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LIGNANS FROM *KRAMERIA IXINA**

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Key Word Index—*Krameria ixina*; Krameriaceae; roots; lignans and neolignans; allyl-substituted 2-phenylbenzofurans; substituted [2-(3-phenyl-1-propen-2-yl)]anisols; *trans*-(2′*S*)-2-[1′-(4-methoxyphenyl)prop-2′-yl]anethol.

Abstract—From a methylene chloride extract of the roots of *Krameria ixina* nine new neolignans/*nor*-neolignans besides 24-methylenecycloartanol and eight further lignan-type compounds already known from other Krameriaceae were isolated.

INTRODUCTION

In the course of our investigations on the non-polar constituents of *Krameria* species [1–6] we studied the roots and aerial parts of *K. ixina* L., in Venezuela known as *Savanilla* [7]. The plant is discussed as an adulteration of *K. triandra* Ruiz et Pavon [8, 9], a species used medicinally as an astringent against inflammations [9]. In Curaçao a weak root decoction is used to expel kidney stones [10]. While we detected various widely spread triterpenoids such as squalene, lupeol and β-sitosterin in the aerial parts, work-up of the roots led to the isolation of several new neolignan-type compounds.

RESULTS AND DISCUSSION

Extraction and chromatography of the roots of *K. ixina* afforded the nine known compounds **1–5**, **10**, **12**, **19**, **20** [2–4, 11, 12] and the hitherto unknown lignans **6–9**, **11**, **13–16**.

The NMR data for **6** showed great similarity to *nor*-neolignans highly oxygenated at ring A [3]. The fact that the signals of the protons at ring A appear as two sharp singlets and the ^{13}C NMR resonances for the three methoxy groups all give resonance at *ca* δ56 indicates 2,4,5-substitution [13–16].

The data for compound **7** demonstrate its identity with the methylation product of eupomatenoid 6 (**1**) [17], which up to now has not been described as a natural product.

In the ^{1}H NMR spectra of **8** and **9** typical multiplets at δ3.5, 5.0, 5.1 and 6.0 indicate the presence of an allyl substituent [18–20] instead of the 'common' (*E*)-propenyl group. The position of the allyl at C-5 was corroborated by NOE studies. Consequently, **8** was hydrogenated to yield a dihydroderivative identical with the hydrogenation product of **1**. Compound **9** was finally confirmed to constitute the methyl ether of **8** by treatment of **8** with diazomethane. Comparison of spectral properties demonstrated **11** to be the methyl ether of conocarpan (**10**).

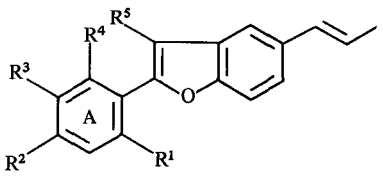
According to their spectra, **13–16** should structurally be related to hermosillol (**12**) recently isolated from *K. sonorae* [2]. While **13** was easily proven to be the methylation product of **12**, **14** and **15** have to carry an allyl instead of the propenyl group in **12** and **13**. Consequently, **14** was hydrogenated and the resulting product shown to be identical with the hydrogenation product of **12**. Methylation of **14** yielded **15**. With regard to the ^{13}C NMR data of **12** (Table 1) it should be mentioned that DEPT-measurements require a correction of some assignments recently published [2].

In contrast to significant similarities to **12–15** in the ^{1}H NMR, the signals for the exo-methylene protons (at δ5.05) were 'missed' in **16**. On the other side, a doublet (three protons) at δ1.15 indicated the presence of an additional methyl group. From these observations and in agreement with its optical activity the tentative structure **16** was proposed. The deduced structure was corroborated and the absolute configuration established by synthetic interconversion of conocarpan (**10**) to dihydro-**16**: catalytic hydrogenation of **10** using Pd/C in acetic acid–methanol [21] yielded **18**, whose methylation product was found to be identical with **17** (=hydrogenated **16**).

