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# LIGNANS AND A BICHROMAN FROM *PLEIONE BULBOCODIOIDES*

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**Key Word Index**—*Pleione bulbocodioides*; Orchidaceae; tubers; sanjidin A; sanjidin B; pleionin A; lignans; bichroman; relative stereochemistry.

**Abstract**—From tubers of *Pleione bulbocodioides* three novel compounds, two lignans and one bichroman, were isolated. The two lignans, named sanjidins A and B, were elucidated as *cis*-3,4-bis(4′-hydroxy-3′-methoxy-α-acetoxybenzyl)tetrahydrofuran and its *trans*-isomer. The bichroman, named pleionin A, was shown to be 6,6′-dihydroxy-4,4′-dimethoxy-3,3′-bichroman on the basis of its spectroscopic data. Copyright © 1996 Elsevier Science Ltd

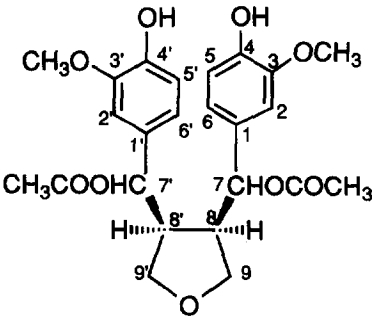
## INTRODUCTION

The tubers of *Pleione bulbocodioides* have been used in Chinese traditional medicine for the treatment of tumours [1]. We have studied the constituents of *P. bulbocodioides* and previously reported dihydrophenanthropyrans [2] and stilbenoids [3]. Further investigation of the same plant has resulted now in the isolation of three new compounds, sanjidin A (**1**), sanjidin B (**2**) and pleionin A (**4**) whose structures were determined on the basis of their spectral data.

## RESULTS AND DISCUSSION

Compound **1** showed IR absorptions at 3400 (hydroxyl), 1730 (carbonyl), 1600 and 1510 $cm^{-1}$ (benzenoids). The mass spectrum exhibited a $[M]^+$ at *m/z* 460 ($C_{24}H_{28}O_9$) and significant peaks at *m/z* 400[M − HAc]$^+$ and 340[M − HAc × 2]$^+$ due to sequential cleavages of two acetoxyl groups, suggesting the presence of two acetoxyls, but only one signal was recognized in the $^1H$ NMR spectrum at $\delta$ 1.97 due to an acetyl methyl. Acetylation of **1** afforded a diacetate with $[M]^+$ at *m/z* 544, suggesting the presence of two hydroxyl groups, but the $^1H$ NMR spectrum of the acetate exhibited only one additional signal at $\delta$ 2.32. The $^{13}C$ NMR spectrum displayed 12 signals for all 24 carbons, indicating that **1** is a symmetric molecule. The $^1H$ NMR spectrum also supported the symmetrical structure since there was no doubling up of signals from the moieties present in the molecule. Analysis of the $^1H$ NMR spectral data indicated that **1** belongs to the tetrahydrofuran class of lignan. The $^1H$ NMR spectrum of **1** showed signals at $\delta$ 4.92 assignable to H-7, $\delta$ 2.47 assignable to H-8 and $\delta$ 4.23 and 4.25 assignable to H-9, and their chemical shifts were very similar to those due to H-7′, 8′ and H-9′ in a known 9,9′-epoxylignan triacetate **3** [4]. The location of the acetoxyl group was confirmed to be at C-7 since the H-7 correlated with C-1, the carbonyl carbon of an acetyl group and H-8 in the COLOC and $^1H$–$^1H$ COSY spectra. Furthermore, the location of a methoxyl group on the phenyl was determined to be at C-3 by a NOE experiment. Because **1** was a symmetrical molecule and its acetate showed no optical rotation ($[\alpha]_D = 0°$), the relative stereochemistry of H-8 and H-8′ was identified to be *cis* with a *meso*-form. On the basis of the above findings, **1** was concluded to be a novel 9,9′-epoxylignan, *cis*-3,4-bis(4′-hydroxy-3′-methoxy-α-acetoxybenzyl)tetrahydrofuran.

