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A SESQUITERPENOID FROM *SANTALUM AUSTROCALEDONICUM* VAR. *AUSTROCALEDONICUM*

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Key Word Index—*Santalum austrocaledonicum* var. *austrocaledonicum*; Santalaceae; campherenane-type sesquiterpenoid; campherene-2,13-diol; 1D and 2D NMR.

Abstract—A new sesquiterpenoid, campherene-2,13-diol, has been isolated and characterized from the heartwood of *Santalum austrocaledonicum* var *austrocaledonicum*. Its structure has been established by the use of 1D and 2D NMR spectral techniques and shown to contain the campherenane skeleton. © 1997 Elsevier Science Ltd

INTRODUCTION

As part of our continuing investigation of the chemical composition of Sandalwood from the Pacific area, we have studied *Santalum austrocaledonicum*. var *austrocaledonicum* [1] which constitutes an interesting raw material for perfumery and cosmetics. In a previous paper we reported on the occurrence and the characterization of new bisabolane sesquiterpenoids from this New-Caledonian sandalwood [2]. We now report on the isolation and characterization of a new sesquiterpenoid, campherene-2,13-diol (**1**), from the same plant.

RESULTS AND DISCUSSION

Compound **1** displayed a large hydroxyl IR band (3375 cm^{-1}) and characteristic double bond (1634 cm^{-1}) absorption. No $[M]^+$ peak could be seen in its EIMS spectrum, which showed significant fragments *m/z* 220 and 202 corresponding to $[M-H_2O]^+$ and $[M-2H_2O]^+$, respectively. This EI mass spectrum data linked with the Cl(CH_4 and NH_3)-mass spectral data suggested the molecular formula $C_{15}H_{26}O_2$. The ^{13}C NMR spectrum of compound **1** contained signals for 15 carbon atoms of which two were resonating down field at δ 134.1 and 129.2, respectively. These latter two signals were deshielded and attributable to two sp^2 hybridized carbons. The presence of two oxygen-bearing carbons was evident from the typical ^{13}C NMR chemical shifts at δ 77.4 and 61.6 which could be assigned to two alcohol groups. The DEPT [3] pulse sequence spectrum indicated that the carbon skeleton of compound **1** contained three methyl groups, six methylene groups, three methine groups and three quaternary carbon atoms. This preliminary information led to the conclusion that compound **1** must be a bicyclic sesquiterpenoid.

The most prominent signals in the ^1H NMR spectrum of compound **1** were three singlets observed at δ 0.82, 0.86 and 1.77 which were attributable to three methyl groups linked to quaternary carbons. The signal resonating at δ 1.77 corresponded to an ethylenic methyl group. Another ethylenic proton signal was observed as a triplet at δ 5.28 (^3J = 6.8 Hz). Two isochronous protons resonating as a broad singlet at δ 4.11 could be assigned as a vinylic hydroxymethylene group. The signal observed at δ 4.05 ppm, a doublet of multiplets (^3J = 9.9 Hz), integrating for one proton, was attributable to a hydroxylated methine group.

Direct carbon–proton correlations were established using the heteronuclear correlation spectroscopy HMQC sequence [4] beginning the network [5, 6] by the above-mentioned ^1H NMR signals. HMBC [7] analysis was utilized to build up bond by bond the skeleton of compound **1**. The main correlations observed (homo-nuclear and hetero-nuclear) of connectivities of compound **1** are summarized in Fig. 1. From the results of the combined analysis by HMQC and HMBC, the ^1H and ^{13}C NMR assignment of compound **1** was achieved and are present in Table 1.

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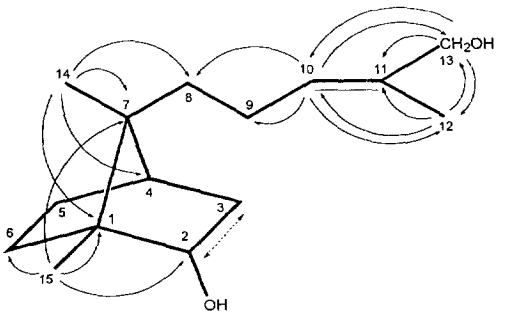

Fig 1. Proton–carbon (→) and proton–proton (----->) coupling pathways of campherene-2,13-diol (**1**) determined from HMBC and COSY experiments.

