Regioselective and oxidant-free sulfinylation of indoles and pyrroles with sulfinamides

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2. General Information

Common reagents and materials were purchased from commercial sources and were used without further purification. TLC plates were visualized by exposure to ultra violet light (UV). IR spectra were recorded by using an Electrothermal Nicolet 380 spectrometer. High-resolution mass spectra (HRMS) were recorded by using an Electrothermal LTQ-Orbitrap mass spectrometer. Melting points were measured by using a Gongyi X-5 microscopy digital melting point apparatus and are uncorrected. $^1$H NMR and $^{13}$C NMR spectra were obtained by using a Bruker Avance III 400 MHz or a JNM-ECZ400S/L1 400 MHz NMR spectrometer. Chemical shifts for protons are reported in parts per million (δ scale) and are referenced to residual protium in the NMR solvents [CDCl$_3$: δ 7.26, DMSO-$d_6$: δ 2.50]. Chemical shifts for carbon resonances are reported in parts per million (δ scale) and are referenced to the carbon resonances of the solvent (CDCl$_3$: δ 77.0, DMSO-$d_6$: δ 39.43). Data are represented as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), integration, and coupling constant in Hertz (Hz).

3. General Procedures for the Preparation of Sulfinamides 1

3.1 General procedure for the preparation of sulfinamides 1a–1c and 1e–1g [1]

To a three-necked round bottomed flask was added sodium arylsulfinate (2 mmol, 1 equiv.) in anhydrous toluene (5 mL) under argon atmosphere. After cooling the solution to 0 °C oxalyl chloride (2.2 mmol, 1.1 equiv.) was added dropwise. The reaction mixture was heated to room temperature during 1 h to generate sulfinyl chloride in situ. A second round bottomed flask was charged with the corresponding amine (2.4 mmol, 1.2 equiv.) and trimethylamine (3.0 mmol, 1.5 equiv.) in anhydrous toluene (6 mL). To this flask, the in situ generated sulfinyl chloride was added dropwise at 0 °C. The reaction mixture was stirred for 1 h at room temperature and then poured in H$_2$O (5 mL) and extracted with EtOAc (5 mL) three times. The combined organic layers were dried over anhydrous Na$_2$SO$_4$ and concentrated in vacuo. The crude product was purified by flash chromatography on silica gel (100–200 mesh). The product was identified by NMR and HRMS spectra.
N-butyl-4-methylbenzenesulfinamide (1a)

White solid, 311.0 mg, 73% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.57 (d, $J = 7.9$ Hz, 2H), 7.28 (d, $J = 7.8$ Hz, 2H), 4.18 (s, 1H), 3.13–3.05 (m, 1H), 2.84–2.76 (m, 1H), 2.40 (s, 3H), 1.51–1.44 (m, 2H), 1.35–1.25 (m, 2H), 0.85 (t, $J = 7.3$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.1, 140.9, 129.3, 125.8, 40.6, 32.4, 21.2, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C$_{11}$H$_{17}$NaNOS [M+Na]$^+$: 234.0923. Found: 234.0919.

4-Methyl-N-propylbenzenesulfinamide (1b)

White solid, 275.8 mg, 70% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.53 (d, $J = 8.2$ Hz, 2H), 7.23 (d, $J = 8.1$ Hz, 2H), 4.32 (s, 1H), 3.04–2.96 (m, 1H), 2.76–2.68 (m, 1H), 2.35 (s, 3H), 1.51–1.42 (m, 2H), 0.83 (t, $J = 7.4$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.1, 140.9, 129.2, 125.8, 42.6, 23.6, 21.1, 11.1; HRMS (ESI) m/z: Calcd for C$_{13}$H$_{19}$NaNOS [M+Na]$^+$: 220.0767. Found: 220.0769.

N,N-diisopropyl-4-methylbenzenesulfinamide (1c)

White solid, 258.1 mg, 54% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.49 (d, $J = 8.2$ Hz, 2H), 7.24 (d, $J = 8.0$ Hz, 2H), 3.57–3.47 (m, 2H), 2.36 (s, 3H), 1.37 (d, $J = 6.8$ Hz, 6H), 1.08 (d, $J = 6.8$ Hz, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.4, 140.2, 129.2, 126.4, 46.3, 23.7, 23.6, 21.1; HRMS (ESI) m/z: Calcd for C$_{13}$H$_{22}$NaNOS [M+Na]$^+$: 262.1236. Found: 262.1231.
**N-butylbenzensulfinamide (1e)**

Yellow liquid, 279.7 mg, 71% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.71–7.69 (m, 2H), 7.51–7.44 (m, 3H), 4.07 (s, 1H), 3.15–3.07 (m, 1H), 2.85–2.77 (m, 1H), 1.51–1.44 (m, 2H), 1.35–1.24 (m, 2H), 0.85 (t, $J = 7.3$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 144.2, 130.6, 128.6, 125.8, 40.7, 32.4, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C$_{10}$H$_{15}$NaNOS [M+Na]$^+$: 220.0767. Found: 220.0762.

**N-butyl-4-chlorobenzenesulfinamide (1f)**

Yellow liquid, 300.3 mg, 65% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.64–7.62 (m, 2H), 7.48–7.46 (m, 2H), 4.07–4.06 (m, 1H), 3.14–3.06 (m, 1H), 2.82–2.74 (m, 1H), 1.52–1.44 (m, 2H), 1.35–1.24 (m, 2H), 0.86 (t, $J = 7.3$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 142.8, 137.1, 128.9, 127.4, 40.7, 32.4, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C$_{10}$H$_{14}$ClNaNOS [M+Na]$^+$: 254.0377. Found: 254.0380.

**N-butyl-4-fluorobenzenesulfinamide (1g)**

Yellow liquid, 236.5 mg, 55% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.67–7.64 (m, 2H), 7.17–7.12 (m, 3H), 4.28 (s, 1H), 3.10–3.02 (m, 1H), 2.79–2.71 (m, 1H), 1.49–1.41 (m, 2H), 1.32–1.23 (m, 2H), 0.83 (t, $J = 7.3$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 164.2 (d, $J_{C,F} = 250.9$ Hz), 139.8 (d, $J_{C,F} = 2.8$ Hz), 128.2 (d, $J_{C,F} = 8.9$ Hz), 115.8 (d, $J_{C,F} = 22.3$ Hz), 40.5, 32.4, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C$_{10}$H$_{15}$FNaNOS [M+Na]$^+$: 238.0672. Found: 238.0675.
3.2 General procedure for the preparation of sulfinamide 1d \[2\]

To a solution of \(p\)-toluensulfonyl chloride (190 mg, 1 mmol, 1 equiv) and triethylamine (1.4 mL, 10 mmol, 10 equiv.) in \(CH_2Cl_2\) (3.0 mL) solution at 0 °C under argon atmosphere, was added a solution of triphenylphosphine (262 mg, 1 mmol, 1 equiv.) and benzylic amine (109 µl, 1 mmol, 1 equiv.) in \(CH_2Cl_2\) (3.0 mL) solution over a period of 1 h. After addition, TLC showed all of the sulfonyl chloride was consumed. The reaction mixture was concentrated by rotavap. The crude product was purified by flash chromatography on silica gel (100–200 mesh) to give the desired sulfinamide.

\[N\text{-benzyl-4-methylbenzenesulfinamide (1d)}\]

![Image of N-benzyl-4-methylbenzenesulfinamide](image)

White solid, 303.8 mg, 62% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.63 (d, \(J = 8.0\) Hz, 2H), 7.31–7.24 (m, 7H), 4.44 (s, 1H), 4.22 (dd, \(J = 13.5, 5.1\) Hz, 1H), 3.88 (dd, \(J = 13.5, 7.2\) Hz, 1H), 2.40 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 141.2, 140.7, 137.7, 129.5, 128.5, 128.2, 127.5, 125.9, 44.4, 21.2; HRMS (ESI) m/z: Calcd for \(C_{14}H_{15}Na\text{NOS}\)[M+Na]: 268.0767. Found: 268.0771.

