

STRUCTURE OF MULBERROFURAN P, A NOVEL 2-ARYLBENZOFURAN
DERIVATIVE FROM THE CULTIVATED MULBERRY TREE (MORUS ALBA L.)¹

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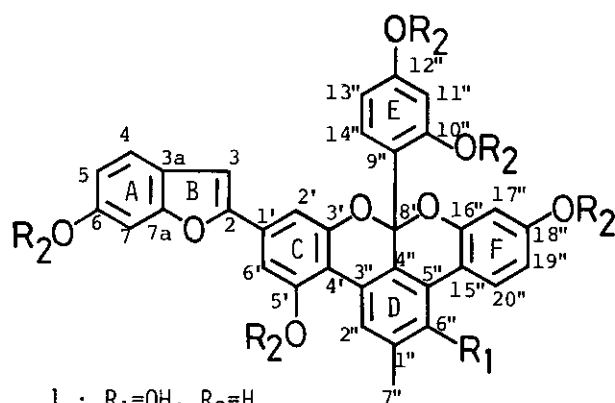
Abstract — A novel 2-arylbenzofuran derivative, mulberro-
furan P, was isolated from an acetone extract of the reddish
violet powder obtained from the surface of the root bark of
cultivated mulberry tree (Ichinose, a cultivated variety of
Morus alba L.). Its structure was shown to be 1 on the basis
of spectral evidence. Mulberrofuran P is regarded biogenetically
as a variation of a Diels-Alder type adduct of a chalcone deri-
vative and a dehydroprenyl-2-arylbenzofuran derivative.

Previously we reported the structure determination of a 2-arylbenzofuran derivative
named mulberrofuran I (2)² and of two stilbene derivatives, kuwanols A (3)³ and B
(4)³ from the reddish violet powder obtained from the surface of the Morus root
bark (Ohshimasō, a cultivated variety of Morus bombycis Koidz.⁴). In the course of
extended studies of the reddish violet powder, we isolated a novel 2-arylbenzofuran
derivative, mulberrofuran P, from the powder (Ichinose, a cultivated variety of
Morus alba L.⁴). In this paper, the structure determination of the compound is
described.

The acetone extract of the reddish violet powder was fractionated sequentially by
silica gel column chromatography, and then by preparative tlc, resulting in the
isolation of mulberrofuran P (1).

Mulberrofuran P (1), a blue amorphous powder,⁵ $[\alpha]_D^{24} +19.5^\circ$ (ethanol) gave the FD-
MS showing a molecular ion peak at m/z 574, and the ¹³C nmr spectrum indicating the
presence of thirty-four carbon atoms [four aliphatic carbons (1 x -CH₃, 1 x >C^O,
1 x -CH=C^O), thirty aromatic carbons (12 x CH, 9 x C, 9 x C-O)] (Table I).

Work-up of 1 with acetic anhydride in pyridine gave the hexaacetate (1a) which
showed a molecular ion peak at m/z 826 in its EI-MS. These results indicated the



1 : $R_1=OH$, $R_2=H$

1a : $R_1=OAc$, $R_2=Ac$

5 : $R_1=R_2=H$

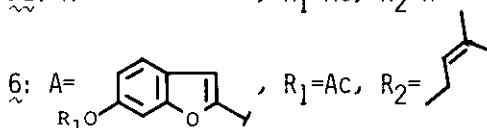
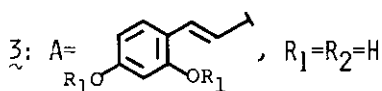
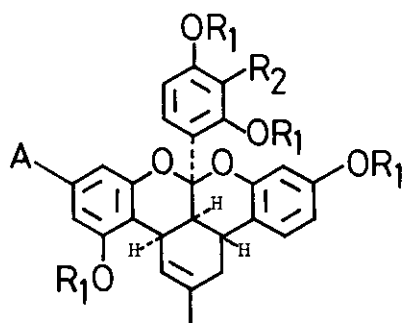
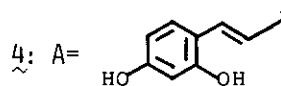
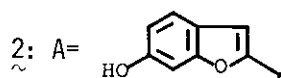
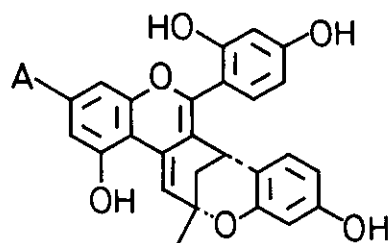


