC, figure 1) experiments. Furthermore, the methoxyls were located at the acetal carbons based on the HMBC cross-peaks of $\delta_H$ 3.55/$\delta_C$ 99.2 and $\delta_H$ 6.22/$\delta_C$ 56.0 (figure 1). This molecule possesses two identically chiral carbons at C-5 and C-10. An X-ray crystallographic analysis of **1** (figure 2) displayed both absolute configurations to be *R*. Therefore, **1** was formulated to (5*R*,10*R*)-2,7-dibromo-3,8-dihydroxy-5,10-dimethoxyl-5,10-dihydrochromeno[5,4,3-cde]chromene. A biogenetic pathway from

Table 1. NMR data of **1** (400 MHz for $^1$H and 100 MHz for $^{13}$C, $\delta$, ppm (*J*, Hz), acetone-$d_6$).

| *Position* | $\delta_C$ *(mult)* | $\delta_H$ *(mult)* | *HMBC (H → C)* |
|---|---|---|---|
| 1, 6 | 123.6 (d) | 7.32 (s) | C-2, C-3, C-10, C-10a, C-10b |
| 2, 7 | 109.9 (s) | | |
| 3, 8 | 144.4 (s) | | |
| 3a, 8a | 136.2 (s) | | |
| 5, 10 | 99.2 (d) | 6.22 (s) | C-1, C-10a, C-10b, C-8a, $OCH_3$ |
| 5a, 10a | 113.8 (s) | | |
| 10b, 10c | 120.4 (s) | | |
| $OCH_3$ | 56.0 (q) | 3.55 (s) | C-10 |
| OH | | 9.10 (s) | C-2, C-3, C-3a |

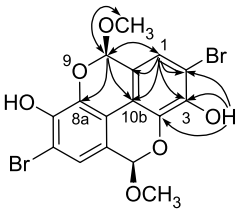


Figure 1. Key HMBC correlations of **1** (H to C).

**2** to **1** is proposed in figure 3. To the best of our knowledge, urceolatol is rare example of tetracyclic bromobenzaldehyde dimer isolated from marine organisms.

## 3. Experimental

### *3.1 General experimental procedures*

Melting points were determined on an XT-4 micro melting point apparatus and are uncorrected. IR spectra were recorded on a Nicolet Magna-FTIR-750 spectrophotometer. UV spectra were obtained on a Shimadzu UV 250 spectrophotometer. Low-resolution EI-MS was measured on a MAT-95 spectrometer and HREI-MS on a MAT-77 spectrometer. NMR data were obtained on a Bruker AM-400 NMR instrument with TMS as internal standard. Column chromatography (CC) was performed with silica gel (200–300, 400 mesh) and Sephadex LH-20. TLC was carried out with glass pre-coated silica gel $GF_{254}$ plates. Spots were visualised under UV light or by spraying with 7% sulphuric acid in EtOH followed by heating.



### *3.2 Plant material*

The red alga *Polysiphonia urceolata* was collected at the coast of Qingdao, China, in May 2003 and identified by Dr Kui-Shuang Shao of the Institute of Oceanology, Chinese Academy of Sciences. A voucher specimen (No. 200305) is deposited in the same institute.

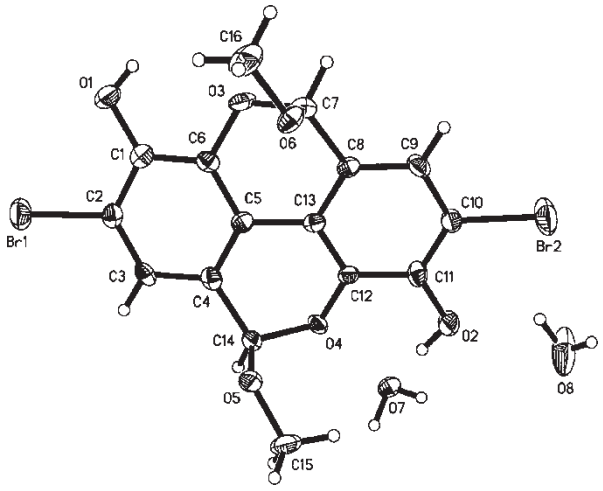


Figure 2. The ORTEP viewing of **1**.

