

A four-component reaction of aryldiazonium tetrafluoroborates, sulfur dioxide, 1,2-dibromoethane, and hydrazines

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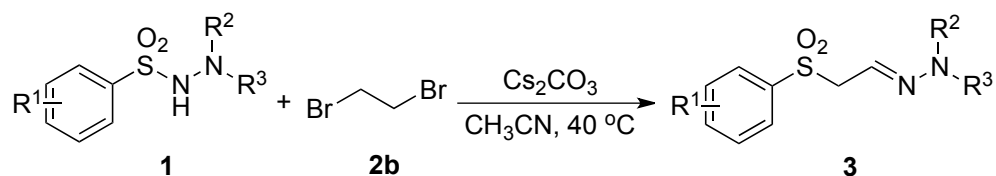
Supporting Information

1. General experimental methods (S2).
2. General experimental procedure and characterization data (S2-S9).
3. ¹H and ¹³C NMR spectra of compounds **3** (S10 –S45).

General experimental methods:

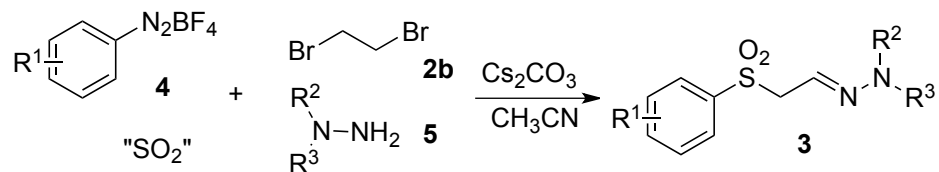
Unless otherwise stated, all commercial reagents were used as received. All solvents were dried and distilled according to standard procedures. Flash column chromatography was performed using silica gel (60-Å pore size, 32–63µm, standard grade). Analytical thin-layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Thin layer chromatography plates were visualized by exposure to ultraviolet light. Organic solutions were concentrated on rotary evaporators at ~20 Torr at 25–35°C. Nuclear magnetic resonance (NMR) spectra are recorded in parts per million from internal tetramethylsilane on the δ scale. ^1H and ^{13}C NMR spectra were recorded in CDCl_3 on a Bruker DRX-400 spectrometer operating at 400 MHz and 100 MHz, respectively. All chemical shift values are quoted in ppm and coupling constants quoted in Hz. High resolution mass spectrometry (HRMS) spectra were obtained on a micrOTOF II Instrument.

*General experimental procedure for the reaction of N-aminosulfonamides **1** with 1,2-dibromoethane **2b***

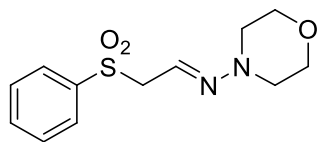


Dihaloalkane **2** (5 equiv.) and Cs_2CO_3 (0.6 mmol, 2.0 equiv.) were added to a solution of N-aminosulfonamide **1** (0.3mmol) in CH_3CN (2.0 mL). The mixture was stirred at 40°C for 10-15 hours. After completion of reaction as indicated by TLC, the mixture was directly purified by flash column chromatograph ($\text{EtOAc}/n\text{-hexane}$, 1:1) to give the desired product **3**.

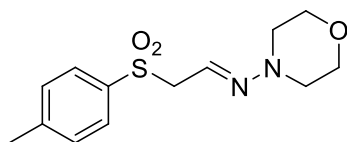
General experimental procedure for the one-pot synthesis of 2-arylsulfonyl hydrazones



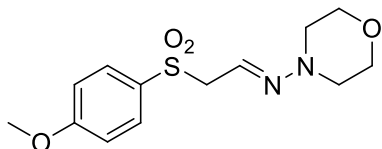
Aryldiazonium tetrafluoroborate **4** (0.30 mmol) in CH₃CN (1.0 mL) was added dropwisely to a solution of DABCO•(SO₂)₂ (0.18 mmol) and hydrazine **5** (0.36 mmol) in CH₃CN (2.0 mL) under N₂ in 10 minutes. The mixture was stirred at room temperature for another 10 minutes. Then 1,2-dibromoethane **2b** (5 equiv.) and Cs₂CO₃ (3 equiv.) were added to the above mixture. The mixture was stirred at 80 °C for 5h. After completion of reaction as indicated by TLC, the mixture was directly purified by flash column chromatograph (EtOAc/*n*-hexane, 1:1) to give the desired product **3**.