Compound **2** showed the UV and IR spectra to be closely similar to those of **1**. The mass spectrum of **2** exhibited the same $[M]^+$ and fragment peaks as shown in **1**. The $^1H$ and $^{13}C$ NMR spectra of **2** were very similar to those of **1**, but each signal appeared as paired signals, suggesting that **2** might be an unsymmetrical isomer of **1**. All connectivities and the location of the functional groups were determined by $^1H$–$^1H$ COSY and COLOC spectra. It was, therefore, presumed that the difference between **1** and **2** was only in the relative stereochemistry at C-8 and C-8′ which, thus might be *trans* in compound **2**. This assumption was further supported by the optical rotation observed for **2** acetate ($[\alpha]_D = -4.4°$) and by NOE experiments. In a NOE experiment, irradiation of H-8 (H-8′) enhanced the signals from H-7 (H-7′) and H-9 (H-9′), while no NOE was observed between H-8 and H-8′. The above results established that **2** must be the diastereomer of **1**, *trans*-3,4-bis(4′-hydroxy-3′-methoxy-α-acetoxybenzyl)tetrahydrofuran. In terms of systematic nomenclature, **1** and **2** may be called *cis*-3,4-bis(4′-hydroxy-3′-methoxy-α-acetoxybenzyl)tetrahydrofuran and *trans*-3,4-



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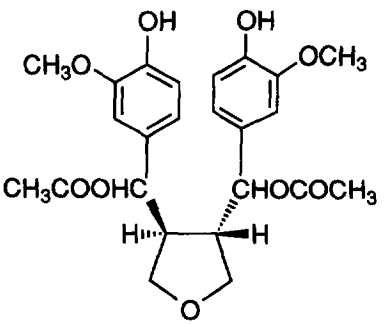

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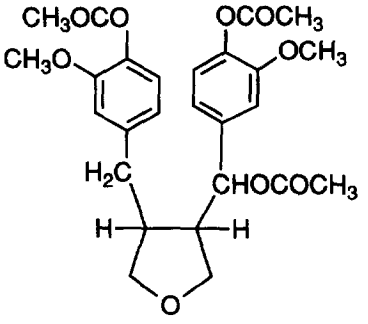

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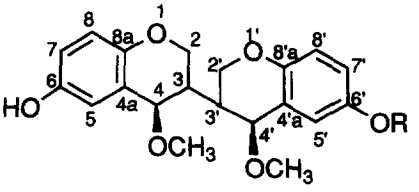

4

bis(4′ - hydroxy - 3′ - methoxy - α - acetoxybenzyl)tetrahydrofuran, respectively, although the lignan numbering system has been used in this report for convenience of comparison of spectral data.

Compound **4**, $[\alpha]_D = 8.0$ (methanol), showed IR absorptions at 3030(OH), 1595 and 1500 $cm^{-1}$ (benzenoids). The mass spectrum exhibited a $[M]^+$ at *m/z* 358 ($C_{20}H_{22}O_6$) and a significant peak at *m/z* 180 corresponding to the fragment $[M/2 + 1]^+$, suggesting that **4** was a dimer. Acetylation of **4** afforded a diacetate ($[M]^+$ *m/z* 442) indicating the presence of two hydroxyl groups. As the total number of oxygens present as hydroxyl and methoxyl groups was four and no carbonyl absorption was observed in the IR spectrum, the remaining two oxygens were likely to be ethers. The $^{13}C$ NMR spectrum confirmed the dimeric structure since there were only 10 signals due to 20 carbons. The $^1H$ NMR spectrum also supported the dimeric structure with a symmetrical coupling of chroman since there was no doubling up of signals from each chroman; only the signals for three aromatic protons due to an ABX system, two protons due to methylene, a pair of methines and a methoxyl group were observed. The hydroxyl groups were attached to C-6 and C-6′, which was confirmed by the COLOC spectrum (Table 1). The locations of the methoxyl groups were deduced by the NOE enhancement. Irradiations of the methoxyl groups at δ 3.86 only gave a NOE enhancement for the H-5(H-5′) signal. This result established that the methoxyl groups were located at C-4 and C-4′, and the two chroman moieties were connected at C-3 and C-3′. The relative stereochemistry of H-3(H-3′) and H-4(H-4′) was assumed to be *cis* from the coupling constant ($J = 4.5$ Hz) between H-3(H-3′) and H-4(H-4′) [5] in the $^1H$ NMR spectrum. Accordingly, **4** was determined to be 6,6′-dihydroxy-4,4′-dimethoxy-3,3′-bichroman.

