D-Gulonolactone as a Synthron for L-Noviose: First Preparation of 4-O-Demethyl-L-noviofuranose and Related Derivatives

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SUPPORTING INFORMATION

Melting points were determined on a Kofler micro hot stage, and are uncorrected. ^1H and ^{13}C NMR (75 MHz) spectra were recorded with the Bruker Avance DPX 300 spectrometer at 302 K, using TMS as an internal standard. The coupling constants (J) are given in Hz. IR spectra were obtained with a Bio-Rad FTS 3000MX spectrophotometer (KBr pellets for solid products and film on NaCl plates for liquids). Mass spectra were recorded with a VG-Analytical AutoSpec Q instrument. Elemental analyses (C, H, N) were performed with a Perkin Elmer 2400 CHN Analyzer. Optical rotations were measured in a 1 dm path-length cell on a Perkin-Elmer 241 MC Polarimeter and the concentrations are given in g/100 mL. X-Ray data were collected on Nonius KappaCCD diffractometer. Column chromatography was performed with Silica Gel 60 (Merck, 60–63 μm). Thin-layer chromatography was carried out on Fluka silica gel TLC-cards. Diethyl ether was dried over sodium and distilled before use. Diazomethane was prepared as described in the literature.¹⁸ All other reagents were used as received from commercial suppliers (Aldrich, Fluka).

Benzyl 2,3-*O*-(1-methylethylidene)- α -L-lyxofuranosiduronaldehyde [Benzyl (5*R*)-3,4-*O*-(1-methylethylidene)-L-arabino-pentodialdo-5,2-furanoside] (5).

A solution of sodium periodate (8.31 g, 38.9 mmol) in water (60 mL) was added dropwise over 1 h to a stirred solution of the diol **4** (11 g, 35.5 mmol) in methanol (180 mL). After

additional stirring at rt for 1 h methanol was evaporated under reduced pressure, water (150 mL) was added and the resulting mixture was extracted with diethyl ether (6x60 mL). Each extract was washed with saturated aqueous solution of sodium chloride (40 mL), combined phases were dried over Na₂SO₄, filtered and evaporated under reduced pressure to give yellow oil **5** (7.22 g, 73%); [α]_D +39.6° (*c* 0.53, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1737, 1495, 1456, 1373; ¹H NMR (CDCl₃) δ 1.24 (3H, s), 1.31 (3H, s), 4.49–4.68 (4H, m), 5.21 (1H, dd, *J*₁ 4.3 Hz, *J*₂ 6 Hz), 5.22 (1H, s), 7.34 (5H, m), 9.57 (1H, s); ¹³C NMR (CDCl₃) δ 25.2, 25.4, 71.0, 79.9, 80.3, 81.4, 101.3, 115.3, 127.8, 127.9, 128.3, 136.8, 199.1; EI-MS *m/z* 263 [(M-Me)⁺, 6], 91 (100). HRMS Calcd for C₁₄H₁₅O₅ [(M-Me)⁺]: 263.0919. Found: 263.0923.

Benzyl 2,3-*O*-(1-methylethylidene)- α -L-lyxofuranosiduronic acid (6).

A solution of silver nitrate (4.13 g, 24.3 mmol) in water (6 mL) was added to the stirred solution of lyxofuranosiduronaldehyde **5** (2.03 g, 7.30 mmol) in ethanol (50 mL), followed by dropwise addition of a solution of potassium hydroxide (2.73 g, 48.7 mmol) in water (53 mL) (over 1.5 h). After 6 h the suspension was filtered, ethanol was evaporated from the filtrate under reduced pressure and the residual solution was washed with diethyl ether (3x10 mL). Upon cooling to 0 °C diethyl ether (30 mL) was added, the stirred two-phase mixture was carefully acidified to pH 4–5 with hydrochloric acid (1:1). The ethereal phase was separated and the aqueous phase was additionally extracted with diethyl ether (2x30 mL). The combined extracts were washed with saturated aqueous solution of sodium chloride (10 mL), dried over MgSO₄, filtered and evaporated under reduced pressure to give α -L-lyxofuranosiduroic acid **6** (1.97 g, 92%) as a yellow oil, which crystallized as a white solid; mp 97–101 °C (diethyl ether) [Ref.^{17b} gives for enantiomeric α -D-lyxofuranosiduronic acid derivative mp 99–101 °C]; [α]_D –60.4° (*c* 0.38, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1758br, 1558br, 1495; ¹H NMR (CDCl₃) δ 1.30 (3H, s), 1.45 (3H, s), 4.52 (1H, d, *J* 12.0 Hz), 4.70 (3H, m), 5.06 (1H, dd, *J*₁ 4.3 Hz, *J*₂ 5.8 Hz), 5.28 (1H, s), 7.32 (5H, m), 8.76 (1H, br s); ¹³C NMR (CDCl₃) δ 25.3, 26.3, 69.8, 79.9, 80.9, 84.6, 106.1, 113.9, 128.4, 128.5, 128.9, 137.2, 172.1; EI-MS *m/z* 295 (MH)⁺, 2], 279 (M-Me), 91 (100). HRMS Calcd for C₁₅H₁₉O₆ (MH⁺): 295.1181. Found: 295.1193.

