

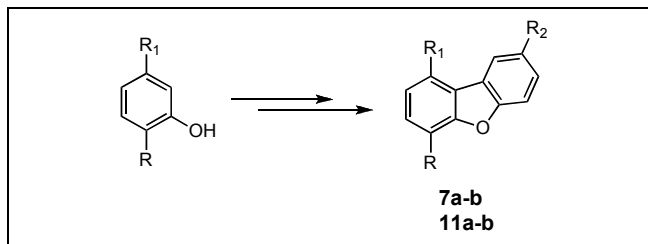
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The synthesis of multi-substituted dibenzo[*b,d*]furan derivatives **7a-b** and **11a-b** from readily available starting materials is described. These compounds are important intermediates for synthesis of molecules having wide therapeutic applications.

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INTRODUCTION

Polynuclear heterocyclic compounds such as dibenzo[*b,d*]furan derivatives are important class of heterocycles which have found wide applicability in various therapeutic areas such as antidiabetics [1], antiallergics and antiasthmatic [2], anticancers [3] and PDE 4 inhibitors [4] *etc.*

In our attempts towards preparation of novel molecules as non steroidal anti-inflammatory agents (NSAIDs), we required to synthesize various appropriately multi-substituted dibenzo[*b,d*]furans **7a-b** and **11a-b** as intermediates.

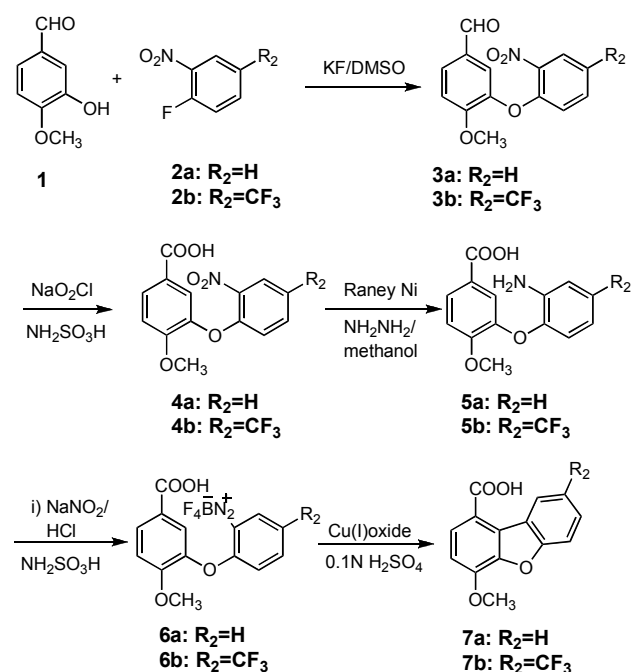
A literature survey revealed that most of the substituted dibenzo[*b,d*]furans have been synthesized by electrophilic substitution of commercially available dibenzo[*b,d*]furan. Such reactions provide, either mono substituted [5] or multi-substituted dibenzo[*b,d*]furans [6]. However the disadvantage of such reactions is that we tend to get substitutions at undesired position on the heterocycle. Therefore, constructing the dibenzo[*b,d*]furan moiety from appropriately substituted starting materials would be a better strategy to get substitution on desired positions. Very few methods in the literature report such strategy for the synthesis of multi-substituted dibenzo[*b,d*]furans [7].

RESULTS AND DISCUSSION

In our attempts to synthesize multi-substituted dibenzo[*b,d*]furan as intermediates towards our target molecules, we have developed some synthetic methods (Scheme 1 and Scheme 2) which not only gave the corresponding dibenzo[*b,d*]furans but are also easily

scalable to multi-kilogram scale. Here, we wish to report this method.