3.3 General procedure for the preparation of sulfinamide 1h-1j \[1\]

To a solution of sulfonyl chloride (2 mmol, 1.0 equiv.) and triethylamine (4 mmol, 2.0 equiv.) in anhydrous \(CH_2Cl_2\) (6 mL) at 0 °C under argon atmosphere, was added a solution of butan-1-amine (2 mmol, 1.0 equiv.) and triphenylphosphine (2 mmol, 1.0 equiv.) in anhydrous \(CH_2Cl_2\) (6 mL) over a period of 12 min. The reaction mixture was stirred for 18 h. The reaction mixture was concentrated by rotavap. The crude product was purified by flash chromatography on silica gel (100–200 mesh) to give the desired sulfinamide.
N-butyl-4-(trifluoromethyl)benzenesulfinamide (1h)

White solid, 296.8 mg, 56% yield; \( ^1\)H NMR (400 MHz, CDCl\(_3\) \( \delta \)): 7.83 (d, \( J = 8.1 \) Hz, 2H), 7.75 (d, \( J = 8.2 \) Hz, 2H), 4.28–4.19 (m, 1H), 3.18–3.04 (m, 1H), 2.79–2.70 (m, 1H), 1.51–1.44 (m, 2H), 1.36–1.26 (m, 2H), 0.85 (t, \( J = 7.3 \) Hz, 3H); \( ^{13}\)C NMR (100 MHz, CDCl\(_3\) \( \delta \)): 148.4, 132.8 (q, \( J_{C-F} = 32.8 \) Hz), 126.7, 125.8 (q, \( J_{C-F} = 3.7 \) Hz), 123.6 (q, \( J_{C-F} = 272.6 \) Hz), 40.9, 32.4, 19.9, 13.6; HRMS (ESI) m/z: Calcd for C\(_{11}\)H\(_{14}\)F\(_3\)NaNOS [M+Na]\(^+\): 288.0640. Found: 288.0648.

N-butyl-4-nitrobenzenesulfinamide (1i)

Yellow solid, 246.8 mg, 51% yield; \( ^1\)H NMR (400 MHz, CDCl\(_3\) \( \delta \)): 8.35–8.32 (m, 2H), 7.91–7.87 (m, 2H), 4.35–4.32 (m, 1H), 3.17–3.08 (m, 1H), 2.76–2.68 (m, 1H), 1.52–1.44 (m, 2H), 1.36–1.26 (m, 2H), 0.85 (t, \( J = 7.5 \) Hz, 3H); \( ^{13}\)C NMR (100 MHz, CDCl\(_3\) \( \delta \)): 151.2, 149.4, 127.4, 123.9, 40.9, 32.4, 19.9, 13.6; HRMS (ESI) m/z: Calcd for C\(_{15}\)H\(_{14}\)NaNOS [M+Na]\(^+\): 265.0617. Found: 265.0623.

N-butyl-3-nitrobenzenesulfinamide (1j)

Yellow solid, 174.2 mg, 36% yield; \( ^1\)H NMR (400 MHz, CDCl\(_3\) \( \delta \)): 8.53 (t, \( J = 2.0 \) Hz, 1H), 8.32 (ddd, \( J = 8.2, 2.2, 1.1 \) Hz, 1H), 8.03 (dt, \( J = 7.8, 1.4 \) Hz, 1H), 7.70 (t, \( J = 7.9 \) Hz, 1H), 4.51–4.38 (m, 1H), 3.15–3.07 (m, 1H), 2.77–2.69 (m, 1H), 1.52–1.45 (m, 2H), 1.36–1.25 (m, 2H), 0.84 (t, \( J = 7.4 \) Hz, 3H); \( ^{13}\)C NMR (100 MHz, CDCl\(_3\) \( \delta \)):...
148.4, 147.1, 132.1, 129.9, 125.5, 121.5, 40.8, 32.4, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C_{10}H_{14}NaN_{2}O_{3}S [M+Na]^{+}: 265.0617. Found: 265.0619.

3.4 General procedure for the preparation of sulfinamide 1k \[1\]

To a solution of thiophene-2-sulfonyl chloride (2 mmol, 1.0 equiv.) in anhydrous CH_{2}Cl_{2} (6 mL) at 0 °C under argon atmosphere, was added a solution of butan-1-amine (2 mmol, 1.0 equiv.), triphenylphosphine (2 mmol, 1.0 equiv.) and triethylamine (2 mmol, 2.0 equiv.) in anhydrous CH_{2}Cl_{2} (6 mL) over a period of 12 min. The reaction mixture was stirred for 18 h. The reaction mixture was concentrated by rotavap. The crude product was purified by flash chromatography on silica gel (100–200 mesh) to give the desired sulfinamide.

\textit{N}-butylthiophene-2-sulfinamide (1k)

Yellow liquid, 263.9 mg, 65% yield; \textsuperscript{1}H NMR (400 MHz, CDCl_{3}) \delta: 7.55 (d, J = 4.9 Hz, 1H), 7.37 (d, J = 3.5 Hz, 1H), 7.09 (t, J = 4.2 Hz, 1H), 4.43–4.41 (m, 1H), 3.21–3.13 (m, 1H), 3.03–2.94 (m, 1H), 1.56–1.49 (m, 2H), 1.38–1.29 (m, 2H), 0.87 (t, J = 7.3 Hz, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl_{3}) \delta: 147.2, 131.0, 129.7, 127.7, 41.0, 32.5, 19.8, 13.5; HRMS (ESI) m/z: Calcd for C_{9}H_{13}NaNOS_{2} [M+Na]^{+}: 226.0331. Found: 226.0333.

3.5 General procedure for the preparation of sulfinamide 1l \[3\]

The dimethyl disulfide (10 mmol, 1.0 equiv.) and acetic acid (20 mmol, 2.0 equiv.) were mixed and cooled to -20 °C. Sulfuryl chloride (31 mmol, 3.1 equiv.) was added dropwise with stirring over a period of 30 min. The reaction mixture was then stirred for 3 h at -20 °C and then allowed to warm to room temperature over a period of about 2 h. Evolution of SO_{2} and HCl was observed during this time. The mixture was warmed to 35 °C for 1 h. The resulting acetyl chloride was evaporated under reduced pressure, providing the desired product methanesulfinic chloride as a liquid which was used without further purification.
The crude product methanesulfonic chloride in CH₂Cl₂ (7 mL) was added dropwise to a solution of benzylamine (40 mmol, 2.0 equiv.) in CH₂Cl₂ (40 mL) at -78 °C. The mixture was stirred for 3 h at room temperature. The solution was filtered and the filtrate was washed with water and then dried over anhydrous Na₂SO₄, filtered, and concentrated. The residue was purified by flash chromatography on silica gel (100–200 mesh) to afford the desired sulfinamide.

\[ \text{N-benzylmethanesulfinamide (1l)} \]

Yellow liquid, 2.54g, 75% yield; \(^1\)H NMR (400 MHz, CDCl₃) \( \delta \): 7.31–7.24 (m, 5H), 4.43–4.40 (m, 1H), 4.28–4.17 (m, 2H), 2.60 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl₃) \( \delta \): 137.9, 128.6, 128.0, 127.6, 45.8, 41.6; HRMS (ESI) m/z: Calcd for C₉H₁₁NaNOS [M+Na]^+: 192.0454. Found: 192.0459.
4. Experimental Procedure of Sulfoxides

4.1 Experimental Procedure of Sulfoxides 3a-3ag

The mixture of an arylsulfiniamide (0.2 mmol, 1 equiv.), an indole (0.24 mmol, 1.2 equiv.) and TMSCl (0.36 mmol, 1.8 equiv.) in CH$_2$Cl$_2$ (1.0 mL) was stirred at 25 °C for 10 min, then water (5 mL) and dichloromethane (10 mL) were added. The two layers were separated, and the aqueous phase was extracted with dichloromethane (3 × 10 mL). The combined organic extracts were washed by brine, dried over anhydrous Na$_2$SO$_4$, filtered, and concentrated. The residue was purified by flash chromatography on silica gel (100–200 mesh) to afford the desired sulfoxide.

1-Methyl-3-(p-tolylsulfinyl)-1H-indole (3a)

White solid, m.p. = 138–139 °C; 44.7 mg, 83% yield; $^1$H NMR (400 MHz, CDCl$_3$) δ: 7.62 (d, $J = 8.2$ Hz, 2H), 7.48 (d, $J = 8.7$ Hz, 2H), 7.34–7.24 (m, 4H), 7.12–7.08 (m, 1H), 3.79 (s, 3H), 2.40 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ: 140.9, 140.3, 137.6, 132.5, 129.5, 124.8, 124.3, 123.2, 121.3, 119.8, 116.5, 110.0, 33.2, 21.2; FTIR (film): 3458, 3051, 2921, 1515, 1458, 1173, 1033, 1013, 810, 765, 742, 621 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{16}$H$_{15}$NaNO$_2$[M+Na]$^+$: 292.0767. Found: 292.0765.

