Green, lithium salt free synthesis of 2-alkylated 1,4-benzenediols in hydroalcoholic media

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All commercially available reagents were purchased and used without further purification (Aldrich, Fluka). All solvents including, EtOH, AcOEt and n-hexanes were purified by distillation. All reactions were monitored by thin layer chromatography (TLC) performed on 0.25 mm silica gel glassplates (60 F254) using UV light, Iodine and Brady solution as visualizing agents. Flash column chromatography was carried out with silica gel (spherical, neutral, 63-210 μm grade). Yields refer to chromatographically and spectroscopically homogeneous materials. Melting points were measured on a melting point apparatus (Gallenkamp) and were uncorrected. Mass spectra (EI MS) was obtained on a Shimadzu GC-EI MS QP 1100 EX spectrometer. 1H-NMR spectra (400 MHz) and 13C-NMR (100 MHz) were recorded in the indicated solvent on a Bruker Advance DPX 400 MHz spectrometers. Chemical shifts (δ) are reported in delta (δ) units, parts per million (ppm). Chemical shifts for 1H-NMR spectra are given relative to signals for internal tetramethylsilane (0 ppm) or residual nondeuterated solvents, i.e., methanol (3.30 ppm). Chemical shifts for 13C-NMR spectra are given relative to the signal for chloroform-d (77.0 ppm) or dimethyl sulphoxide-d6 (39.5 ppm). Multiplicities are reported by the following abbreviations: s (singlet), d (doublet), t (triplet), p (pentet), m (multiplet), dd (double doublet), dt (double triplet), br-s (broad singlet). Coupling constants (J) are represented in hertz (Hz).

General procedure: A solution of K2CO3(1 mmol) in a water ethanol 9:1 mixture (20 mL) is heated with stirring. Once the solution is under reflux, 1,4-cyclohexanedione (1 mmol) is added slowly. Afterwards, the aldehyde (2 mmol) is added slowly in portions. When the reaction is complete, HCl 10% solution is added dropwise while still hot, until neutral (especially with amphotheric compounds) or slightly acidic pH. The aqueous solution is extracted with ethyl acetate and the organic extract is washed with brine, dried and evaporated in vacuo. Purification is performed by column chromatography.

In the case of aldehydes with free hydroxyls (7a-7e and 7l) and carboxylic acids (9f) one equivalent more of base was used per acid group.

For the synthesis of dimers 13 and 15, 2 equivalents of cyclohexanedione and base were used per equivalent of aldehyde.

2-benzyl-1,4-benzenediol (3): 1H-RMN (400 MHz, CDCl3) δ (ppm): 3.92 (s, 2H) 6.51 (d, J=3.0 Hz, 1H) 6.55 (dd, J1=3.0 Hz J2=8.5 Hz, 1H) 6.68 (d, J=8.5 Hz, 1H) (7.15-7.28) (m, 5H); Mp=122-124°C; Yield: 84%. (9)

2-(4-chlorobenzyl)-1,4-benzenediol (5a): 1H-RMN (400 MHz, CDCl3) δ (ppm): 3.87 (s, 2H) 6.51 (d, J=2.9 Hz, 1H) 6.55 (dd, J1=2.9 Hz J2=8.5 Hz, 1H) 6.64 (d, J=8.5 Hz, 1H) 7.14 (d, J=8.6 Hz, 2H) 7.22 (d, J=8.6 Hz, 2H); Mp= 143-144°C; Yield: 72%. (9)