Scheme 1

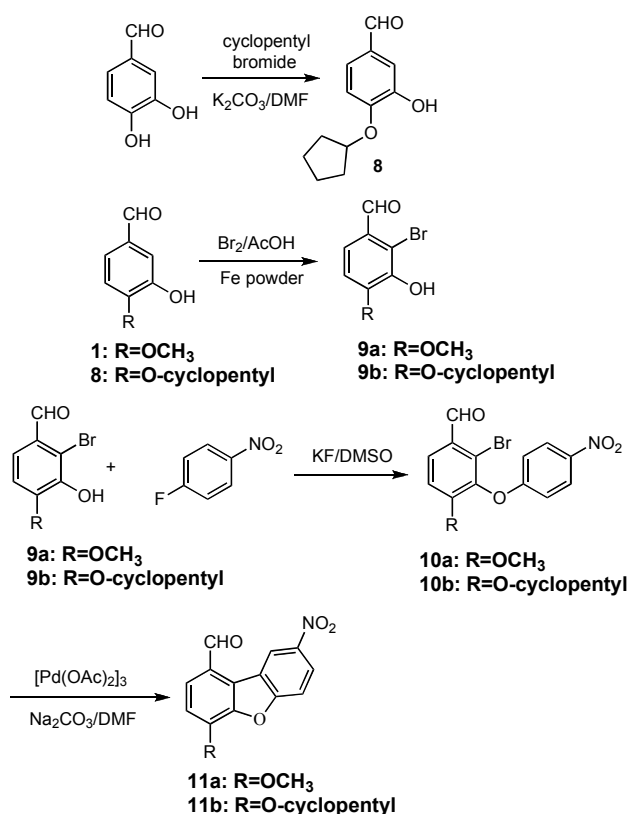


In Scheme 1, diphenyl ethers **3a-b** were prepared by reacting isovanillin **1** with 2-fluoronitrobenzenes **2a-b** in the presence of anhydrous potassium fluoride using DMSO as a solvent [8]. Oxidation of **3a-b** by sodium chlorite in presence of sulphamic acid gave corresponding carboxylic acids **4a-b** [9]. Reduction of **4a-b** by hydrazine

monohydrate using raney nickel catalyst [10] in methanol afforded the corresponding amines **5a-b**. Copper (I) oxide

induced *Pschorr* ring closure [11] of **5a-b** provided the required title compounds **7a-b**. In Scheme 2 appropriately substituted bromohydroxy benzaldehydes **9a-b** were reacted with 4-fluoronitrobenzene in presence of anhydrous potassium fluoride in DMSO to give the diphenyl ethers. Palladium catalyzed cyclisation [12] of **10a-b** in presence of anhydrous sodium carbonate afforded the desired title compounds **11a-b** in good yield. The required bromohydroxy benzaldehydes were prepared by bromination of corresponding hydroxybenzaldehydes **1** and **8**.

Scheme 2



Thus, we have successfully demonstrated the synthesis of appropriately substituted dibenzo[*b,d*]furans in multigram quantities from commercially available starting materials using the methods described above.

EXPERIMENTAL

General. Melting points were measured using LABINDIA (MR-VRS) visual melting range apparatus and are uncorrected. ¹H and ¹³C nmr spectra were recorded on Varian Mercury VX 300 spectrometer, using tetramethylsilane as an internal standard. The infrared spectra were acquired on Perkin-Elmer Spectrum One FT-IR spectrometer. The mass spectra were run

on Finnigan Navigator spectrometer at 20 eV or 50 eV. Elemental analyses were carried out with a Perkin-Elmer Model 2400-Series II apparatus. The results of elemental Analyses (C, H, N) were within $\pm 0.4\%$ of the calculated values.