3-(p-Tolylsulfinyl)-1H-indole (3b)

White solid, m.p. = 120–122 °C; 45.4 mg, 89% yield; $^1$H NMR (400 MHz, CDCl$_3$) δ: 10.49 (s, 1H), 7.54 (d, $J = 8.2$ Hz, 2H), 7.34 (d, $J = 8.0$ Hz, 1H), 7.26 (d, $J = 8.1$ Hz, 2H), 7.21 (d, $J = 8.2$ Hz, 1H), 7.16 (d, $J = 2.3$ Hz, 1H),
7.10 (t, J = 7.6 Hz, 1H), 6.98 (t, J = 7.5 Hz, 1H), 2.38 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ: 140.5, 139.8, 137.1, 130.0, 129.6, 124.9, 123.4, 123.3, 121.3, 119.1, 115.8, 112.5, 21.2; FTIR (film): 3166, 2978, 2920, 2852, 1491, 1426, 1081, 1021, 1002, 809, 763, 743 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{13}$NaNO$_3$ [M+Na$^+$]: 278.0610. Found: 278.0611.

1-Methyl-3-(phenylsulfinyl)-1H-indole (3c)

White solid, m.p. = 126–128 °C; 45.9 mg, 90% yield; $^1$H NMR (400 MHz, CDCl$_3$) δ: 7.72 (d, J = 6.9 Hz, 2H), 7.50–7.41 (m, 5H), 7.32 (d, J = 8.2 Hz, 1H), 7.25 (t, J = 7.6 Hz, 1H), 7.07 (t, J = 7.5 Hz, 1H), 3.80 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ: 144.1, 137.6, 132.8, 130.0, 128.7, 124.8, 124.2, 123.2, 121.3, 119.7, 116.2, 110.0, 33.2; FTIR (film): 3452, 3053, 2922, 2850, 2359, 1516, 1473, 1458, 1033, 997, 742, 695 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{13}$NaNO$_3$ [M+Na$^+$]: 278.0610. Found: 278.0613.

3-(Phenylsulfinyl)-1H-indole (3d)

White solid, m.p. = 126–128 °C; 45.3 mg, 94% yield; $^1$H NMR (400 MHz, DMSO-d$_6$) δ: 11.97 (s, 1H), 8.13 (d, J = 2.7 Hz, 1H), 7.66 (d, J = 7.4 Hz, 2H), 7.56–7.42 (m, 4H), 7.26 (d, J = 8.0 Hz, 1H), 7.15 (t, J = 7.6 Hz, 1H), 6.96 (t, J = 7.5 Hz, 1H); $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ: 144.8, 136.9, 130.7, 129.8, 128.8, 124.3, 123.1, 122.7, 120.5, 118.9, 116.2, 112.6; FTIR (film): 3164, 2918, 2851, 1455, 1424, 1243, 1016, 993, 742 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{14}$H$_{11}$NaNO$_3$ [M+Na$^+$]: 264.0454. Found: 264.0451.
3-((4-Chlorophenyl)sulfinyl)-1-methyl-1H-indole (3e)

White solid, m.p. = 144–146 °C; 48.0 mg, 83% yield; ^1H NMR (400 MHz, CDCl₃) δ: 7.66 (d, J = 8.3 Hz, 2H), 7.55 (s, 1H), 7.47–7.42 (m, 3H), 7.36 (d, J = 8.3 Hz, 1H), 7.29 (t, J = 7.6 Hz, 1H), 7.12 (t, J = 7.5 Hz, 1H), 3.83 (s, 3H); ^13C NMR (100 MHz, CDCl₃) δ: 142.9, 137.7, 136.1, 132.9, 129.0, 126.2, 124.0, 123.4, 121.5, 119.6, 115.7, 110.2, 33.3; FTIR (film): 3455, 3052, 2924, 1515, 1471, 1457, 1085, 1031, 1008, 975, 821, 765, 738 cm⁻¹; HRMS (ESI) m/z: Calcd for C₂₅H₁₂NaClNO₃S [M+Na]^+ : 312.02. Found: 312.0218.

3-((4-Chlorophenyl)sulfinyl)-1H-indole (3f)

White solid, m.p. = 128–130 °C; 50.1 mg, 91% yield; ^1H NMR (400 MHz, CDCl₃) δ: 10.42 (s, 1H), 7.69 (dd, J = 8.7, 5.1 Hz, 2H), 7.43 (d, J = 7.9 Hz, 2H), 7.30 (d, J = 7.9 Hz, 1H), 7.24–7.22 (m, 2H), 7.13 (t, J = 7.6 Hz, 1H), 7.01 (t, J = 7.5 Hz, 1H); ^13C NMR (100 MHz, CDCl₃) δ: 141.7, 137.1, 136.4, 130.3, 129.2, 126.3, 123.6, 123.1, 121.6, 119.0, 115.3, 112.6; FTIR (film): 3159, 2923, 2849, 1473, 1424, 1004, 742 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₄H₁₀NaClNO[S] [M+Na]^+ : 298.0064. Found: 298.0068.

3-((4-Fluorophenyl)sulfinyl)-1-methyl-1H-indole (3g)

White solid, m.p. = 130–132 °C; 45.9 mg, 84% yield; ^1H NMR (400 MHz, CDCl₃) δ: 7.69 (dd, J = 8.7, 5.1 Hz, 2H), 7.51 (s, 1H), 7.40 (d, J = 8.0 Hz, 1H), 7.33 (d, J = 8.3 Hz, 1H), 7.25 (t, J = 7.6 Hz, 1H), 7.14 (t, J = 8.6 Hz, 2H), 7.08 (t, J = 7.5 Hz, 1H), 3.78 (s, 3H); ^13C NMR (100 MHz, CDCl₃) δ: 163.7 (d, J_CF = 250.7 Hz), 139.8 (d, J_CF = 2.9 Hz), 137.8, 132.8, 127.1 (d, J_CF = 8.8 Hz), 124.1, 123.4, 121.5, 119.7, 116.2, 116.1 (d, J_CF = 22.6 Hz,
1C), 110.1, 33.3; FTIR (film): 3438, 3093, 2924, 1586, 1516, 1488, 1458, 1247, 1221, 1031, 1011, 833, 765, 742 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₅H₁₂NaFNO₃S [M+Na⁺]: 296.0516. Found: 296.0513.

3-((4-Fluorophenyl)sulfinyl)-1H-indole (3h)

![Chemical Structure](image)

Pale yellow oil, 48.2 mg, 93% yield; ¹H NMR (400 MHz, CDCl₃) δ: 10.72 (s, 1H), 7.66 (dd, J = 8.7, 5.1 Hz, 2H), 7.32 (d, J = 8.0 Hz, 1H), 7.26–7.23 (m, 2H), 7.19–7.11 (m, 5H), 7.02 (t, J = 7.6 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ: 163.8 (d, J_C-F = 250.8 Hz), 138.5, 137.2, 130.4, 127.1 (d, J_C-F = 8.8 Hz), 123.5, 123.1, 121.5, 118.9, 116.2 (d, J_C-F = 22.6 Hz), 115.2, 112.6; FTIR (film): 3398, 2062, 2924, 1587, 1487, 1223, 1140, 1010, 823, 744 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₄H₁₀NaFNO₃S [M+Na⁺]: 282.0359. Found: 282.0362.

1-Methyl-3-((4-(trifluoromethyl)phenyl)sulfinyl)-1H-indole (3i)

![Chemical Structure](image)

White solid, m.p. = 149–151 °C; 54.3 mg, 84% yield; ¹H NMR (400 MHz, CDCl₃) δ: 7.83 (d, J = 8.4 Hz, 2H), 7.72 (d, J = 8.3 Hz, 2H), 7.58 (s, 1H), 7.39 (d, J = 8.0 Hz, 1H), 7.35 (d, J = 8.3 Hz, 1H), 7.30–7.25 (m, 1H), 7.11–7.07 (m, 1H), 3.83 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ: 149.0, 137.8, 133.3, 131.9 (q, J_C-F = 32.7 Hz), 125.8, (q, J_C-F = 3.7 Hz), 125.3, 124.1, 123.63, 123.58 (q, J_C-F = 271.0 Hz), 121.8, 119.7, 115.5, 110.3, 33.5; FTIR (film): 2924, 2358, 1518, 1398, 1322, 1168, 1060, 1034, 745 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₆H₁₂NaF₃NO₃S [M+Na⁺]: 346.0484. Found: 346.0490.