2-(3-chlorobenzyl)-1,4-benzenediol (5b): 1H-RMN (400 MHz, CDCl3) δ (ppm): 3.79 (s, 2H) 6.44 (m, 2H) 6.62 (d, J=8.0 Hz, 1H) 7.20 (m, 3H) 7.29 (t, J1=J2=7.6 Hz, 1H) 8.61 (s, 1H, OH) 8.75 (s, 1H, OH); 13C-NMR (100 MHz, CDCl3) δ (ppm): 35.4, 114.1, 116.1, 117.2, 126.0, 127.7, 127.8, 128.8, 130.4, 133.2, 144.4, 147.7, 150.1; EI MS: m/z 234 (M+, 69); 122 (100); Mp=126-127°C; Yield: 73%.
2-(4-fluorobenzyl)-1,4-benzenediol (5c): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.87 (s, 2H) 6.52 (d, \(J=3.0\) Hz, 1H) 6.54 (dd, \(J_1=3.0\) Hz \(J_2=8.5\) Hz, 1H) 6.64 (d, \(J=8.5\) Hz, 1H) 6.94 (t, \(J=8.8\) Hz, 2H) 7.14-7.18 (m, 2H); \(^13\)C-NMR (100 MHz, CDCl\(_3\)) \(\delta\) (ppm): 35.2, 113.9, 115.0 (d, \(J^2=21\) Hz), 116.1, 117.3, 128.5, 130.2 (d, \(J^3=7.8\) Hz), 136.1 (d, \(J^4=3.3\) Hz), 147.4, 149.6, 161.4 (d, \(J=244.1\) Hz); IR (NaCl) \(\nu\) (cm\(^{-1}\)): 3300, 1510, 1225, 820; EI MS \(m/z\) : 218 (M\(^+\), 50); 122 (100); Mp: 142-144\(^\circ\)C; Yield: 50%.

2-(2-fluorobenzyl)-1,4-benzenediol (5d): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.94 (s, 2H) 6.52 (d, \(J=2.9\) Hz, 1H) 6.54 (dd, \(J_1=2.9\) Hz \(J_2=8.5\) Hz, 1H) 6.65 (d, \(J=8.5\) Hz, 1H) 7.01-7.03 (m, 2H) 7.15-7.19 (m, 2H); \(^13\)C-NMR (100 MHz, CDCl\(_3\)) \(\delta\) (ppm): 28.6, 113.8, 115.0 (d, \(J=22.0\) Hz), 115.9, 117.0, 123.9 (d, \(J=3.7\) Hz), 127.2, 127.4 (d, \(J=15.9\) Hz), 127.6 (d, \(J=8.1\) Hz), 131.1 (d, \(J=4.7\) Hz), 147.6, 149.6, 161.1 (d, \(J=244.9\) Hz); IR (NaCl) \(\nu\) (cm\(^{-1}\)): 3225, 1490, 1460, 1225, 1210, 800, 745; EI MS \(m/z\) : 218 (M\(^+\), 85); 122 (100); 111 (32); 97 (54); Mp: 153-155\(^\circ\)C; Yield: 45%.

2-(4-bromobenzyl)-1,4-benzenediol (5e): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.75 (s, 2H) 6.41-6.44 (m, 2H) 6.60 (d, \(J=8.6\) Hz, 1H) 7.16 (d, \(J=8.4, 2H\) 7.45 (d, \(J=8.4, 2H\) 8.59 (s, 1H, OH) 8.71 (s, 1H, OH); \(^13\)C-NMR (100 MHz, CDCl\(_3\)) \(\delta\) (ppm): 35.1, 114.0, 116.1, 117.2, 119.1, 127.9, 131.3, 131.4, 141.3, 147.8, 150.2; EI MS: \(m/z\) 280 (M\(^+\), 34); 278 (35); 122 (100); Mp: 82-85\(^\circ\)C; Yield: 51%.

2-(2-hydroxybenzyl)-1,4-benzenediol (7a): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 4.03 (s, 2H) 6.43 (d, \(J=2.9\) Hz, 1H) 6.57 (dd, \(J_1=2.9\) Hz \(J_2=8.5\) Hz, 1H) 6.68 (d, \(J=8.5\) Hz, 1H) 7.06 (td, \(J_1=1.8\) Hz \(J_2=7.8\) Hz, 1H) 7.12 (dd, \(J_1=1.7\) Hz \(J_2=7.5\) Hz, 1H) 7.19 (td, \(J_1=1.2\) Hz \(J_2=7.5\) Hz, 1H) 7.55 (dd, \(J_1=1.2\) Hz \(J_2=7.9\) Hz, 1H); \(^13\)C-NMR (100 MHz, CDCl\(_3\)) \(\delta\) (ppm): 35.9, 113.8, 115.8, 117.0, 124.9, 126.9, 127.4, 129.8, 130.8, 132.5, 141.3, 147.6, 149.6; IR (NaCl) \(\nu\) (cm\(^{-1}\)): 3350, 1500, 1460, 1200, 800, 750; EI MS: \(m/z\) 280 (M\(^+\), 64); 278 (66); 199 (56); 122 (100); Mp: 150-152\(^\circ\)C; Yield: 82%.

