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A Novel Stilbene Tetramer, Leachianol C, Isolated from *Sophora leachiana*

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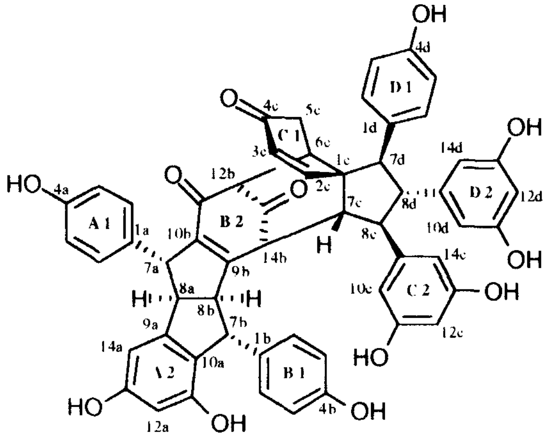
Abstract: A novel resveratrol tetramer, leachianol C, composed of a pallidol and two resveratrol units was isolated from the roots of *Sophora leachiana*. The structure and the relative stereochemistry were determined by means of 2D NMR spectroscopy including PSNOESY.

In continuation of our chemosystematic studies on the genus *Sophora* (Leguminosae), we have characterized the structures of flavonoids with isoprenyl, geranyl and lavandulyl group(s),[1-4] flavonostilbenes (flavanone derivatives condensed with a resveratrol unit)[5,6], and of oligostilbenes[6,7] in the roots of *S. leachiana* PECK. The latter two compounds are exclusively abundant in the roots in this plant as compared with other *Sophora* species. In particular, the presence of such oligostilbenes formed by resveratrol oligomerization[7] through pallidol (5,11-*p*-hydroxyphenyl-2,4,8,10-tetrahydroxydibenzo[a,e]tetrahydropentalene)[8] has been first reported as naturally occurring compounds. Further investigation of the unusual oligostilbenes in the roots resulted in the isolation of another novel resveratrol tetramer consisting of a pallidol and two resveratrol units.

An EtOAc soluble portion (15 g) of acetone extract (60 g) of the pulverized roots (580 g) of *S. leachiana* was repeatedly subjected to column chromatography on silica gel (C_6H_6-acetone system, gradient), Sephadex LH 20 (MeOH, or acetone : H_2O = 4 : 1), and vacuum liquid chromatography using silica gel 60H ($CHCl_3$: MeOH = 10 : 1) to give **1** (56 mg).

Leachianol C (**1**),[9] obtained as a brown solid, showed a $[M-H]^-$ ion at *m/z* 907 in the negative ion FAB-MS corresponding to the molecular formula $C_{56}H_{44}O_{12}$ as a tetrastilbene of resveratrol ($C_{14}H_{12}O_3$). The absorption bands at 1720 and 1670 cm^{-1} in the IR spectrum and carbon signals at δ 194.1, 194.5 and 206.0 in the ^{13}C-NMR spectrum indicated the presence of two unsaturated and an isolated carbonyl groups. The ^{1}H-^{1}H long range COSY and the COLOC spectrum revealed that the structure of **1** was closely related to that of leachianol A (**2**) which is a resveratrol trimer isolated from the roots of this plant[7] with regard to a partial structure attributed to a pallidol moiety. Concerning the rest of two resveratrol units, the ^{1}H-NMR and the ^{1}H-^{1}H COSY spectrum supported the presence of a 4-hydroxyphenyl (ring-D1), two 3,5-dihydroxyphenyl groups (rings-C2 and -D2), and the sequence of aliphatic proton successively coupled through ^3J [H-5c(*eq*)/H-5c(*ax*)/H-6c/H-7c/H-8c/H-8d/H-7d (in the case of H-6c/H-7c: ^4J)] as well as the mutually coupled olefinic protons which were assigned to the protons (H-2c and H-3c) at α- and β- position of the α,β-unsatu-



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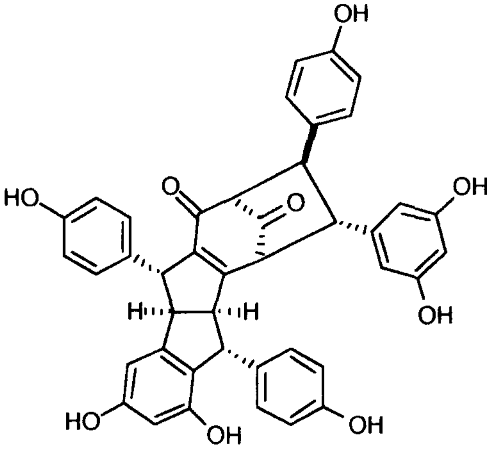

2

rated carbonyl group. Furthermore, the long range couplings between H-12b/H-6c, H-14b/H-7c, H-2c/H-6c and H-3c/H-5c(*eq*) were observed in the ^{1}H-^{1}H and the ^{1}H-^{1}H long range COSY spectrum, which substantiated the presence of a 1,1,2-trisubstituted-2-cyclohexen-4-one ring (ring-C1), of the linkage between the resveratrol unit (marked c in the present numbering system) and the pallidol unit *via* C-12b/C-6c and C-14b/C-7c. The correlations [H-12b/C-1c, H-14b/C-1c, H-7c/C-2c, H-10(14)c/C-8c, H-7d/C-1c, H-7d/C-1d, and H-10(14)d/C-8d] observed in the COLOC and the HMBC spectrum allowed us to conclude that the planar structure of leachianol C was as depicted in Fig. 1. The relative stereochemistry of 1 was assigned by the results of phase sensitive NOESY and difference NOE experiments (Fig. 1). The NOE interactions observed between H-8a/H-8b, H-8a/H-2(6)a, and H-8b/H-2(6)b indicated that rings-A1 and -B1, and H-8a and H-8b are oriented in *cis*, respectively. On the basis of the following NOE results [H-7a/H-3c, H-7b/H-7c, H-2c/H-7c, H-7c/H-10(14)c, H-8c/H-10(14)d, H-10(14)c/H-8d, H-2(6)d/H-8d, H-7d/H-10(14)d, H-5c(*ax*)/H-7d, and H-12b/H-5c(*eq*)], the relative configuration was finally shown as **1**. An unusual chemical shift (δ 4.74) of H-2c was caused by the shielding effect of spatial closeness between rings-A2 and -D1, which also supported the configuration. Leachianol C is the first naturally occurring tetrastilbene possessing a cyclohexanone ring derived from a 4-hydroxyphenyl group, in which a resveratrol molecule and a pallidol unit are condensed at C-1c and C-6c with respect, and will play an important role as chemical marker for the chemosystematics of the genus *Sophora*.

