

DITERPENES FROM PERICARPS
OF *CHAMAECYPARIS FORMOSENSIS*

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ABSTRACT.—Four new diterpenoids, formosanoxide [**1**], formosanolide [**2**], formosanone [**3**], and formosanic acid [**4**], were isolated from the pericarps of *Chamaecyparis formosensis*. Their structures were determined by spectral methods.

Chamaecyparis formosensis Matsum. (Cupressaceae), known as Taiwan red cypress (1), is indigenous to high mountain areas of Taiwan. It is called red cypress because the bark has a slightly reddish brown color. The wood is frequently used as lumber and for making furniture. The chemical constitution of the roots, bark, wood, and leaves of this plant has been investigated (2-4). *C. formosensis* is known to possess strong resistance to wood-decaying fungi (5-7), and its constituent chamaecynone (8) has been found to exhibit activity against termites (5,6). We report herein four novel diterpenes isolated from the pericarp of *C. formosensis*. The Me₂CO extract of the pericarp was subjected to chromatography to yield the novel diterpene components **1-4**.

The molecular formula C₂₀H₂₈O₂ for **1** was deduced from its exact mass [M]⁺ at *m/z* 300.208. A broad ir absorption at

3219 cm⁻¹ was attributable to a hydroxyl group. The ¹H-nmr spectrum showed signals typical for an abietane-type diterpene including an isopropyl group at δ 1.23 (6H, d) and 3.18 (1H, sept.), and two aromatic protons at δ 6.56 (s) and 7.01 (s). In contrast to the usual abietane substitution with three methyl groups attached to tertiary carbons, **1** exhibited only two such methyl groups at δ 0.81 (s) and 1.13 (s) in the ¹H-nmr spectrum. The structure of **1** was assigned as 7β,20-epoxyabiet-8,11,13-trien-12-ol, and the compound was given the trivial name formosanoxide. The protons α to the ether group occurred at δ 4.82 (H-7), 4.31 (H-20), and 2.83 (H-20), and the corresponding carbon signals appeared at δ 70.4 (d, C-7) and 67.7 (t, C-20). The ¹³C-¹H COLOC spectrum correlated H-7 with C-5, C-9, and C-14. NOe experiments supported the assigned

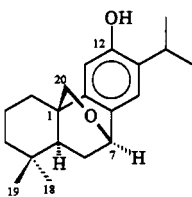
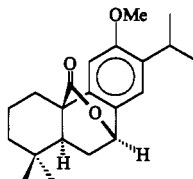
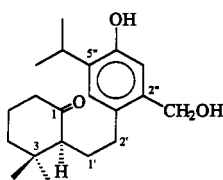
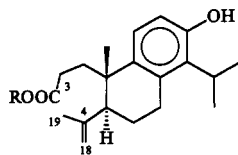
**1****2****3****4** R=H**5** R=Me

TABLE 1. $^1\text{H-Nmr}$ Spectral Data of Compounds **1**, **2**, and **5** (δ , CDCl_3).^a

Proton	Compound		
	1	2	5
5	1.12 m	1.49 dd (10,6)	2.31 dd (9,5.5)
6	2.05 ddd (13,6,4)	2.23 ddd (13,6,4)	
	1.56 m	1.90 m	
7	4.82 dd (4,2)	5.48 dd (4,1)	
11	6.56 s	6.73 s	6.96 d (8.5)
12			6.55 d (8.5)
14	7.01 s	7.07 s	
15	3.18 sept. (7)	3.28 sept. (7)	3.25 sept. (7)
16	1.23 d (7)	1.15 d (7)	1.31 d (7)
17	1.23 d (7)	1.16 d (7)	1.34 d (7)
18	0.81 s	0.84 s	4.68 br s
			4.93 br s
19	1.13 s	0.92 s	1.78 s
20	2.83 dd (8,2)		1.20 s
MeO	4.31 d (8)	3.81 s	

^aCoupling constants (*J* in Hz) in parentheses.

stereochemistry by exhibiting a 17% enhancement of H-14 (at δ 7.01) on irradiation of H-7 (at δ 4.82) and a 12% enhancement of H-20 (at δ 2.83) on irradiation of H-19 (at δ 1.13). A related dinorabietane, *przewalskin*, having a methyl group at C-13 instead of the usual isopropyl group, has been reported from *Salvia przewalski* (9).

Compound **2** ($\text{C}_{21}\text{H}_{28}\text{O}_3$) showed a diagnostic ir absorption at 1742 cm^{-1} for a lactone group. The $^1\text{H-nmr}$ spectrum (Table 1) showed a methoxy group at δ 3.81 (s), an isopropyl group at δ 1.15 (d), 1.16 (d), and 3.28 (sept.), two methyl groups at δ 0.84 (s) and 0.92 (s), two aromatic protons at δ 6.73 (s) and 7.07 (s), and a signal at δ 5.48 attributable to the H-7 proton of a lactone group. As supported by the $^{13}\text{C-nmr}$ data (Table 2), compound **2** was determined to be 12-methoxyabietate-8,11,13-trien-7 β ,20-olide, and was given the trivial name *formosanolide*. The structure assignment was supported by DEPT, $^{13}\text{C-}^1\text{H COSY}$, $^{13}\text{C-}^1\text{H COLOC}$, and nOe experiments. Carnosol and isocarnosol found in *Salvia lanigera* are abietane lactones based on the same skeleton (10).