2-(4-hydroxybenzyl)-1,4-benzenediol (7b): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.65 (s, 2H) 6.36 (d, \(J=2.9\) Hz, 1H) 6.38 (d, \(J=2.9\) Hz \(J_2=8.4\) Hz, 1H) 6.58 (d, \(J=8.4\) Hz, 1H) 6.66 (d, \(J=8.5\) Hz, 2H) 6.99 (d, \(J=8.5\) Hz, 2H) 8.51 (s, 1H, OH) 8.60 (s, 1H, OH) 9.15 (s, 1H, OH); Mp: 150-152\(^\circ\)C; Yield: 50%.(9)

2-(3-hydroxybenzyl)-1,4-benzenediol (7b): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.84 (s, 2H) 6.53-6.55 (m, 2H) 6.63-6.67 (m, 3H) 6.75 (ddd, \(J_1=0.9\) Hz \(J_2=1.4\) Hz \(J_3=7.7\) Hz, 1H) 7.11 (t, \(J_1=J_2=7.7\) Hz, 1H); \(^13\)C-NMR (100 MHz, CDCl\(_3\)) \(\delta\) (ppm): 35.8, 113.0, 113.7, 115.7, 116.2, 117.3, 120.5, 128.5, 128.4, 142.1, 147.4, 149.6, 156.5; EI MS: \(m/z\) 216 (M\(^+\), 100); 123 (47); 122 (85); 94 (37); Mp: 120-123\(^\circ\)C; Yield: 32%

2-(2,5-dihydroxybenzyl)-1,4-benzenediol (7d): \(^1\)H-NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 3.64 (s, 2H) 6.38 (d, \(J=2.9\) Hz, 2H) 6.41 (dd, \(J_1=2.9\) Hz \(J_2=8.4\) Hz, 2H) 6.61 (d, \(J=8.4\) Hz, 2H) 8.52 (s, 2H) 8.61 (s, 2H); Mp: 270-271\(^\circ\)C; Yield: 73%.(16)
2-(3,4-dihydroxybenzyl)-1,4-benzenediol (7e): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.59 (s, 2H) 6.35 (d, $J=2.8$ Hz, 1H) 6.38 (dd, $J_1=2.8$ Hz $J_2=8.4$ Hz, 1H) 6.45 (dd, $J_1=2.0$ Hz $J_2=8.0$ Hz, 1H) 6.56 (d, $J=2.0$ Hz, 1H) 6.58 (d, $J=8.4$ Hz, 1H) 6.61 (d, $J=8.0$ Hz, 1H) 8.50 (s, 1H, OH) 8.56 (s, 1H, OH); $^{13}$C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 34.9, 113.4, 115.7, 115.9, 116.7, 117.1, 119.9, 129.2, 132.4, 143.6, 145.3, 147.6, 150.0; EI MS: m/z 232 (M+, 65); 123 (100); 110 (50); Mp=141-143°C; Yield=51%.

2-(4-methoxybenzyl)-1,4-benzenediol (7f): $^1$H-RMN (400 MHz, CDCl$_3$) δ (ppm): 3.74 (s, 3H) 3.82 (s, 2H) 6.47 (d, $J=2.9$ Hz, 1H) 6.50 (dd, $J_1=2.9$ Hz $J_2=8.5$ Hz, 1H) 6.62 (d, $J=8.5$ Hz, 1H) 6.78 (d, $J=8.7$ Hz, 2H) 7.11 (d, $J=8.7$ Hz, 2H); Mp=146-148°C; Yield: 92%.