3-((4-(Trifluoromethyl)phenyl)sulfinyl)-1H-indole (3j)

![Chemical Structure](image)

White solid, m.p. = 127–129 °C; 55.6 mg, 90% yield; ¹H NMR (400 MHz, DMSO-d₆) δ: 12.08 (s, 1H), 8.24 (d, J = 2.9 Hz, 1H), 7.89–7.84 (m, 4H), 7.49 (d, J = 8.2 Hz, 1H), 7.22 (d, J = 8.0 Hz, 1H), 7.16 (t, J = 7.2 Hz, 1H); 6.97
(t, J = 7.6 Hz, 1H); $^{13}$C NMR (100 MHz, DMSO-$d_6$) $\delta$: 150.1, 137.1, 131.5, 130.0 (q, J$_{C,F}$ = 32.1 Hz), 125.9, (q, J$_{C,F}$ = 3.9 Hz), 125.4, 123. 8 (q, J$_{C,F}$ = 271.5 Hz), 123.0, 120.9, 118.7, 115.2, 112.8; FTIR (film): 3165, 2981, 2359, 1605, 1321, 1125, 1059, 1006, 747 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{10}$Na$_2$F$_3$NOS [M+Na]$^+$: 332.0327. Found: 332.0332.

1-Methyl-3-((4-nitrophenyl)sulfinyl)-1H-indole (3k)

0.72 mmol of TMSCI was used.

Yellow solid, m.p. = 144–146 °C; 51.6 mg, 86% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 8.28 (d, J = 8.8 Hz, 2H), 7.86 (d, J = 8.8 Hz, 2H), 7.64 (s, 1H), 7.35–7.24 (m, 3H), 7.07 (t, J = 7.5 Hz, 1H), 3.83 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 152.2, 148.7, 137.8, 133.6, 125.9, 123.9, 123.8, 121.9, 119.5, 114.7, 110.4, 33.5; FTIR (film): 3094, 2926, 2359, 1517, 1343, 1041, 852, 747 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{12}$Na$_2$O$_3$S [M+Na]$^+$: 323.0461. Found: 323.0465.

3-((4-Nitrophenyl)sulfinyl)-1H-indole (3l)

0.72 mmol of TMSCI was used.

Yellow solid, m.p. = 149–151 °C; 51.5 mg, 90% yield; $^1$H NMR (400 MHz, DMSO-$d_6$) $\delta$: 12.12 (s, 1H), 8.33 (d, J = 8.4 Hz, 2H), 8.27 (d, J = 2.8 Hz, 1H), 7.89 (d, J = 8.5 Hz, 2H), 7.50 (d, J = 8.2 Hz, 1H), 7.22 (d, J = 8.0 Hz, 1H); 7.16 (t, J = 7.6 Hz, 1H), 6.97 (t, J = 7.6 Hz, 1H); $^{13}$C NMR (100 MHz, DMSO-$d_6$) $\delta$: 152.6, 148.3, 137.1, 131.8, 125.9, 124.0, 123.0, 122.9, 121.0, 118.7, 114.8, 112.9; FTIR (film): 3413, 2358, 1524, 1345, 1025, 1005, 749 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{14}$H$_{10}$Na$_2$O$_3$S [M+Na]$^+$: 309.0304. Found: 309.0308.
1-Methyl-3-((3-nitrophenyl)sulfinyl)-1H-indole (3m)

0.72 mmol of TMSCl was used.

Pale yellow oil, 50.4 mg, 84% yield; $^1$H NMR (400 MHz, CDCl$_3$) δ: 8.48 (t, $J$ = 2.0 Hz, 1H), 7.26–7.23 (m, 1H), 8.09 (d, $J$ = 8.7 Hz, 2H), 7.26 (t, $J$ = 8.1 Hz, 1H), 7.07 (t, $J$ = 8.0 Hz, 1H), 3.84 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ: 148.4, 147.6, 137.9, 133.6, 130.6, 129.9, 124.7, 123.8, 123.7, 121.9, 120.1, 119.5, 114.8, 110.5, 33.5; FTIR (film): 3091, 2927, 1526, 1457, 1348, 1037, 731 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{12}$NaN$_2$O$_3$S [M+Na]$^+$: 323.0461. Found: 323.0468.

3-((3-Nitrophenyl)sulfinyl)-1H-indole (3n)

0.72 mmol of TMSCl was used.

Pale yellow oil, 48.6 mg, 85% yield; $^1$H NMR (400 MHz, DMSO-d$_6$) δ: 12.10 (s, 1H), 8.49 (t, $J$ = 2.0 Hz, 1H), 8.31 (ddd, $J$ = 8.2, 2.4, 1.0 Hz, 1H), 8.26 (s, 1H), 7.98 (dt, $J$ = 7.9, 1.3 Hz, 1H), 7.78 (t, $J$ = 8.0 Hz, 1H); 7.49 (d, $J$ = 8.1 Hz, 1H), 7.22–7.14 (m, 2H), 6.99–6.95 (m, 1H); $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ: 148.1, 147.7, 137.0, 131.9, 130.8, 130.7, 124.8, 123.0, 122.9, 121.0, 119.0, 118.7, 114.9, 112.8; FTIR (film): 3414, 2925, 1717, 1351, 1275, 1051, 1025, 1006, 749 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{14}$H$_{10}$NaN$_2$O$_3$S [M+Na]$^+$: 309.0304. Found: 309.0310.

1-Methyl-3-(thiophen-2-ylsulfinyl)-1H-indole (3o)

0.72 mmol of TMSCl was used.
Pale yellow oil, 44.4 mg, 85% yield; $^1$H NMR (400 MHz, CDCl$_3$) δ: 7.58 (d, J = 9.8 Hz, 2H), 7.55 (dd, J = 5.0, 1.2 Hz, 1H), 7.52 (dd, J = 3.7, 1.2 Hz, 1H), 7.37 (d, J = 8.3 Hz, 1H), 7.30 (dd, J = 7.6, 1.0 Hz, 1H), 7.15 (dd, J = 7.5, 1.0 Hz, 1H), 7.09 (dd, J = 5.0, 3.7 Hz, 1H), 3.85 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ: 147.6, 137.8, 131.5, 130.8, 129.5, 127.3, 124.2, 123.4, 121.4, 119.9, 116.6, 110.2, 33.4; FTIR (film): 3096, 2922, 2236, 1516, 1483, 1335, 1036, 907, 729 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{11}$H$_{11}$NOS$_2$[M+Na]$^+$: 284.0174. Found: 284.0172.

3-(Thiophen-2-ylsulfinyl)-1H-indole (3p)

0.72 mmol of TMSCI was used.

Pale yellow oil, 42.5 mg, 86% yield; $^1$H NMR (400 MHz, DMSO-d$_6$) δ: 12.00 (s, 1H), 8.07 (t, J = 3.2 Hz, 1H), 7.85–7.84 (m, 1H), 7.53–7.45 (m, 3H), 7.23–7.04 (m, 3H); $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ: 148.2, 137.0, 131.1, 129.5, 128.8, 127.6, 123.0, 122.8, 120.6, 119.1, 116.7, 112.6; FTIR (film): 3177, 2923, 2851, 2362, 1659, 1422, 1244, 1008, 744 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{12}$H$_9$NaNOS$_2$[M+Na]$^+$: 270.0021. Found: 227.0021.