Compound **3** ($\text{C}_{20}\text{H}_{30}\text{O}_3$) exhibited

TABLE 2. $^{13}\text{C-Nmr}$ Spectral Data of Compounds **1**, **2**, and **5** (δ , CDCl_3).

Carbon	Compound		
	1	2	5
1	28.7 t	27.4 t	35.3 t
2	18.8 t	18.5 t	28.1 t
3	41.2 t	41.0 t	174.8 s
4	33.7 s	34.3 s	146.8 s
5	42.9 d	45.4 d	46.3 d
6	30.2 t	29.9 t	24.8 t
7	70.4 d	77.3 d	29.5 t
8	131.6 s	130.4 s	130.9 s
9	145.2 s	139.3 s	135.4 s
10	37.5 s	47.0 s	40.9 s
11	106.9 s	104.7 d	125.1 d
12	152.4 s	156.9 s	114.9 d
13	131.3 s	135.5 s	152.2 s
14	120.9 d	120.6 d	135.9 s
15	26.8 d	26.8 d	27.3 d
16	22.7 q	22.6 q	20.2 q
17	22.7 q	22.7 q	20.4 q
18	32.7 q	31.5 q	114.1 t
19	20.8 q	19.3 q	22.8 q
20	67.7 t	176.1 s	27.9 q
OMe		55.7 q	

an exact mass $[\text{M}]^+$ at m/z 318.220. The ir absorptions at 1691 and 3361 cm^{-1} were attributable to the carbonyl and hydroxyl groups, respectively. By analysis of the $^1\text{H-}$, $^{13}\text{C-}$, and COLOC nmr

spectra (Table 3) the structure of **3** was determined to be 3,3-dimethyl-2-[2-(4-hydroxy-2-hydroxymethyl-5-isopropylphenyl)ethyl]cyclohexanone, and was given the trivial name formosanone. This compound can be considered a 9(10→20)-*abeo*-abietane. The ¹H-nmr spectrum exhibited signals for an isopropyl group at δ 1.19 (d), 1.21 (d), and 3.32 (sept.), two methyl groups at δ 0.69 (s) and 1.04 (s), two aromatic protons at δ 6.85 (s) and 6.92 (s), and two protons geminal to the hydroxyl group at δ 4.56 and 4.66 (AB pattern). The carbon signal of the carbonyl group appeared at δ 215.4. Compound **3** was tentatively assigned to have 2*S*-chirality by analogy to those abietanes found in the same plant.

The diterpenoid acid **4** was converted to its corresponding methyl ester **5** (C₂₁H₃₀O₃). The ¹H-nmr spectrum of **5** showed resonances at δ 6.55 (d, *J*=8.5 Hz) and 6.96 (d, *J*=8.5 Hz) attributable to two adjacent aromatic protons of the totarane type. Two geminal olefinic protons occurred at δ 4.68 and 4.93 as broad singlets. The H-5 proton oriented axially resonated as a doublet of doublets (*J*=9.0 and 5.5 Hz). From the ¹H- and ¹³C-nmr spectra (Tables 1 and 2), the structure of **5** was assigned as 13-hydroxy-3,4-secototara-4(18),8,11,13-tetraen-3-oic acid methyl ester, and has been given the

trivial name formosanone methyl ester. The mass spectrum displayed a parent peak at *m/z* 330 and an intense signal at *m/z* 243 due to elimination of a moiety of CH₂CH₂CO₂Me. 12-*O*-Methylcandelasone found in *Salvia candelabrum* (11) is the only other 3,4-secoabietane previously reported.

In summary, this first investigation of the pericarps of *C. formosensis* led to isolation of two new abietanes **1** and **2** having an oxacyclic ring, a novel 9(10→20)-*abeo*-abietane, **3**, and an uncommon 3,4-secoabietane, **4**.

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Mps were measured on a Yanagimoto micro-melting point apparatus. Infrared spectra were measured on a Perkin-Elmer 983G infrared spectrophotometer. Ultraviolet spectra were measured on a Perkin-Elmer 555 uv/vis spectrophotometer; a quartz cell (1-cm length) was used. ¹H-Nmr spectra were recorded at 200 or 300 MHz (Bruker AC-200 or AM-300WB spectrometer); TMS served as internal standard. ¹³C-Nmr spectra were recorded at 50 or 75 MHz. Mass spectra were recorded (Finnigan TSQ46c spectrometer) at an ionizing voltage of 70 eV. Hrms were recorded on a JEOL SX-102A spectrometer. Optical rotation measurements were conducted on a Jasco Dip-360 or a Schmidt/Haensch polarimeter; a quartz cuvette (length 10 cm) was used. Merck Si gel 60F sheets were used for analytical tlc. Hplc was carried out on a Hibar Lichrosorb Si 60 (7 μm or 10 μm) column (25 cm×1 cm).