## EXPERIMENTAL

Mps: uncorr.; IR: KBr; UV: MeOH; $^1H$ and $^{13}C$ NMR: 500 and 125 MHz, respectively, $CDCl_3$ with TMS. The peaks marked with asterisks overlap and are not resolved. MS; EIMS, 70 eV. CC and TLC were performed using Merck silica gel.

*Plant materials.* See ref. [2].

*Extraction and isolation.* See ref. [2]; fr. 4 was rechromatographed over silica gel, LH-20 and Cosmosil $C_{18}$ to give **4** (8 mg) and a mixt. of **1** and **2**. The

Table 1. COLOC correlations of compound **4**

| C | H |
|---|---|
| 2 (2′) | 3 (3′), 4 (4′) |
| 6 (6′) | 7 (7′), 8 (8′) |
| 8 (8′) | 6 (6′)-OH |
| 8a (8′a) | 7 (7′), 2 (2′) |

mixt. of **1** and **2** was not separable by silica gel CC, but **1** and **2** could be isolated from each other by CC on Backerbond $NH_2$ ($CHCl_3$–MeOH) to give 3 and 4 mg of **1** and **2**, respectively.

*Sanjidin A* (**1**). Oil. IR $\nu_{max}$ $cm^{-1}$: 3400, 1730, 1600, 1510. UV $\lambda_{max}$ nm (log $\varepsilon$) 236 (4.25), 286 (4.15). MS *m/z* (rel. int.): 460 (54), 400 (4), 340 (4). $^1H$ NMR: $\delta$ 1.97 (6H, *s*, 2 × OCO$\underline{CH_3}$), 2.47 (2H, *m*, H-8, H-8′), 3.92 (6H, *s*, 3, 3′-OMe), 4.23 (2H, *dd*, *J* = 11.8, 4.9 Hz, H-9, H-9′), 4.25 (2H, *dd*, *J* = 11.8, 5.6 Hz, H-9, H-9′), 4.92 (2H, *d*, *J* = 7.7 Hz, H-7, H-7′), 5.57 (2H, *s*, 4, 4′-OH), 6.88 (2H, *dd*, *J* = 8.1, 1.7 Hz, H-6, H-6′), 6.90 (2H, *d*, *J* = 8.1 Hz, H-5, H-5′), 6.94 (2H, *d*, *J* = 1.7 Hz, H-2, H-2′). $^{13}C$ NMR: $\delta$ 20.7 (*q*, 2 × OCO$\underline{CH_3}$), 50.3 (*d*, C-8, H-8′), 56.0 (*q*, 3, 3′-OMe), 63.7 (*t*, C-9, 9′), 83.0 (*d*, C-7, C-7′), 108.7 (*d*, C-2, C-2′), 114.3 (*d*, C-5, C-5′), 119.3 (*d*, C-6, C-6′), 133.2 (*s*, C-1, C-1′), 145.5 (*s*, C-4, C-4′), 146.8 (*s*, C-3, C-3′), 170.8 (*s*, 2 × O$\underline{CO}$CH$_3$). Diacetate: oil. $[\alpha]_D$ 0° (*c* = 0.1, $CHCl_3$). $^1H$ NMR: $\delta$ 1.98 (6H, *s*, 2 × OCO$\underline{CH_3}$), 2.32 (6H, *s*, 2 × OCO$\underline{CH_3}$), 2.48 (2H, *m*, H-8, H-8′), 3.85 (6H, *s*, 3, 3′-OMe), 4.25 (4H, *d*, *J* = 5.1 Hz, H-9, H-9′), 4.98 (2H, *d*, *J* = 7.3 Hz, H-7, H-7′), 6.96 (2H, *dd*, *J* = 8.1, 1.9 Hz, H-6, H-6′), 7.03 (2H, *d*, *J* = 8.1 Hz, H-5, H-5′), 7.05 (2H, *d*, *J* = 1.9 Hz, H-2, H-2′). MS *m/z* (rel. int.): 544 $[M]^+$ (45), 502 (12), 460 (3).