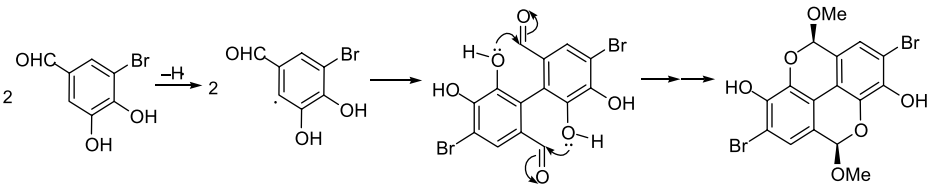

Figure 3. Hypothetical biogenetic route from **2** to **1**.

### *3.3 Extraction and isolation*

Air-dried *P. urceolata* (9.6 kg) was extracted with 95% EtOH (3 × 10 L) at room temperature. Solvents were removed *in vacuo* to yield a dark residue. The residue was suspended in water and then partitioned with EtOAc. The EtOAc fraction (200 g) was chromatographed over a silica gel (2 kg) column eluted with a gradient increasing $Me_2CO$ (0–100%) in $CHCl_3$ (changing when the eluent being colourless). The 20% $Me_2CO$ fraction (2.3 g) was divided into EtOAc-soluble and precipitate portion. The former was further subjected to silica gel CC eluted with petroleum ether/$Me_2CO$ (4:1), subsequently purified through a Sephadex LH-20 column, to yield **1** (62 mg); **2** (714 mg) was obtained from the latter after repeated CC over silica gel with $CHCl_3$/$Me_2CO$ (3:1) as eluent.

**3.3.1 (5*R*,10*R*)-2,7-Dibromo-3,8-dihydroxy-5,10-dimethoxyl-5,10-dihydrochromeno [5,4,3-cde]chromene (1)**. Colourless prisms (petroleum ether/$Me_2CO$, 3:1), mp 188.5–189.5°C (decom); $[\alpha]_D^{20}$: −2 (*c* 0.367, $Me_2CO$); $UV_{max}$ (MeOH): 229.0 (log ε 4.65), 289.0 (4.35), 318.5 (3.89) nm; IR (KBr): 3491, 2920, 1618, 1479, 1419, 1342, 1242, 1093, 1018, 955, 928, 879 $cm^{-1}$; $^1H$ NMR and $^{13}C$ NMR data: see table 1; EI-MS *m/z* 462, 460, 458 ($M^+$, 18%/36%/18%), 431 (50), 429 (100), 427 (50), 399 (37), 397 (74), 395 (37), 149 (8); HREI-MS *m/z* 457.9003 $[M]^+$ (calcd for $C_{16}H_{12}^{79}Br_2O_6$, 457.9001).

**3.3.2 X-ray crystal data of compound 1**. $C_{16}H_{12}Br_2O_6 \cdot (3/2)H_2O$, orthorhombic, $P2_12_12$, $a = 18.483$ (2), $b = 9.4125$ (10), $c = 10.0721$ (11)Å, $\alpha = \beta = \gamma = 90°$, $V = 1752.2$ (3)Å$^3$, $Z = 2$, crystal size: 0.515 × 0.372 × 0.068 mm. A total of 2323 unique reflections were collected using graphite monochromated MoKα radiation ($\lambda = 0.71073$ Å) on a Rigaku AFCFR diffractometer. The structure was solved by direct methods (SIR-97) refined by full matrix least squares techniques based on $F^2$ to give $R = 0.1192$, $wR2 = 0.2020$ with 0.00 (9) as absolute structure parameter. Crystallographic data (excluding structure factors) for the structure in this paper have been deposited at the Cambridge Crystallographic Data Centre as supplementary publication number CCDC 243844. Copies of the data can be obtained, free of charge, on application to the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (fax: +44-1223-336033 or . E-mail: deposit@ccdc.cam.ac.uk).

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