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SESQUITERPENES AND A PHENOLIC COMPOUND FROM THE LIVERWORT *OMPHALANTHUS FILIFORMIS*

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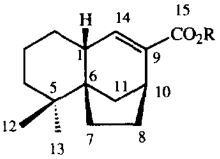
Key Word Index—*Omphalanthus filiformis*; Hepaticae; lejeuneaceae; liverwort; methyl omphalate; methyl chamigrenate; omphalane-type sesquiterpene; chamigrane-type sesquiterpene.

Abstract—Methyl omphalate, a new rearranged chamigrane-type sesquiterpene, as well as previously known chamigrane-type sesquiterpenes and a phenolic compound have been isolated from the Colombian liverwort *Omphalanthus filiformis* and their structures determined by spectroscopic techniques.

INTRODUCTION

We have recently reported on the presence of interesting chemical constituents in liverworts collected in South America [1]. Thus africanane-type sesquiterpenoids were isolated from *Porella swartziana* from Colombia [2, 3], chenopodene, a compound with a new carbon skeleton, from *Marchantia chenopoda* from Venezuela [4] and spirodensifolins from *Frullanoides densifolia* from Bolivia [5]. GC-MS has been used to detect some steroids and sesquiterpenoids from *Omphalanthus paramicola* and *O. platycoleus* [6]. However, no compound has been isolated so far from this genus. We have investigated the chemical constituents of *O. filiformis* and found a new sesquiterpene having a novel carbon skeleton, methyl omphalate (**1a**) as a methyl ester, as well as a previously known long chain alkyl phenol (**2a**) [7, 8], β-chamigrene (**3**) [9, 10] and methyl chamigrenate (**4a**) [11–13].



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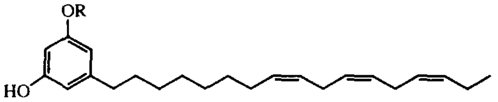
1b R=H



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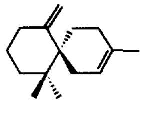

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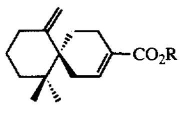

4a R=Me
4b R=H

RESULTS AND DISCUSSION

The ether extract of *O. filiformis* was purified by a combination of Sephadex LH-20 and silica gel CC. From the less polar frs β-chamigrene (**3**) was isolated. The polar frs were methylated with diazomethane, after the NMR of the residue was measured and the absence of methoxyl groups was confirmed. The methylated frs were further purified by silica gel CC and HPLC to afford methyl omphalate (**1a**), methyl chamigrenate (**4a**) and 5-heptadeca-8(*Z*),11(*Z*),14(*Z*)-trienylresorcinol monomethyl ether (**2a**).

Compound **1a** exhibited a molecular ion peak at *m/z* 248 and was assigned the molecular formula $C_{16}H_{24}O_2$ by HR-mass spectrometry. Since the ^{13}C NMR spectrum contained 16 peaks, it had to be a sesquiterpene methyl ester. Three methyls (including a methoxyl group), six methylenes, three methines and four quaternary carbons were observed in DEPT spectra. The IR spectrum indicated the presence of an α,β-unsaturated ester (1705 and 1640 cm^{-1}). As there was one olefin (δ134.9 and 142.4) and one carbonyl group (δ167.6) in the molecule and the degree of unsaturation was five, the compound had to be tricyclic. The ^1H–^1H and ^{13}C–^1H COSY spectra suggested the partial structures (A) and (B) as shown in Fig. 1. The TOCSY spectrum revealed a further proton network as shown in the partial structure (C). The HMBC spectrum connected these partial structures to give a new rearranged chamigrane skeleton (Fig. 2). The stereochemistries were determined from the NOESY spectrum (Fig. 3). Thus methyl omphalate (**1a**) was established as an omphalane-type sesquiterpene ester as depicted in the formula. However, the absolute configuration was not

Table 1. NMR spectral data of methyl omphalate (**1a**) (600 MHz, $CDCl_3$)