*Sanjidin B* (**2**). Oil. IR $\nu_{max}$ $cm^{-1}$: 3400, 1730, 1600, 1510. UV $\lambda_{max}$ nm (log $\varepsilon$): 230 sh (4.12), 270 (4.09). MS *m/z* (rel. int.): 460 (62), 400 (3), 340 (3). $^1H$ NMR: $\delta$ 1.88 (3H, *s*, OCO$\underline{CH_3}$), 2.02 (3H, *s*, OCO$\underline{CH_3}$), 2.38 (1H, *m*, H-8), 2.69 (1H, *m*, H-8′), 3.88 (3H, *s*, 3-OMe), 3.94 (3H, *s*, 3′-OMe), 3.77 (1H, *dd*, *J* = 11.2, 8.6 Hz, H-9′), 3.85 (1H, *dd*, *J* = 11.2, 6.1 Hz, H-9′), 4.23 (1H, *dd*, *J* = 11.4, 6.0 Hz, H-9), 4.28 (1H, *dd*, *J* = 11.4, 5.6 Hz, H-9), 4.62 (1H, *d*, *J* = 8.6 Hz, H-7), 5.10 (1H, *d*, *J* = 6.8 Hz, H-7′), 5.54 (1H, *s*, 4-OH), 5.60 (1H, *s*, 4′-OH), 6.89* (2H, *m*, H-5, H-6), 6.91 (1H, *d*, *J* = 2.6 Hz, H-2), 6.93 (1H, *d*, *J* = 8.1 Hz, H-5′), 6.97 (1H, *dd*, *J* = 8.1, 2.1 Hz, H-6′), 7.00 (1H, *d*, *J* = 2.1 Hz, H-2′). $^{13}C$ NMR: $\delta$ 20.6 (*q*, OCO$\underline{CH_3}$), 20.7 (*q*, OCO$\underline{CH_3}$), 45.6 (*d*, C-8′, 50.2 (*d*, C-8), 56.0 (*q*, 3-OMe), 55.9 (*q*, 3′-OMe), 64.3 (*t*, C-9), 64.6 (*t*, C-9′), 81.1 (*d*, C-7′), 83.1 (*d*, C-7), 108.8 (*d*, C-2′), 109.3 (*d*, C-2), 114.3 (*d*, C-5′), 114.5 (*d*, C-5), 119.3 (*d*, C-6′), 119.7 (*d*, C-6), 129.6 (*s*, C-1′), 132.2 (*s*, C-1), 145.2 (*s*, C-4′), 145.7 (*s*, C-4), 146.5 (*s*, C-3′), 146.7 (*s*, C-3), 170.6 (*s*, O$\underline{CO}$Me) 170.8 (*s*, O$\underline{CO}$Me). Diacetate: oil, $[\alpha]_D$ −4.4° (*c* = 0.36, $CHCl_3$). $^1H$ NMR: $\delta$ 1.84 (3H, *s*, OCO$\underline{CH_3}$), 2.05 (3H, *s*, OCO$\underline{CH_3}$), 2.29 (3H, *s*, OCO$\underline{CH_3}$), 2.31 (3H, *s*, OCO$\underline{CH_3}$), 2.39 (1H, *m*, H-8), 2.75 (1H, *m*, H-8′), 3.83 (3H, *s*, 3-OMe), 3.87 (3H, *s*, 3′-OMe), 3.75 (1H, *dd*, *J* = 11.3, 8.3 Hz, H-9′), 3.91 (1H, *dd*, *J* = 11.3, 6.6 Hz, H-9′), 4.25 (1H, *dd*, *J* = 11.3, 6.0 Hz, H-9), 4.32 (1H, *dd*, *J* = 11.3, 6.0 Hz, H-9), 4.69 (1H, *d*, *J* = 8.1 Hz, H-7), 5.14 (1H, *d*, *J* = 6.8 Hz, H-7′), 6.97 (1H, *dd*, *J* = 8.3, 1.5 Hz, H-6), 7.03* (4H, *m*, H-2, 2′, 3′, 5), 7.10 (1H, *br s*, H-2′). MS *m/z* (rel. int.): 544 $[M]^+$ (96), 502 (61), 460 (9), 425 (42).

