

**Supporting Information for:**

Green Chemical Synthesis of 2-Benzenesulfonyl-pyridine and Related Derivatives.

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All sulfone synthesis reported are analogous to the preparation reported for compound **1**, unless otherwise noted.

**2-benzenesulfonyl-pyridine, 1:** A 2-L flask is charged with 2-chloropyridine (75 mL, 790 mmol), thiophenol (90 mL, 852 mmol), and DMF (450 mL).  $K_2CO_3$  (134.6 g, 962 mmol) is added, then the mixture is heated to 110°C and stirred for 20 hours. The mixture is filtered through polypropylene, and the waste cake rinsed with DMF (195 mL), then the crude sulfide solution and rinsings are transferred to a 5-L flask. The oxidation is carried out by addition of glacial HOAc (57 mL, 995 mmol), heating to 40 °C, and addition of 13 wt % NaOCl solution (850 mL, 1.7 mol) slowly over 2 h. The conversion of the sulfide to sulfoxide and sulfone is monitored by HPLC. When the oxidation is complete, water (530 mL) is added and the heating ceased. The pH of the mixture is raised to 9 with 20 % (w/v) NaOH solution (250 mL), and the resulting slurry is cooled to <5 °C. The mixture is stirred cold for 1.5 h, filtered through polypropylene, then the wetcake rinsed with water (3 x 200 mL). The cake was dried in a 55 °C vacuum oven for at least 12 hours to provide 2-benzenesulfonyl pyridine (149 g, 676 mmol) in 86 % yield and >99% purity.  $^1H$  NMR (500 MHz,  $CDCl_3$ )  $\delta$  8.66 (d,  $J$  = 5.5 Hz, 1H), 8.19 (d,  $J$  = 7.7 Hz, 1H), 8.05 (m, 2H), 7.92 (ddd,  $J$  = 9.3, 7.7, 1.6 Hz, 1H), 7.60 (m, 1H), 7.54 (m, 2H), 7.44 (m, 1H); IR (KBr) 788, 984, 1124, 1166, 1306, 1424, 1446, 1575, 3085  $cm^{-1}$ ; MS (TOF)  $m/z$  220.0439 (220.0427 calcd for  $C_{11}H_{10}NO_2S$ , MH); Anal. calcd for  $C_{11}H_9NO_2S$ : C, 60.26; H, 4.14; N, 6.39; S, 14.62. Found: C, 60.40; H, 4.02; N, 6.40; S, 14.76.

**3-benzenesulfonyl-pyridine, 3:** The procedure used for preparation of **1** produced **3** in 73% yield and 98% purity. For Characterization data see Bandyar, B.P. *Organic Lett.* **2004**, 6(13), 2105.

**4-benzenesulfonyl-pyridine, 4:** The procedure used for preparation of **1** produced **4** in 83% yield and 98% purity. For Characterization data see Furukawa, N. et. al. *Heterocycles.* **1986**, 24(12), 3337.

**3-chloro-2-benzenesulfonyl-pyridine, 5:** The procedure used for preparation of **1** produced **5** in 85% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.51 (dd,  $J = 4.4, 1.1$  Hz, 1H), 8.04 (m, 2H), 7.83 (dd,  $J = 5.2, 1.1$  Hz, 1H), 7.66 (m, 1H), 7.55 (m, 2H), 7.43 (m, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 154.5, 146.9, 140.6, 138.4, 134.0, 130.6, 129.3, 128.9, 127.8 ppm; IR (KBr) 588, 681, 777, 805, 1039, 1082, 1126, 1151, 1307, 1395, 1447, 1582  $\text{cm}^{-1}$ ; Anal. calcd for  $\text{C}_{11}\text{H}_8\text{ClNO}_2\text{S}$ : C, 52.08; H, 3.18; Cl, 13.97; N, 5.52; S, 12.64. Found: C, 51.87; H, 3.17; Cl, 14.06; N, 5.40; S, 12.78.