2-(3-methoxybenzyl)-1,4-benzenediol (7g): $^1$H-RMN (400 MHz, CDCl$_3$) δ (ppm): 3.77 (s, 3H) 3.91 (s, 2H) 6.55-6.59 (m, 2H) 6.66 (dd, $J_1=0.7$ Hz $J_2=8.1$ Hz, 1H) 6.75 (dd, $J_1=2.3$ Hz $J_2=8.1$ Hz, 1H) 6.79-6.80 (m, 1H) 6.83 (dd, $J_1=0.7$ Hz $J_2=7.6$ Hz, 1H) 7.21 (t, $J_1=J_2=7.9$ Hz, 1H); $^{13}$C-NMR (100 MHz, CDCl$_3$) δ (ppm): 36.2, 55.2, 111.4, 113.9, 114.6, 116.2, 117.3, 121.3, 128.3, 129.5, 141.8, 147.5, 149.7, 159.7; EI MS: m/z 230 (M+, 86); 122 (41); 108 (100); Mp=110-112°C; Yield: 60%.

2-(2-methoxybenzyl)-1,4-benzenediol (7h): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.74 (s, 2H) 3.78 (s, 3H) 6.28 (d, $J=2.9$ Hz, 1H) 6.40 (dd, $J_1=2.9$ Hz $J_2=8.5$ Hz, 1H) 6.60 (d, $J=8.5$ Hz, 1H) 6.83 (td, $J_1=1.0$ Hz $J_2=7.4$ Hz, 1H) 6.96-6.99 (m, 2H) 7.19 (td, $J_1=1.8$ Hz $J_2=8.1$ Hz, 1H) 8.48 (s, 1H, OH) 8.58 (s, 1H, OH); $^{13}$C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 29.7, 55.7, 111.1, 113.5, 115.7, 117.0, 120.6, 127.6, 127.8, 129.1, 130.4, 148.0, 150.1, 157.5; EI MS: m/z 230 (M+, 61); 122 (41); 108 (100); Mp=82-84°C; Yield 73%.

2-(3,4-methylenedioxybenzyl)-1,4-benzenediol (7i): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.69 (s, 2H) 5.94 (s, 2H) 6.40 (m, 2H) 6.59 (m, 1H) 6.67 (dd, $J_1=1.7$ Hz $J_2=7.9$ Hz, 1H) 6.79 (d, $J=1.7$ Hz, 1H) 6.79 (d, $J=7.9$ Hz, 1H) 8.48 (s, 1H, OH); $^{13}$C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 36.1, 55.9, 60.7, 105.9, 113.5, 115.7, 116.9, 128.4, 135.8, 136.7, 147.5, 149.6, 152.9; EI MS: m/z 290 (M+, 71); 168 (100); 153 (35); Mp=157-158°C; Yield: 87%.

2-(3,4,5-trimethoxybenzyl)-1,4-benzenediol (7j): $^1$H-RMN (400 MHz, CDCl$_3$) δ (ppm): 3.78 (m, 5H) 3.90 (s, 6H) 6.15 (s, 2H) 6.55 (d, $J=3.1$ Hz $J_2=8.6$ Hz, 1H) 6.69 (d, $J=8.6$ Hz, 1H) 6.91 (d, $J=3.1$ Hz, 1H); $^{13}$C-NMR (100 MHz, CDCl$_3$) δ (ppm): 36.1, 55.9, 60.7, 105.9, 113.5, 115.7, 116.9, 128.4, 135.8, 136.7, 147.5, 149.6, 152.9; EI MS: m/z 290 (M+, 71); 168 (100); 153 (35); Mp=157-158°C; Yield: 43%.

2-(2,4,6-trimethoxybenzyl)-1,4-benzenediol (7k): $^1$H-RMN (400 MHz, CDCl$_3$) δ (ppm): 3.78 (m, 5H) 3.90 (s, 6H) 6.15 (s, 2H) 6.55 (dd, $J_1=3.1$ Hz $J_2=8.6$ Hz, 1H) 6.69 (d, $J=8.6$ Hz, 1H) 6.91 (d, $J=3.1$ Hz, 1H); $^{13}$C-NMR (100 MHz, CDCl$_3$) δ (ppm): 23.4, 55.4, 55.9, 91.1, 108.9, 114.1, 116.6, 117.9, 127.7, 148.3, 148.5, 157.8, 160.0; EI MS: m/z 290 (M+, 38); 168 (100); 139 (40); Mp=122-124°C; Yield: 81%.

