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ARYLBENZOFURANS FROM *DALBERGIA PARVIFLORA*

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Key Word Index—*Dalbergia parviflora*; Leguminosae; arylbenzofurans; 5-hydroxy-6-methoxy-3-methyl-2-phenylbenzofuran; 5-hydroxy-6-methoxy-2-methyl-3-phenylbenzofuran.

Abstract—The isolation of two polysubstituted arylbenzofurans from the heartwood of *Dalbergia parviflora* is described. Their structures were elucidated mainly by spectroscopic techniques (UV, IR, ^{1}H and ^{13}C NMR). They were named parvifuran (5-hydroxy-6-methoxy-3-methyl-2-phenylbenzofuran) and isoparvifuran (5-hydroxy-6-methoxy-2-methyl-3-phenylbenzofuran) and are the first compounds of this class isolated from a *Dalbergia* species.

INTRODUCTION

In connection with our interest in the biologically active principles from Thai traditional drugs we investigated the chemical constituents of *Dalbergia parviflora* [1]. A number of neoflavanoids have previously been reported in *ca* 20 *Dalbergia* species [2–6]. To our knowledge this is the first report of a phytochemical investigation of a *Dalbergia* species, which has resulted in the isolation and characterization of arylbenzofurans, which are known as phytoalexins from Leguminosae [7–14] and as compounds with antifungal activity [15–17].

RESULTS AND DISCUSSION

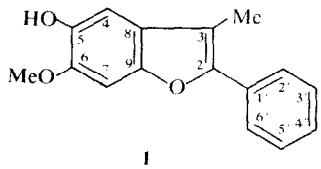
By extensive chromatography of the petrol extract of the heartwood of *D. parviflora* two arylbenzofurans were isolated as minor constituents, which have been assigned structures **1** and **2**; they are structural isomers. Their mass spectra reveal the structural formula $C_{16}H_{14}O_3$ (M^+ 254) and they show similar fragmentation differing only in a few peaks of low intensity. Both show similar IR absorptions with the characteristic peaks for phenolic OH and aromatic OMe at 3500 and 2830, weak absorption at 1630 and the absorption band at 1255 cm^{-1}, typical for cyclic vinyl group and cyclic ether respectively. Also in the IR spectra were characteristic bands for mono- and 1,2,4,5-substituted benzenes. ^{1}H NMR data revealed that **1** and **2** each contain one C–Me, one OMe and one free phenolic OH group. For the corresponding signals only small differences in the δ-values are observed. Compound **1** shows a broadened singlet for two aromatic protons at δ 7.02 ppm and a multiplet for 5 protons between δ 7.26 and δ 7.85, while in compound **2** two slightly broadened singlets at δ 7.0 and δ 7.09 ppm appear jointly with a rather narrow multiplet for 5 protons between δ 7.3 and δ 7.5 ppm. Together with these data, the unsaturation number of 10 leads to a phenylsubstituted aromatic two ring system containing one more oxygen atom and a double bond, i.e. the benzofuran skeleton with the 4 substituents OH, Me, OMe and phenyl. From the chemical shifts and the splitting of the signals for each of the two aromatic protons of **1** and **2** it can be deduced that they are located in the para position C-4 and C-7 of benzofuran.

The distribution pattern of the 4 different substituents on C-2, -3, -5 and -6 has been elucidated by combined ^{1}H NMR, mass- and UV spectroscopy. The highfield shift of both H-4 and H-7 against the respective protons of the unsubstituted benzofuran indicate, that C-5 and C-6 are oxygenated, thus leaving the Me and the phenyl group for C-2/3. Obtusafuran **4**, a 2,3-dihydrobenzofuran obtained by thermal rearrangement of obtusaquinol **3** from *D. retusa*, and melanoxin **5** from *D. melanoxylon* are known from literature [18, 19], both of which are hydroxylated in position 5 and methoxylated in position 6. A comparable substitution pattern is also found for the neoflavanoids isolated from *D. parviflora* (unpublished observations) and other species and is supposed as well for the biogenetically related benzofurans **1** and **2**. This is confirmed by their mass spectra which are in agreement with the fragmentation of the substituted benzofuran fragment ion of melannein [20], thus the loss of ether–Me first and then of CO result in the fragment ions *m/e* 239 and 211.