**3-bromo-2-benzenesulfonyl-pyridine, 6:** The procedure used for preparation of **1** produced **6** in 76% yield and 97% purity.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.45 (d, 1H,  $J = 4.2$  Hz); 7.90 (m, 3H); 7.90 (t, 1H,  $J = 6.9$  Hz); 7.49 (m, 2H); 7.30 (dd, 1H,  $J = 8.1, 4.5$  Hz);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75.5 MHz) 155.5, 147.3, 144.1, 138.1, 134.0, 129.3 (2C), 128.9 (2C), 127.9, 117.9.

**6-chloro-2-benzenesulfonyl-pyridine, 7:** The procedure used for preparation of **1** produced **7** in 85% yield and 92% purity. For characterization see Koyakumar, K. et. al. Preparation of 2-Substituted Pyridine Derivatives, WO2004069551A1.

**5-methyl-2-benzenesulfonyl-pyridine, 8:** The procedure used for preparation of **1** produced **8** in 85% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.47 (m, 1H), 8.07 (d,  $J = 7.8$  Hz, 2H), 8.03 (m, 2H), 7.69 (m, 1H), 7.58 (m, 1H), 7.50 (m, 2H), 2.38 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 155.6, 151.0, 140.7, 138.1, 137.6, 133.5, 129.0, 128.7, 122.0, 18.5 ppm; IR (KBr) 747, 844, 1026, 1074, 1116, 1166, 1313, 1447, 1575, 3098  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  234.0590 (234.0583 calcd for  $\text{C}_{12}\text{H}_{12}\text{NO}_2\text{S}$ , MH); Anal. calcd for  $\text{C}_{12}\text{H}_{11}\text{NO}_2\text{S}$ : C, 61.78; H, 4.75; N, 6.00; S, 13.74. Found: C, 61.79; H, 4.81; N, 5.96; S, 13.90.

**5-nitro-2-benzenesulfonyl-pyridine, 9:** The procedure used for preparation of **1** produced **9** in 93% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  9.41 (d,  $J = 2.4$  Hz, 1H), 8.70 (dd,  $J = 7.9, 1.9$  Hz, 1H), 8.41 (d,  $J = 8.6$  Hz, 1H), 8.08 (m, 2H), 7.68 (m, 1H), 7.58 (m, 2H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 163.3, 145.7, 145.2, 137.4, 134.6, 133.6, 129.4, 122.6 ppm; IR (KBr) 561, 610, 718, 746, 1074, 1126, 1168, 1325, 1530, 1600  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  265.0302 (265.0278 calcd for  $\text{C}_{11}\text{H}_9\text{N}_2\text{O}_4\text{S}$ , MH); Anal. calcd for  $\text{C}_{11}\text{H}_8\text{N}_2\text{O}_4\text{S}$ : C, 50.00; H, 3.05; N, 10.60; S, 12.13. Found: C, 50.30; H, 3.08; N, 10.53; S, 12.15.

**3-nitro-2-benzenesulfonyl-pyridine, 10:** The procedure used for preparation of **1** produced **10** in 93% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.79 (dd,  $J = 4.8, 2.0$  Hz, 1H), 8.11 (m, 2H), 8.06 (dd,  $J = 8.1, 1.7$  Hz, 1H), 7.68 (m, 2H), 7.59 (m, 2H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 151.5, 137.9, 134.5, 132.9, 129.6, 129.1, 127.8 ppm; IR (KBr) 593, 746, 1156, 1166, 1322, 1362, 1531, 1586  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  265.0263 (265.0278 calcd for  $\text{C}_{11}\text{H}_9\text{N}_2\text{O}_4\text{S}$ , MH); Anal. calcd for

C<sub>11</sub>H<sub>8</sub>N<sub>2</sub>O<sub>4</sub>S: C, 50.00; H, 3.05; N, 10.60; S, 12.13. Found: C, 49.92; H, 3.08; N, 10.40; S, 12.02.

**2-benzenesulfonyl-pyridine N-oxide, 11:** The procedure used for preparation of **1** produced **11** in 66% yield and >99% purity. For characterization data see Naomichi et. al. *Heterocycles* **1986**, 24(11), 3019.