2-(3-hydroxy-4-methoxybenzyl)-1,4-benzenediol (7l): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.64 (s, 2H) 3.71 (s, 3H) 6.37-6.41 (m, 2H) 6.58-6.62 (m, 3H) 6.79 (d, $J=8.1$ Hz, 1H); $^{13}$C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 35.0, 56.2, 112.7, 113.6, 115.9, 116.7, 117.1, 119.8, 129.0, 134.3, 146.2, 146.7, 147.7, 150.1; EI MS: m/z 246 (M+, 46); 124 (100); 109 (17); Mp=138-140°C; Yield 41%.
2-(4-methylbenzyl)-1,4-benzenediol (9a): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 2.25 (s, 3H) 3.72 (s, 2H) 6.36 (d, $J=2.9$ Hz, 1H) 6.39 (dd, $J_i=8.4$ Hz $J_J=2.9$ Hz, 1H) 6.58 (d, $J=8.4$ Hz, 1H) 7.04-7.09 (m, 4H) 8.51 (s, 1H) 8.62 (s, 1H); Mp= 99-100°C; Yield: 72%. ($^{15}$).

2-(4-phenylbenzyl)-1,4-benzenediol (9b): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.83 (s, 2H) 6.43 (dd, $J_i=2.9$ Hz $J_J=8.4$ Hz, 1H) 6.46 (d, $J=2.9$ Hz, 1H) 6.62 (d, $J=8.4$ Hz, 1H) 7.30 (d, $J=8.3$ Hz, 2H) 7.32-7.36 (m, 1H) 7.43-7.47 (m, 2H) 7.56 (d, $J=8.4$ Hz, 1H) 7.63 (m, 2H) 8.57 (s, 1H, OH) 8.69 (s, 1H, OH); 13C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 35.4, 113.9, 116.1, 117.3, 126.9, 127.0, 128.3, 129.3, 129.7, 138.1, 140.6, 141.1, 147.8, 150.2; EI MS: m/z 276 (M+, 48); 154 (100); 122 (21); Mp=159-160°C; Yield: 58%.

2-(4-N,N-dimethylaminobenzyl)-1,4-benzenediol (9c): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 2.88 (s, 6H) 3.83 (s, 2H) 6.50 (d, $J=2.9$ Hz, 1H) 6.53 (dd, $J_i=2.9$ Hz $J_J=8.3$ Hz, 1H) 6.64 (d, $J=8.3$ Hz, 2H) 7.10 (d, $J=8.8$ Hz, 2H); 13C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 35.0, 41.1, 113.3, 113.6, 115.9, 117.1, 129.0, 129.3, 129.5, 147.4, 149.2, 149.6; IR (NaCl) ν (cm$^{-1}$): 3350, 1510, 1200, 810; EI MS: m/z 243 (M+, 41); 121 (100); 120 (31); Mp=185-187ºC; Yield: 38%.

2-(4-acetamidebenzyl)-1,4-benzenediol (9d): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 2.01 (s, 3H) 3.72 (s, 2H) 6.37 (d, $J=2.9$ Hz, 1H) 6.40 (dd, $J_i=2.9$ Hz $J_J=8.4$ Hz, 1H) 6.59 (d, $J=8.4$ Hz, 1H) 7.11 (d, $J=8.5$ Hz, 2H) 7.45 (d, $J=8.8$ Hz, 2H); 13C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 24.3, 35.1, 113.7, 116.0, 117.1, 119.4, 128.7, 129.3, 136.3, 137.5, 147.7, 150.1, 168.5; IR (NaCl) ν (cm$^{-1}$): 3300, 1650, 1615, 1510, 1205, 820; EI MS: m/z 257 (M+, 50); 136 (62); 93 (100); Mp=185-187ºC; Yield: 70%.