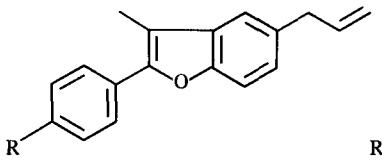
Compounds **5** and **10** are the main constituents of *K. ixina*, while **1**, **3**, **8**, **11**, **12**, **14** and **19** should be regarded as further major components. All other compounds were found as minor or very minor constituents only.

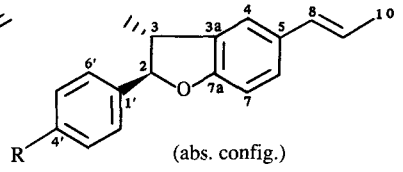
From a chemotaxonomic point of view, it seems worthwhile to mention that *K. ixina* is the first *Krameria* species containing neolignans with an allylic side chain. These neolignans, which are characteristic for *K. ixina* and are not present in other *Krameria* species hitherto investigated, therefore, could be used as chemotaxonomic markers for the detection of roots from *K. ixina* in other plant material and particularly as a potential adulterant of the medicinally used *K. triandra*.

*Part 7 in the series 'Studies on Krameriaceae'. For part 6 see ref. [1].



	R¹	R²	R³	R⁴	R⁵	
1	H	OH	H	H	Me	(Eupomatenoid 6=Ratanhiaphenol II)
2	OH	OMe	H	OMe	H	
3	OH	OMe	H	H	H	(Ratanhiaphenol I)
4	H	OH	H	H	H	
5	OH	OH	H	H	H	
6	OMe	OMe	OMe	H	H	
7	H	OMe	H	H	Me	

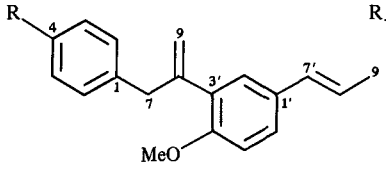


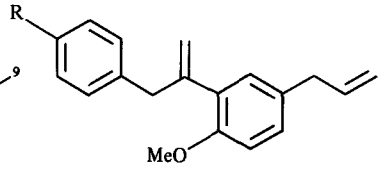


(abs. config.)

8 R = OH
9 R = OMe

10 R = OH (Conocarpan)
11 R = OMe





12 R = OH (Hermosillol)
13 R = OMe

14 R = OH
15 R = OMe

EXPERIMENTAL

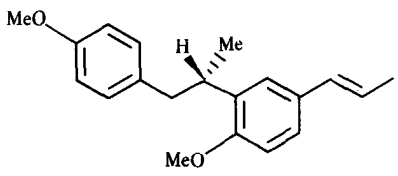
Plant material. Plants were collected on the outskirts of Barquisimeto, Terapaima National Park (Venezuela) in August 1989. Identification was made by James L. Luteyn (The New York Botanical Garden); a voucher specimen is kept at the University of Los Andes under H. A. Rodriguez *et al.* No. 15,101 (MER) and in Erlangen under No. 89-02.

Extraction and chromatography. The concd CH_2Cl_2 extract (3.2 g from 550 g dried roots) was first chromatographed over Sephadex LH-20 using MeOH–$CHCl_3$ (7:3) and then over silica gel (MPLC, CC) using CH_2Cl_2, CH_2Cl_2–MeOH, $CHCl_3$–MeOH, petrol–EtOAc, cyclohexane–EtOAc mixts; further sepn was achieved by CC on Fractogel PVA 500 (Merck) and on LiChrosorb RP-18 (Merck) (HPLC).

General. TLC was performed on ready-made plates (silica gel), using the systems: S-1 = $CHCl_3$; S-2 = $CHCl_3$–MeOH (49:1), with detection by UV and anisaldehyde [22] followed by heating. IR spectra were recorded in $CHCl_3$ solns and KBr pellets, respectively. UV were recorded in MeOH. CD spectra were measured in MeOH. ^{1}H NMR spectra were recorded in Me_2CO-d_6 at 400 MHz, ^{13}C NMR spectra in $CDCl_3$ at 100 MHz, unless otherwise stated; int. ref. TMS. MS were run at 70 eV using a direct inlet system. Identification of **1–5**, **10** and **12** is based on their comparison with authentic substances [2–4]. Compounds **19** and **20** were identified from their physicochemical properties [11, 12].

