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NEOLIGNANS FROM *MAGNOLIA DENUDATA*

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Key Word Index—*Magnolia denudata*; Magnoliaceae; neolignans; burchellin; veraguensin; futoenone; denudatin A and B; denudatone.

Abstract—New neolignans, denudatin A and B (hydrobenzofuranoids) and denudatone [spiro(5,5)undecanoid], together with three known neolignans including burchellin, veraguensin and futoenone, were isolated from the leaves of *Magnolia denudata*. On the basis of spectral data, denudatin A and B were characterized as (7*S*,8*R*,5′*R*)-1′-allyl-5′-methoxy-7-piperonyl and (7*S*,8*R*,5′*R*)-1′-allyl-5′-methoxy-7-veratryl-8-methyl-7,8,5′,2′-tetrahydro-2′-oxo-benzofurans, and denudatone as rel-(7*S*,8*R*,1′*S*,8′*S*)-2′,5′-diene-2′,8′-epoxy-5′-methoxy-8-methyl-4′-oxo-7′-tri-*O*-methylpyrogallyl spiro(5,5)undecane.

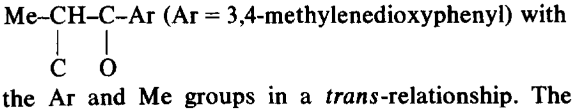
INTRODUCTION

Magnolia denudata, a valuable Japanese decorative plant, contains many terpenes [1]. As a part of our investigations of sesquiterpene lactones or lignans from plants belonging to the Magnoliaceae, we have investigated the neutral components of *M. denudata*. Three types of neolignan were isolated from the plant [hydrobenzofuranoids (**1**, **2**, **5**); tetrahydrofuranoid (**4**); spiro(5,5)undecanoids (**6**, **7**)]. Among these six compounds, three of them were new neolignans named denudatin A (**1**), denudatin B (**2**) and denudatone (**7**). The others were already known viz. burchellin (**5**) [2–4], veraguensin (**4**) [5–8] and futoenone (**6**) [9, 10]. We now report the isolation and structural elucidation of the new compounds.

RESULTS AND DISCUSSION

5′β-*Methoxybenzofuranoid neolignans* [*denudatin A* (1) *and denudatin B* (2)]

Denudatin A was recognized as a neolignan by ^{1}H NMR and mass spectra (*m*/*z* 162, 100%), clearly pointing in both cases to the partial structure Me–CH–C–Ar (Ar = 3,4-methylenedioxyphenyl) with



$\mathrm{Me{-}\underset{\substack{|\\ C}}{CH}{-}\underset{\substack{|\\ O}}{C}{-}Ar}$ (Ar = 3,4-methylenedioxyphenyl)

the Ar and Me groups in a *trans*-relationship. The additional C_6–C_3 unit must be represented by a cyclohexadienone (IR ν_{max} cm^{-1}: 1675, 1645; UV λ_{max} nm: 238, 293) linked at the fully substituted *sp*^{3}-C to a methoxyl (δ 3.09) and at a *sp*^{2}-C to an allyl group. Denudatin A causes a positive Cotton effect in the 301 nm region and a negative Cotton effect in the 280 nm region.

A comparative ^{13}C NMR study of denudatin A (**1**) with mirandin B (**3**) [11–14] also led to the formula (**1**) for denudatin A (Table 1). Instead of the piperonyl group of denudatin A, denudatin B (**2**) bears a veratryl substituent by analysis of the ^{1}H NMR spectrum.

Spiro(5,5)*undecanoid neolignan* [*denudatone* (5)]

Denudatone (**7**) had a mp of 238–240°, $[\alpha]_D - 78.3°$ ($CHCl_3$), $C_{18}H_{12}O_2(OMe)_4$ (M^+, 386), IR ν_{max} cm^{-1}: 1655, 1620, 1600; UV λ_{max} nm: 258, 299. The spectral data suggested that **7** was a neolignan, and had a substituted benzene ring and an $\alpha,\beta,\alpha',\beta'$-dienone moiety. The ^{1}H NMR spectrum indicated that the substituted benzene was a tri-*O*-methylpyrogallyl (Tp) function. In addition to the Tp function, the ^{1}H NMR and mass spectra revealed the presence of a

Table 1. ^{13}C NMR data (δ values) for denudatin A (**1**), denudatin B (**2**) and mirandin B (**3**)