4-Methoxy-3-(2-nitrophenoxy)benzaldehyde (3a). A suspension of 3-hydroxy-4-methoxy benzaldehyde (5.0 g, 32 mmoles), 1-fluoro-2-nitro benzene (4.5 g, 32 mmoles) and anhydrous potassium fluoride (2.2 g, 38 mmoles) in dry dimethyl sulfoxide (50 mL) was stirred at 140-145°C for 2 hours. The mixture was cooled and 5% aqueous sodium hydroxide solution was added and stirred for 30 minutes. The crude product was collected by filtration, washed with water (3x100 mL) and crystallized from ethanol to give 4.0 g (56%) of **3a** as white solid, mp: 105-106°C; ir (potassium bromide): 2842, 1690, 1612, 1523, 1432, 1345, 1285, 1117, 1017 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.87 (s, 3H, OCH₃), 6.98 (d, 1H, *J* = 8.7 Hz, aromatic), 7.32 (t, 1H, *J* = 8.1 Hz, aromatic), 7.43 (d, 1H, *J* = 7.8 Hz, aromatic), 7.59 (s, 1H, aromatic), 7.64 (t, 1H, *J* = 7.8 Hz, aromatic), 7.88 (d, 1H, *J* = 8.4 Hz, aromatic), 8.06 (d, 1H, *J* = 8.4 Hz, aromatic), 9.87 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 191.14, 156.00, 149.83, 143.65, 140.30, 135.14, 130.17, 129.59, 125.81, 123.77, 120.77, 118.80, 113.80, 56.63 ppm; ms: *m/z* (%) 274 (M⁺, 100), 123 (5), 137 (24), 95 (15). *Anal.* Calcd. for C₁₄H₁₁NO₅: C, 61.54; H, 4.06, N, 5.13. Found: C, 61.55; H, 4.07, N, 5.15.

4-Methoxy-3-(2-nitrophenoxy) benzoic acid (4a). To a solution of **3a** (4.0 g, 14.6 mmoles), sulphamic acid (2.13 g, 21.9 mmoles) and water (12.5 mL) in acetone (50 mL), a solution of sodium chlorite (1.35 g, 18.2 mmole) in water (12.5 mL) was slowly added at 5-10°C. The reaction mixture was stirred at room temperature for 30 minutes and poured into water (50 mL). The precipitated crude product was collected by filtration, washed with water (3x25 mL) and crystallized from ethanol to give 3.6 g (85%) of **4a** as white solid, mp 231-233 °C; ir (potassium bromide): 3425, 2573, 1687, 1614, 1523, 1442, 1346, 1236, 1138, 1020, 735 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.83 (s, 3H, OCH₃), 6.94 (d, 1H, *J* = 8.1 Hz, aromatic), 7.34 (m, 2H, aromatic), 7.61 (m, 2H, aromatic), 7.87 (dd, 1H, *J* = 8.4 and 2.4 Hz, aromatic), 8.04 (dd, 1H, *J* = 8.1 and 1.8 Hz, aromatic), 13.92 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 166.59, 154.73, 150.16, 142.78, 140.26, 135.10, 128.46, 125.79, 123.97, 123.54, 121.98, 118.61, 113.38, 56.42 ppm; ms: *m/z* (%) 288 [(M-H)⁻, 100], 138 (95). *Anal.* Calcd. for C₁₄H₁₁NO₆: C, 58.13; H, 3.83, N, 4.84. Found: C, 58.32; H, 3.82; N, 4.85.

3-(2-Aminophenoxy)-4-methoxybenzoic acid (5a). To a suspension of compound **4a** (3.6 g, 12.45 mmoles), raney nickel catalyst (360 mg, 10% w/w) in methanol (40 mL), hydrazine monohydrate (3.11 g, 62.25 mmoles) was added slowly at reflux. Reflux was maintained for 3.0 hours. Reaction mixture was cooled to room temperature. Catalyst was removed by filtration. Filtrate was concentrated under reduced pressure and acidified with 5% aqueous HCl solution (100 mL) and filtered to give the crude product which was crystallized from ethyl acetate to give 2.5 g (77%) of compound **5a** as off-white solid, mp 206-207 °C; ir (potassium bromide): 3450, 3369, 1601, 1501, 1439, 1307, 1277, 1217, 1153, 1098, 1017, 947 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.89 (s, 3H, OCH₃), 4.90 (br, s, 2H, NH₂), 6.52 (t, 1H, *J* = 8.7, aromatic), 6.68 (d, 1H, *J* = 8.1 Hz, aromatic), 6.80 (d, 1H, *J* = 8.1, aromatic), 6.90 (t, 1H, aromatic), 7.20 (m, 2H, aromatic), 7.67 (dd, 1H, *J* = 8.4 and 1.8 Hz, aromatic), 13.72 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆):

δ 167.03, 153.97, 146.00, 142.19, 140.31, 125.61, 125.11, 123.31, 119.52, 117.93, 116.76, 116.04, 112.45, 56.16 ppm; ms: m/z (%) 258 [(M-H)⁻, 100], 226 (13), 214 (9), 199 (16), 182 (12). *Anal.* Calcd. for C₁₄H₁₃NO₄: C, 64.86; H, 5.02, N, 5.41. Found: C, 64.76; H, 5.03; N, 5.43.