2-(4-formylbenzyl)-1,4-benzenediol (9e): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.85 (s, 2H) 6.43-6.46 (m, 2H) 6.62 (d, $J=8.7$ Hz, 2H) 7.31 (d, $J=8.2$ Hz, 2H); 13C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 36.0, 113.6, 114.2, 116.0, 117.1, 119.4, 128.7, 129.3, 136.3, 137.5, 147.7, 150.1, 168.5; IR (NaCl) ν (cm$^{-1}$): 3300, 1650, 1615, 1510, 1205, 820; EI MS: m/z 228 (M+, 100); 122 (61); Mp=122-124°C; Yield: 68%.

2-(4-carboxybenzyl)-1,4-benzenediol (9f): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.85 (s, 2H) 6.41-6.44 (m, 2H) 6.60-6.62 (m, 1H) 7.33 (d, $J=8.2$ Hz, 1H) 7.31 (d, $J=8.2$ Hz, 2H) 9.37 (s, 1H, OH) 9.50 (s, 1H, OH) 12.75 (br-s, 1H, COOH); 13C-NMR (100 MHz, CDCl$_3$) δ (ppm): 40.5, 118.9, 120.9, 122.1, 132.4, 133.5, 134.0, 134.5, 151.9, 152.6, 155.0, 172.5; EI MS: m/z 244 (M+, 100); 122 (57); Mp=178-181ºC; Yield: 46%.

2-(4-trifluoromethylbenzyl)-1,4-benzenediol (9g): $^1$H-RMN (400 MHz, (CD$_3$)$_2$SO) δ (ppm): 3.87 (s, 2H) 6.42-6.45 (m, 2H) 6.61 (d, $J=7.7$ Hz, 1H) 7.41 (d, $J=7.7$ Hz, 2H) 7.63 (d, $J=7.7$ Hz, 2H) 8.60 (s, 1H, OH) 8.74 (s, 1H, OH); 13C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 35.7, 114.2, 116.2, 117.3, 125.3 (q, $^1J_C$=272.0 Hz), 125.5 (q, $^3J_C$=3.8 Hz), 126.9 (q, $^1J_C$=31.6 Hz), 127.4, 129.8, 146.8, 147.8, 150.2; EI MS: m/z 268 (M+, 100); 122 (50); Mp=84-87ºC; Yield: 93%.

2-(4-cyanobenzyl)-1,4-benzenediol (9h): $^1$H-RMN (400 MHz, CDCl$_3$) δ (ppm): 3.96 (s, 2H) 6.52 (d, $J=2.9$ Hz, 1H) 6.54-6.59 (m, 1H) 6.65 (d, $J=8.1$ Hz, 2H) 7.54 (d, $J=8.1$ Hz, 2H); 13C-NMR (100 MHz, CDCl$_3$) δ (ppm): 36.2, 114.2, 116.0,
2-methyl-1,4-benzenediol (11a): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 2.17 (s, 3H) 6.50 (d, J₁=8.5 Hz J₂=3.0 Hz, 1H) 6.60 (d, J=2.8 Hz, 1H) 6.62 (d, J=8.6 Hz, 1H); Mp=133-134°C; Yield: 92%.

2-pentyl-1,4-benzenediol (11b): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 0.87-0.91 (m, 3H) 1.30-1.35 (m, 4H) 1.54-1.62 (m, 2H) 2.51-2.55 (m, 2H) 6.51 (dd, J₁=2.9 Hz J₂=8.5 Hz, 1H) 6.60 (d, J=2.9 Hz, 1H) 6.62 (d, J=8.5 Hz, 1H); Mp=96-98°C; Yield: 86%.

2-hexyl-1,4-benzenediol (11c): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 0.88 (t, J₁=J₂=6.8 Hz, 3H) 1.28-1.38 (m, 6H) 1.55-1.62 (m, 2H) 2.54 (t, J₁=J₂=7.5 Hz, 2H) 6.55 (dd, J₁=2.9 Hz J₂=8.5 Hz, 1H) 6.62 (d, J=2.9 Hz, 1H) 6.64 (d, J=8.5 Hz, 1H); ¹³C-NMR (100 MHz, CDCl₃) δ (ppm): 14.1, 22.6, 29.2, 29.6, 30.1, 31.7, 113.2, 116.0, 116.8, 147.3, 149.2; EI MS: m/z : 194 (M⁺, 100); 124 (52); 123 (100); Mp=77-79°C; Yield: 62%.