C	^1H	^{13}C
1	2.21 *dt*, (12.7, 4.3)	45.1
2α	1.19 *m*	30.0
2β	*ca* 1.7 *m*	
3α	1.51 *m*	21.6
3β	1.56 *m*	
4α	1.32 *td* (13.4, 3.9)	38.5
4β	1.25 *m*	
5	—	34.5
6	—	48.0
7α	1.78 *ddd* (13.2, 10, 3.4)	32.2
7β	1.15 *m*	
8	1.66 *m*	35.3
	1.68 *m*	
9	—	134.9
10	3.01 *t* (4.4)	37.4
11α	1.58 *m*	30.2
11β	1.44 *dd* (11.5, 4.4)	
12	0.93 *s*	23.5
13	0.87 *s*	25.8
14	6.58 *dd* (4.3, 0.6)	142.4
15	—	167.6
-OMe	3.72 *s*	51.5

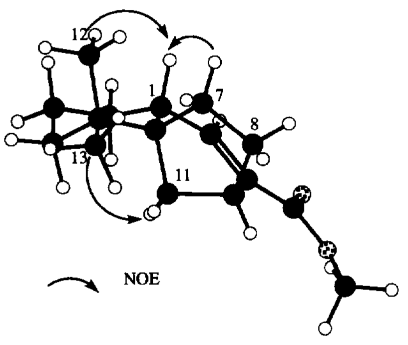

Fig. 3. NOEs detected for methyl omphalate (**1a**).

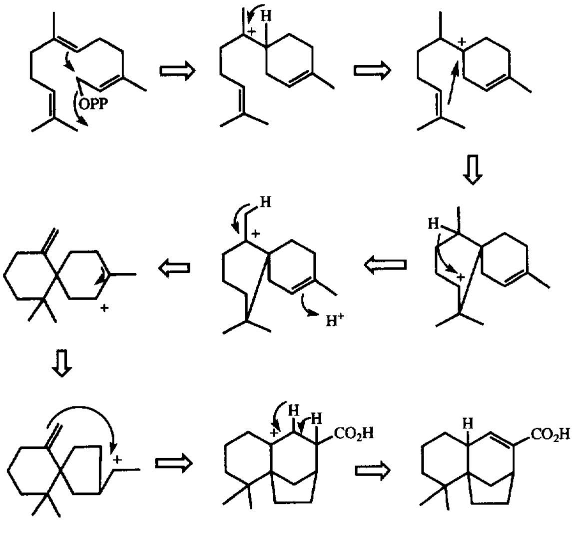

Fig. 4. Plausible biogenetic pathway to omphalic acid (**1b**).

determined. Thus the natural product was its free acid **1b**. A plausible biogenetic pathway is shown in Fig. 4. Compound **1a** is presumably derived from a chamigrane-type intermediate by ring contraction and cyclization. The numbering follows this hypothesis and we propose the name, omphalane, for this new skeleton.

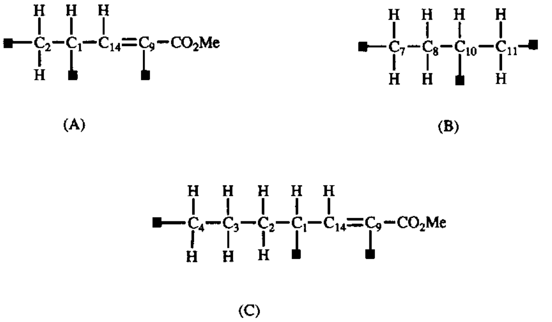

Fig. 1. Partial structures A–C of methyl omphalate (**1a**).

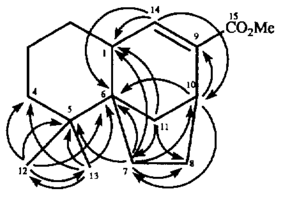

Fig. 2. Long-range correlations detected by HMBC of **1a**.

Compound **2a** was isolated as a monomethyl ether, *m/z* 357 (CI-MS) $[M + 1]^+$, and was found to contain a methoxyl group (δ3.76, *s*), three mutually coupled aromatic protons (δ6.32, 6.25, 6.23), six olefinic protons (δ5.36) and a triplet methyl group (δ0.97). From these data, it was identified as 5-heptadeca-8(*Z*),11(*Z*),14(*Z*)-trienylresorcinol monomethyl ether (**2a**) [7, 8]. Thus the natural product must be **2b**. The spectral data of **3** was identical with those of chamigrene and the specific rotation indicated the absolute configuration [9, 10].