1-Methyl-3-(methylsulfinyl)-1H-indole (3q)

Pale yellow oil, 20.0 mg, 52% yield; $^1$H NMR (400 MHz, DMSO-d$_6$) δ: 7.92 (s, 1H), 7.88 (d, J = 8.3 Hz, 1H), 7.57 (d, J = 8.3 Hz, 1H), 7.30 (t, J = 7.6 Hz, 1H), 7.20 (t, J = 7.5, 1.0 Hz, 1H), 3.83 (s, 3H), 2.95 (s, 3H); $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ: 137.3, 130.8, 123.9, 122.7, 120.7, 119.2, 115.9, 111.0, 40.5, 32.9; FTIR (film): 3401, 2360, 1562, 1519, 1264, 1023, 1000, 746 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{10}$H$_{11}$NaNOS[M+Na]$^+$: 216.0454. Found: 216.0457.
3-(Methylsulfinyl)-1H-indole (3r)

Pale yellow oil, 21.1 mg, 59% yield; \(^1\)H NMR (400 MHz, DMSO-\(d_6\)) \(\delta\): 11.85 (s, 1H), 7.90 (s, 1H), 7.88 (d, \(J = 8.0\) Hz, 1H), 7.51 (d, \(J = 8.2\) Hz, 1H), 7.23 (t, \(J = 7.6\) Hz, 1H), 7.15 (t, \(J = 7.5\), 1H), 2.96 (s, 3H); \(^13\)C NMR (100 MHz, DMSO-\(d_6\)) \(\delta\): 136.8, 127.1, 123.6, 122.6, 120.4, 119.0, 116.9, 112.6, 40.3; FTIR (film): 3419, 2359, 1652, 1023, 1003, 751 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_9\)H\(_9\)NaNO\(_2\)S [M+Na]+: 202.0297. Found: 202.0302.

5-Methoxy-1-methyl-3-((p-tolyl)sulfinyl)-1H-indole (3s)

White solid, m.p. = 147–149 °C; 52.1 mg, 87% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.62 (d, \(J = 8.2\) Hz, 2H), 7.42 (s, 1H), 7.29 (d, \(J = 7.7\) Hz, 2H), 7.20 (d, \(J = 8.9\) Hz, 1H), 6.89 (dd, \(J = 8.9, 2.4\) Hz, 1H), 6.85 (d, \(J = 2.3\) Hz, 1H), 3.77 (s, 3H), 3.68 (s, 3H), 2.40 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 155.0, 140.7, 140.2, 132.8, 132.7, 129.4, 125.0, 124.9, 115.8, 113.7, 110.8, 101.0, 55.4, 33.4, 21.2; FTIR (film): 3457, 3094, 2921, 1513, 1491, 1462, 1371, 1061, 1034, 1014, 976, 809, 790, 635 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{17}\)H\(_{17}\)NaNO\(_2\)S [M+Na]+: 322.0872. Found: 322.0869.

5-Methoxy-3-((p-tolyl)sulfinyl)-1H-indole (3t)

Yellow solid, m.p. = 120–122 °C; 53.0 mg, 93% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.64 (s, 1H), 7.55 (d, \(J = 8.2\) Hz, 2H), 7.27 (d, \(J = 8.1\) Hz, 2H), 7.15 (d, \(J = 3.0\) Hz, 1H), 7.08 (d, \(J = 8.8\) Hz, 1H), 6.74–6.70 (m, 2H), 3.55 (s, 3H), 2.38 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 154.8, 140.5, 139.8, 131.9, 130.2, 129.6, 124.9, 124.1, 115.5, 113.7, 113.2, 100.4, 55.3, 21.2; FTIR (film): 3156, 2926, 2830, 1585, 1487, 1466, 1438, 1294, 1208.
1172, 1022, 1001, 808, 631 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{18}\)H\(_{15}\)NaNO\(_2\)S [M+Na]\(^+\): 308.0716. Found: 308.0714.

7-Methoxy-1-methyl-3-(p-tolylsulfinyl)-1H-indole (3u)

Pale yellow oil, 49.1 mg, 82% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.58 (d, \(J = 8.2\) Hz, 2H), 7.32 (s, 1H), 7.26 (d, \(J = 8.0\) Hz, 2H), 7.03 (dd, \(J = 8.1, 0.8\) Hz, 1H), 6.94 (t, \(J = 7.9\) Hz, 1H), 6.62 (d, \(J = 7.7\) Hz, 1H), 4.05 (s, 3H), 3.88 (s, 3H), 3.23 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 147.9, 141.0, 140.2, 133.2, 129.5, 127.4, 126.8, 124.9, 122.0, 116.3, 112.2, 103.8, 55.3, 37.2, 21.2; FTIR (film): 3424, 3099, 2922, 2850, 1578, 1493, 1415, 1370, 1322, 1260, 1171, 1103, 1036, 810, 779, 732 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{17}\)H\(_{15}\)NaNO\(_2\)S [M+Na]\(^+\): 322.0875. Found: 322.0876.

7-Methoxy-3-(p-tolylsulfinyl)-1H-indole (3v)

Yellow solid, m.p. = 120–123 °C; 49.6 mg, 87% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.03 (s, 1H), 7.64 (d, \(J = 8.2\) Hz, 2H), 7.43 (d, \(J = 2.9\) Hz, 1H), 7.24 (d, \(J = 8.0\) Hz, 2H), 7.00–6.91 (m, 3H), 6.59 (d, \(J = 7.5\) Hz, 1H), 3.81 (s, 3H), 2.36 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 146.4, 140.6, 140.3, 129.5, 129.5, 127.5, 127.5, 125.0, 124.9, 121.9, 117.6, 111.9, 103.1, 55.2, 21.2; FTIR (film): 3110, 2920, 2850, 1581, 1493, 1424, 1255, 1099, 1002, 780, 731 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{18}\)H\(_{16}\)NaNO\(_2\)S [M+Na]\(^+\): 322.0875. Found: 322.0875.

4-Bromo-1-methyl-3-(p-tolylsulfinyl)-1H-indole (3w)

Pale yellow oil, 21.6 mg, 31% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.64 (d, \(J = 7.7\) Hz, 2H), 7.38–7.36 (m, 2H), 7.30–7.25 (m, 3H), 7.18 (t, \(J = 7.7\)Hz, 1H), 3.77 (s, 3H), 2.38 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 142.5,
4-Bromo-3-(p-tolylsulfanyl)-1H-indole (3x)

Pale yellow oil, 28.0 mg, 42% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 10.93 (s, 1H), 7.58 (d, $J = 8.2$ Hz, 2H), 7.30–7.26 (m, 3H), 7.23 (d, $J = 8.0$ Hz, 1H), 7.01 (d, $J = 1.0$ Hz, 1H), 6.98 (l, $J = 7.9$ Hz, 1H), 2.43 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.3, 140.8, 137.8, 129.7, 128.9, 125.8, 125.2, 124.7, 123.9, 118.3, 112.3, 111.8, 21.3; FTIR (film): 2924, 2853, 2366, 1616, 1490, 1178, 1123, 1008, 683 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{15}$H$_{14}$NaBrNO$_2$S [M+Na]$^+$: 369.9872. Found: 369.9875.

5-Bromo-1-methyl-3-(p-tolylsulfanyl)-1H-indole (3y)

White solid, m.p. = 142–144 °C; 43.7 mg, 63% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.65 (s, 1H), 7.59 (d, $J = 7.8$ Hz, 2H), 7.44 (s, 1H), 7.34–7.29 (m, 3H), 7.18 (d, $J = 8.5$ Hz, 1H), 3.78 (s, 3H), 2.41 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 140.6, 140.5, 136.3, 133.1, 129.6, 126.2, 125.8, 124.6, 122.2, 116.4, 114.7, 111.5, 33.4, 21.2; FTIR (film): 3444, 2922, 1619, 1513, 1486, 1448, 1219, 1132, 1031, 1014, 809 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{16}$H$_{14}$NaBrNO$_2$S [M+Na]$^+$: 355.9715. Found: 355.9711.
5-Bromo-3-(p-tolylsulfinyl)-1H-indole (3z)

Yellow solid, m.p. = 125–127 °C; 60.0 mg, 90% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 11.08 (s, 1H), 7.52 (d, \(J = 8.2\) Hz, 2H), 7.49 (d, \(J = 1.5\) Hz, 1H), 7.29 (d, \(J = 8.1\) Hz, 2H), 7.17 (d, \(J = 2.9\) Hz, 1H), 7.15 (dd, \(J = 8.7, 1.8\) Hz, 1H), 7.03 (d, \(J = 8.7\) Hz, 1H), 2.40 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 141.0, 139.1, 135.8, 130.7, 129.9, 126.3, 124.9, 124.7, 121.5, 115.4, 114.6, 114.1, 21.3; FTIR (film): 3145, 2920, 2870, 1492, 1453, 1412, 1295, 1112, 1080, 1021, 1002, 885, 806, 732 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{15}\)H\(_{12}\)BrNOS [M+Na]\(^{+}\): 355.9715. Found: 355.9713.