**5-Benzenesulfonyl-nicotinonitrile, 12:** The procedure used for preparation of **1** produced **12** in 86% yield. <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 9.28 (d, *J* = 2.2 Hz, 1H), 9.01 (d, *J* = 1.6 Hz, 1H), 8.46 (m, 1H), 7.98 (m, 2H), 7.68 (m, 1H), 7.59 (m, 2H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) 155.5, 151.4, 139.5, 139.0, 138.4, 134.6, 130.0, 128.1, 114.9, 110.8 ppm; IR (KBr) 1158, 1227, 1315, 1451, 1584, 2234 cm<sup>-1</sup>; MS (TOF) *m/z* 245.0392 (245.0385 calcd for C<sub>12</sub>H<sub>9</sub>N<sub>2</sub>O<sub>2</sub>S, MH); Anal. calcd for C<sub>12</sub>H<sub>8</sub>N<sub>2</sub>O<sub>2</sub>S: C, 59.00; H, 3.30; N, 11.47; S, 13.13. Found: C, 59.03; H, 3.29; N, 11.48; S, 12.94.

**2-benzenesulfonyl-quinoxaline, 13:** 2-chloroquinoxaline (5.0 g, 30 mmol), benzenethiol (3.2 mL, 30 mmol), and DMF (25 mL) are charged to a 50-mL flask, then K<sub>2</sub>CO<sub>3</sub> (7.4 g, 53 mmol) is added. The mixture is heated to 110 °C for 1 h, at which point HPLC analysis indicated nearly complete reaction. The mixture is cooled to room temperature, vacuum filtered, then the waste cake rinsed with DMF (12 mL). The crude sulfide solution and rinsings are transferred to a 250-mL flask, then glacial HOAc (2.2 mL, 39 mmol) is added and the resulting solution is heated to 40 °C. A 12 wt % bleach solution of bleach is slowly added, periodically checking the reaction's progress by HPLC analysis, and after addition of 54 mL of 12% bleach (105 mmol), the sulfone

product and sulfoxide intermediate had precipitated and no further conversion could be achieved. The thick mixture is allowed to cool to room temperature, then the pH is adjusted to 11 with 50 % (w/v) NaOH solution (2 mL). The slurry is filtered through polypropylene, rinsed with water (70 mL), and the resulting cake was dried overnight in a 50 °C vacuum oven.

The dried solid (6.7 g) is dissolved in DMF (40 mL), heated to 40 °C, then HOAc (2.0 mL, 35 mmol) is added, followed by slow addition of 9 wt % bleach (10 mL, 14 mmol). After 10 min analysis by HPLC indicates all the sulfoxide intermediate is converted to sulfone, and the mixture is allowed to cool to room temperature. The pH is raised to 10 with 50 % (w/v) NaOH solution (1.8 mL), then the mixture is cooled to <5 °C, stirred for 1 hour, and vacuum filtered. The resulting wetcake is rinsed with water (50 mL), then the solid dried in a 55 °C vacuum oven overnight to provide the pure 2-benzenesulfonylquinoxaline (6.14g, 76 %) as a pale yellow solid. <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 9.56 (s, 1H), 8.16 (m, 4H), 7.88 (m, 2H), 7.64 (m, 1H), 7.56 (m, 2H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) 153.2, 143.4, 141.5, 141.1, 138.5, 134.3, 133.0, 131.7, 130.3, 129.5, 129.4, 129.2 ppm; IR (KBr) 547, 641, 685, 728, 757, 1077, 1142, 1176, 1330, 1446, 3053 cm<sup>-1</sup>; MS (TOF) *m/z* 271.0543 (271.0536 calcd for C<sub>14</sub>H<sub>11</sub>N<sub>2</sub>O<sub>2</sub>S, MH); Anal. calcd for C<sub>14</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub>S: C, 62.21; H, 3.73; N, 10.36; S, 11.86. Found: C, 62.16; H, 3.69; N, 10.36; S, 12.08.