2-nonyl-1,4-benzenediol (11d): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 0.87 (t, J=6.8 Hz, 3H) 1.25 (m, 12 H) 1.57 (p, J=7.6 Hz, 2H) 2.52 (t, J₁=J₂=7.7 Hz, 2H) 6.50 (dd, J₁=2.9 Hz J₂=8.5 Hz, 1H) 6.59-6.61 (m, 2H); Mp=98-100°C; Yield: 41%.

2-isobutyl-1,4-benzenediol (11e): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 0.91 (d, J=6.6 Hz, 6H) 1.99-1.86 (m, 1H) 2.42 (d, J=7.2 Hz, 2H) 6.52 (dd, J₁=2.9 Hz J₂=8.5 Hz, 1H) 6.57 (d, J=2.9 Hz, 1H) 6.62 (d, J=8.5 Hz, 1H); Mp=134-135°C. Yield: 58%.

2-cyclehexylmethyl-1,4-benzenediol (11f): ¹H-RMN (400 MHz, (CD₃)₂SO) δ (ppm): 0.91 (m, 2H) 1.12 (m, 3H) 1.49 (m, 1H) 1.61 (m, 5H) 2.31 (d, J=7.1 Hz, 2H) 6.37 (dd, J₁=2.9 Hz J₂=8.3 Hz 1H) 6.40 (d, J=2.9 Hz, 1H) 6.54 (d, J=8.3 Hz, 1H) 8.39 (s, 1H, OH) 8.49 (s, 1H, OH); Mp=174-176°C; Yield: 64%.

2-phenethyl-1,4-benzenediol (11g): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 2.80-2.92 (m, 4H), 6.52 (dd, J₁=2.9 J₂=8.5 Hz, 1H) 6.57 (d J=2.9 Hz, 1H) 6.63 (d J=8.5 Hz, 1H) 7.14-7.28 (m, 5H); Mp=122-124°C; Yield: 90%.

2-(1-naphthalenylmethyl)-1,4-benzenediol (11h): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 4.37 (s, 2H) 6.27 (d, J=3.0 Hz, 1H) 6.53 (dd, J₁=3.0 Hz J₂=8.6 Hz, 1H) 6.71 (d, J=8.6 Hz, 1H) 7.29 (d, J=6.5 Hz, 1H) 7.34-7.44 (m, 3H) 7.73 (d, J=8.2 Hz, 1H) 7.83 (m, 1H) 8.01 (m, 1H); Mp=192-194°C; Yield: 61%.

2-(2-naphthalenylmethyl)-1,4-benzenediol (11i): ¹H-RMN (400 MHz, (CD₃)₂SO) δ (ppm): 3.96 (s, 2H) 6.43-6.46 (m, 2H) 6.65 (d, J=8.3 Hz, 1H) 7.39 (dd, J₁=1.6 Hz J₂=8.3 Hz, 1H) 7.45 (pd, J₁=1.6 Hz J₂=6.8 Hz, 2H) 7.69 (s, 1H) 7.80-7.86 (m, 3H) 8.57 (s, 1H, OH) 8.75 (s, 1H, OH); ¹³C-NMR (100 MHz, (CD₃)₂SO) δ (ppm): 35.9, 113.9, 116.1, 117.3, 125.6, 126.4, 126.9, 127.7, 127.9, 128.0, 128.3, 132.0, 133.6, 139.4, 147.8, 150.2; Mp=151-153°C; Yield: 78%.