Carbon no.	1	2	3
1	131.2*s*	129.7*s*	132.7*s*
2	106.7*d*	109.6*d*	103.5*d*
3	148.3*s*	149.8*s*	153.3*s*
4	148.2*s*	149.4*s*	138.4*s*
5	108.2*d*	111.1*d*	153.3*s*
6	120.9*d*	120.0*d*	103.5*d*
7	91.3*d*	91.4*d*	91.2*d*
8	50.0*d*	49.8*d*	49.8*d*
9	6.7*q*	6.8*q*	6.9*q*
1′	143.0*s*	142.9*s*	142.8*s*
2′	187.0*s*	187.0*s*	186.8*s*
3′	102.8*d*	102.7*d*	102.7*d*
4′	174.5*s*	174.6*s*	174.3*s*
5′	77.7*s*	77.8*s*	77.6*s*
6′	131.1*d*	131.1*d*	130.9*d*
7′	33.5*t*	33.5*t*	33.5*t*
8′	135.1*d*	135.1*d*	134.8*d*
9′	117.2*t*	117.2*t*	117.1*t*
5′-O$\underline{C}H_3$	51.1*q*	51.1*q*	51.1*q*
O$\underline{C}H_2$O	101.3*t*	—	—
Ar-O$\underline{C}H_3$	—	55.9*q* × 2	56.1*q* × 2, 60.7*q*

Run in $CDCl_3$ at 25 MHz; *s*, singlet; *d*, doublet; *t*, triplet; *q*, quartet. Assignment established by frequency off-resonance decoupling.

Me–CH–CH–Ar moiety (*m/z* 209, $\mathrm{Ar}-\underset{+}{=}-\mathrm{Me}$) and two isolated olefinic proton signals at δ 5.44 and 5.75.

The ^{13}C NMR spectrum of (**7**) was superimposable on that of futoenone (**6**), previously isolated from *Piperum futokadzura*, except for the presence of a piperonyl function (Table 2). Therefore, compound **7** was represented by the formula shown.

In addition to three new neolignans discussed above, three known neolignans were isolated, burchellin (**5**), veraguensin (**4**) and futoenone (**6**).

EXPERIMENTAL

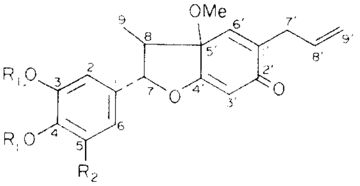
Mps are uncorr. ^{1}H NMR (100 MHz) and ^{13}C NMR (25 MHz) spectra were determined in $CDCl_3$. MS (70 eV) direct insertion. IR: $CHCl_3$. $[\alpha]_D$: $CHCl_3$ or MeOH. UV: MeOH or EtOH. Spots were detected after TLC in UV light (254 nm). Si gel 60 (70–230 mesh) was used for CC and Si gel 60 F-254 for TLC and prep. TLC (0.5 mm).

Extraction and separation of compounds. The MeOH extract of fr. leaves (10 kg) of *M. denudata* Desr. collected in October 1980 at Anpachi, Gifu Prefecture, was divided into *n*-hexane- and $CHCl_3$-soluble fractions (43 g). The residue was chromatographed over a column of Si gel (400 g) using C_6H_6 with gradually increasing proportions of EtOAc as eluant and further purified by prep. TLC. The first fraction (C_6H_6–EtOAc, 20 : 1) gave denudatin A (**1**, 480 mg), denudatin B (**2**, 60 mg) and veraguensin (**4**, 280 mg). The second fraction (5 : 1) gave burchellin (**5**, 280 mg) and futoenone (**6**, 650 mg) and the third fraction (1 : 1) gave denudatone (**7**, 100 mg).

Denudatin A [(7S,8R,5′R) - *1′ - allyl - 5′ - methoxy - 7 - piperonyl - 8 - methyl - 7,8,5′,2′ - tetrahydro - 2′ - oxobenzofuran*] (**1**). Mp 106–107° (Et_2O). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1675, 1645, 1625. UV λ_{max}^{MeOH} nm: 208, 238, 293 (ε 19537, 15457, 9443). $[\alpha]_D + 122.3°$ (MeOH; *c* 2.46). MS *m/z*: 340 $[M]^+$ ($C_{20}H_{20}O_5$), 325, 309, 162. CD (0.355 mg/3 ml MeOH): $[\theta]_{254} + 28732$, $[\theta]_{269}$ 0, $[\theta]_{280} - 10344$, $[\theta]_{286}$ 0, $[\theta]_{301} + 55166$, $[\theta]_{334}$ 0, $[\theta]_{350} - 11493$, $[\theta]_{400}$ 0. ^{1}H NMR: δ 1.12 (3H, *d*, *J* = 7 Hz, Me-8), 2.12 (1H, *m*, H-8), 3.09 (3H, *s*, OMe-5′), 3.14 (2H, *m*, H-7′),

Table 2. ^{13}C NMR data (δ values) for futoenone (**6**) and denudatone (**7**)