Table I ^{13}C nmr spectra of 1 and 5

	1	5		1	5
C-2	157.6	158.2	C-9"	111.6	111.6
C-3	102.2	103.2	C-10"	158.2	160.2
C-3a	121.1	123.0	C-11"	104.4	105.0
C-4	121.5	122.3	C-12"	160.0	160.8
C-5	112.9	113.5	C-13"	106.9	107.6
C-6	154.6	155.0	C-14"	131.1	131.6
C-7	98.1	98.5	C-15"	115.3*	115.7*
C-7a	156.7	157.4	C-16"	152.0	152.7
C-1'	130.9	129.8	C-17"	104.8	105.4
C-2'	105.5	106.1	C-18"	152.0	153.6
C-3'	156.3	157.4	C-19"	110.3	111.6
C-4'	114.9*	116.0*	C-20"	128.2	126.7
C-5'	155.8	157.1			
C-6'	106.0	106.5			
C-1"	127.2	140.8			
C-2"	130.0	125.3			
C-3"	126.1	132.7**			
C-4"	122.5*	122.5*			
C-5"	117.7*	130.1**			
C-6"	151.3	121.3			
C-7"	17.5	22.3			
C-8"	106.5	106.7			

solvent: CD_3OD

*, **: Assignments may be interchangeable.

Table II ^1H nmr chemical shifts and acetylation shifts (ppm)

	$\tilde{\nu}^a$	$\tilde{\nu}^a$	$\tilde{\nu}^b$	$\tilde{\nu}^b$	Δ
3-H	6.93 (br s)	6.97 (d, J=0.5)	7.08 (d, J=1)	7.35 (br s)	-0.27
4-H	7.34 (d, J=8)	7.35 (d, J=9)	7.41 (d, J=8)	7.67 (d, J=8)	-0.26
5-H	6.73 (dd, J=2,8)	6.74 (dd, J=2.5,9)	6.81 (dd, J=2,8)	7.06 (dd, J=2,8)	-0.25
7-H	6.90 (br d, J=2)	6.90 (br d, J=2.5)	6.98 (br d, J=2)	7.41 (br d, J=2)	-0.43
2'-H	6.98 (s)	6.99 (d, J=1.5)	7.08 (d, J=2)	7.47 (d, J=2)	-0.39
6'-H	6.98 (s)	7.01 (d, J=1.5)	7.12 (d, J=2)	7.42 (d, J=2)	-0.30
1"-CH ₃	2.65 (s)	2.51 (s)	2.49 (s)	2.40 (s)	+0.09
2"-H	8.35 (s)	8.39 (br s)	8.45 (s)	8.14 (s)	+0.31
6"-H	—	7.52 (br s)	—	—	—
11"-H	6.24 (d, J=2)	6.26 (d, J=2.5)	6.29 (d, J=2)	6.94 (d, J=2)	-0.65
13"-H	5.85 (dd, J=2,8)	5.85 (dd, J=2.5,9)	5.92 (dd, J=2,8)	6.72 (br)	-0.80
14"-H	6.20 (d, J=8)	6.13 (d, J=9)	6.24 (d, J=8)	6.72 (br)	-0.48
17"-H	6.47 (d, J=2)	6.47 (d, J=2.5)	6.58 (d, J=2)	6.91 (d, J=2)	-0.33
19"-H	6.46 (dd, J=2,9)	6.52 (dd, J=2.5,9)	6.53 (dd, J=2,8)	6.92 (dd, J=2,8)	-0.39
20"-H	8.38 (d, J=9)	7.61 (d, J=9)	8.43 (d, J=8)	8.13 (br)	+0.30
			COCH ₃	$\left\{ \begin{array}{l} 2.13 \\ 2.24 \\ 2.29 \\ 2.46 \\ 2.47 \\ 2.56 \end{array} \right.$	

solvent a: CD₃OD, b: acetone-d₆

(J in Hz)