6-Chloro-1-methyl-3-(p-tolylsulfinyl)-1H-indole (3aa)

Yellow solid, m.p. = 134–136 °C; 36.7 mg, 60% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.59 (d, \(J = 8.1\) Hz, 2H), 7.49 (s, 1H), 7.37 (d, \(J = 8.6\) Hz, 1H), 7.33 (d, \(J = 1.5\) Hz, 1H), 7.29 (d, \(J = 8.0\) Hz, 2H), 7.06 (dd, \(J = 8.6, 1.6\) Hz, 1H), 3.78 (s, 3H), 2.40 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 140.7, 140.5, 138.1, 133.0, 129.5, 129.3, 124.7, 122.7, 121.9, 120.7, 117.2, 110.1, 33.3, 21.2; FTIR (film): 3484, 3101, 2922, 1608, 1514, 1491, 1460, 1331, 1174, 1080, 1070, 1035, 1014, 829, 807, 648 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{16}\)H\(_{14}\)ClNOS [M+Na]\(^{+}\): 326.0377. Found: 326.0379.

6-Chloro-3-(p-tolylsulfinyl)-1H-indole (3ab)

Yellow solid, m.p. = 119–121 °C; 41.1 mg, 71% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.28 (s, 1H), 7.53 (d, \(J = 8.1\) Hz, 2H), 7.30–7.26 (m, 3H), 7.24 (d, \(J = 8.6\) Hz, 1H), 7.18 (d, \(J = 1.0\) Hz, 1H), 6.97 (dd, \(J = 8.6, 1.4\) Hz, 1H), 2.40 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 140.9, 139.7, 137.4, 130.0, 129.8, 129.5, 124.8, 122.2, 121.9, 120.0,
116.9, 112.4, 21.3; FTIR (film): 3151, 3103, 2923, 1666, 1615, 1492, 1443, 1403, 1270, 1081, 1021, 1006, 908, 806, 785 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{15}\)H\(_{12}\)NaClNO[S] [M + Na]\(^+\): 312.0220. Found: 312.0222.

6-Fluoro-1-methyl-3-(p-tolylsulfinyl)-1H-indole (3ac)

White solid, m.p. = 143–145 °C; 40.2 mg, 70% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.60 (d, \(J = 8.1\) Hz, 2H), 7.49 (s, 1H), 7.38 (dd, \(J = 8.8, 5.2\) Hz, 1H), 7.29 (d, \(J = 8.1\) Hz, 2H), 7.01 (dd, \(J = 9.3, 2.0\) Hz, 1H), 6.85 (dt, \(J = 9.3, 2.1\) Hz, 1H), 3.78 (s, 3H), 2.41 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 160.3 (d, \(J_{C-F} = 241.0\) Hz), 140.8, 140.5, 138.0 (d, \(J_{C-F} = 11.9\) Hz), 132.9, 129.6, 124.8, 121.0 (d, \(J_{C-F} = 10.1\) Hz), 120.6, 117.1 (d, \(J_{C-F} = 3.0\) Hz), 110.2 (d, \(J_{C-F} = 24.7\) Hz), 96.7 (d, \(J_{C-F} = 26.5\) Hz), 33.4, 21.2; FTIR (film): 3440, 3102, 2923, 2853, 1622, 1583, 1516, 1491, 1462, 1335, 1244, 1098, 1033, 1014, 897, 828, 808, 689 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{16}\)H\(_{13}\)FNO[S] [M + Na]\(^+\): 310.0672. Found: 310.0675.

6-Fluoro-3-(p-tolylsulfinyl)-1H-indole (3ad)

Yellow solid, m.p. = 102–104 °C; 45.9 mg, 84% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.78 (s, 1H), 7.53 (d, \(J = 8.1\) Hz, 2H), 7.28 (d, \(J = 8.0\) Hz, 2H), 7.24–7.21 (m, 2H), 6.85 (dd, \(J = 9.3, 1.9\) Hz, 1H), 6.73 (dt, \(J = 9.3, 2.1\) Hz, 1H), 2.39 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 160.2 (d, \(J_{C-F} = 240.5\) Hz), 140.8, 139.5, 137.4 (d, \(J_{C-F} = 12.5\) Hz), 130.3 (d, \(J_{C-F} = 2.5\) Hz), 129.8, 124.8, 120.0 (d, \(J_{C-F} = 10.0\) Hz), 119.7, 116.2, 110.3 (d, \(J_{C-F} = 24.7\) Hz), 98.9 (d, \(J_{C-F} = 26.2\) Hz), 21.3; FTIR (film): 3128, 3091, 3060, 2920, 1626, 1592, 1513, 1448, 1417, 1340, 1240, 1145, 1022, 1002, 950, 805, 615 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{15}\)H\(_{12}\)NaFNS [M + Na]\(^+\): 296.0516. Found: 296.0514.
1,2-Dimethyl-3-(p-tolylsulfinyl)-1H-indole (3ae)

![Chemical structure of 1,2-Dimethyl-3-(p-tolylsulfinyl)-1H-indole (3ae)](image)

White solid, m.p. = 128–130 °C; 48.1 mg, 85% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.53 (d, $J = 8.2$ Hz, 2H), 7.30–7.23 (m, 4H), 7.16 (t, $J = 7.7$ Hz, 1H), 6.98 (t, $J = 7.5$ Hz, 1H), 3.68 (s, 3H), 2.68 (s, 3H), 2.37 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 142.3, 141.1, 139.6, 137.1, 129.4, 124.7, 123.9, 122.3, 121.1, 119.3, 112.6, 109.3, 29.6, 21.1, 10.9; FTIR (film): 3049, 2918, 1526, 1474, 1399, 1037, 1015, 760, 740 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{17}$H$_{17}$NaNO$_3$ [M+Na]$^+$: 306.092 3. Found: 306.0925.

2-Methyl-3-(p-tolylsulfinyl)-1H-indole (3af)

![Chemical structure of 2-Methyl-3-(p-tolylsulfinyl)-1H-indole (3af)](image)

Yellow solid, m.p. = 120–122 °C; 47.4 mg, 88% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 9.99 (s, 1H), 7.54 (d, $J = 8.1$ Hz, 2H), 7.28 (d, $J = 7.5$ Hz, 2H), 7.19 (t, $J = 7.7$ Hz, 2H), 6.92 (d, $J = 7.6$ Hz, 1H), 6.92 (t, $J = 7.6$ Hz, 1H), 6.82 (t, $J = 7.6$ Hz, 1H), 5.31 (s, 2H), 2.40 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 142.3, 140.1, 140.0, 135.8, 129.6, 124.8, 124.3, 122.5, 121.0, 118.9, 111.7, 111.4, 21.2, 11.6; FTIR (film): 3178, 3103, 2924, 1618, 1490, 1451, 1409, 1082, 1003, 923, 808, 743 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{16}$H$_{15}$NaNO$_3$ [M+Na]$^+$: 292.0767. Found: 292.0763.

1-Benzyl-3-(p-tolylsulfinyl)-1H-indole (3ag)

![Chemical structure of 1-Benzyl-3-(p-tolylsulfinyl)-1H-indole (3ag)](image)

White solid, m.p. = 140–142 °C; 48.3 mg, 70% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 7.64 (d, $J = 7.9$ Hz, 2H), 7.59 (s, 1H), 7.49 (d, $J = 8.0$ Hz, 1H), 7.35–7.29 (m, 6H), 7.21 (t, $J = 7.7$ Hz, 1H), 7.17 (d, $J = 7.2$ Hz, 1H), 7.09 (t, $J = 7.5$ Hz, 1H), 5.31 (s, 2H), 2.40 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 140.8, 140.3, 137.3, 135.6, 131.9, 129.5, 128.9, 128.0, 126.9, 124.8, 124.4, 123.3, 121.4, 120.0, 117.2, 110.5, 50.5, 21.2; FTIR (film): 3456, 3031,
2922, 1510, 1455, 1386, 1162, 1080, 1034, 810, 761, 742, 732, 697 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{22}\)H\(_{19}\)NaNOS [M+Na]\(^+\): 368.1080. Found: 368.1084.

