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A NOVEL BICYCLO[2. 2. 2]OCTANE SKELETON DITERPENE, OBTUNONE, FROM THE HEARTWOOD OF *CHAMAECYPARIS OBTUSA* VAR. *FORMOSANA*

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Obtunone, a novel bicyclo[2. 2. 2]octane skeleton diterpene, was isolated from the heartwood of *Chamaecyparis obtusa* var. *formosana*. Its structure was determined spectroscopically by interpretation of 2D-NMR experiments, including HMBC and NOESY.

KEY WORDS *Chamaecyparis obtusa* var. *formosana*; Cupressaceae; bicyclo[2. 2. 2]octane; diterpene; obtunone

Due to its strong resistance to wood-decaying fungi, the wood of *Chamaecyparis obtusa* S. et Z. var. *formosana* Rehd. (Taiwan hinoki; Cupressaceae) is an important building material in Taiwan. Previously, Kafuku and Nozoe studied the essential oil$^{1)}$ and acidic components$^{2)}$ (isolated 1-rhodinic acid, carvacrol, 2-methoxy-5-isopropylphenol, and β-thujaplicine). Afterward, Lin$^{3)}$ continued the component studies and found *p*-cresol, α-thujaplicine, 1-rhodinic acid, β-thujaplicine, terpine hydrate, and 4-isopropylsalicylaldehyde. We have investigated the chemical components of the bark of this plant, from which two carbamates together with steroids, diterpenes, and lignan$^{4)}$ were identified. No further investigation of the components of the heartwood of this plant has been reported, which led us to undertake the present study.

The acetone extract of the heartwood of this plant was partitioned with ethyl acetate and water. After repeated purification with SiO_2 on column chromatography and HPLC, a novel diterpene obtunone (**1**) together with 3,10-dihydroxydielmentha-5,11-diene-4,9-dione (**2**)$^{5)}$ were isolated. Based on the following spectral evidence (COSY, HMQC, HMBC, and NOESY), the novel diterpene was assigned as structure (**1**), a peculiar bicyclo[2. 2. 2]octane skeleton diterpene.

Obtunone (**1**), a colorless liquid, $[\alpha]^{25}_D = -47.6°$ (c = 0.43, $CHCl_3$) was formulated as $C_{20}H_{30}O_2$ on the basis of HRMS (M^+ *m/z* 302.2249, calc. 302.2246). It contained a hydroxy group (3435 cm^{-1}), a carbonyl group (1726 cm^{-1}), and an isopropyl group attached on a double bond [1382 and 1366 cm^{-1}; 0.89 and 0.97 (3 H each, d, J = 6.9 Hz), 2.10 (1 H, sept d, J = 6.9, 1.6 Hz)], an isobutylidene moiety [1.58 and 1.65 (3 H each, br s), 5.06 (1 H, br t, J = 5.3 Hz)], one trisubstituted and 1,1-disubstituted double bond [6.03 (1 H, ddd, J = 6.9, 1.6, 1.6 Hz), 4.68 and 4.75 (1 H each, s)], an ethylene group linked between two olifinic groups [1.98-2.12 (4 H, m)], a methine proton located between the carbonyl and olefinic groups [3.07 (1 H, dd, J = 1.6, 1.6 Hz)], and a methyl group attached to a quaternary carbon bearing a hydroxy group [1.22 (3 H, s)] discernible in its spectral data. A methine proton at δ 2.81 was considered to be linked

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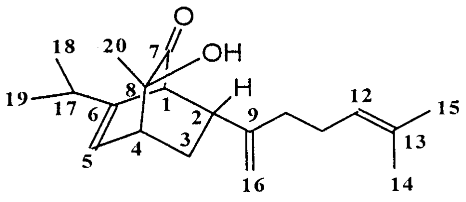
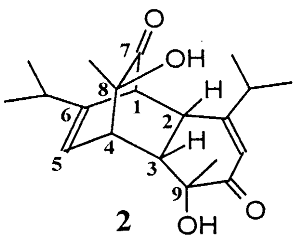
between an olifinic group and a methylene group due to the presence of a coupling pattern with ddd ($J = 6.9, 2.8, 2.8$ Hz). The remaining signals for the methine and methylene protons are at δ 2.69 (1 H, ddd, $J = 9.6, 6.1, 1.6$ Hz) and δ 1.33 (1 H, ddd, $J = 13.0, 6.1, 2.8$ Hz), and 2.37 (1 H, ddd, $J = 13.0, 9.6, 2.8$ Hz), respectively. Irradiation at δ 2.37, the signals at 1.33, 2.69, and 2.81 simplified to dd ($J = 6.1, 2.8$ Hz), dd ($J = 6.1, 1.6$ Hz), and dd ($J = 6.9, 2.8$ Hz), respectively. Due to the molecular formula $C_{20}H_{30}O_2$ of **1**, the index of hydrogen deficiency (IHD) of **1** is six. Therefore, obtunone (**1**) is a bicyclic compound. Due to ^{1}H-^{1}H COSY and HMQC spectra (Table 1), the NMR data and attachment of the spin-system were reasonably assigned. Its structural inferences were reinforced by the HMBC (Table 1) technique. Regarding the stereochemistry, the pronounced NOESY correlation (structure **3**) between H-5 and H-20, H-1 and H-2, and H-3 and H-4 established the formulated configuration in **1**. The unique skeleton of diterpene has not yet been observed.