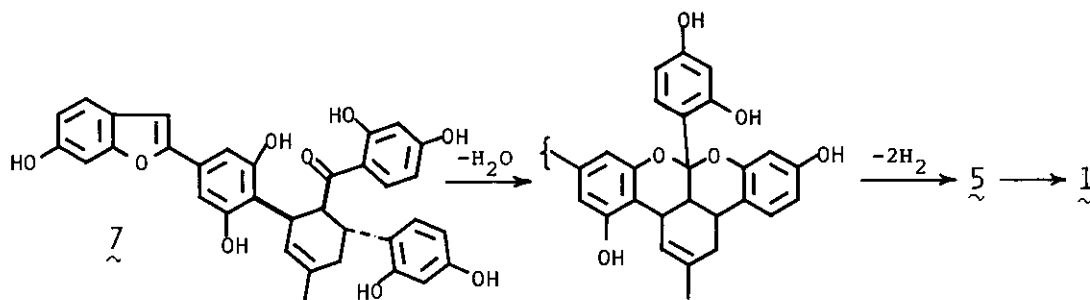


Chart 1

composition of mulberrofuran P to be $C_{34}H_{22}O_9$. Mulberrofuran P was positive to the methanolic ferric chloride test, and its ir spectrum showed absorption bands due to hydroxyl and benzene ring moieties. The uv spectrum of 1 exhibited maxima at 210, 284, 315, 336, 351, and 370 nm, and was similar to that of albanol B (5).^{6,7} The 1H nmr spectrum of 1 (CD_3OD) was examined being compared with that of 5, and showed the presence of the following moieties in 1: 1) protons in a 2-arylbenzofuran moiety, δ 6.73 (1H, dd, J=2 and 8, C-5-H), 6.90 (1H, br d, J=2, C-7-H), 6.93 (1H, br s, C-3-H), 6.98 (2H, s, C-2' and C-6'-H),⁸ 7.34 (1H, d, J=8, C-4-H), 2) protons in two 2,4-dioxygenated phenyl moieties, δ 5.85 (1H, dd, J=2 and 8, C-13"-H), 6.20 (1H, d, J=8, C-14"-H), 6.24 (1H, d, J=2, C-11"-H); δ 6.46 (1H, dd, J=2 and 9, C-19"-H), 6.47 (1H, d, J=2, C-17"-H), 8.38 (1H, d, J=9, C-20"-H), 3) an aromatic proton, δ 8.35 (1H, s), and 4) protons of a methyl group, δ 2.65 (3H, s). Comparison of the ^{13}C nmr spectra of 1 and 5 indicated that the chemical shifts of the carbon atoms of 1 were similar to those of the relevant carbon atoms of 5, except in the carbon atoms of D-ring skeleton which were affected by additional substituent (Table I). Compared with the 1H nmr spectrum of 1 with that 5, the spectrum of 1 indicated the absence of the proton at the C-6" position, and the C-20" proton signal shifted 0.77 ppm toward downfield from the corresponding proton of 5 (Table II). These results suggest that 1 is a 6"-hydroxy-albanol B. This suggestion was further supported by the following result. Comparison of the 1H nmr spectra of 1 and 1a indicated that the acetylation of the hydroxyl groups at C-5' and C-6" positions caused larger upperfield shifts of the protons at the C-2" and C-20" positions (C-2"-H: +0.31 ppm, C-20"-H: +0.30 ppm) (Table II). The similar shifts were observed in the case of both mulberrofuran F pentaacetate (6)⁷ and kuwanol A hexaacetate (3a).³ From the above results, we propose the formula 1 for the structure of mulberrofuran P. Biogenetically, mulberrofuran P seems to be a derivative of the Diels-Alder type adducts, such as mulberrofuran C (7),⁹ and is produced possibly through the steps described in Chart 1.

EXPERIMENTAL

Abbreviations: s=singlet, d=doublet, dd=double doublet, br=broad, sh=shoulder.

The general experimental procedures used are described in the previous paper.⁷

The following instruments were used: 1H and ^{13}C nmr spectra; JEOL GX-400 FTNMR spectrometer, uv spectrum; Hitachi 340 UV spectrometer, ir spectrum; Hitachi 260-30

IR spectrometer, ms; JEOL JMS 01SG-2 mass spectrometer, optical rotation; JASCO DIP-4.

Isolation of Mulberrofuran P (1)

The reddish violet powder (760 g) obtained from the surface of the root bark of cultivated mulberry tree (Ichinose, a cultivated variety of Morus alba L.) was extracted with acetone. Evaporation of the acetone solution to dryness yielded 69 g of residue. The residue (10 g) was chromatographed on silica gel (200 g) with chloroform-acetone as an eluent, each fraction being monitored by tlc. The fractions eluted with chloroform containing 5 % acetone, which showed on the tlc plate a characteristic blue spot, were evaporated to give the residue (2.2 g). To isolate the colored compound, the residue (2.2 g) was fractionated by preparative tlc (solvent systems, chloroform:acetone=1:1, *n*-hexane:acetone=1:1, chloroform:methanol=6:1) to give mulberrofuran P (1, 2 mg).

Mulberrofuran P (1)

Compound 1 was obtained as a blue amorphous powder. $[\alpha]_D^{24} +19.5^\circ$ ($c=0.0113$, ethanol). FD-MS m/z : 574 (M^+), 465. $FeCl_3$ test: positive (blue $\rightarrow$ reddish brown). $\nu_{max}^{KBr} \text{ cm}^{-1}$: 3370 (br), 1680 (sh), 1620, 1600 (sh). λ_{max}^{EtOH} nm(log ϵ): 210 (4.72), 284 (4.17), 315 (sh 4.33), 336 (4.53), 351 (4.61), 370 (4.56). ^{13}C and 1H nmr spectra are described in Table I and II, respectively.

Mulberrofuran P Hexaacetate (1a)

A mixture of mulberrofuran P (1, 3 mg), acetic anhydride (1 ml) and pyridine (0.2 ml) was kept at room temperature for 15 h, and treated as usual. The reaction product was purified by preparative tlc (*n*-hexane:acetone=3:2) to give hexaacetate (1a, 2 mg). The compound 1a was obtained as colorless powder, $FeCl_3$ test: negative. EI-MS m/z : 826 (M^+), 784, 742, 700. 1H nmr spectrum is described in Table II.

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