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RICCARDIN C, A NOVEL CYCLIC BIBENZYL DERIVATIVE FROM *REBOULIA HEMISPHAERICA*

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Key Word Index—*Reboulia hemisphaerica*; Marchantiales; Hepaticae; riccardin C; cyclic bibenzyl derivative; *ent*-aristolone; sesquiterpene ketone.

Abstract—Riccardin C, a novel cyclic bibenzyl derivative with a biphenyl ether and biphenyl linkages, and the previously known *ent*-aristolone have been isolated from the liverwort *Reboulia hemisphaerica.* Riccardin C trimethyl ether was identical to the dimethoxy derivative of riccardin A isolated from the liverwort *Riccardia multifida.*

INTRODUCTION

The liverwort *Reboulia hemisphaerica* (L.) Raddi. grows on soil and rocks and its receptacle emits a fragrant odour when it is crushed. The crude extract of thalli of this liverwort is strongly antimicrobial. During the course of an investigation of the antifungal active substances of *R. hemisphaerica*, we have isolated riccardin C (**1**), a novel cyclic bibenzyl derivative, together with *ent*-aristolone (**5**). The present paper reports the elucidation of the structure of riccardin C (**1**).

RESULTS AND DISCUSSION

CC and prep. TLC on Si gel of the combined ether and methanol extracts of the air-dried and ground material resulted in the isolation of riccardin C (**1**) and *ent*-aristolone (**5**) [1]. The IR and ^{1}H NMR data showed that riccardin C, $C_{28}H_{24}O_4$ (M^+ 424), contained phenolic hydroxyl groups {3600, 3560, 3400 cm^{-1}; δ 4.95 and 5.70 [each 1H, *s*(*br*), lost on addition of D_2O]}, four benzylic methylenes [δ 2.60 and 2.83, each 4H, *s*(*br*)] and 13 protons on four benzene rings [δ 5.31 (1H, *d*, $J = 2$ Hz), 6.15 (1H, *dd*, $J = 8, 2$), 6.31 (1H, *d*, $J = 2$) and 6.81 (10H, complex *m*)]. Methylation of **1** with MeI afforded a trimethyl ether (**3**), indicating that one of four oxygens in **1** was an ether group.

Recently, riccardin A (**2**) and B (**4**), two unique cyclic bibenzyl derivatives, have been isolated from the liverwort *Riccardia multifida* (L.) S. Gray and the stereostructure of riccardin A (**2**) established by X-ray crystallographic analysis [2]. The spectral data of riccardin C (**1**) were quite similar to those of riccardin A (**2**), indicating that **1** possessed the same skeleton as that of **2**. In fact, the spectral data and chromatographic behavior of the trimethyl ether of **1** were identical to those of the dimethyl ether of **2**. Thus, riccardin C is the demethoxy derivative of riccardin A.

Most of the liverworts belonging to the Jungermanniales, Metzgeriales and Marchantiales produce lunularic acid **6** and lunularin **7**. *R. hemisphaerica* and *Riccardia multifida* commonly produce the bibenzyls **6** and **7** [3]. It is suggested that the cyclic bibenzyls **1**, **2** and **4**) may be formed from the bibenzyl monomers **6** and **7** present in each species.

EXPERIMENTAL

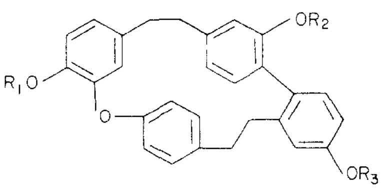
UV, IR, ^{1}H NMR, EIMS (direct inlet), CD, and $[\alpha]_D$ were measured in the manner described in the preceding paper [4]. TLC: precoated Si gel F_{254}, solvent systems: *n*-hexane–EtOAc (4:1), C_6H_6–EtOAc (4:1). Spots were detected by UV light (254 nm) and spraying with 30% H_2SO_4 and then heating at 120°.

Plant material. R. hemisphaerica (L.) Raddi., identified by Dr. S. Hattori, is deposited in the Herbarium, Institute of Pharmacognosy, Tokushima Bunri University.

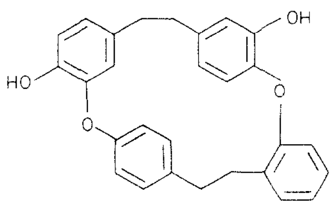
Extraction and isolation. R. hemisphaerica was collected in Kumamoto prefecture (Kyushu) on 3 April 1981, and was washed with H_2O to remove soil and then air-dried for 5 days. The ground material (1.5 kg) was extracted with Et_2O and then with MeOH. The two extracts were combined and the solvents were evaporated *in vacuo* to give a green oil (16.0 g) which was subjected to CC on Si gel using a C_6H_6–EtOAc gradient collected as 50 fractions. Fractions 16–27 were combined and rechromatographed on Si gel using the solvent described above to give aristolone (**5**) (150 mg): $C_{15}H_{22}O$ (M^+ 218); $[\alpha]_D + 243°$ (*c*, 0.2); spectral data (UV, IR, ^{1}H NMR, MS and CD) identical to those of *ent*-aristolone (**5**) isolated from the liverwort *Porella caespitans* [1].

Fractions 28–35 were also combined and rechromatographed on Si gel using C_6H_6–EtOAc to afford crude cyclic bibenzyl derivatives which were purified by prep. TLC to give riccardin C (**1**) (23 mg). $C_{28}H_{24}O_4$; IR ν_{max} cm^{-1}: 3600, 3560, 3400 (OH), 1605, 1590, 1515, 1510, 1490, 850, 818 (aromatic ring), 1445, 1440, 1340, 1270, 1190, 1165, 1110; MS *m/z* (rel. int.): 425 $[M+1]^+$ (24), 424 $[M]^+$ (71), 213 (27), 212 (30), 211 (100), 197 (11), 189 (16), 149 (11), 107 (17), 91 (12).

Methylation of riccardin C (**1**). Riccardin C (**1**) (20 mg) in



1 $R_1 = R_2 = R_3 = H$
2 $R_1 = R_2 = H$, $R_3 = Me$
3 $R_1 = R_2 = R_3 = Me$



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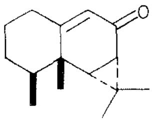

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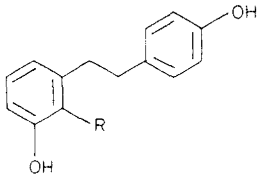

6 R = COOH
7 R = H

Me_2CO was methylated with MeI in the presence of dried K_2CO_3 to afford the trimethyl ether **3** (18 mg); $C_{31}H_{30}O_4$; IR ν_{max} cm^{-1}: 1610, 1580, 1515, 1510, 1490, 1468, 1445, 1420, 1410, 1260, 1165, 1130, 1040, 1020, 980, 905, 875, 850, 660; ^1H NMR: δ 2.71 (4H, *s br*), 2.85 (4H, *s br*), 3.61, 3.81, 3.90 (each 3H, *s*), 5.33 (1H, *d*, $J = 2$ Hz), 6.18 (1H, *dd*, $J = 8, 2$), 6.36 (1H, *s br*), 6.58–7.05 (10H, complex *m*); MS *m/z* (rel. int.): 467 $[M+1]^+$ (51), 466 $[M]^+$ (85), 240 (19), 239 (100), 233 (14), 227 (12), 225 (14), 211 (16), 121 (13), 105 (11), 91 (15). The above spectral data and chromatographic behavior of (**3**) were identical to those of riccardin A dimethyl ether (**3**) prepared from riccardin A (**2**) [2].

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