4.2 Experimental Procedure of Sulfoxides 7a-7g and 8a-8g

The mixture of an arylsufiniamide (0.2 mmol, 1 equiv.), a pyrrole (0.24 mmol, 1.2 equiv.) and TMSCl (0.36 mmol, 1.8 equiv.) in CH\(_2\)Cl\(_2\) (1.0 mL) was stirred at 0 °C for 10 min (for 7) or 4 h (for 8), then water (5 mL) and dichloromethane (10 mL) were added. The two layers were separated, and the aqueous phase was extracted with dichloromethane (3 × 10 mL). The combined organic extracts were washed by brine, dried over anhydrous Na\(_2\)SO\(_4\), filtered, and concentrated. The residue was purified by flash chromatography on silica gel (100–200 mesh) to afford the desired sulfoxide.

![Reaction diagram]

1-Methyl-2-(p-tolylsulfinyl)-1H-pyrrole (7a)

White solid, m.p. = 47–49 °C; 33.3 mg, 76% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) : 7.43 (d, \(J = 7.9\) Hz, 2H), 7.29 (d, \(J = 7.9\) Hz, 2H), 6.74 (s, 1H), 6.53–6.52 (m, 1H), 6.12 (s, 1H), 3.56 (s, 3H), 2.40 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) : 140.5, 139.6, 129.6, 128.8, 124.8, 117.1, 108.0, 34.6, 21.2; FTIR (film): 2949, 2359, 2342, 1739, 1372, 1274, 1238, 1045, 764, 668 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{12}\)H\(_{13}\)NaNOS [M+Na]\(^+\): 242.0610. Found: 242.0611.

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1-Methyl-2-(phenylsulfinyl)-1H-pyrrole (7b)

Yellow solid, m.p. = 57–59 °C; 22.1 mg, 54% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.55–7.53 (m, 2H), 7.49–7.42 (m, 3H), 6.74 (s, 1H), 6.55 (dd, \(J = 3.7, 1.4\) Hz, 1H), 6.13–6.11 (m, 1H), 3.53 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 143.0, 130.1, 129.4, 129.0, 128.9, 124.8, 117.4, 108.1, 34.6; FTIR (film): 3102, 2926, 1442, 1291, 1082, 1035, 731 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{11}\)H\(_{11}\)NaNOS [M+Na]\(^+\): 228.0454. Found: 228.0457.

2-((4-Chlorophenyl)sulfinyl)-1-methyl-1H-pyrrole (7c)

Pale yellow oil, 33.9 mg, 71% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.49–7.43 (m, 4H), 6.75 (s, 1H), 6.55 (dd, \(J = 3.8, 1.6\) Hz, 1H), 6.13–6.12 (m, 1H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 141.7, 136.4, 129.3, 129.1, 128.9, 126.3, 117.6, 108.2, 34.6; FTIR (film): 3102, 2925, 1571, 1488, 1290, 1222, 1037, 1009, 823, 737 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{11}\)H\(_{10}\)NaClNOS [M+Na]\(^+\): 262.0064. Found: 262.0061.

2-((4-Fluorophenyl)sulfinyl)-1-methyl-1H-pyrrole (7d)

Pale yellow oil, 20.1 mg, 45% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.53 (dd, \(J = 8.6, 5.1\) Hz, 2H), 7.18 (t, \(J = 8.6\) Hz, 2H), 6.76 (s, 1H), 6.52 (dd, \(J = 3.7, 1.4\) Hz, 1H), 6.13–6.12 (m, 1H), 3.56 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 163.8 (d, \(J_{CF} = 250.8\) Hz), 138.5 (d, \(J_{CF} = 3.0\) Hz), 129.3, 129.2, 127.1 (d, \(J_{CF} = 8.7\) Hz), 117.4, 116.2 (d, \(J_{CF} = 22.6\) Hz), 108.2, 34.6; FTIR (film): 3099, 2925, 1588, 1488, 1290, 1222, 1037, 835, 732 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{11}\)H\(_{10}\)NaFNOs [M+Na]\(^+\): 246.0359. Found: 246.0363.
2-(p-Tolylsulfinyl)-1H-pyrrole (7e)

![Chemical Structure](image)

White solid, m.p. = 100–102 °C; 28.3 mg, 69% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.75 (s, 1H), 7.53 (d, \(J = 7.8\) Hz, 2H), 7.28 (d, \(J = 7.8\) Hz, 2H), 6.92 (s, 1H), 6.54 (s, 1H), 6.18 (d, \(J = 2.0\) Hz, 1H), 2.41 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 141.0, 140.0, 129.7, 129.3, 124.9, 124.4, 114.3, 109.0, 21.3; FTIR (film): 3178, 3049, 2936, 2854, 1492, 1081, 1022, 1009, 808, 738 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{11}\)H\(_{11}\)NaClO \([M+Na]^+\): 228.0454. Found: 228.0457.

1-Benzyl-2-(p-tolylsulfinyl)-1H-pyrrole (7f)

Pale yellow oil, 33.6 mg, 57% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.39 (d, \(J = 8.2\) Hz, 2H), 7.24–7.18 (m, 5H), 6.97–6.94 (m, 2H), 6.74–6.73 (m, 1H), 6.51 (dd, \(J = 2.8, 1.7\) Hz, 1H), 6.17 (dd, \(J = 3.7, 2.9\) Hz, 1H), 5.29 (d, \(J = 15.5\) Hz, 1H), 5.12 (d, \(J = 15.5\) Hz, 1H), 2.36 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 140.5, 139.8, 136.6, 131.0, 129.5, 128.5, 127.6, 127.5, 127.3, 124.7, 116.4, 108.8, 50.9, 21.2; FTIR (film): 3031, 2923, 1454, 1287, 1080, 1038, 810, 728 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{18}\)H\(_{17}\)NaClO \([M+Na]^+\): 318.0923. Found: 318.0927.

2-Methyl-5-(p-tolylsulfinyl)-1H-pyrrole (7g)

Pale yellow oil, 28.1 mg, 64% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 10.46 (s, 1H), 7.50 (d, \(J = 7.9\) Hz, 2H), 7.26 (d, \(J = 7.9\) Hz, 2H), 6.48–6.46 (m, 1H), 5.80 (t, \(J = 3.0\) Hz, 1H), 2.39 (s, 3H), 2.12 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 140.7, 140.1, 136.0, 129.6, 126.8, 124.9, 116.0, 107.1, 21.3, 12.9; FTIR (film): 3177, 2924, 2359, 1566, 1274, 1148, 1024, 764 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{12}\)H\(_{13}\)NaClO \([M+Na]^+\): 242.0610. Found: 242.0617.
1-Methyl-3-(p-tolylsulfinyl)-1H-pyrrole (8a)

White solid, m.p. = 84–86 °C; 32.0 mg, 73% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.56 (d, \(J = 8.1\) Hz, 2H), 7.30 (d, \(J = 8.4\) Hz, 2H), 6.98 (s, 1H), 6.61 (d, \(J = 2.3\) Hz, 1H), 6.18 (dd, \(J = 2.6, 1.7\) Hz, 1H), 3.66 (s, 3H), 2.42 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 141.8, 140.2, 129.3, 126.8, 124.4, 124.2, 123.8, 107.3, 36.4, 21.1; FTIR (film): 3452, 3105, 2922, 1673, 1516, 1493, 1420, 1121, 1080, 1034, 1013, 810, 706, 635 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{12}\)H\(_{13}\)NaNO\(_3\)[M+Na]\(^{+}\): 242.0610. Found: 242.0607.

1-Methyl-3-(phenylsulfinyl)-1H-pyrrole (8b)

The reaction was performed for 5 h.

Yellow solid, m.p. = 82–84 °C; 30.0 mg, 73% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.64 (d, \(J = 6.8\) Hz, 2H), 7.48–7.40 (m, 3H), 6.97 (m, 2H), 6.58 (t, \(J = 2.3\) Hz, 1H), 6.14 (dd, \(J = 2.6, 1.6\) Hz, 1H), 3.63 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 145.0, 130.0, 128.7, 126.6, 124.5, 124.0, 107.6, 36.5; FTIR (film): 3445, 3108, 2920, 1670, 1515, 1442, 1419, 1304, 1121, 1081, 1032, 996, 750, 691, 632 cm\(^{-1}\); HRMS (ESI) m/z: Calcd for C\(_{13}\)H\(_{14}\)NaNO\(_3\)[M+Na]\(^{+}\): 228.0454. Found: 228.0452.

