SUPPLEMENTARY MATERIAL

Acanthophoraine A, a new pyrrolidine alkaloid from the red alga

Acanthophora spicifera

Jia-Li Lin\textsuperscript{a}, Yong-Qian Liang\textsuperscript{a}, Xiao-Jian Liao\textsuperscript{a}, Jian-Ting Yang\textsuperscript{a}, Dai-Chun Li\textsuperscript{a}, Yu-Ling Huang\textsuperscript{a}, Zhi-Hui Jiang\textsuperscript{b,\ast}, Shi-Hai Xu\textsuperscript{a,\ast}, Bing-Xin Zhao\textsuperscript{a,\ast}

\textsuperscript{a} Department of Chemistry, College of Chemistry and Materials Science, Jinan University, Guangzhou, 510632, P. R. China

\textsuperscript{b} Department of Pharmacy, Guangzhou General Hospital of Guangzhou Military Command, 510010, P. R. China

\textsuperscript{\ast} Corresponding authors

E-mail addresses: zbx840622@163.com; txush@jnu.edu.cn; zh.86.jiang@gmail.com.

Abstract: A new pyrrolidine alkaloid, acanthophoraine A (1), along with six known alkaloids (2-7), had been isolated from the red alga Acanthophora spicifera. The structures of these compounds were identified by spectroscopic analyses. The absolute configuration of 1 was established by ECD calculation. Compound 1 represents the first example of \textit{N}-isobutyl pyrrolidone with an urea arm. The antimicrobial activity of 1 was also evaluated.

Keywords: red alga; Acanthophora spicifera; alkaloids
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Quantum chemical ECD calculations of 1

The molecules of \(5R\)-1 and \(5S\)-1 were converted into SMILES codes before their initial 3D structures were generated with CORINA version 3.4. Conformer databases were generated in CONFLEX version 7.0 using the MMFF94s force-field, with an energy window for acceptable conformers (ewindow) of 5 kcal mol\(^{-1}\) above the ground state, a maximum number of conformations per molecule (maxconf) of 100, and an RMSD cutoff (rmsd) of 0.5Å. Then each conformer of the acceptable conformers was optimized with HF/6-31G(d) method in Gaussian09. Further optimization at the APFD/6-31G(d) level with methanol led the dihedral angles to be got. After that, nine stable conformers (above 1% population) were found out. The optimized conformers were taken for the ECD calculations, which were performed with Gaussian09 (APFD/6-311++G(2d,p)). The solvent effect was taken into account by the polarizable-conductor calculation model (IEFPCM, methanol as the solvent). Comparisons of the experimental and calculated spectra were done with the software SpecDis2,3. It was also used to apply a UV shift to the ECD spectra, Gaussian broadening of the excitations, and Boltzmann weighting of the spectra.

Table S1. Conformers distribution of \(5R\)-1 at the APFD/6-31G(d) level with solvated model

| Conformers | Population % | Conformers | Population % | Conformers | Population % |
|------------|--------------|------------|--------------|------------|--------------|
| 1          | 32.33        | 4          | 7.97         | 7          | 4.33         |
| 2          | 24.57        | 5          | 6.94         | 8          | 3.63         |
| 3          | 12.10        | 6          | 6.07         | 9          | 2.06         |

Figure S1. Experimental ECD spectrum of 1 and calculated ECD spectra of \((5R)\)-1 and \((5S)\)-1
(UV correction = 0 nm, band width \(\sigma = 0.3\) eV)
Table S2. $^1$H and $^{13}$C NMR spectral data of 1 (in DMSO-$d_6$, δ, $J$ in Hz)\(^a\)

| No. | $\delta_H$ | $\delta_C$ |
|-----|------------|------------|
| 2   | -          | 173.1      |
| 3   | a 2.24     | 29.1       |
|     | b 2.17     |            |
| 4   | a 2.25     | 26.1       |
|     | b 1.63 m   |            |
| 5   | 5.29 m     | 64.1       |
| 6   | 6.68 d (9.6)| -         |
| 7   | -          | 157.8      |
| 8   | 5.62 s     | -          |
| 1’  | a 3.08 dd (13.2, 8.7) | 46.4 |
|     | b 2.67 dd (13.2, 6.0) |    |
| 2’  | 1.94 m     | 26.0       |
| 3’  | 0.82 d (6.9)| 20.3      |
| 4’  | 0.74 d (6.9)| 19.9      |

\(^a\) Overlapped signals are reported without designating multiplicity.

Figure S2. Key $^1$H-$^1$H COSY and HMBC correlations of 1.
Figure S3. UV spectrum of 1

Figure S4. IR spectrum of 1
Figure S5. HR-ESI-MS spectrum of 1

Figure S6. $^1$H NMR spectrum of 1 (300 MHz in DMSO-$d_6$)
Figure S7. $^{13}$C NMR spectrum of 1 (75 MHz in DMSO-$d_6$)

Figure S8. $^1$H-$^1$H COSY spectrum of 1
Figure S9. HSQC spectrum of 1

Figure S10. HMBC spectrum of 1