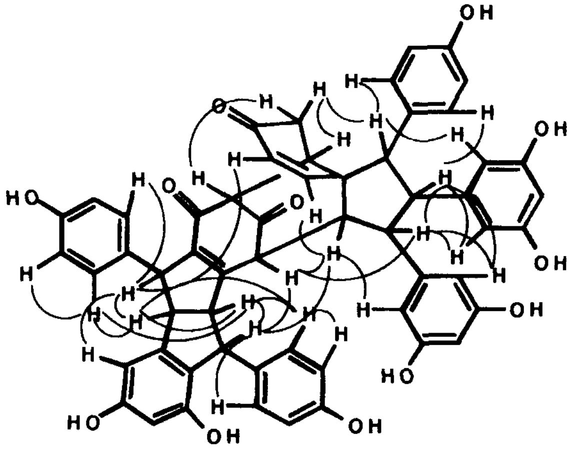

Fig. 1 NOE interactions of **1** in the PSNOESY and DIFNOE spectra

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9. Leachianol C (**1**): A brown solid; Negative ion FAB-MS *m/z*: 907 ([M-H]$^-$, $C_{56}H_{44}O_{12}$); IR ν (cm^{-1}, KBr): 3400, 1720, 1670, 1610; UV λ (MeOH, nm): 220sh, 276; $[\alpha]_D^{23}$ -30.3° (*c* 0.10, MeOH); CD (MeOH): $\Delta\varepsilon_{250}$ +5.5, $\Delta\varepsilon_{283}$ -6.6, $\Delta\varepsilon_{298}$ -5.0, $\Delta\varepsilon_{340}$ +2.8; ^{1}H-NMR (400 MHz, acetone-d_6) δ : 2.50

(1H, d, J= 18 Hz, H-5c(*eq*)), 2.94 (1H, dd, J= 18, 6 Hz, H-5c(*ax*)), 3.08 (1H, d, J= 3 Hz, H-12b), 3.21 (1H, m, H-7c), 3.25 (1H, m, H-8c), 3.27 (1H, d, H-6c), 3.35 (1H,d, J= 10 Hz, H-7d), 3.48 (1H, br s, H-14b), 3.57 (1H, t, J= 10 Hz, H-8d), 3.72 (1H, d, J= 5 Hz, H-8a), 3.79 (1H, br d, J= 5 Hz, H-8b), 3.98 (1H, br s, H-7a), 4.72 (1H, br s, H-7b), 4.74 (1H, d, J= 10 Hz, H-2c), 4.84 (1H, d, J= 10 Hz, H-3c), 6.07 (3H, br s, H-10(12, 14)d), 6.39 (1H, t like m, H-12c), 6.58 (1H, br s, H-12a), 6.62 (1H, br s, H-14a), 6.63 (2H, br s, H-10(14)c), 6.66 (6H, d, J= 8 Hz, H-3(5)a, H-3(5)b and H-3(5)d), 6.94 (4H, d, J= 8 Hz, H-2(6)b and H-2(6)d), 6.97 (2H, d, J= 8 Hz, H-2(6)a), 7.92 (x 2), 8.00, 8.03, 8.12, 8.23 (x 2), 8.25, 8.70 (1H, each br s, OH); ^{13}C-NMR (100 MHz, acetone-d_6) δ : 38.1 (t, C-5c), 47.2 (s, C-1c), 48.8 (d, C-7b), 51.2 (d, C-14b), 51.5 (d, C-6c), 52.9 (d, C-7a), 55.6 (d, C-8c), 58.5 (d, C-8a), 62.1 (d, C-7c), 62.2 (d, C-8d), 64.5 (d, C-8b), 65.8 (d, C-7d), 68.7 (d, C-12b), 102.4 (d, C-12d), 103.2 (d, C-12c), 103.8 (d, C-12a), 104.5 (d, C-14a), 107.5 (d, C-10(14)d), 108.4 (d, C-10(14)c), 116.3 (d, C-3(5)a and C-3(5)d), 116.5 (d, C-3(5)b), 123.7 (s, C-10a), 126.7 (d, C-3c), 129.4 (d, C-2(6)a), 129.7 (d, C-2(6)b and C-2(6)d), 133.4 (s, C-1d), 134.2 (s, C-1a), 136.5 (s, C-1b), 143.4 (s, C-9c), 144.4 (s, C-10b), 144.9 (s, C-9d), 150.2 (s, C-9a), 155.4 (s, C-11b), 157.0 (s, C-4b), 157.2 (s, C-4a and C-4b), 158.5 (d, C-2c), 159.5 (s, C-11(13)d), 160.3 (s, C-13a and C-11(13)c), 163.3 (s, C-9b), 194.1 (s, C-11b), 194.5 (s, C-4c), 206.0 (s, C-13b).

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