Table 1. ^1H and ^{13}C NMR chemical shifts for **1**

^{13}C	Group*	Assignment†	^1H‡§
51.35	C	1	—
77.41	CH	2	4.05 *dm* (9.9)
38.86	CH_2	3	0.96 *dd* (13.4; 3) and 2.13 *m*
42.09	CH	4	1.75
28.07	CH_2	5	1.65 and 1.24
26.99	CH_2	6	1.87 and 1.20
50.46	C	7	—
32.88	CH_2	8	1.29 and 1.08
23.86	CH_2	9	1.61 and 1.15
129.20	CH	10	5.28 *t* (6.8)
134.05	C	11	—
21.30	CH_3	12	1.77 *br s*
61.58	CH_2	13	4.11 *br s*
16.65	CH_3	14	0.86 *s*
13.40	CH_3	15	0.82 *s*

* Determined from DEPT spectra.

† Information from 2D experiments (HMQC, HMBC and COSY).

‡ Determined from the cross-sections of heteronuclear chemical shift correlation diagrams (HMQC).

§ *J* (Hz) in parentheses.

In addition, a cross-linked correlation between H-2 and H-3 from the COSY [8, 9] spectrum was observed revealing the environment the hydroxylated methine proton.

The ^{13}C chemical shift of C-6 in compound **1** had a similar value to that of the corresponding carbons in bicyclo [2.2.1] heptan-2-ol [10], in which the hydroxyl group was endo-positioned [10]. In fact, the C-6 carbon atom was subjected to a γ-effect by the alcohol function on the C-2 carbon atom which was assigned to be in the endo-position. Considering the ^1H NMR data, the coupling constant value ($^3J_{H2\alpha\text{-}H3\beta} = 9.9$ Hz) for H-2 was found to match the endo-positioned OH group in campherenol [11] and added weight to the argument for a similarly endo positioned OH group in compound **1**. The ^{13}C NMR chemical shifts of the isopentenol group (C-8, C-9, C-10, C-11, C-12 and C-13) were in good agreement with the analogous in signals of lanceol and the dihydroxy bisabolane

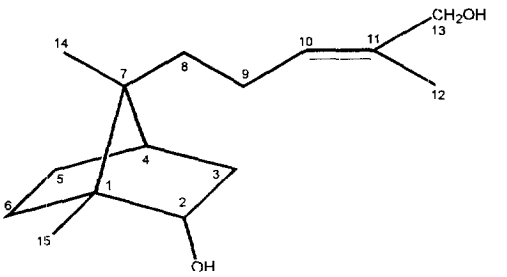

Fig 2.

derivatives found in sandalwood extracts [2]. Thus, in keeping with these molecules, the double bond in compound **1** must be (E) as shown in Fig. 2.

Consequently, the structure of compound **1** (campherene-2,13-diol) was established as bicyclo[2.2.1]heptan-2-ol, 1,7-dimethyl-7-(-4-methyl-3-penten-5-ol). This compound is a newly characterized campherenane-type sesquiterpenoid. Until now, no dihydroxyl derivative of campherenane had been reported from a natural source.

EXPERIMENTAL

1D and 2D NMR: 400.13 MHz (^1H) and 100.61 MHz (^{13}C), $CDCl_3$, TMS as int. standard. Standard Bruker pulse sequences were used for homo- and hetero-nuclear correlation experiments. Dried heartwood of *S. austrocaledonicum* var. *austrocaledonicum* (Herbarium Voucher PR no 016/96 deposited at the laboratory LC2A) (690 g) was finely chopped before extraction with CH_2Cl_2 for 8 hr in a Soxhlet apparatus. The crude extract (40 g) was distilled under red. press. (vacuum: 0.3 mm Hg) yielding 2.4 g of heavy fr. This was chromatographed over a silica gel column using successively hexane and EtOAc for elution to separate the hydrocarbon fr. from the polar fr. The last fr. (1.1 g), which contained mainly sesquiterpenoids, was then sepd by CC on silica gel using $CHCl_3$–*iso*PrOH (99:1). Repeated elutions were performed to isolate compound **1** (30 mg).

Campherene-2,13-diol (**1**). $C_{15}H_{26}O_2$. Oil; $[\alpha]_D^{25} = -47.8°$ ($CHCl_3$; *c* 0.15); IR ν_{max} cm^{-1}: 3375, 2951, 1634, 1454, 1378, 1104, 1018; EIMS 70 eV, *m/z* (rel. int.): 238 $[M]^+$ (Absent), 220 $[M\text{-}H_2O]^+$ (1), 207 (2), 205 (1), 202 (1), 187 (2), 161 (2), 145 (3), 125 (13), 107 (14), 95 (15), 93 (13), 81 (12), 79 (11), 67 (16), 55 (16), 43 (100), 41 (22).

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