*Pleionin* (**4**). Powder, $[\alpha]_D$ 8.0° (*c* = 0.4, MeOH). IR $\nu_{max}$ $cm^{-1}$. 3030, 1595, 1500. UV $\lambda_{max}$ nm (log $\varepsilon$): 204 (4.75), 217 (3.92), 231 (407), 281 (3.68). MS *m/z* (rel. int.): 358 (100), 327 (12), 180 (13). $^1H$ NMR: $\delta$ 3.13 (2H, *ddd*, *J* = 6.4, 4.5, 3.8 Hz, H-$3_{ax}$, H-$3'_{ax}$), 3.83 (2H, *dd*, *J* = 8.7, 3.8 Hz, H-$2_{eq}$, $2'_{eq}$), 3.86 (6H, *s*, 4, 4′-OMe), 4.23 (2H, *dd*, *J* = 8.7, 6.4 Hz, H-$2_{ax}$, $2'_{ax}$), 4.71 (2H, *d*, *J* = 4.5 Hz, H-$4_{eq}$, H-$4'_{eq}$), 5.57 (*s*, OH), 6.77 (2H, *d*, *J* = 8.1 Hz, H-8, H-8′), 6.81 (2H, *dd*, *J* = 8.1, 1.5 Hz, H-7, H-7′), 6.95 (2H, *d*, *J* = 1.5 Hz, H-5, H-5′). $^{13}C$ NMR: $\delta$ 54.2 (*d*, C-3, C-3′), 56.0 (*q*, 4, 4′-OMe), 71.7 (*t*, C-2, C-2′), 85.9 (*d*, C-4, C-4′), 108.7 (*d*, C-5, C-5′), 114.3 (*d*, C-8, C-8′), 119.0 (*d*, C-7, C-7′), 133.0 (*s*, C-4a, C-4′a), 145.3 (*s*, C-6, C-6′), 146.7 (*s*, C-8a, C-8′a). Diacetate: plates, mp 155–158° (MeOH). $^1H$ NMR: $\delta$ 2.30 (6H, *s*, OCO$\underline{CH_3}$). 3.09 (2H, *m*, H-3, H-3′), 3.84 (6H, *s*, 4, 4′-OMe), 3.94 (2H, *dd*, *J* = 9.0, 3.4 Hz, H-2, H-2′), 4.28 (2H, *dd*, *J* = 9.0, 6.8 Hz, H-2, H-2′), 4.80 (2H, *d*, *J* = 4.3 Hz, H-4, H-4′), 6.88 (2H, *dd*, *J* = 8.1, 1.9 Hz, H-7, H-7′), 6.99 (2H, *d*, *J* = 1.9 Hz, H-5, H-5′), 7.00 (2H, *d*, *J* = 8.1 Hz, H-8, H-8′). MS *m/z* (rel. int.): 442 $[M]^+$ (40), 400 (94), 358 (97), 327 (16).

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