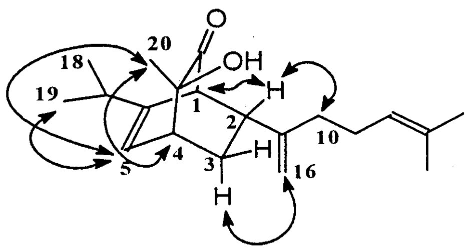
Compound **2**,[5] isolated from *Callitris macleayana*, was obtained from compound **4** (unobserved in the natural state) *via* endo addition of bio-Diels-Alder self-dimerization. The absolute configuration of **2** was obtained from CD measurements and determined to be 8*R* and 9*R*. Compound **2**, isolated from *C. obtusa* var. *formosana*, expressed the specific rotation value as isolated from *Callitris macleayana*. Obtunone (**1**) was also yielded from **4** and myrcene (**5**) *via* the bio-Diels-Alder addition. The absolute configuration of C-8 in obtunone (**1**) was assigned as the *R*-configuration like that in compound **2** based on the same biological pathway. The formation of compound **2** was proceeded by endo addition from compound **4**. Obtunone (**1**) was also obtained by endo addition between compounds **4** and **5** *via* the bio-Diels-Alder reaction. Therefore, C-2 can be assigned to have the *R*-configuration. Carman [6] endeavored to carry out self-Diels-Alder dimerization of compound **4**. The resulting product **2** was not yielded probably because the desired electron-deficient dienophile and electron-rich diene place contradictory demands upon a single unit. Finally, on reflux with ethanolic sulfuric acid[6], compound **6** afforded dimerization to give **2** in low yield (30%).



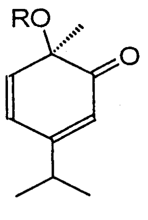
1



2



3 NOESY ⟷



4 R = H
6 R = Ac

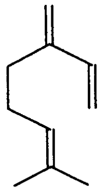


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Table 1. NMR Data, COSY, HMBC, and NOESY Correlation of **1** (500 MHz, 125 MHz in $CDCl_3$)

n° C	DEPT	δ ^{13}C	δ ^1H (*J*=Hz)	COSY	HMBC	NOESY
1	CH	55.4	3.07 dd (1.6,1.6)	2, 5	2, 3, 5, 17	2, 17, 18
2	CH	39.8	2.69 ddd (9.6, 6.1, 1.6)	1, 3	1, 3, 4, 10, 16	1, 10
3	CH_2	26.1	2.37(β) ddd (13.0, 9.6, 2.8)	2, 3α, 4	1, 2, 4	2, 4
			1.33(α) ddd (13.0, 6.1, 2.8)	2, 3β, 4		4, 16
4	CH	42.8	2.81 ddd (6.9,2.8, 2.8)	3, 5	3, 5, 20	3, 5
5	CH	125.3	6.03 ddd (6.9.1.6,1.6)	1, 4, 17	1, 3, 4, 17	19, 20
6	C	144.7			1, 2, 4, 17, 18, 19	
7	C	213.2			1, 2, 4, 20	
8	C	72.2			1, 3, 4, 5, 20	
9	C	150.2			1, 2, 3, 10, 11, 16	
10	CH_2	36.3	2.04-2.10 m	11	2, 11, 16	2
11	CH_2	26.5	1.98, 2.12 m	10, 12	10, 12	12
12	CH	123.7	5.06 br t (5.3)	11	10, 11, 14, 15	15
13	C	131.8			14, 15	
14	CH_3	17.7	1.58 s		12, 15	15
15	CH_3	25.6	1.65 s		12, 14	12, 14
16	CH_2	109.8	4.68 s, 4.75 s		2, 10	3, 11
17	CH	33.1	2.10 sept d (6.9, 1.6)	5, 18, 19	1, 5, 18, 19	1
18	CH_3	21.0	0.89 d (6.9)	17	17, 19	17
19	CH_3	19.8	0.97 d (6.9)	17	17, 18	5
20	CH_3	25.9	1.22 s		4	5

($J_{1,2}=J_{1,5}=J_{5,17}=$ 1.6 Hz, $J_{2,3\alpha}=$ 6.1 Hz, $J_{2,3\beta}=$ 9.6 Hz, $J_{3\alpha,\beta}=$ 13 Hz, $J_{3\alpha,4}=J_{3\beta,4}=$ 2.8 Hz, $J_{4,5}=J_{17,18}=J_{17,19}=$ 6.9 Hz, $J_{11,12}=$ 5.3 Hz)

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