4-Methoxy-3-(2-diazoniumfluoroborylphenoxy) benzoic acid (6a). To a suspension of compound **5a** (2.5 g, 9.65 mmoles), concentrated HCl (12.5 mL) and water (12.5 mL), a solution of sodium nitrite (0.8 g, 11.5 mmoles) in water (4.0 mL) was added slowly at 0-5°C. The reaction mixture was stirred at 0-5 °C for 30 minutes. A solution of sodium fluoroborate (1.57 g, 14.4 mmoles) in water (7.5 mL) was added to the reaction mixture at 0-5°C and stirred for 30 minutes. The precipitated product was collected by filtration and washed with 5% aqueous sodium fluoroborate solution and dried to give 2.5 g (74%) of compound **6a** as yellow solid, mp 189-190°C (decom.); ir (potassium bromide): 3317, 2924, 2259, 1726, 1710, 1616, 1574, 1481, 1382, 1219, 1127, 1069, 1021 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.91 (s, 3H, OCH₃), 7.14 (d, 1H, J = 9.0 Hz, aromatic), 7.45 (d, 1H, J = 8.7 Hz, aromatic), 8.01 (m, 2H, aromatic), 8.12 (t, 1H, J = 8.4 Hz, aromatic), 8.66 (d, 1H, J = 8.4 Hz, aromatic), 13.09 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 166.34, 159.85, 154.86, 143.94, 140.46, 132.94, 130.48, 124.85, 124.29, 123.90, 116.99, 113.97, 104.20, 56.71 ppm; ms: m/z (%) 358 (6.2), 271 (88), 243 (34), 228 (91), 198 (100), 183 (94), 171 (50). *Anal.* Calcd. for C₁₄H₁₁BF₄N₂O₄: C, 46.96; H, 3.10, N, 7.82. Found: C, 46.79; H, 3.09, N, 7.84.

4-Methoxydibenzo[b,d]furan-1-carboxylic acid (7a). To a suspension of Cu (I) oxide (1.5 g, 10.5 mmoles) in 0.1 N H₂SO₄ (750 mL), finely powdered compound **6a** (2.5 g, 7.0 mmoles) was added at 40-45°C and stirred for 30 minutes. The mixture was cooled to room temperature; ethyl acetate (250 mL) was added and stirred rapidly for 10 minutes. The inorganic material was removed by filtration. The organic layer was separated and dried over anhydrous sodium sulfate. The solvent was evaporated under reduced pressure to give crude product. The crude product was purified on silica gel column using chloroform:ethyl acetate (98:2) as eluent to give 250 mg (15%) of compound **7a** as white solid, mp 278-280 °C; ir (potassium bromide): 3320, 2977, 1682, 1570, 1416, 1286, 1235, 1149, 1096, 744 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 4.06 (s, 3H, OCH₃), 7.27 (d, 1H, J = 8.7 Hz, aromatic), 7.42 (t, 1H, J = 8.1 Hz, aromatic), 7.76 (d, 1H, J = 8.4 Hz, aromatic), 8.02 (d, 1H, J = 8.7 Hz, aromatic), 8.88 (d, 1H, J = 7.8 Hz, aromatic), 13.11 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 167.38, 157.83, 149.01, 145.68, 128.84, 125.38, 124.24, 124.04, 123.78, 123.31, 122.85, 118.06, 112.94, 110.04, 56.57 ppm; ms: m/z (%) 241 [(M-H)⁻, 100], 182 (42), 197 (27), 167 (5). *Anal.* Calcd. for C₁₄H₁₀O₄: C, 69.42; H, 4.16. Found: C, 69.36; H, 4.15.