5-(E)-*Propenyl*-2-(2,4,5-*trimethoxyphenyl*)*benzofuran* (**6**). Crystals (6 mg), mp 131–134°. TLC (S-1): R_f 0.36, green-blue with anisaldehyde. IR ν_{max} cm^{-1}: 3025, 3016, 1612, 1515; UV λ_{max} nm (log ε): 219 (sh, 4.12), 239 (4.21), 256 (sh, 4.15), 278 (4.00), 291 (3.99), 315 (sh, 4.06), 332 (4.22), 345 (sh, 4.18). ^{1}H NMR: δ1.87 (3H, *dd*, J_1 = 6, J_2 = 1.5 Hz, Me-10), 3.87 (3H, *s*, OMe), 3.92 (3H, *s*, OMe), 4.03 (3H, *s*, OMe), 6.26 (1H, *dq*, J_1 = 16, J_2 = 6 Hz, H-9), 6.52 (1H, *dm*, J = 16 Hz, H-8), 6.88 (1H, *s*, H-3′), 7.24 (1H, *d*, J = 1 Hz, H-3), 7.32 (1H, *dd*, J_1 = 8, J_2 = 1.5 Hz, H-6), 7.44 (1H, *br d*, J = 8 Hz, H-7), 7.55 (1H, *s*, H-6′), 7.57 (1H, *d*, J = 1.5 Hz, H-4). ^{13}C NMR: δ18.50 (C-10), 56.11 (OMe), 56.22 (OMe), 56.55 (OMe), 97.39 (C-3′), 104.70 (C-3), 110.06 (C-6′), 110.49 (C-7), 111.34 (C-1′), 117.84 (C-4), 121.90 (C-6), 124.10 (C-9), 130.31 (C-3a), 131.27 (C-8), 132.92 (C-5), 143.20 (C-5′ or C-4′ or C-2′), 149.77 (C-4′ or C-5′ or C-2′), 151.44 (C-2′ or C-4′ or C-5′), 152.58 (C-2 or C-7a), 152.97 (C-7a or C-2). MS *m/z* (rel. int.): 324.1359 (100, [M]$^+$, calcd for $C_{20}H_{20}O_4$: 324.1361), 309 (16), 281 (11).

2-(4-*methoxyphenyl*)-3-*Methyl*-5-(E)-*propenylbenzofuran* (**7**). Crystals (1.5 mg), mp 110–115°. TLC (S-1): R_f 0.57, grey-blue with anisaldehyde. IR ν_{max} cm^{-1}: 3020, 1610, 1511; UV λ_{max} nm



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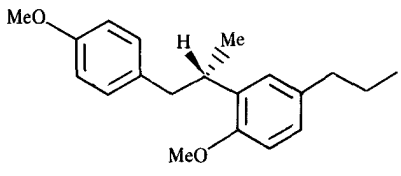

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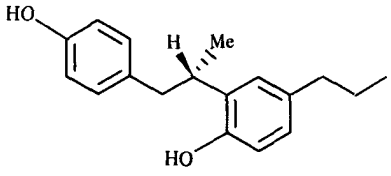

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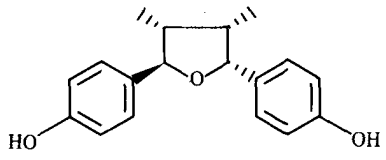

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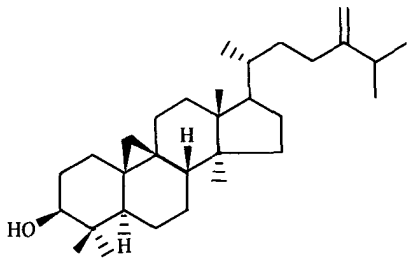