Compound **1** shows a metastable peak at m* 225 for the first step, which is not observed for **2**. The fragment ions at lower *m/e* values follow the fragmentation for benzofuran derivatives [21–24] with the attached phenyl group similar to arylbenzothiophene [25]. A doubly charged molecular ion at *m/e* 127 appears for **1** and **2**.

The UV-spectra of **1** and **2** are significantly differing from one other. **1** shows a λ_{max} at 321 nm ($\log\varepsilon = 4.34$), while the maximum UV absorption for **2** is found at the shorter wavelength of 235 nm ($\log\varepsilon = 4.17$). The bathochromic shift for **1** is expected if the 2-phenyl-3-methyl substitution pattern is valid, thus representing a *trans* stilbene structure type. Similar absorptions have been published for 2-phenylbenzofurans [9, 15, 16, 26]. The isomeric 2-methyl-3-phenyl-substitution pattern of **2** explains the hypsochromic shift of λ_{max}, as it is similarly observed for 2-methyl-3-phenyl-benzofuran [27].

The substitution patterns of **1** and **2** can be confirmed by ^{13}C NMR spectral data. Chemical shifts of the Me groups of **1** and **2** in position 3 and 2 respectively are in



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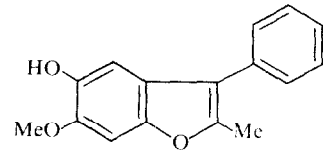

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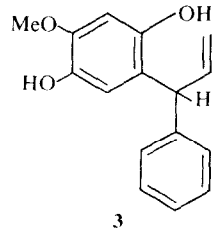

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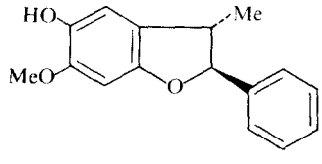

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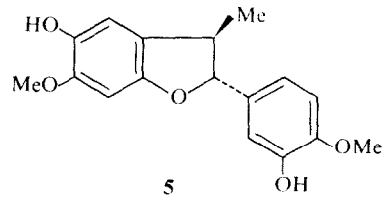

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agreement with 3-methyl- and 2-methyl-benzofurans [28]. The substitution effects on the chemical shifts of C-4, C-5, C-6 and C-7 are consistent with those of the 5-hydroxy-6-methoxy-benzofuran derivative, Moracin B [15]. Assignments of other carbon shifts are mainly based on the literature values of 2- and 3-methyl substituted benzofurans [28], as well as those of the chemical shifts of 2- and 3-arylbenzofurans [29]. The results of the combined spectroscopic elucidation confirm the structure 5-hydroxy-6-methoxy-3-methyl-2-phenylbenzofuran for **1**, for which the name parvifuran is proposed, and the structure 5-hydroxy-6-methoxy-2-methyl-3-phenylbenzofuran for compound **2**, named isoparvifuran.

Parvifuran has been synthesized by Ollis *et al.* [30, 31], while isoparvifuran is a new benzofuran. Both are to our knowledge the first compounds of this class which have been isolated from a *Dalbergia* species.

EXPERIMENTAL

General. D. parviflora Roxb. heartwood, specimen No. 68143 at The Forest Herbarium (BKF), Bangkok, was collected in Thailand and identified by the Forest Product Research Division, Forest Department, Bangkok, Thailand. The heartwood was extracted with petrol. Separation of the constituents from the extraction residue was carried out using Si gel (0.053–0.2 mm) Macherey–Nagel with petrol–C_6H_6 (1:1). Fractionation of **1** and **2** was performed on a Si gel column with petrol–Et_2O (19:1) and was determined by TLC using Polygram Sil G/UV$_{254}$, Macherey–Nagel with petrol–Et_2O (9:1) as running solvent. The spots were detected under UV light. Mps are uncorr.

MS were recorded at high resolution using a data system. ^1H NMR spectra were run at 90 MHz. ^{13}C NMR spectra at 20 MHz.