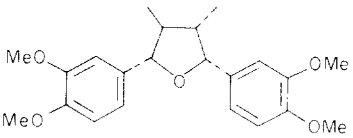
Carbon no.	**6**	**7**
1	137.3*s*	139.1*s*
2	107.7*d*	104.8*d*
3	148.0*s*	153.3*s*
4	146.4*s*	139.1*s*
5	108.3*d*	153.3*s*
6	121.1*d*	104.8*d*
7	46.2*d*	46.9*d*
8	45.5*d*	45.3*d*
9	14.5*q*	14.6*q*
1′	50.3*s*	50.4*s*
2′	180.1*s*	180.1*s*
3′	101.4*d*	101.4*d*
4′	183.1*s*	183.1*s*
5′	153.4*s*	153.3*s*
6′	109.0*d*	109.0*d*
7′	43.7*t*	43.6*t*
8′	81.9*d*	81.9*d*
9′	38.0*t*	37.9*t*
5′-O$\underline{C}H_3$	55.2*q*	55.2*q*
O$\underline{C}H_2$O	101.0*t*	—
Ar-O$\underline{C}H_3$	—	56.2*q* × 2, 60.8*q*



1 R1 = –CH2–, R2 = H

2 R1 = Me, R2 = H

3 R1 = Me, R2 = OMe



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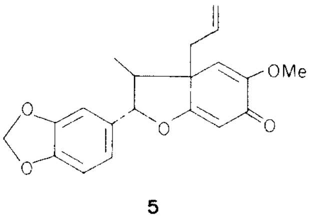

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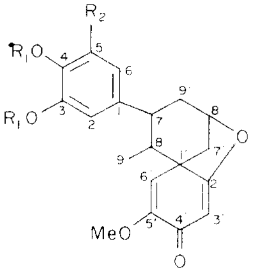

6 R1 = –CH2–, R2 = H

7 R1 = Me, R2 = OMe

4.96–5.20 (2H, *m*, H-9′), 5.26 (1H, *d*, $J = 9.5$ Hz, H-7), 5.7–6.1 (1H, *m*, H-8′), 5.76 (1H, *s*, H-3′), 5.92 (2H, *s*, OCH_2O), 6.2 (1H, *br s*, H-6′), 6.74 (3H, *s*, Ar-H). ^{13}C NMR: Table 1.

Denudatin B [(7S,8R,5′R) - 1′ - *allyl* - 5′ - *methoxy* - 7 - *veratryl* - 8 - *methyl* - 7,8,5′,2′ - *tetrahydro* - 2′ - *oxobenzofuran*] (**2**). Oil. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1675, 1645, 1625. UV λ_{max}^{MeOH} nm: 207, 233, 285, 301 (ϵ 18021, 17822, 6886, 6367). $[\alpha]_D + 82.7^\circ$ (MeOH; *c* 2.67). MS *m/z*: 356 $[M]^+$ ($C_{21}H_{24}O_5$), 341, 325, 178. CD (0.412 mg/4 ml MeOH): $[\theta]_{246}$ 0, $[\theta]_{255} + 20071$, $[\theta]_{270}$ 0, $[\theta]_{276} - 4845$, $[\theta]_{282}$ 0, $[\theta]_{302} + 44987$, $[\theta]_{336}$ 0, $[\theta]_{350} - 9689$, $[\theta]_{400}$ 0. ^1H NMR: δ 1.15 (3H, *d*, $J = 7$ Hz, Me-8), 2.15 (1H, *m*, H-8), 3.12 (3H, *s*, OMe-5′), 3.16 (2H, *m*, H-7′), 3.86 (6H, *s*, Ar-OMe), 4.96–5.20 (2H, *m*, H-9′), 5.32 (1H, *d*, $J = 9.5$ Hz, H-7), 5.60–6.08 (1H, *m*, H-8′), 5.78 (1H, *s*, H-3′), 6.24 (1H, *br s*, H-6′), 6.72–6.88 (3H, *m*, Ar-H). ^{13}C NMR: Table 1.

Denudatone [*rel*(7S,8R,1′S,8′S) - 2′,5′ - *diene* - 2′,8′ - *epoxy* - 5′ - *methoxy* - 8 - *methyl* - 4′ - *oxo* - 7′ - *tri* - O - *methylpyrogallyl spiro*(5,5)*undecane*] (**7**). Mp 238–240°(C_6H_6). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1655, 1620, 1600. UV λ_{max}^{EtOH} nm: 258, 299 (ϵ 19964, 3237). $[\alpha]_D - 78.3^\circ$ ($CHCl_3$; *c* 0.4). MS *m/z*: 386 $[M]^+$ ($C_{22}H_{26}O_6$), 222, 210, 209, 196. ^1H NMR: δ 0.64 (3H, *d*, $J = 6$ Hz, Me-8), 1.76 (1H, *dd*, $J = 13, 11$ Hz, H-9′α), 2.20 (1H, *d*, $J = 11$ Hz, H-7′α), 2.56 (1H, *m*, H-7), 3.63 (3H, *s*, OMe-5′), 3.78, 3.80 (9H, each *s*, Ar–OMe), 5.0 (1H, *br t*, $J = 5$ Hz, H-8′), 5.44 (1H, *s*, H-6′), 5.75 (1H, *s*, H-3′), 6.34 (2H, *s*, Ar–H). ^{13}C NMR: Table 2.

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