4-Methoxy-3-(2-nitro-4-trifluoromethylphenoxy)benzaldehyde (3b). This compound was obtained from **2b**, similarly to **3a**, yield 71%, mp 95-97°C; ir (potassium bromide): 2847, 1697, 1630, 1607, 1540, 1335, 1284, 1117, 1015 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.87 (s, 3H, OCH₃), 7.06 (d, 1H, J = 8.4 Hz, aromatic), 7.48 (d, 1H, J = 8.4 Hz, aromatic), 7.80 (d, 1H, J = 1.8 Hz, aromatic), 8.47 (d, 1H, J = 2.4 Hz, aromatic), 9.90 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 191.14, 156.00, 149.83, 143.65, 140.30, 135.14, 130.17, 129.59, 125.81, 123.77, 120.77, 118.80, 113.80, 56.63 ppm; ms: m/z (%) 340 (M⁺, 16), 326 (26), 308 (23), 206 (59), 151 (82), 87 (100).

Anal. Calcd. for C₁₅H₁₀F₃NO₅: C, 52.79; H, 2.93, N, 4.11. Found: C, 52.67; H, 2.92; N, 4.12.

4-Methoxy-3-(2-nitro-4-trifluoromethylphenoxy) benzoic acid (4b). This compound was obtained from **3b**, similarly to **4a**, yield 83%, mp 221-222°C; ir (potassium bromide): 3079, 2944, 2567, 1693, 1609, 1542, 1442, 1327, 1284, 1132, 1016, 906 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.83 (s, 3H, OCH₃), 7.04 (d, 1H, J = 9.3 Hz, aromatic), 7.36 (d, 1H, J = 9.0 Hz, aromatic), 7.75 (s, 1H, aromatic), 7.94 (d, 2H, J = 8.7 Hz, aromatic), 8.45 (s, 1H, aromatic), 12.52 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 166.46, 154.81, 153.28, 141.24, 139.26, 131.65, 129.51, 124.32, 123.51, 123.42, 123.32, 123.02, 118.41, 113.69, 56.56 ppm; ms: m/z (%) 356 [(M-H)⁻, 100], 206 (60). *Anal.* Calcd. for C₁₅H₁₀F₃NO₆: C, 50.42; H, 2.80, N, 3.92. Found: C, 50.26; H, 2.81; N, 3.91.

3-(2-Amino-4-trifluoromethylphenoxy)-4-methoxy benzoic acid (5b). This compound was obtained as off white solid from **4b**, similarly to **5a**, yield 78%, mp 178-179 °C; ir (potassium bromide): 3458, 3369, 1689, 1611, 1514, 1442, 1336, 1278, 1209, 1167, 1099, 947 cm⁻¹; ¹H-nmr (dimethyl sulfoxide-d₆): δ 3.85 (s, 3H, OCH₃), 5.45 (br, s, 2H, NH₂), 6.60 (d, 1H, J = 7.8 Hz, aromatic), 6.76 (d, 1H, J = 7.8 Hz, aromatic), 7.06 (s, 1H, aromatic), 7.23 (d, 1H, J = 9.0 Hz, aromatic), 7.38 (s, 1H, aromatic), 7.77 (d, 1H, J = 8.4 Hz, aromatic), 12.75 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 164.25, 154.13, 146.24, 143.68, 139.80, 127.04, 126.47, 124.83, 124.41, 123.99, 122.87, 120.75, 116.40, 112.71, 111.24, 56.16 ppm; ms: m/z (%) 326 [(M-H)⁻, 76], 306 (48), 294 (28), 262 (12), 176 (100), 156 (5). *Anal.* Calcd. for C₁₅H₁₂F₃NO₄: C, 55.04; H, 3.66, N, 4.28. Found: C, 54.89; H, 3.67; N, 4.27.