3-((4-Chlorophenyl)sulfinyl)-1-methyl-1H-pyrrole (8c)

The reaction was performed for 5 h.

Yellow solid, m.p. = 64–66 °C; 32.0 mg, 67% yield; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\): 7.55 (d, \(J = 8.5\) Hz, 2H), 7.41 (d, \(J = 8.5\) Hz, 2H), 6.98 (s, 1H), 6.58 (t, \(J = 2.4\) Hz, 1H), 6.11 (t, \(J = 2.2\) Hz, 1H), 3.62 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 143.7, 136.0, 128.9, 126.1, 125.9, 124.7, 124.2, 107.4, 36.5; FTIR (film): 3457, 3109, 2923,
2235, 1515, 1472, 1419, 1120, 1077, 1034, 1009, 907, 820, 793, 738, 726, 632 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₁H₁₀NaClNO[S] [M+Na]+: 262.0064. Found: 262.0062.

3-((4-Fluorophenyl)sulfinyl)-1-methyl-1H-pyrrole (8d)

Pale yellow oil, 30.0 mg, 67% yield; ¹H NMR (400 MHz, CDCl₃) δ: 7.64–7.60 (m, 2H), 7.17–7.12 (m, 2H), 6.97 (s, 1H), 6.59 (t, J = 2.4 Hz, 1H), 6.12–6.11 (m, 1H), 3.64 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ: 163.7 (d, J_CF = 250.1 Hz), 140.7 (d, J_CF = 3.1 Hz), 126.7 (d, J_CF = 8.7 Hz), 126.5, 124.5, 124.1, 115.9 (d, J_CF = 22.6 Hz), 107.4, 36.5; FTIR (film): 3443, 3109, 2922, 1673, 1558, 1516, 1489, 1420, 1220, 1152, 1121, 1080, 1032, 1010, 835, 812, 635 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₁H₁₀NaFNO[S] [M+Na]+: 246.0359. Found: 262.0362.

3-(p-Tolylsulfinyl)-1H-pyrrole (8e)

White solid, m.p. = 150–152 °C; 25.4 mg, 62% yield; ¹H NMR (400 MHz, CDCl₃) δ: 10.06 (s, 1H), 7.53 (d, J = 8.1 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 7.05 (d, J = 1.1 Hz, 1H), 6.69 (d, J = 1.7 Hz, 1H), 6.16 (s, 1H), 2.42 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ: 141.3, 140.6, 129.5, 124.7, 121.8, 121.8, 120.5, 106.6, 21.3; FTIR (film): 3189, 3050, 2922, 2850, 1491, 1082, 1042, 1021, 1008, 808, 636 cm⁻¹; HRMS (ESI) m/z: Calcd for C₁₁H₁₀NaFNO[S] [M+Na]+: 228.0454. Found: 228.0456.

1-Benzyl-3-(p-tolylsulfinyl)-1H-pyrrole (8f)

White solid, m.p. = 103–105 °C; 36.0 mg, 61% yield; ¹H NMR (400 MHz, CDCl₃) δ: 7.56 (d, J = 8.1 Hz, 2H), 7.38–7.32 (m, 3H), 7.29 (d, J = 8.0 Hz, 1H), 7.15–7.13 (m, 2H), 7.08 (t, J = 1.8 Hz, 1H), 6.67 (t, J = 2.5 Hz, 1H), 527

The reaction was performed for 5 h.

White solid, m.p. = 103–105 °C; 36.0 mg, 61% yield; ¹H NMR (400 MHz, CDCl₃) δ: 7.56 (d, J = 8.1 Hz, 2H), 7.38–7.32 (m, 3H), 7.29 (d, J = 8.0 Hz, 1H), 7.15–7.13 (m, 2H), 7.08 (t, J = 1.8 Hz, 1H), 6.67 (t, J = 2.5 Hz, 1H), 527
6.19 (dd, $J = 2.8$, 1.8 Hz, 1H), 5.03 (s, 2H), 2.41 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.9, 140.3, 136.1, 129.4, 128.8, 128.0, 127.2, 127.1, 124.5, 123.8, 123.3, 107.5, 53.7, 21.2; FTIR (film): 3449, 3106, 3031, 2922, 1505, 1454, 1397, 1114, 1080, 1031, 1014, 907, 809, 708, 634 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{18}$H$_{17}$NaNOS [M+Na]$^+$: 318.0923. Found: 318.0920.

**2-Methyl-4-(p-tolylsulfinyl)-1H-pyrrole (8g)**

![Methyl-4-(p-tolylsulfinyl)-1H-pyrrole](image)

0.72 mmol of TMSCI was used for 12 h.

Pale yellow oil, 31.1 mg, 71% yield; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$: 10.13 (s, 1H), 7.47 (d, $J = 8.1$ Hz, 2H), 7.25 (d, $J = 7.6$ Hz, 2H), 6.45–6.43 (m, 1H), 5.89–5.87 (m, 1H), 2.38 (s, 3H), 2.32 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$: 141.3, 140.1, 133.6, 129.5, 124.6, 118.3, 106.6, 103.6, 21.3, 11.0; FTIR (film): 3187, 3101, 2959, 2857, 1492, 1205, 1082, 1005, 808, 729 cm$^{-1}$; HRMS (ESI) m/z: Calcd for C$_{12}$H$_{13}$NaNOS [M+Na]$^+$: 242.0610. Found: 242.0615.
5. NMR Spectra of Sulfanamides and Sulfoxides

Sulfanamide 1a

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1b

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1c

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1d

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1e

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1f

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1g

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1h

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1i

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfinamide 1j

$^1$H NMR (400 MHz, CDCl₃)

$^{13}$C NMR (100 MHz, CDCl₃)
Sulfinamide 1k

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
**Sulfinamide 11**

\(^1\)H NMR (400 MHz, CDCl\(_3\))

\[^{13}\)C NMR (100 MHz, CDCl\(_3\))
Sulfoxide 3a

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3b

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3c

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)

ppm (H)

ppm (C)
Sulfoxide 3d

$^1$H NMR (400 MHz, DMSO-$d_6$)

$^{13}$C NMR (100 MHz, DMSO-$d_6$)
Sulfoxide 3e

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3f

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3g

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3h

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3i

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3j

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3k

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3i

$^{1}H$ NMR (400 MHz, DMSO-$d_6$)

$^{13}C$ NMR (100 MHz, CDCl$_3$)
Sulfoxide 3m

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3n

$^1$H NMR (400 MHz, DMSO-$d_6$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3o

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
**Sulfoxide 3p**

$^1$H NMR (400 MHz, DMSO-$d_6$)

$^{13}$C NMR (100 MHz, DMSO-$d_6$)
Sulfoxide 3q

$^1$H NMR (400 MHz, DMSO-$d_6$)

$^{13}$C NMR (100 MHz, DMSO-$d_6$)
Sulfoxide 3r

$^1$H NMR (400 MHz, DMSO-$d_6$)

$^{13}$C NMR (100 MHz, DMSO-$d_6$)
Sulfoxide 3s

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
**Sulfoxide 3t**

**$^1$H NMR (400 MHz, CDCl$_3$)**

![NMR spectrum of sulfoxide 3t](image)

**$^{13}$C NMR (100 MHz, CDCl$_3$)**

![NMR spectrum of sulfoxide 3t](image)
Sulfoxide 3u

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3v

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3w

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3x

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3y

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3z

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3aa

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3ab

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide \(3\text{ac}\)

\(^1\text{H NMR (400 MHz, CDCl}_3\)
Sulfoxide 3ad

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3ae

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3af

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 3ag

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 7a

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 7b

$^1$H NMR (400 MHz, CDCl$_3$)

13C NMR (100 MHz, CDCl$_3$)
**Sulfoxide 7c**

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 7e

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 7f

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
**Sulfoxide 7g**

$^1$H NMR (400 MHz, CDCl₃)

$^{13}$C NMR (100 MHz, CDCl₃)
Sulfoxide 8a

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8b

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8c

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8d

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8e

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8f

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
Sulfoxide 8g

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (100 MHz, CDCl$_3$)
6. References