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Table 1. ^{13}C NMR resonances of compounds **12–16** (100 MHz in $CDCl_3$)

C	12	13	14	15	16
1	132.23[a]	132.00[a]	132.15[a]	132.03[a]	135.37[a]
2	130.36	130.13	130.34	130.15	130.04
3	115.03	113.55	114.92	113.49	113.39
4	153.73	157.79	153.62	157.77	157.65
5	115.03	113.55	114.92	113.49	113.39
6	130.36	130.13	130.34	130.15	130.04
7	41.84	41.69	41.74	41.72	42.65
8	148.75	148.83	148.75	148.79	34.19
9	115.49	115.52	115.39	115.36	19.23
1′	130.69[a]	130.50[a]	131.77[a]	131.78[a]	130.46
2′	125.78[b]	125.74[b]	128.20[b]	128.18[b]	124.14[b]
3′	132.00[a]	131.94[a]	131.80[a]	131.83[a]	133.53[a]
4′	155.71	155.59	154.90	154.91	156.00
5′	110.97	110.73	110.71	110.70	110.52
6′	127.76[b]	127.69[b]	130.52[b]	130.51[b]	124.30[b]
7′	130.36	130.27	39.20	39.20	130.74
8′	123.62	123.59	137.77	137.79	123.17[b]
9′	18.28	18.38	115.39	115.36	18.41
MeO-4	—	55.19	—	55.19	55.21
MeO-4′	55.65	55.59	55.60	55.60	55.50

[a–c] Assignments may be interchangeable.

($\log\varepsilon$): 225 (3.98), 254 (4.20), 294 (4.13), 305 (sh, 4.11), 319 (sh, 4.04). ^1H NMR: δ1.87 (3H, *dd*, $J_1=6$, $J_2=1.5$ Hz, Me-10), 2.46 (3H, *s*, Me-3), 3.88 (3H, *s*, OMe), 6.30 (1H, *dq*, $J_1=16$, $J_2=6$ Hz, H-9), 6.55 (1H, *dm*, $J=16$ Hz, H-8), 7.10 (2H, AA′BB′-system, H-3′, H-5′), 7.34 (1H, *dd*, $J_1=8$, $J_2=1.5$ Hz, H-6), 7.41 (1H, *d*, $J=8$ Hz, H-7), 7.57 (1H, *d*, $J=1.5$ Hz, H-4), 7.77 (2H, AA′BB′-system, H-2′, H-6′). MS *m/z* (rel. int.): 278.1299 (100, $[M]^+$, calcd for $C_{19}H_{18}O_2$: 278.1307), 263 (19), 139 (7).

Compound **7** *by methylation of* **1**. Compound **1** (1 mg) was methylated with CH_2N_2 to give **7** (1 mg).

5-*Allyl*-2-(4-*hydroxyphenyl*)-3-*methylbenzofuran* (**8**). Crystals (20 mg), mp 79–83°. TLC (S-1): R_f 0.16, grey-blue with anisaldehyde. IR ν_{max} cm^{-1}: 3593 (OH), 3014, 1613, 1511. UV λ_{max} nm ($\log\varepsilon$): 242 (sh, 3.68), 280 (sh, 4.08), 308 (4.26), 325 (sh, 3.98); +NaOH: 281 (sh, 3.89), 323 (4.31). ^1H NMR: δ2.43 (3H, *s*, Me-3), 3.50 (2H, *br d*, $J=7$ Hz, CH_2-8), 5.04 (1H, *dm*, $J=10$ Hz, H_A-10), 5.11 (1H, *dm*, $J=16$ Hz, H_B-10), 6.04 (1H, *ddt*, $J_1=16$, $J_2=10$, $J_3=7$ Hz, H-9), 7.0 (2H, AA′BB′-system, H-3′, H-5′), 7.13 (1H, *dd*, $J_1=8$, $J_2=1.5$ Hz, H-6), 7.39 (1H, *d*, $J=8$ Hz, H-7), 7.39 (1H, *br d*, $J=1.5$ Hz, H-4), 7.69 (2H, AA′BB′-system, H-2′, H-6′), 8.70 (1H, *s*, OH). ^{13}C NMR (Me_2CO-d_6): δ9.40 (Me-3), 40.82 (C-8), 109.92 (C-3), 111.09 (C-7), 115.56 (C-10), 116.56 (C-3′, C-5′), 119.51 (C-4), 123.90 (C-1′), 125.53 (C-6), 129.10 (C-2′, C-6′), 132.49 (C-3a), 135.17 (C-5), 139.34 (C-9), 152.34 (C-2 or C-7a), 153.29 (C-7a or C-2), 158.49 (C-4′). MS *m/z* (rel. int.): 264.1159 (100, $[M]^+$, calcd for $C_{18}H_{16}O_2$: 264.1150), 237 (7).

