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A POLYHALOGENATED INSECTICIDAL MONOTERPENE FROM THE RED ALGA, *PLOCAMIUM TELFAIRIAE*

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Key Word Index—*Plocamium telfairiae*; Plocamiaceae; polyhalogenated monoterpene; telfairine; insecticidal activity.

Abstract—A new polyhalogenated insecticidal monoterpene was isolated from the red alga, *Plocamium telfairiae*. Its structure was elucidated by NOE difference spectrum (NOED) analysis. This compound exhibited strong insecticidal activity against mosquito larvae (*Culex pipiens pallens*).

INTRODUCTION

A number of polyhalogenated acyclic and monocyclic monoterpenes have been isolated from red seaweeds of the families Plocamiaceae and Rhizophyllidaceae or sea hares of the genus *Aplysia* [1]. Among them, two cyclic monoterpenes, violacene [2] and plocamene B [3] from *Plocamium violaceum* have been reported to exhibit insecticidal activity and growth inhibitory activity against tobacco hornworm larvae and mosquito larvae, respectively [4]. In the course of our research program for pesticidally active compounds of natural origin, we isolated a new polyhalogenated monoterpene (**1**), named as telfairine and a known compound (**2**) from the red alga, *P. telfairiae*. We describe here the structure elucidation of telfairine (**1**) and the insecticidal activity of compounds **1** and **2**.

RESULTS AND DISCUSSION

Telfairine (**1**) was obtained as colourless amorphous powders: mp 62–63°; $C_{10}H_{14}Cl_3Br$ (high resolution MS). The presence of a *trans*-2-bromovinyl group was shown by the signal at δ 138.8 and 108.8 in the ^{13}CNMR spectrum and by an AB quartet at δ 6.45 and 6.32 (J = 13.6 Hz) in the ^1H NMR spectrum, and the molecular formula indicated that telfairine (**1**) had a monocyclic skeleton. The remaining signals in the ^1H and ^{13}CNMR spectra (Table 1) suggested the presence of two tertiary methyl groups (9-Me and 10-Me), two halomethine groups (2-H and 4-H), their neighbouring methylene group (3-H_{eq} and 3-H_{ax}) and an isolated methylene group (6-H_{eq} and 6-H_{ax}). These spectral data indicated that the carbon skeleton of compound **1** was 1-ethyl-1,5-dimethylcyclohexane. The diaxial arrangement of 2-H and 4-H was obvious from $J_{2,3ax}$ (12.5 Hz) and $J_{3ax,4}$ (12.8 Hz) characteristic of a chair form cyclohexane. The difference NOE (NOED) spectrum led to the determination of the relative stereochemistry of telfairine (**1**) in comparison with that of compound **2** whose absolute configuration was determined by X-ray crystallographic analysis [5]. On irradiation at the signal for 9-Me on C-1 of compound **1**, the signals for 8′-H, 2-H, 6-H_{ax} and 6-H_{eq} exhibited NOE enhancements. Saturation of the signal for 10-Me induced NOE to 7′-H, 3-H_{ax} and 6-H_{eq} (Fig. 1). These spectral features are consistent with those of a monoterpene (**3**) from *P. cartilagineum* whose structure was deduced by X-ray analysis [6] and revised by NOED [7]. On the other hand, irradiation at the signal for 9-Me of compound **2** induced NOE enhancement to 10-Me as well as 3-H_{ax} and 6-H_{eq}. This result reflected on the diaxial disposition of the two tertiary methyl group on C-1 and C-5 (Fig. 1). The difference of the NOED data between compound **1** and **2** suggested that the stereochemistry at C-1 of telfairine (**1**) is opposite to that of compound **2**, indicating that the two tertiary methyl groups of telfairine (**1**) were oriented in an equatrial position on C-1 (9-Me) and in an axial position on C-5 (10-Me), respectively. Accordingly, the relative configurations of telfairine were deduced as **1**.