**2-benzenesulfonyl-quinoline, 14:** A procedure similar to that of the quinoxaline derivative provided the pure quinoline sulfone (7.08 g, 85 %) as a white solid: <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.37 (d, *J* = 8.3 Hz, 1H), 8.21 (d, *J* = 9.1 Hz, 1H), 8.14 (m, 3H), 7.87 (d, *J* = 8.2 Hz, 1H), 7.78 (m, 1H), 7.65 (m, 1H), 7.60 (m, 1H), 7.53 (m, 2H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) 158.1, 147.4, 139.2, 138.7, 133.7, 131.0, 130.4, 129.2, 129.1, 129.0, 128.8, 127.7, 117.7 ppm; IR (KBr) 640,

723, 755, 8.24, 1075, 1163, 1322, 1447, 1496, 3058  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  270.0580 (270.0583 calcd for  $\text{C}_{15}\text{H}_{12}\text{NO}_2\text{S}$ , MH); Anal. calcd for  $\text{C}_{15}\text{H}_{11}\text{NO}_2\text{S}$ : C, 66.89; H, 4.12; N, 5.20; O, 11.88; S, 11.91. Found: C, 66.78; H, 4.06; N, 5.28; S, 11.99.

**2-(3-chlorobenzenesulfonyl)-pyridine, 15:** The procedure used for preparation of **1** produced **15** in 76% yield and > 99% purity.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.60 (d, 1H,  $J = 4.5$  Hz); 8.11 (d, 1H,  $J = 7.8$  Hz); 7.88 (d, 1H,  $J = 1.5$  Hz), 7.84-7.96 (m, 2H); 7.38-7.54 (m, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75.5 MHz) 158.0, 150.6, 140.6, 138.4, 135.2, 133.9, 130.5, 128.8, 127.4, 127.0, 122.3.

**2-(3-fluorobenzenesulfonyl)-pyridine, 16:** The procedure used for preparation of **1** produced **16** in 87% yield and 95% purity.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.59 (dd, 1H,  $J = 4.8, 0.9$  Hz); 8.11 (d, 1H;  $J = 7.8$  Hz); 7.90(dt, 1H;  $J = 8.1, 1.8$  Hz); 7.40-7.80 (m, 4H); 7.20 (dt,  $J = 7.8, 1.5$  Hz);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75.5 MHz) 162.2 (d,  $J = 250$  Hz), 158, 150.6, 140.9 (d,  $J = \text{Hz}$ ), 138.4, 131.0 (d,  $J = 7.7$  Hz), 127.4, 124.66 (d,  $J = 3.1$  Hz), 122.3, 121.05(d,  $J = 21$ Hz); 116.05 (d,  $J = 24$  Hz).

**2-(bis 3,5-trifluoromethylbenzenesulfonyl)-pyridine, 17:** The procedure used for preparation of **1** produced **17** in 72% yield and 97% purity.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.68(dd, 1H,  $J = 5.4, 0.9$  Hz); 8.54 (br s, 2H); 8.26 (d, 1H, 6.9 Hz); 8.02 (t, 1H,  $J = 7.8$  Hz); 7.53, (dd, 1H;  $J = 4.5, 0.9$  Hz);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75.5 MHz) 157.3, 150.8, 141.7, 138.5, 133 (2 X  $\text{CF}_3$ , q,  $J = 558$  Hz), 129.4, 127.4, 124.2, 122.4, 120.5, 116.9;  $^{19}\text{F}$  NMR: -63.0 ppm.

**2-(2-bromobenzenesulfonyl)-pyridine, 18:** The procedure used for preparation of **1** produced **18** in 75% yield and 98% purity.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.51 (dd, 1H,  $J = 7.8, 0.6$  Hz); 8.37(dd, 1H,  $J = 7.8, 1.5$  Hz); 8.25(d, 1H;  $J = 7.8$  Hz); 7.89 (dt, 1H,  $J = 7.8, 1.5$  Hz), 7.3- 7.6 (m, 4H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75.5 MHz) 157.54, 150.06, 137.94, 137.82, 135.17, 135.12, 132.48, 127.94, 127.26, 123.63, 121.03.