Hydrogenation of compound **8**. Compound **8** (1 mg) was hydrogenated in MeOH at room temp. using Pd (10% on C). CC on 10 g PVA yielded dihydro-**8** as an oil (1 mg) identical with the hydrogenation product of **1** [4].

5-*Allyl*-2-(4-*methoxyphenyl*)-3-*methylbenzofuran* (**9**). Oil (4 mg). TLC (S-1): R_f 0.56, green-blue with anisaldehyde. IR ν_{max} cm^{-1}: 3022, 1611, 1511. UV λ_{max} nm ($\log\varepsilon$): 243 (sh, 4.08), 280 (sh, 4.44), 309 (4.63), 324 (sh, 4.38). ^1H NMR: δ2.44 (3H, *s*, Me-3), 3.50 (2H, *br d*, $J=7$ Hz, CH_2-8), 3.88 (3H, *s*, OMe), 5.04 (1H, *dm*, $J=10$ Hz, H_A-10), 5.11 (1H, *dm*, $J=16$ Hz, H_B-10), 6.04 (1H, *ddt*, $J_1=16$, $J_2=10$, $J_3=7$ Hz, H-9), 7.10 (2H, AA′BB′-

system, H-3′, H-5′), 7.14 (1H, *dd*, $J_1=8$, $J_2=1.5$ Hz, H-6), 7.41 (1H, *d*, $J=8$ Hz, H-7), 7.41 (1H, *br d*, $J=1.5$ Hz, H-4), 7.77 (2H, AA′BB′-system, H-2′, H-6′). ^{13}C NMR (Me_2CO-d_6): δ9.39 (Me-3), 40.74 (C-8), 55.65 (OMe), 110.36 (C-3), 111.13 (C-7), 115.06 (C-3′, C-5′), 115.57 (C-10), 119.58 (C-4), 124.73 (C-1′), 125.69 (C-6), 128.85 (C-2′, C-6′), 132.30 (C-3a), 135.16 (C-5), 139.28 (C-9), 151.85 (C-2 or C-7a), 153.21 (C-7a or C-2), 160.57 (C-4′). MS *m/z* (rel. int.): 278.1297 (100, $[M]^+$, calcd for $C_{19}H_{18}O_2$: 278.1307), 263 (26), 139 (7).

Compound **9** *by methylation of* **8**. Compound **8** (2 mg) was methylated with CH_2N_2 to give **9** (2 mg).