5-Hydroxy-6-methoxy-3-methyl-2-phenylbenzofuran (**1**). Recrystallized from Et_2O–petrol (40–60°) 9:1 as white needles, (total 27 mg or 0.001% dry wt basis), mp 159–160°, MS: (probe 70 eV), *m/e* (rel. int.): 255 (14), M$^+$ 254 (78), 240 (21), 239 (100), 225 (5), 211 (7), 165 (6), 141 (6), 127 (9), 115 (8) and 77 (8), (found M 254.0955, $C_{16}H_{14}O_3$ requires 254.2882), UV λ_{max}^{EtOH} nm (log ε): 203 (4.47), 216 (4.28), 286 (4.10), 297 (4.12) and 321 (4.34), IR ν_{max}^{KBr} cm^{-1}: 3500 (OH), 2830 (OMe), 1630 (cyclic —CH=CH—), 1435, 1370 (CH_3), 1255 (=C—O—C—), ^1H NMR (90 MHz, $CDCl_3$, δ ppm, TMS int. standard): 2.42 (3 H, *s*, CH_3), 3.96 (3 H, *s*, OMe), 5.52 (1 H, *s*, OH), 7.02 (2 H, *s*, H-4, H-7), 7.26–7.85 (5 H, *m*, H-2′–6′, J = 8 and 2 Hz). ^{13}C NMR (20 MHz, $CDCl_3$, δ ppm, downfield from TMS, $\delta_{TMS} = 0$) measured from internal $CDCl_3$ and corrected by using the equation $\delta_{TMS} = \delta_{CDCl_3} - 76.89$: 9.45 (*q*, 3-$CH_3$), 56.30 (*q*, OMe), 94.31 (*d*, C-7), 103.06 (*d*, C-4), 111.27 (*s*, C-3), 123.95 (*d*, C-8), 126.10 (*d*, C-2′, 6′), 127.21 (*d*, C-4′), 128.44 (*d*, C-3′, 5′), 131.66 (*s*, C-1′), 142.42 (*s*, C-5), 145.33 (*s*, C-6), 147.90 (*s*, C-9), 149.97 (*s*, C-2).

5-Hydroxy-6-methoxy-2-methyl-3-phenylbenzofuran (**2**). Recrystallized from Et_2O–petrol (9:1) as white crystals (total 21 mg or 0.001% dry wt basis), mp 121–122°, MS: (probe 70 eV), *m/e* (rel. int.): 255 (9), M$^+$ 254 (81), 240 (10), 239 (100), 211 (4), 165 (3), 141 (4), 139 (4), 127 (3) and 115 (4), (found M 254.0940, $C_{16}H_{14}O_3$ requires 254.2882), UV λ_{max}^{EtOH} nm (log ε): 203 (4.46),

235 (4.17), 253 (3.99), 297 (3.86), 302 (3.86) and 308 (3.79), IR ν_{max}^{KBr} cm^{-1}: 3500 (OH), 2830 (OMe), 1630 (cyclic —CH=CH—), 1435, 1370 (CH_3), 1255 (=C—O—C—), ^{1}H NMR (90 MHz, $CDCl_3$, δ ppm, TMS int. standard): 2.48 (3 H, *s*, CH_3), 3.82 (3 H, *s*, OMe), 5.47 (1 H, *s*, OH), 7.0 and 7.09 (2 H, 2*s*, H-4, H-7), 7.31–7.51 (5 H, *m*, H-2′–6′ $J = 8$; 2 and 1 Hz). ^{13}C NMR (20 MHz, $CDCl_3$, δ ppm): 12.73 (*q*, 2-CH_3), 56.35 (*q*, OMe), 94.36 (*d*, C-7), 103.47 (*d*, C-4), 116.71 (*s*, C-3), 121.40 (*s*, C-8), 126.70 (*d*, C-4′), 128.61 (*d*, C-2′, 3′, 5′, 6′), 132.96 (*s*, C-1′), 142.59 (*s*, C-5), 144.53 (*s*, C-6), 147.93 (*s*, C-9), 150.23 (*s*, C-2).

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