**2-(4-nitrobenzenesulfonyl)-pyridine, 19:** The procedure used for preparation of **1** produced **19** in 82% yield and 89% purity.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.72 (d, 1H,  $J = 5.0$  Hz); 8.40-8.45 (m, 2H), 8.30(t, 1H,  $J = 8.2$  Hz); 8.23-8.28 (m, 2H); 8.20(dt, 1H;  $J = 8.2, 1.6$  Hz); 7.73 (dd, 1H,  $J = 4.4, 1.2$  Hz).

**2-(4-methylbenzenesulfonyl)-pyridine, 20:** The procedure used for preparation of **1** produced **20** in 89% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.65 (d,  $J = 4.9$  Hz, 1H), 8.17 (d,  $J = 7.7$  Hz, 1H), 7.92 (m, 3H), 7.43 (m, 1H), 7.31 (d,  $J = 8.2$  Hz, 2H), 2.40 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 159.1, 150.4, 144.8, 138.0, 136.0, 129.8, 129.0, 126.7, 122.0, 21.6 ppm; IR (KBr) 545, 581, 657, 740, 1124, 1170, 1317, 1427  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  234.0589 (234.0583 calcd for  $\text{C}_{12}\text{H}_{12}\text{NO}_2\text{S}$ , MH); Anal. calcd for  $\text{C}_{12}\text{H}_{11}\text{NO}_2\text{S}$ : C, 61.78; H, 4.75; N, 6.00; S, 13.74. Found: C, 62.10; H, 4.74; N, 6.03; S, 13.45.

**2-(4-methoxy-benzenesulfonyl)-pyridine, 21:** The procedure used for preparation of **1** produced **21** in 61% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.64 (d,  $J = 4.9$  Hz, 1H), 8.14 (d,  $J = 7.7$  Hz, 1H), 7.97 (m, 2H), 7.89 (ddd,  $J = 9.9, 7.7, 2.2$  Hz, 1H), 7.42 (m, 1H), 6.98 (m, 2H), 3.83 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 163.9, 159.4, 150.3, 138.0, 161.2, 130.3, 126.6, 121.8,

114.4, 55.6 ppm; IR (KBr) 1125, 1166, 1268, 1309, 1320, 1426, 1499, 1575, 1593  $\text{cm}^{-1}$ ; MS (TOF)  $m/z$  250.0529 (250.0532 calcd for  $\text{C}_{12}\text{H}_{12}\text{NO}_3\text{S}$ , MH); Anal. calcd for  $\text{C}_{12}\text{H}_{11}\text{NO}_3\text{S}$ : C, 57.82; H, 4.45; N, 5.62; S, 12.86. Found: C, 57.58; H, 4.39; N, 5.54; S, 12.83.

**2-(2-trifluoromethylbenzenesulfonyl)-pyridine, 22:** The procedure used for preparation of **1** produced **22** in 78% yield.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.60 (m, 1H), 8.56 (m, 1H), 8.22 (d,  $J = 8.2$  Hz, 1H), 7.97 (dt,  $J = 7.7, 1.6$  Hz, 1H), 7.84 (m, 2H), 7.78 (m, 1H), 7.47 (ddd,  $J = 7.7, 4.8, 1.1$  Hz, 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz) 159.0, 149.9, 138.0, 137.0, 134.1, 133.9, 132.3, 129.0, 128.3, 128.2, 128.2, 128.1, 127.0, 123.9, 121.8, 121.8, 121.2 ppm; IR (KBr) 11.28, 1140, 1167, 1311, 1326, 1424, 1458, 1578  $\text{cm}^{-1}$ ; MS (APCI)  $m/z$  287.0028 (287.0228 calcd for  $\text{C}_{12}\text{H}_8\text{F}_3\text{NO}_2\text{S}$ ); Anal. calcd for  $\text{C}_{12}\text{H}_8\text{F}_3\text{NO}_2\text{S}$ : C, 50.17; H, 2.81; F, 19.84; N, 4.88; S, 11.16. Found: C, 49.99; H, 2.84; F, 18.35; N, 4.85; S, 7.78.