(2R,3R)-2,3-*Dihydro*-2-(4-*methoxyphenyl*)-3-*methyl*-5-(E)-*propenylbenzofuran* (**11**). Crystals (30 mg), mp 68–73°. TLC (S-1): R_f 0.51, grey-blue with anisaldehyde. $[\alpha]_D^{20}$ +98° (*c* 2.3; MeOH). IR ν_{max} cm^{-1}: 1611, 1515, 1484; UV λ_{max} nm (log ε): 226 (sh, 4.08), 263 (4.09), 270 (sh, 4.05), 302 (3.35). ^{1}H NMR (90 MHz): δ1.39 (3H, *d*, $J=7$ Hz, Me-3), 1.82 (3H, *br d*, $J=5$ Hz, Me-10), 3.36 (1H, *m*, H-3), 3.81 (3H, *s*, OMe), 5.10 (1H, *d*, $J=9$ Hz, H-2), 5.9–6.2 (1H, *m*, H-9), 6.35 (1H, *dm*, $J=16$ Hz, H-8), 6.69 (1H, *d*, $J=8$ Hz, H-7), 6.95 (2H, AA′BB′-system, H-3′, H-5′), 7.0–7.2 (2H, *m*, H-4, H-6), 7.38 (2H, AA′BB′-system, H-2′, H-6′). ^{13}C NMR (Me_2CO-d_6, 22.5 MHz): δ18.26 (Me-3 or C-10), 18.42 (C-10 or Me-3), 46.08 (C-3), 55.61 (OMe), 93.24 (C-2), 109.73 (C-7), 114.83 (C-3′, C-5′), 121.84 (C-4), 123.12 (C-9), 127.15 (C-6), 128.40 (C-2′, C-6′), 131.97 (C-8), 132.16 (C-5 or C-1′ or C-3a), 133.52 (C-1′ or C-5 or C-3a), 133.95 (C-3a or C-1′ or C-5), 159.47 (C-7a or C-4′), 160.77 (C-4′ or C-7a). MS *m/z* (rel. int.): 280.1457 (100, $[M]^+$, calcd for $C_{19}H_{20}O_2$: 280.1463), 265 (18), 121 (16).

Compound **11** *by methylation of* **10**. Compound **10** (4 mg) was methylated with CH_2N_2 to give **11** (4 mg).

trans-2-[3-(4-*methoxyphenyl*)-1-*Propen*-2-*yl*]*anethol* (**13**). Oil (2.5 mg). TLC (S-2): R_f 0.62, violet with anisaldehyde. IR ν_{max} cm^{-1}: 3020, 1611, 1511. UV λ_{max} nm (log ε): 226 (4.35), 262 (4.19), 271 (sh, 4.11), 285 (sh, 3.50), 298 (sh, 3.31), 310 (sh, 3.22). ^{1}H NMR: δ1.79 (3H, *dd*, $J_1=6$, $J_2=2$ Hz, Me-9′), 3.71 (3H, *s*, OMe-4), 3.74 (2H, *br s*, CH_2-7), 3.84 (3H, *s*, OMe-4′), 5.05 (2H, *m*, CH_2-9), 6.06 (1H, *dq*, $J_1=16$, $J_2=6$ Hz, H-8′), 6.28 (1H, *dm*, $J=16$ Hz, H-7′), 6.77 (2H, AA′BB′-system, H-3, H-5), 6.89 (1H, *d*, $J=8$ Hz, H-5′), 7.05 (1H, *d*, $J=2$ Hz, H-2′), 7.07 (2H, AA′BB′-system, H-2, H-6), 7.20 (1H, *dd*, $J_1=8$, $J_2=2$ Hz, H-6′). ^{13}C NMR (90 MHz): see Table 1. MS *m/z* (rel. int.): 294.1620 (100, $[M]^+$, calcd for $C_{20}H_{22}O_2$: 294.1620), 145 (9), 121 (26).

Compound **13** *by methylation of* **12**. Compound **12** (1 mg) was methylated with CH_2N_2 to give **13** (1 mg).