3-(2-Diazoniumfluoroboryl-4-(trifluoromethylphenoxy)-4-methoxybenzoic acid (6b). This compound was obtained as yellow solid form **5b**, similarly to **6a**, yield 70%, mp 204-205 °C; ir (potassium bromide): 3107, 2277, 1688, 1609, 1576, 1510, 1433, 1332, 1290, 1184, 1010, 948 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 3.91 (s, 3H, OCH₃), 7.35 (d, 1H, J = 9.0 Hz, aromatic), 7.48 (d, 1H, J = 9.0 Hz, aromatic), 8.04 (m, 2H, aromatic), 8.45 (d, 1H, J = 9.0 Hz, aromatic), 9.24 (s, 1H, aromatic), 13.15 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 166.27, 161.75, 154.58, 140.21, 140.05, 131.35, 130.91, 124.58, 124.39, 124.12, 123.82, 118.40, 114.16, 106.03, 56.82 ppm; ms: m/z (%) 426.9 [(M+H)⁺, 100], 302 (28), 285 (15), 274 (8). *Anal.* Calcd. for C₁₅H₁₀BF₇N₂O₄: C, 42.27; H, 2.35, N, 6.57. Found: C, 42.42; H, 2.35, N, 6.55.

4-Methoxy-8-trifluoromethylidibenzo[b,d]furan-1-carboxylic acid (7b). This compound was obtained as white solid form **6b**, similarly to **7a**, yield 15%, mp 255-257 °C; ir (potassium bromide): 2975, 1693, 1575, 1421, 1327, 1273, 1154, 1105, 1058, 913 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 4.09 (s, 3H, OCH₃), 7.38 (d, 1H, J = 9.0 Hz, aromatic), 8.0 (m, 2H, aromatic), 8.10 (d, 1H, J = 9.0 Hz, aromatic), 9.32 (s, 1H, aromatic), 13.25 ppm (br, s, 1H, COOH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 167.62, 156.28, 148.91, 144.91, 128.58, 128.20, 126.48, 124.75, 123.22, 122.97, 118.10, 111.79, 109.07, 56.44 ppm; ms: m/z (%) 309 [(M-H)⁻, 100], 285 (42), 235 (35). *Anal.* Calcd. for C₁₅H₉F₃O₄: C, 58.06; H, 2.90. Found: C, 57.88; H, 2.89.

2-Bromo-3-hydroxy-4-methoxy benzaldehyde (9a). To a well stirred solution of compound **1** (5.0 g, 32 mmoles), anhydrous sodium acetate (5.4 g, 65 mmoles) and iron powder (0.146 g, 2.6 mmoles) in glacial acetic acid (30 mL), bromine (5.75 g, 36 mmoles) was added under nitrogen atmosphere at

10-15 °C and stirred at room temperature for 1 hour. The mixture was poured into ice water (150 mL). The crude product was collected by filtration and crystallized from ethanol to give 4.5 g (60 %) of compound **9a** as white solid, mp 205-206 °C (dec.); ir (potassium bromide): 3233, 1669, 1593, 1564, 1494, 1286, 1205, 1019, 805 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 4.05 (s, 3H, OCH₃), 6.10 (br, s, 1H, OH), 6.89 (d, 1H, *J* = 8.4 Hz), 7.56 (d, 1H, *J* = 8.4 Hz), 10.22 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 191.03, 153.52, 144.21, 126.84, 122.18, 113.64, 110.58, 56.66 ppm; ms: m/z (%) 229 [(M-H)⁺, 100], 215 (10). *Anal.* Calcd. for C₈H₇BrO₃: C, 41.57; H, 3.03. Found: C, 41.55; H, 3.02.

2-Bromo-4-methoxy-3-(4-nitrophenoxy)benzaldehyde (10a).

To a solution of compound **9a** (4.5 g, 19 mmoles) and 4-fluoro-1-nitro benzene (4.5 g, 23 mmoles) in dry dimethyl sulfoxide (45 mL), potassium fluoride (1.24 g, 21 mmoles) was added and stirred at 120-125 °C for 3 hours. The mixture was cooled and water (250 mL) was added. The crude product was purified on silica gel column using petroleum ether: ethyl acetate (8:2) as eluent. The desired compound was crystallized from chloroform:methanol (9:1) to give 3.5 g (51%) of **10a** as white solid, mp 136-137 °C; ir (potassium bromide): 3435, 1689, 1584, 1486, 1348, 1285, 1253, 1025, 848 cm⁻¹; ¹H-nmr (dimethyl sulfoxide-d₆): δ 3.86 (s, 3H, OCH₃), 6.91 (d, 2H, *J* = 7.2 Hz), 7.08 (d, 1H, *J* = 8.4 Hz), 7.91 (d, 1H, *J* = 8.4 Hz), 8.19 (d, 2H, *J* = 7.2 Hz), 10.24 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 190.18, 161.68, 157.73, 142.62, 139.24, 129.59, 127.29, 126.39, 121.91, 115.59, 113.06, 57.15 ppm; ms: m/z (%) 353 (M⁺, 8), 274 (8), 199 (44), 184 (100), 171 (81), 155 (22), 137 (42). *Anal.* Calcd. for C₁₄H₁₀BrNO₅: C, 47.74; H, 2.84, N, 3.97. Found: C, 47.65; H, 2.85; N, 3.96.