Compound **4a** was isolated as a methyl ester. The 2D NMR spectra as well as the mass and IR spectra of **4a** suggested that it was a chamigrene derivative with the methyl ester at C-15 [11–13]. Although this compound has already been reported [11–13], its absolute configuration has not been reported. Therefore, the structure **4a** is tentatively shown as depicted in the formula, following the structure of (+)-chamigrene [9, 10] and the report by Kuo *et al.* [11, 12].

Liverworts belonging to *Lejeunea* were divided into six chemo-types [1] and the present liverwort must be included in chemo-type V producing mainly chamigrane-type sesquiterpenes. The phenol **2b** is worth mentioning since it has been isolated from not only a higher plant [7] but also brown algae [8], suggesting evolutionary similarity between algae and liverworts [1].

EXPERIMENTAL

^{1}H NMR: 400 or 600 MHz; ^{13}C NMR: 100 MHz (in $CDCl_3$ soln, TMS as int. standard); CC: silica gel 60 (70–230 mesh, Merck) and Sephadex LH-20 (Pharmacia); TLC: silica gel 60 F_{254} plates (Merck).

Omphalanthus filiformis (Sw.) Nees. (54 g) was collected in Colombia. The voucher specimen is deposited in the herbarium of Tokushima Bunri University. After drying, the material was ground and extracted with Et_2O to afford a crude extract (1.85 g). CC over Sephadex LH-20 ($CHCl_3$–MeOH, 1 : 1) afforded frs A–C. Fr. C was sepd by silica gel CC to yield a less polar fr. (379 mg) and a polar fr. (464 mg). The less polar fr. was further sepd by silica gel CC to afford β-chamigrene (**3**) (89 mg). The polar fr. was methylated with CH_2N_2 followed by CC on silica gel and HPLC to yield methyl chamigrenate (**4a**) (50 mg), 5-heptadeca-8(Z),11(Z),14(Z)-trienylresorsinol monomethyl ether (**2a**) (10 mg) and methyl omphalate (**1a**) (10 mg).

Methyl omphalate (**1a**). Oil; $[\alpha]_D^{22}$ + 74.5 ($CHCl_3$; *c* 1.14); HRMS: Obs. *m/z* 248.1757. $C_{16}H_{24}O_2$ requires 248.1776; MS: *m/z* 248 $[M^+]$, 233 (100), 216, 201, 173, 160, 145, 131, 119, 105, 91, 77, 59 and 41; IR (FT): 1705 and 1640 cm^{-1}.

β-*Chamigrene* (**2a**). Oil; $[\alpha]_D^{22}$ + 81.7 ($CHCl_3$; *c* 1.25) (lit. − 52.7°) [9].

Methyl chamigrenate (**3**). Oil; $[\alpha]_D^{22}$ + 99.5 ($CHCl_3$; *c* 1.52).

5-*Heptadeca*-8(Z),11(Z),14(Z)-*trienylresorsinol monomethyl ether* (**4a**). Oil; MS (CI-$^iC_4H_{10}$): *m/z* 357 $[M + 1]^+$; δ_H (400 MHz, $CDCl_3$) 0.97 (3H, *t*, J = 7.3 Hz), 1.31 (8H, *m*), 1.58 (2H, *m*), 2.05 (4H, *m*), 2.51 (2H, *m*), 2.81 (4H, *m*), 3.76 (3H, *s*), 4.95 (1H, *br s*, -OH), 5.36 (6H, *m*), 6.23 (1H, *m*), 6.25 (1H, *br s*) and 6.32 (1H, *br s*); δ_C (100 MHz, $CDCl_3$) 14.3 (*q*), 20.6 (*t*), 25.5 (*t*), 25.6 (*t*), 27.2 (*t*), 29.2 (*t*), 29.3 (*t*), 29.4 (*t*), 29.6 (*t*), 31.1 (*t*), 36.0 (*t*), 55.3 (q), 98.7 (*d*), 106.8 (*d*) 107.9 (*d*), 127.2 (*d*), 127.7 (*d*), 128.3 (*d* × 3), 130.4 (*d*), 132.0 (*d*), 145.7 (*s*), 156.5 (*s*) and 160.8 (*s*); IR ν_{max} cm^{-1}: 3400, 1610, 1600, 1500, 1460 and 1440.

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