4-[2-(5-*allyl*-2-*methoxyphenyl*)*allyl*]*Phenol* (**14**). Oil (11 mg). TLC (S-1): R_f 0.12, violet with anisaldehyde. IR ν_{max} cm^{-1}: 3599 (OH), 3020, 1638, 1617, 1513, 1495. UV λ_{max} nm (log ε): 228 (sh, 4.16), 278 (3.55), 287 (sh, 3.44); +NaOH: 235 (sh, 4.22), 282 (3.62). ^{1}H NMR: δ3.24 (2H, *br d*, $J=7$ Hz, CH_2-7′), 3.69 (2H, *br s*, CH_2-7), 3.82 (3H, *s*, OMe), 4.95–5.02 (4H, CH_2-9, CH_2-9′), 5.90 (1H, *ddt*, $J_1=16$, $J_2=10$, $J_3=7$ Hz, H-8′), 6.68 (2H, AA′BB′-system, H-3, H-5), 6.87 (1H, *d*, $J=8$ Hz, H-5′), 6.88 (1H, *d*, $J=2$ Hz, H-2′), 6.96 (2H, AA′BB′-system, H-2, H-6), 7.02 (1H, *dd*, $J_1=8$, $J_2=2$ Hz, H-6′), 8.05 (1H, *s*, OH). ^{13}C NMR: see Table 1. MS *m/z* (rel. int.): 280.1468 (100, $[M]^+$, calcd for $C_{19}H_{20}O_2$: 280.1463), 224 (8), 132 (18), 131 (17), 107 (15).

Hydrogenation of compound **14**. Compound **14** (1 mg) was hydrogenated with Pd/C at 15° in MeOH soln. CC (10 g PVA) yielded 1 mg product identical with the hydrogenation product of **12**, which was prepared in the same way. For spectral data see ref. [2].

4-*Allyl*-2-[3-(4-*methoxyphenyl*)-1-*propen*-2-*yl*]*anisol* (**15**). Oil (2 mg). TLC (S-1): R_f 0.55, violet with anisaldehyde. IR ν_{max} cm^{-1}: 3020, 1611, 1511. UV λ_{max} nm (log ε): 229 (sh, 4.16), 277 (3.53), 283 (3.53). ^{1}H NMR: δ3.25 (2H, *br d*, $J=7$ Hz, CH_2-7′), 3.72 (3H, *s*, OMe-4), 3.73 (2H, *br s*, CH_2-7), 3.83 (3H, *s*, OMe-4′), 4.94–5.02 (4H, CH_2-9, CH_2-9′), 5.89 (1H, *ddt*, $J_1=16$, $J_2=10$, $J_3=7$ Hz, H-8′), 6.77 (2H, AA′BB′-system, H-3, H-5), 6.88 (1H, *d*, $J=8$ Hz, H-5′), 6.88 (1H, *d*, $J=2$ Hz, H-2′), 7.03 (1H, *dd*, $J_1=8$, $J_2=2$ Hz, H-6′), 7.06 (2H, AA′BB′-system, H-2, H-6). ^{13}C NMR: see Table 1. MS *m/z* (rel. int.): 294.1620 (100, $[M]^+$, calcd for $C_{20}H_{22}O_2$: 294.1620), 175 (14), 145 (10), 134 (24), 132 (16), 131 (23), 121 (43), 91 (19).

Compound **15** *by methylation of* **14**. Compound **14** (1 mg) was methylated with CH_2N_2 to give **15** (1 mg).

trans-(2′S)-2-[1′-(4-*methoxyphenyl*)*prop*-2′-*yl*]*Anethol* (**16**). Oil (3 mg). TLC (S-2): R_f 0.62, violet with anisaldehyde. $[\alpha]_D$ −74° (*c* 0.2; MeOH). CD nm (Δε): 225 (−2.94), 243 (−0.09), 257 (−0.24), 275 (+0.06), 297 (−0.15). IR ν_{max} cm^{-1}: 3021, 1610, 1511; UV λ_{max} nm (log ε): 225 (sh, 4.26), 260 (4.16), 268 (sh, 4.08), 284 (sh, 3.53), 294 (sh, 3.38), 308 (sh, 3.05). ^{1}H NMR: δ1.15 (3H, *d*, $J=6$ Hz, Me-9), 1.82 (3H, *dd*, $J_1=6$, $J_2=2$ Hz, Me-9′), 2.64 (1H, *dd*, $J_1=13$, $J_2=8$ Hz, H_A-7), 2.90 (1H, *dd*, $J_1=13$, $J_2=6$ Hz, H_B-7), 3.41 (1H, *m*, H-8), 3.74 (3H, *s*, OMe-4), 3.81 (3H, *s*, OMe-4′), 6.11 (1H, *dq*, $J_1=16$, $J_2=6$ Hz, H-8′), 6.34 (1H, *dm*, $J=16$ Hz, H-7′), 6.79 (2H, AA′BB′-system, H-3, H-5), 6.86 (1H, *d*, $J=8$ Hz, H-5′), 7.07 (2H, AA′BB′-system, H-2, H-6), 7.14 (1H, *dd*, $J_1=8$, $J_2=2$ Hz, H-6′), 7.24 (1H, *d*, $J=2$ Hz, H-2′). ^{13}C NMR: see Table 1. MS *m/z* (rel. int.): 296.1774 (32, $[M]^+$, calcd for $C_{20}H_{24}O_2$: 296.1776), 175 (100), 121 (23).