PLANT MATERIAL.—The pericarps of

TABLE 3. ¹H-, ¹³C-, and COLOC Nmr Spectral Data of Compound **3** (δ, CDCl₃).

Proton(s)	δ	Carbon	δ	Carbon	δ
H-2	2.19 m	C-1	215.4 s	C-1"	136.4 s
H-3"	6.85 s	C-2	60.5 d	C-2"	131.7 s
H-6"	6.92 s	C-3	40.1 s	C-3"	116.4 d
Me-3	0.69 s, 1.04 s	C-4	39.6 t	C-4"	151.7 s
Me ₂ CH	1.20 d (7), 3.22 sept. (7)	C-5	23.2 t	C-5"	134.4 s
CH ₂ OH	4.56 d (10), 4.66 d (10)	C-6	41.6 t	C-6"	127.4 d
		C-1'	26.3 t	Me ₂ CH	22.5 q, 26.7 d
		C-2'	31.2 t	Me-3	21.5 q, 29.6 q
				CH ₂ OH	62.6 t

H-2→C-1 (δ), C-3 (δ), C-1' (δ), C-2' (δ), Me-3 (δ).

H-1'→C-1 (δ).

H-3"→C-2" (δ), C-4" (δ), C-5" (δ), CH₂OH (δ).

H-6"→C-1" (δ), C-2' (δ), C-4' (δ), Me₂CH (δ).

CH₂OH→C-1" (δ), C-2" (δ), C-3" (δ).

Chamaecyparis formosensis (740 g) were collected at Hohuan mountain (1900 m) in December 1988. A voucher specimen is deposited in our laboratory. The pericarps were extracted exhaustively with Me₂CO (3 liters×3). The combined extracts were concentrated to give an oil (21 g), which was absorbed on 50 g of Si gel and then chromatographed on a column packed with 250 g of Si gel. Elution with gradients of hexane and EtOAc yielded **2** (11.9 mg), **1** (8.8 mg), **3** (30.6 mg), and **4** (22.3 mg), in ascending order of polarity. Compounds **1**–**3** were further purified by hplc. Acid **4** was treated with CH₂N₂ in Et₂O to produce the corresponding methyl ester **5**, which was further purified by hplc.

Formosanoxide [**1**].—Colorless crystals (from hexane-EtOAc, 4:1); mp 218–219.5°; [α]_D²⁶ –65.9° (c =0.44, CHCl₃); ir (neat) ν max 3219 (OH), 2949, 1583, 1494, 1297, 1279, 1235 cm⁻¹; uv (EtOH) λ max (log ϵ) 279.6 (3.47), 208.2 (3.99) nm; nmr data, see Tables 1 and 2; eims (70 eV) m/z 300 [M]⁺ (22), 285 [M]⁺–CH₃ (5), 270 (100), 255 (20), 203 (46), 199 (35), 171 (15), 157 (20); hrms m/z [M]⁺ for C₂₀H₂₈O₂ requires 300.2082, found 300.2084.

Formosanolide [**2**].—Oil, [α]_D²⁵ –23.5° (c =0.6, CHCl₃); ir (neat) ν max 2954, 1742 (C=O), 1582, 1491, 1459, 1282, 1203, 1106, 1091, 988, 734 cm⁻¹; uv (EtOH) λ max (log ϵ) 279.8 (3.50), 209.8 (4.27) nm; nmr data, see Tables 1 and 2; eims (70 eV) m/z 328 [M]⁺ (20), 313 [M]⁺–CH₃ (2), 284 (10), 269 (24), 213 (56), 202 (10), 185 (20), 171 (25); hrms [M]⁺ for C₂₁H₂₈O₃ requires 328.2031, found 328.2029.

Formosanone [**3**].—Oil, [α]_D²⁵ +19.6° (c =1.02, MeOH); ir (neat) ν max 3366 (OH), 2955, 1691 (C=O), 1609, 1508, 1455, 1418, 1255, 1048, 994, 890, 733 cm⁻¹; nmr data, see Table 3; eims (70 eV) m/z 318 [M]⁺ (6), 300 [M]⁺–H₂O (100), 285 (32), 228 (20), 192 (57), 167 (82), 149 (62), 117 (36); hrms m/z [M]⁺ for

C₂₀H₃₀O₃ requires 318.2187, found 318.2199.

Formosan acid methyl ester [**5**].—Oil, [α]_D²⁵ +32.5° (c =0.51, CHCl₃); ir (neat) ν max 3347 (OH), 2947, 1709 (C=O), 1586, 1481, 1278, 1192, 1100, 894, 815 cm⁻¹; nmr data, see Tables 1 and 2.

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