2-(9-anthracenylmethyl)-1,4-benzenediol (11j): ¹H-RMN (400 MHz, CDCl₃) δ (ppm): 4.91 (s, 2H) 5.82 (d, J=2.9 Hz, 1H) 6.47 (dd, J₁=2.9 Hz J₂=8.5 Hz, 1H) 6.73 (d, J=8.5 Hz, 1H) 7.40-7.46 (m, 4H) 8.00-8.02 (m, 2H) 8.16-8.19 (m, 2H) 8.41 (s, 1H); ¹³C-NMR (100 MHz, CDCl₃) δ (ppm): 27.1, 113.2, 115.4, 116.1, 125.0, 125.8, 126.3, 128.4, 147.8, 150.2; EI MS: m/z: 225 (M⁺, 100); 122 (66); 73 (21); 71 (19); Mp=169-170°C; Yield: 92%.
2,2’-[1,4-phenylenebis(methylene)]bis1,4-benzenediol (14): $^1$H-RMN (400MHz, (CD$_3$)$_2$SO) δ (ppm): 3.73 (s, 4H) 6.39-6.42 (m, 4H) 6.60 (d, $J$=8.9 Hz, 2H) 7.09 (s, 4H) 8.54 (s, 2H, OH) 8.64 (s, 2H, OH); $^{13}$C-NMR (100 MHz, (CD$_3$)$_2$SO) δ (ppm): 36.3, 113.7, 116.0, 117.2, 128.7, 129.0, 138.9, 147.7 150.1; EI MS: m/z 322 (M$,^+$, 86); 200 (100); 123 (64); 122 (74); Mp=167-169°C; Yield: 56%.

4,4’-bis-(2,5-dihydroxybenzyl)diphenylether (15): $^1$H-RMN (400MHz, CDCl$_3$) δ (ppm): 3.88 (s, 4H) 6.51 (d, $J$=2.9 Hz, 2H) 6.54 (dd, $J_1$=2.9 Hz $J_2$=8.4 Hz, 2H) 6.66 (d, $J$=8.4 Hz, 2H) 6.87 (d, $J$=8.6 Hz, 4H) 7.16 (d, $J$=8.6 Hz, 4H); $^{13}$C-NMR (100 MHz, CDCl$_3$) δ (ppm): 34.9, 113.4, 115.8, 117.0, 118.4, 128.7, 130.0, 135.5, 147.5, 149.5, 155.4; EI MS: m/z 414 (M$,^+$, 82); 292 (65); 170 (100); Mp=181-183°C; Yield: 45%.
2-(4-fluorobenzyl)-1,4-benzenediol (5c):
2-(2-fluorobenzyl)-1,4-benzenediol (5d):
2-(4-bromobenzyl)-1,4-benzenediol (5e):
2-(2-bromobenzyl)-1,4-benzenediol (5f):
2-(3-hydroxybenzyl)-1,4-benzenediol (7b):
2-(2-hydroxybenzyl)-1,4-benzenediol (7c):
2-(3,4-dihydroxybenzyl)-1,4-benzenediol (7e):
2-(3-methoxybenzyl)-1,4-benzendiol (7g):
2-(2-methoxybenzyl)-1,4-benzendiol (7h):
2-(3,4,5-trimethoxybenzyl)-1,4-benzenediol (7j):
2-(2,4,6-trimethoxybenzyl)-1,4-benzenediol (7k):
2-(3-hydroxy-4-methoxybenzyl)-1,4-benzenediol (7I):
2-(4-phenylbenzyl)-1,4-benzenediol (9b):
2-(4-N,N-dimethylaminobenzyl)-1,4-benzenediol (9c):
2-(4-acetamidebenzyl)-1,4-benzenediol (9d):
2-(4-formylbenzyl)-1,4-benzenediol (9e):
2-(4-carboxybenzyl)-1,4-benzenediol (9f):
2-(4-trifluoromethylbenzyl)-1,4-benzenediol (9g):
2-(4-cianobenzyl)-1,4-benzenediol (9h):
2-hexyl-1,4-benzenediol (11c):
2-(9-anthracenylmethyl)-1,4-benzenediol (11j):
2,2’- [1,4-phenylenebis(methylene)] bis1,4-benzenediol (14):
4,4'-bis-(2,5-dihydroxybenzyl) diphenylether (15)