1-*O*-Benzyl methyl 2,3-*O*-(1-methylethylidene)- α -L-lyxofuranosiduronate (7).

Lyxofuranosiduronic acid **6** (1.65 g, 5.6 mmol) was dissolved in diethyl ether (20 mL) and treated at 0 °C with ethereal solution of diazomethane until nitrogen evolution was completed.

After evaporation under reduced pressure the compound **7** (1.71 g, 99%) was obtained as colorless oil, which later crystallized as a white solid; mp 50–53 °C (diethyl ether); $[\alpha]_D -43.9^\circ$ (c 1.05, CHCl_3) [Ref.^{17b} gives for enantiomeric α -D-lyxofuranosiduronic acid methyl ester $[\alpha]_D +46.4^\circ$]; IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1735, 1496, 1466, 1453, 1437; ^1H NMR ($\text{DMSO}-d_6$) δ 1.24 (3H, s), 1.30 (3H, s), 3.68 (3H, s), 4.48 (1H, d, J 12.1 Hz), 4.63 (3H, m), 5.06 (1H, dd, J_1 4.5 Hz, J_2 6.0 Hz), 5.18 (1H, s), 7.30 (5H, m); ^{13}C NMR (CDCl_3) δ 24.9, 25.8, 52.1, 69.2, 79.6, 80.5, 84.0, 105.6, 113.3, 127.9, 128.0, 128.4, 136.8, 167.8; EI-MS m/z 293 $[(\text{M}-\text{Me})^+, 12]$, 91 (100%). Anal. Calcd for $\text{C}_{16}\text{H}_{20}\text{O}_6 \times 0.5 \text{ EtOAc}$: C, 61.35; H, 6.86. Found: C, 61.14; H, 6.82.

Benzyl 5,5-di-*C*-methyl-2,3-*O*-(1-methylethylidene)- α -L-lyxofuranoside [Benzyl 6-deoxy-5-*C*-methyl-2,3-*O*-(1-methylethylidene)- α -L-lyxo-hexofuranoside] (8a**).**

Iodine (ca. 15 mg, 0.06 mmol) was added to the stirred suspension of Grignard-grade magnesium (300 mg, 12.3 mmol) in 20 mL of diethyl ether, followed by a dropwise addition of a solution of freshly distilled methyl iodide (1.17 mL, 18.8 mmol) in diethyl ether (3 mL). Gentle boiling of the reaction mixture controlled the addition. The reaction mixture was heated for additional 30 min at the reflux temperature. The solution of a methyl ester **7** (1.59 g, 5.16 mmol) in diethyl ether (5 mL) was added dropwise to the solution of methyl-magnesium iodide in diethyl ether and the reaction mixture was heated for 2 h, then it was allowed to cool to rt and poured onto ice-cold 17% solution of ammonium chloride (50 mL). Layers were separated and the aqueous layer was extracted with diethyl ether (2x20 mL), combined organic layers were dried over Na_2SO_4 , filtered and evaporated under reduced pressure to give **8a** (1.51 g, 95%) as yellowish oil, which later crystallized as a white solid; mp 39–40 °C (diethyl ether); $[\alpha]_D -83.3^\circ$ (c 0.56, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1497, 1455, 1401, 1383, 1375, 1364; ^1H NMR ($\text{DMSO}-d_6$) δ 1.20 (3H, s), 1.24 (6H, s), 1.36 (3H, s), 3.73 (1H, d, J 3.4 Hz), 4.29 (1H, s), 4.47 (1H, d, J 12 Hz), 4.56 (1H, d, J 6.0 Hz), 4.61 (1H, d, J 12 Hz), 4.77 (1H, dd, J_1 3.4 Hz, J_2 6.0 Hz), 5.05 (1H, s), 7.29 (5H, m); ^{13}C NMR (CDCl_3) δ 24.5, 26.1, 27.62, 27.65, 69.5, 71.2, 81.1, 83.5, 85.7, 105.3, 113.1, 128.2, 128.4, 128.8, 137.7; FAB-MS m/z 309 (MH^+). Anal. Calcd for $\text{C}_{17}\text{H}_{24}\text{O}_5$: C, 66.21; H, 7.84. Found: C, 66.34; H, 7.56.