4-Methoxy-8-nitrobenzo[*b,d*]furan-1-carbaldehyde (11a).

A suspension of compound **10a** (3.5 g, 9.9 mmoles), anhydrous sodium carbonate (1.28 g, 12.1 mmoles) and hexakis-(acetato)tripalladium (II) (0.22 g, 0.99 mmoles) in dry dimethyl formamide (35 mL) was stirred at 120-125°C for 10 hours. The hot mixture was filtered through celite bed. The filtrate was cooled and water (250 mL) was added. The crude product was collected by filtration and purified on silica gel column using chloroform:ethyl acetate (9:1) as eluent. The desired compound was crystallized from chloroform: ethanol (7:3) to give 1.5 g (55%) of **11a** as white solid, mp 256-257 °C; ir (potassium bromide): 3434, 3115 1682, 1522, 1343, 1295, 1076, 846 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 4.15 (s, 3H, OCH₃), 7.57 (d, 1H, *J* = 8.4 Hz, aromatic), 8.07 (d, 1H, *J* = 9.0 Hz, aromatic), 8.22 (d, 1H, *J* = 8.4 Hz, aromatic), 8.53 (dd, 1H, *J* = 9.0 and *J* = 2.4 Hz, aromatic), 9.85 (d, 1H, *J* = 2.4 Hz aromatic), 10.18 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 192.20, 158.80, 153.02, 144.11, 140.61, 136.29, 128.80, 127.39, 127.23, 124.50, 118.40, 115.70, 109.80, 56.95 ppm; ms: m/z (%) 271[(M+H)⁺, 100], 228 (65), 199 (90), 184 (85). *Anal.* Calcd. for C₁₄H₉NO₅: C, 61.99; H, 3.32, N, 5.17. Found: C, 61.99; H, 3.33; N, 5.15.

4-Cyclopentyl-3-hydroxybenzaldehyde (8). A suspension of 3,4-dihydroxy benzaldehyde (5.0 g, 36.2 mmoles), cyclopentyl bromide (6.5 g, 43.4 mmoles) and anhydrous potassium carbonate (6.0 g, 43.4 mmoles) in dry *N,N*-dimethylformamide (35 mL) was stirred at 70-75 °C for 24 hours. The mixture was cooled, filtered and water (250 mL) was added to the filtrate. The filtrate was extracted with ethyl acetate (3x50 mL), dried over anhydrous sodium sulfate and the solvent was evaporated. The residue was purified on silica gel column

using petroleum ether: ethyl acetate (9:1) as an eluent. The desired compound was crystallized from petroleum ether:ethyl acetate (8:2) to give 5 g (67%) of **8b** as white solid, mp 88-89°C; ir (potassium bromide): 3271, 2948, 1671, 1605, 1580, 1463, 1358, 1270, 1153, 976 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 1.69 (m, 2H, CH₂), 1.88 (m, 4H, 2xCH₂), 1.99 (m, 2H, CH₂), 4.91 (m, 1H, CH), 7.39 (dd, 1H, *J* = 8.1 Hz and 2.1 Hz, aromatic), 7.08 (d, 1H, *J* = 8.7 Hz, aromatic), 7.25 (s, 1H, aromatic), 9.76 (s, 1H, CHO), 9.35 ppm (s, 1H, OH); ¹³C nmr (dimethyl sulfoxide-d₆): δ 191.54, 151.99, 147.81, 129.76, 124.54, 113.92, 80.01, 32.51, 23.98 ppm; ms: m/z (%) 205[(M-H)⁺, 100], 137 (4). *Anal.* Calcd. for C₁₂H₁₄O₃: C, 69.90; H, 6.79. Found: C, 69.87; H, 6.80.