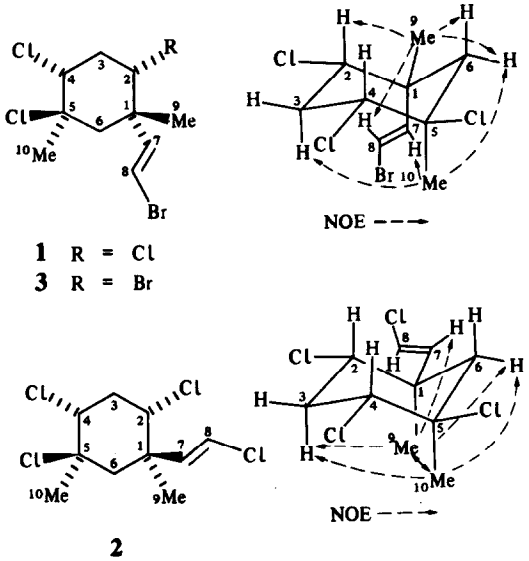

Fig. 1. The structures of telfairine (**1**) and compound **2**.

Table 1. ^1H and ^{13}C NMR chemical shifts for telfairine (1)

C		^1H*	^{13}C†
1			40.7 *s*
2		3.73 (*dd*, 1H)‡	66.8 *d*
3	*ax*	2.26 (*m*, 1H)	55.3 *t*
	eq	2.54 (*dt*, 1H)	
4		4.16 (*dd*, 1H)	64.6 *d*
5			70.9 *s*
6	*ax*	2.14 (*d*, 1H)	45.4 *t*
	eq	2.54 (*d*, 1H)	
7		6.45 (*d*, 1H)	138.8 *d*
8		6.32 (*d*, 1H)	108.8 *d*
9		1.26 (*s*, 3H)	26.4 *q*§
10		1.66 (*s*, 3H)	29.6 *q*§

* 500 MHz in $CDCl_3$, TMS as internal standard.
† 22.5 MHz in $CDCl_3$, TMS as internal standard.
‡ Coupling constants (Hz); 2, 3ax = 12.5, 2, 3eq = 4.0, 3ax, 3eq = 14.0, 3ax, 4 = 12.6, 3eq, 4 = 4.2, 6ax, 6eq = 14.6, 7, 8 = 13.6.
§ Assignments are interchangeable.

Telfairine (**1**) and compound **2** exhibited 100% insecticidal activities against mosquito larvae, *Culex pipiens pallens* at 10 ppm in solution. The study on their insecticidal activities and mode of action will be reported in due course.

EXPERIMENTAL

^1H and ^{13}C NMR spectra were measured at 500 and 22.6 MHz, respectively, with TMS as an internal standard. Analytical TLC and prep. TLC (0.5 mm) were performed on precoated silica gel 60 GF_{254} (Merck). MS were recorded by direct inlet at 70 eV ionization.

Extraction and isolation of compounds **1** *and* **2**. The alga (40 g, wet wt), *P. telfairiae* collected at Wakasa Bay (5 m depth), Fukui Prefecture, Japan in July 1987, was extracted with MeOH. The extract was filtered and concd *in vacuo* to yield a crude syrup (0.350 g) which was purified by prep. TLC (0.5 mm; hexane–EtOAc, 20:1) to give 10 mg of telfairine (**1**) and 15 mg of compound (**2**). Telfairine (**1**). Mp 60 ~ 62° (*n*-hexane), $[\alpha]^{25} = -18.0°$ ($c = 0.1$, MeOH); *m/z* 317.9503 ($C_{10}H_{14}{}^{35}Cl_3{}^{79}Br$, requires 317.9483), MS *m/z* 322, 320, 318 $[M]^+$, 287, 285, 283 $[M-Cl]^+$, 241, 239 $[M-Br]^+$, 167 (base peak); IR ν_{max}^{KBr} cm^{-1}: 2990, 1440, 1385, 1320, 1250, 1150, 1040, 940 and 820. Compound **2**. Mp 158–160° (lit. 160–162° [5]). Then IR and NMR were identical to those of an authentic specimen.

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