Benzyl 2,3-*O*-(1-methylethylidene)-5,5-di-*C*-propyl- α -L-lyxofuranoside (8b**).**

To the stirred solution of 2 M propylmagnesium chloride in diethyl ether (16.2 mL, 32.4 mmol) and additional diethyl ether (20 mL) a solution of methyl ester **7** (4 g, 13.0 mmol) in

diethyl ether (10 mL) was added dropwise to keep the mixture gently boiling. The reaction mixture was heated for additional 2 h at the reflux temperature, and then it was allowed to cool to rt and poured onto ice-cold 17% solution of ammonium chloride (130 mL). Layers were separated and the aqueous layer was extracted with diethyl ether (2x20 mL), combined organic layers were dried over Na₂SO₄, filtered and evaporated under reduced pressure. The crude product was purified by column chromatography (ethyl acetate-petroleum ether 1:20) to give **12b** (2.30 g, 49%) as a yellowish oil, which later crystallized as a white solid; mp 50–51.5 °C (diethyl ether); [α]_D –71.6° (*c* 0.75, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1456, 1424, 1377, 1274, 1213, 1084, 1030; ¹H NMR (CDCl₃) δ 0.95 (6H, m), 1.24–1.72 (8H, m), 1.31 (3H, s), 1.50 (3H, s), 3.60 (1H, s), 3.83 (1H, d, *J* 3.2 Hz), 4.50, (1H, d, *J* 11.7 Hz), 4.64 (1H, d, *J* 5.8 Hz), 4.65 (1H, d, *J* 11.7 Hz), 4.86 (1H, dd, *J*₁ 3.2 Hz, *J*₂ 5.8 Hz), 5.18 (1H, s), 7.32 (5H, m); ¹H NMR (DMSO-*d*₆) δ 0.95 (6H, m), 1.20–1.70 (8H, m), 1.30 (3H, s), 1.49 (3H, s), 3.60 (1H, br s), 3.83 (1H, d, *J* 3.4 Hz), 4.49, (1H, d, *J* 11.7 Hz), 4.64 (1H, d, *J* 5.9 Hz), 4.65 (1H, d, *J* 11.7 Hz), 4.85 (1H, dd, *J*₁ 3.4 Hz, *J*₂ 5.9 Hz), 5.17 (1H, s), 7.31 (5H, m); ¹³C NMR (CDCl₃) δ 14.7, 14.8, 16.6 (two signals), 24.2, 25.7, 37.8, 39.0, 69.1, 74.9, 80.6, 80.8, 85.2, 104.6, 112.7, 127.8, 128.1, 128.4, 137.3; FAB-MS *m/z* 365 (MH⁺). HRMS Calcd for C₂₀H₂₉O₅ [(M-Me)⁺]: 349.2015. Found: 349.2030.

Benzyl 2,3-*O*-(1-methylethylidene)-5,5-di-*C*-phenyl- α -L-lyxofuranoside (8c**).**

To the stirred solution of 3 M phenylmagnesium chloride in diethyl ether (5.4 mL, 16.2 mmol) and additional diethyl ether (15 mL) a solution of methyl ester **7** (2 g, 6.5 mmol) in diethyl ether (10 mL) was added dropwise as fast that the mixture was gently boiling; then the reaction mixture was heated for additional 2 h at the reflux temperature. Upon cooling to rt it was poured onto ice-cold 17% solution of ammonium chloride (60 mL). Layers were separated and the aqueous layer was extracted with diethyl ether (3x20 mL). Combined extracts were dried over Na₂SO₄, filtered and evaporated under reduced pressure. The crude product was purified by column chromatography (ethyl acetate-petroleum ether 1:20) to give yellow oil **8c** (2.28 g, 82%), which crystallized as a white solid; mp 95.2–96.4 °C (diethyl ether); [α]_D –44.1° (*c* 0.81, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1493, 1448, 1381, 1273, 1212; ¹H NMR (DMSO-*d*₆) δ 1.16 (3H, s), 1.33 (3H, s), 4.42 (1H, d, *J* 11.7 Hz), 4.53 (1H, d, *J* 11.7 Hz), 4.64 (1H, d, *J* 5.9 Hz), 4.82 (1H, dd, *J*₁ 3.3 Hz, *J*₂ 5.9 Hz), 5.03 (1H, d, *J* 3.3 Hz), 5.12 (1H, s), 5.15 (1H, s), 7.12–7.67 (15H, m); ¹³C NMR (CDCl₃) δ 24.7, 26.3, 69.9, 78.6, 81.0, 81.6, 85.6, 105.9, 113.6, 125.9, 126.1, 127.2, 127.4, 128.4, 128.5, 128.6, 128.7, 129.0, 137.5, 145.4,