2-Bromo-4-cyclopentyl-3-hydroxybenzaldehyde (9b).

This compound was obtained as white solid from **8**, similarly to **9a**, yield 72%, mp 107-109 °C; ir (potassium bromide): 3327, 2956, 1674, 1587, 1487, 1281, 987 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 1.69 (m, 2H, CH₂), 1.88 (m, 4H, 2xCH₂), 1.99 (m, 2H, CH₂), 4.95 (m, 1H, CH), 6.15 (s, 1H, OH), 6.89 (d, 1H, *J* = 8.7 Hz, aromatic), 7.55 (d, 1H, *J* = 8.7 Hz, aromatic), 10.25 (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 190.82, 151.94, 144.55, 126.34, 122.08, 113.59, 111.85, 80.88, 32.40, 23.98 ppm; ms: m/z (%) 326[(M-H)⁺, 76], 214 (100). *Anal.* Calcd. for C₁₂H₁₃BrO₃: C, 50.54; H, 4.60. Found: C, 50.64; H, 4.61.

2-Bromo-4-cyclopentyl-3-(4-nitrophenoxy)benzaldehyde (10b).

This compound was obtained as white solid from **9b**, similarly to **10a**, yield 62%, mp 115-116 °C; ir (potassium bromide): 2976, 1683, 1593, 1515, 1344, 1280, 1246, 984 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 1.21 ppm (m, 2H, CH₂), 1.45 (m, 4H, 2xCH₂), 1.77 (m, 2H, CH₂), 5.01 (m, 1H, CH), 7.09 (d, 2H, *J* = 9.3 Hz, aromatic), 7.43 (d, 1H, *J* = 8.7 Hz, aromatic), 7.88 (d, 1H, *J* = 8.7 Hz, aromatic), 8.23 (d, 1H, *J* = 9.3 Hz, aromatic), 10.13 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 190.12, 162.07, 155.78, 142.55, 140.16, 129.21, 126.82, 126.21, 121.86, 115.79, 114.37, 81.29, 32.22, 23.31 ppm; ms: m/z (%) 407[(M⁺, 22], 336 (26), 155 (33), 137 (61), 106 (100). *Anal.* Calcd. for C₁₈H₁₆BrNO₅: C, 53.22; H, 3.93; N, 3.44. Found: C, 53.11; H, 3.92; N, 3.43.

4-Cyclopentyl-8-nitrodibenzo[*b,d*]furan-1-carbaldehyde (11b).

This compound was obtained as light yellow solid from **10b**, similarly to **11a**, yield 73%, mp: 207-208 °C; ir (potassium bromide): 1527, 1341, 1291, 1074 cm⁻¹; ¹H nmr (dimethyl sulfoxide-d₆): δ 1.69 (m, 2H, CH₂), 1.86 (m, 4H, 2xCH₂), 2.09 (m, 2H, CH₂), 5.25 (m, 1H, CH), 7.52 (d, 1H, *J* = 8.7 Hz), 8.05 (d, 2H, *J* = 9.3 Hz, aromatic), 8.14 (d, 1H, *J* = 8.1 Hz, aromatic), 8.44 (dd, *J* = 9.0 Hz and 2.4 Hz, aromatic), 9.80 (s, 1H, aromatic), 10.14 ppm (s, 1H, CHO); ¹³C nmr (dimethyl sulfoxide-d₆): δ 192.43, 159.24, 148.96, 146.84, 143.52, 135.05, 124.71, 124.50, 123.59, 122.33, 122.25, 113.15, 112.45, 81.52, 32.53, 23.94 ppm; ms: m/z (%) 326 [(M+H)⁺, (28)], 277 (20), 256 (100). *Anal.* Calcd. for C₁₈H₁₅NO₅: C, 66.46; H, 4.61; N, 4.30. Found: C, 66.32; H, 4.62; N, 4.29.

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