Hydrogenation of compound **16**. Compound **16** (2 mg) was hydrogenated in MeOH using Pd/C at 15° to give **17** (2 mg) as an oil. TLC (S-2): R_f 0.64, violet with anisaldehyde. $[\alpha]_D$ −18° (*c* 0.1; MeOH). CD nm (Δε): 237 (+0.18), 248 (+0.01), 288 (+0.11). IR ν_{max} cm^{-1}: 3022, 1611, 1512; UV λ_{max} nm (log ε): 225 (3.88), 277 (3.21), 283 (3.17). ^{1}H NMR ($CDCl_3$): δ0.92 (3H, *t*, $J=8$ Hz, Me-9′), 1.14 (3H, *d*, $J=7$ Hz, Me-9), 1.60 (2H, *m*, CH_2-8′), 2.51 (2H, *br t*, $J=8$ Hz, CH_2-7′), 2.58 (1H, *dd*, $J_1=13$, $J_2=8$ Hz, H_A-7), 2.91 (1H, *dd*, $J_1=13$, $J_2=6$ Hz, H_B-7), 3.39 (1H, *m*, H-8), 3.78 (6H, *s*, OMe-4, OMe-4′), 6.75–6.81 (3H, H-3, H-5, H-5′), 6.95–6.99 (2H, H-2′, H-6′), 7.05 (2H, AA′BB′-system, H-2, H-6). MS *m/z* (rel. int.): 298 (14, $[M]^+$), 178 (14), 177 (100), 121 (27).

(2′*S*)-4-[2′-(2-*hydroxy*-5-*propylphenyl*)*propyl*]*Phenol* (**18**). Compound **10** (4 mg) was hydrogenated in HOAc–MeOH (1:1) using Pd/C at 30°; CC on 10 g PVA yielded 3 mg **18** as an oil. ^{1}H NMR ($CDCl_3$): δ0.92 (3H, *t*, $J=8$ Hz, Me-9′), 1.21 (3H, *d*, $J=7$ Hz, Me-9), 1.59 (2H, *m*, CH_2-8′), 2.50 (2H, *br t*, $J=8$ Hz, CH_2-7′), 2.68 (1H, *dd*, $J_1=13$, $J_2=8$ Hz, H_A-7), 2.88 (1H, *dd*, $J_1=13$, $J_2=6$ Hz, H_B-7), 3.26 (1H, *m*, H-8), 4.34 (1H, *s*, OH), 4.54 (1H, *s*, OH), 6.63 (1H, *d*, $J=8$ Hz, H-5′), 6.70 (2H, AA′BB′-system, H-3, H-5), 6.86 (1H, *dd*, $J_1=8$, $J_2=2$ Hz, H-6′), 6.95 (1H, *d*, $J=2$ Hz, H-2′), 6.98 (2H, AA′BB′-system, H-2, H-6). MS *m/z* (rel. int.): 270 (16, $[M]^+$), 164 (16), 163 (100), 107 (23).

Compound **17** *by methylation of* **18**. Compound **18** (3 mg) was methylated with CH_2N_2. CC on 10 g PVA yielded the diMe derivative (2 mg) identical with **17**.

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