145.9; FAB-MS m/z 415 $[(MH-H_2O)^+]$. Anal. Calcd for $C_{27}H_{28}O_5$: C, 74.98; H, 6.53. Found: C, 74.88; H, 6.69.

2,3-*O*-(1-Methylethylidene)-5,5-di-*C*-methyl- α -L-lyxofuranose [6-Deoxy-5-*C*-methyl-2,3-*O*-(1-methylethylidene)- α -L-lyxo-hexofuranose] (9a).

To the solution of **8a** (1.69 g, 5.49 mmol) in diethyl ether (50 mL) 10% Pd/C (200 mg) was added, then it was hydrogenated at 4.1 bar (60 psi) for 5 h. The resulting suspension was filtered through a celite pad and evaporated under diminished pressure to give **9a** (1.18 g, 99%) as a white solid; mp 73–77 °C (ethanol); $[\alpha]_D -31.0^\circ$ (c 0.55, MeOH); IR $\nu_{\max}/\text{cm}^{-1}$ 1462, 1376, 1273, 1244, 1211; ^1H NMR ($\text{DMSO}-d_6$) δ 1.19 (3H, s), 1.21 (3H, s), 1.23 (3H, s), 1.35 (3H, s), 3.79 (1H, d, J 3.4 Hz), 4.15 (1H, s), 4.42 (1H, d, J 5.8 Hz), 4.73 (1H, dd, J_1 3.4 Hz, J_2 5.8 Hz), 5.15 (1H, d, J 4.1 Hz), 6.28 (1H, d, J 4.1 Hz); ^{13}C NMR (CDCl_3) δ 24.1, 25.7, 27.2, 27.3, 71.1, 80.9, 83.3, 85.7, 100.6, 112.8; EI-MS m/z 203 $[(M-\text{Me})^+]$, 18, 59 (100). HRMS Calcd for $\text{C}_9\text{H}_{15}\text{O}_5$ $[(M-\text{Me})^+]$: 203.0919. Found: 203.0923.

2,3-*O*-(1-Methylethylidene)-5,5-di-*C*-propyl- α -L-lyxofuranose (9b).

To the solution of **8b** (885 mg, 2.4 mmol) in diethyl ether (50 mL) 10% Pd/C (180 mg) was added, then it was hydrogenated at 4.1 bar (60 psi) for 4.5 h. The resulting suspension was filtered through a celite pad and evaporated under diminished pressure to give **9b** (510 mg, 76%) as a yellowish oil, which later crystallized as a white solid; mp 66.5–69 °C (diethyl ether); $[\alpha]_D -22.4^\circ$ (c 0.37, MeOH); IR $\nu_{\max}/\text{cm}^{-1}$ 1459, 1425, 1377, 1212; ^1H NMR (CDCl_3) δ 0.93 (6H, m), 1.27–1.64 (8H, m), 1.32 (3H, s), 1.50 (3H, s), 3.73 (1H, br s), 3.98 (1H, d, J 3.4 Hz), 4.59 (1H, d, J 5.8 Hz), 4.87 (1H, dd, J_1 3.4 Hz, J_2 5.8 Hz), 5.45 (1H, s); ^1H NMR ($\text{DMSO}-d_6$) δ 0.86 (6H, m), 1.20–1.55 (8H, m), 1.25 (3H, s), 1.37 (3H, s), 3.71 (1H, s), 3.81 (1H, d, J 3.4 Hz), 4.44 (1H, d, J 5.8 Hz), 4.87 (1H, dd, J_1 3.4 Hz, J_2 5.8 Hz), 5.14 (1H, d, J 4.1 Hz), 6.30 (1H, d, 4.1 Hz); ^{13}C NMR (CDCl_3) δ 14.5, 14.7, 16.4, 16.5, 24.1, 25.7, 37.6, 38.7, 75.2, 80.5, 80.9, 85.7, 100.0, 112.6; FAB-MS m/z 275 (MH^+). Anal. Calcd for $\text{C}_{14}\text{H}_{26}\text{O}_5$: C, 61.29; H, 9.55. Found: C, 61.02; H, 9.89.

2,3-*O*-(1-Methylethylidene)-5,5-di-*C*-phenyl- α -L-lyxofuranose (9c).

To the solution of **8c** (1.62 g, 3.7 mmol) in diethyl ether (50 mL) 10% Pd/C (300 mg) was added, then it was hydrogenated at 4.1 bar (60 psi) for 12 h. The resulting suspension was filtered through a celite pad, evaporated under reduced pressure to give **9c** (600 mg, 47%) as a

yellowish oil, which crystallized as a white solid; mp 138–140 °C (diethyl ether); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1599, 1495, 1450, 1378 br, 1337, 1318, 1276; ^1H NMR (CDCl_3) δ 1.18 (3H, s), 1.53, (3H, s), 3.15 (1H, br s), 4.55 (1H, d, J 5.8 Hz), 4.66 (1H, dd, J_1 3.0 Hz, J_2 5.8 Hz), 5.07 (1H, d, J 3.0 Hz), 5.13 (1H, s), 5.42 (1H, s), 7.22 (6H, m), 7.55 (4H, m); ^1H NMR ($\text{DMSO}-d_6$) δ 1.15 (3H, s), 1.33 (3H, s), 4.49 (1H, d, J 5.8 Hz), 4.78 (1H, dd, J_1 3.4 Hz, J_2 5.8 Hz), 5.06 (1H, d, J 3.4 Hz), 5.08 (1H, s), 5.20 (1H, d, J 4.3 Hz), 6.56 (1H, d, J 4.3 Hz), 7.25 (6H, m), 7.48 (2H, m), 7.57 (2H, m); ^{13}C NMR (CDCl_3) δ 24.1, 25.7, 78.1, 80.6, 81.2, 85.4, 100.8, 113.0, 125.4, 125.8, 126.7, 126.9, 128.0, 128.2, 144.9, 145.6; FAB-MS m/z 325 $[(\text{MH}-\text{H}_2\text{O})^+]$. Anal. Calcd for $\text{C}_{20}\text{H}_{22}\text{O}_5$: C, 70.16; H, 6.48. Found: C, 70.35; H, 6.69.

4-*O*-Methyl-5,5-di-*C*-methyl-2,3-*O*-(1-methylethylidene)-*L*-lyxopyranose [6-Deoxy-5-*C*-methyl-4-*O*-methyl-2,3-*O*-(1-methylethylidene)-*L*-lyxo-hexopyranose] (10a).

To the solution of lyxofuranose **9a** (1.05 g, 4.8 mmol) in a mixture of toluene (14 mL) and methylene chloride (6 mL) tetrabutylammonium bromide (213 mg, 0.66 mmol), 20% solution of sodium hydroxide (10 mL) and dimethyl sulfate (1.3 mL, 13.6 mmol) were added. The reaction was carried out in the two-phase mixture under phase-transfer conditions for 22 h at rt. Layers were separated, the aqueous layer was diluted with water (30 mL) and extracted with methylene chloride (3x20 mL). Combined organic extracts were dried over Na_2SO_4 , filtered and evaporated under reduced pressure. Yellow oil was purified by column chromatography (chloroform-petroleum ether 1:2) to give **10a** (0.68 g, 61%) as a yellow oil; $[\alpha]_{\text{D}} -78.7^\circ$ (c 1.56, MeOH); lit.¹² $[\alpha]_{\text{D}} -79.1^\circ$ (c 1.58, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1727, 1464, 1375, 1271. ^{13}C NMR ($\text{DMSO}-d_6$): δ 24.5, 26.1, 27.64, 27.65, 54.8, 71.2, 81.0, 83.3, 85.6, 106.9, 113.1; FAB-MS m/z 233 (MH^+); ^1H NMR (CDCl_3): δ 1.32 (3H, s), 1.35 (3H, s), 1.38 (3H, s), 1.51 (3H, s), 3.33 (3H, s), 3.54 (1H, s), 3.69 (1H, d, J 3.4 Hz), 4.57 (1H, d, J 5.8 Hz), 4.84 (1H, dd, J_1 3.4 Hz, J_2 5.8 Hz), 5.00 (1H, s).

4-*O*-Methyl-2,3-*O*-(1-methylethylidene)-5,5-di-*C*-propyl-*L*-lyxopyranose (10b).

Lyxofuranose **9b** (934 mg, 3.4 mmol) was dissolved in the mixture of methylene chloride (4 mL) and toluene (10 mL). To this solution tetrabutylammonium bromide (150 mg, 0.46 mmol), 20% solution of sodium hydroxide (7 mL) and dimethyl sulfate (0.92 mL, 9.6 mmol) were added. The reaction was carried out in a two-phase mixture under phase-transfer conditions for 12 h at rt. Layers were separated; the aqueous layer was diluted with additional water (30 mL) and extracted with methylene chloride (3x15 mL). Combined organic extracts

were dried over Na_2SO_4 , filtered and evaporated under reduced pressure. Yellow oil obtained was purified by column chromatography (gradient ethyl acetate-petroleum ether 1:20 to 1:10), to give product **10b** (770 mg, 78%) as a yellowish oil; $[\alpha]_{\text{D}} -33.8^\circ$ (c 0.51, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1460, 1413, 1375, 1267; ^1H NMR (CDCl_3) δ 0.94 (6H, m), 1.25–1.68 (8H, m), 1.32 (3H, s), 1.49 (3H, s), 3.31 (3H, s), 3.47 (1H, s), 3.76 (1H, d, J 3.2 Hz), 4.55 (1H, d, J 5.8 Hz), 4.85 (1H, dd, J_1 3.2 Hz, J_2 5.8 Hz), 4.96 (1H, s); ^{13}C NMR (CDCl_3) δ 14.2, 14.4, 16.2, 16.3, 23.8, 25.4, 37.6, 38.6, 54.0, 74.6, 80.0, 80.4, 84.8, 105.9, 112.3; FAB-MS m/z 289 (MH^+). HRMS Calcd for $\text{C}_{14}\text{H}_{25}\text{O}_5$ $[(\text{M}-\text{Me})^+]$: 273.1702. Found: 273.1709.

Methyl 2,3-*O*-(1-methylethylidene)-5,5-di-*C*-phenyl- α -L-lyxofuranoside (12).

To the solution of lyxofuranose **9c** (534 mg, 1.6 mmol) in a mixture of methylene chloride (7 mL) and toluene (2 mL) tetrabutylammonium bromide (80 mg, 0.25 mmol), 20% solution of sodium hydroxide (5 mL) and dimethyl sulfate (0.52 mL, 5.4 mmol) were added. The reaction was carried out in a two-phase mixture under phase-transfer conditions for 12 h at rt. Layers were separated; the aqueous layer was diluted with additional water (30 mL) and extracted with methylene chloride (3x10 mL). Combined organic extracts were dried over Na_2SO_4 , filtered and evaporated under reduced pressure. A yellow oil was purified by column chromatography (gradient ethyl acetate-petroleum ether 1:20 to 1:5) to give **12** (506 mg, 89%) as a yellow oil, which crystallized as a white solid; mp 94–98 °C (petroleum ether); $[\alpha]_{\text{D}} -35.7^\circ$ (c 0.33, MeOH); IR $\nu_{\text{max}}/\text{cm}^{-1}$ 1493, 1450, 1383, 1272, 1213; ^1H NMR (CDCl_3) δ 1.18 (3H, s), 1.54 (3H, s), 3.35 (3H, s), 4.54 (1H, d, J 5.8 Hz), 4.59 (1H, dd, J_1 3.0 Hz, J_2 5.8 Hz), 4.93 (1H, d, J 3.0 Hz), 5.02 (1H, s), 5.15 (1H, br s), 7.24 (6H, m), 7.54 (4H, m); ^{13}C NMR ($\text{DMSO}-d_6$) δ 24.1, 25.7, 55.0, 78.1, 80.1, 80.9, 84.9, 107.2, 112.9, 125.3, 125.5, 126.6, 126.8, 127.9, 128.1, 144.8, 145.4; FAB-MS m/z 339 $[(\text{MH}-\text{H}_2\text{O})^+]$. Anal. Calcd for $\text{C}_{21}\text{H}_{24}\text{O}_5 \times 0.3 \text{H}_2\text{O}$: C, 69.71; H, 6.85. Found: C, 69.59; H, 6.62.