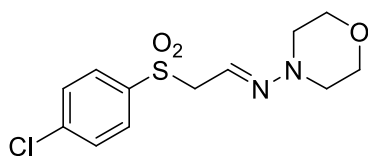
(*E*)-*N*-(2-(Phenylsulfonyl)ethylidene)morpholin-4-amine (**3a**): ^1H NMR (400 MHz, CDCl_3) δ 7.86 (d, $J = 7.2$ Hz, 2H), 7.66 (t, $J = 7.2$ Hz, 1H), 7.56 (t, $J = 7.6$ Hz, 1H), 6.74 (t, $J = 5.6$ Hz, 1H), 4.02 (d, $J = 6.0$ Hz, 2H), 3.76 (t, $J = 4.8$ Hz, 4H), 2.90 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 138.4, 133.8, 129.0, 128.4, 124.2, 66.0, 60.1, 51.2; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{17}\text{N}_2\text{O}_3\text{S}$: 269.0954 ($\text{M} + \text{H}^+$), found: 269.0964.



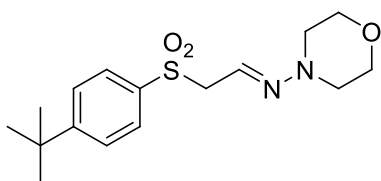
(*E*)-*N*-(2-Tosylethylidene)morpholin-4-amine (**3b**): ^1H NMR (400 MHz, CDCl_3) δ 7.73 (d, $J = 8.4$ Hz, 2H), 7.34 (d, $J = 8.0$ Hz, 2H), 6.74 (t, $J = 5.6$ Hz, 1H), 3.99 (d, $J = 5.6$ Hz, 2H), 3.76 (t, $J = 4.8$ Hz, 4H), 2.91 (t, $J = 4.8$ Hz, 4H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 144.8, 135.6, 129.6, 128.4, 124.6, 66.0, 60.1, 51.2, 21.6; HRMS (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_3\text{S}$: 283.1111 ($\text{M} + \text{H}^+$), found: 283.1115.



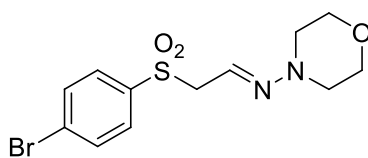
(*E*)-*N*-(2-(4-Methoxyphenylsulfonyl)ethylidene)morpholin-4-amine (**3c**): ^1H NMR (400 MHz, CDCl_3) δ 7.77 (d, $J = 8.4$ Hz, 2H), 7.00 (d, $J = 8.8$ Hz, 2H), 6.75 (t, $J = 5.6$ Hz, 1H), 3.99 (d, $J = 5.6$ Hz, 2H), 3.88 (s, 3H), 3.77 (t, $J = 4.8$ Hz, 4H), 2.93 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 163.8, 130.5, 130.0, 124.8, 114.2, 66.0, 60.3, 55.6, 51.3; HRMS (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_4\text{S}$: 299.1060 ($\text{M} + \text{H}^+$), found: 299.1051.



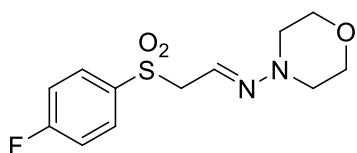
(*E*)-*N*-(2-(4-Chlorophenylsulfonyl)ethylidene)morpholin-4-amine (**3d**): ^1H NMR (400 MHz, CDCl_3) δ 7.80 (d, $J = 8.4$ Hz, 2H), 7.54 (d, $J = 8.4$ Hz, 2H), 6.74 (t, $J = 5.6$ Hz, 1H), 4.01 (d, $J = 5.6$ Hz, 2H), 3.79 (t, $J = 4.8$ Hz, 4H), 2.93 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 140.5, 136.9, 129.9, 129.3, 123.7, 66.0, 60.1, 51.2; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{ClN}_2\text{O}_3\text{S}$: 303.0565 ($\text{M} + \text{H}^+$), found: 303.0557.



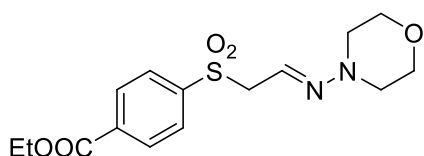
(*E*)-*N*-(2-(4-tert-Butylphenylsulfonyl)ethylidene)morpholin-4-amine (**3e**): ^1H NMR (400 MHz, CDCl_3) δ 7.78 (d, $J = 8.8$ Hz, 2H), 7.56 (d, $J = 8.4$ Hz, 2H), 6.76 (t, $J = 5.6$ Hz, 1H), 4.01 (d, $J = 5.6$ Hz, 2H), 3.76 (t, $J = 4.8$ Hz, 4H), 2.91 (t, $J = 4.8$ Hz, 4H), 1.34 (s, 9H); ^{13}C NMR (100 MHz, CDCl_3) δ 157.7, 135.4, 128.3, 126.0, 124.6, 66.0, 60.1, 51.2, 35.2, 31.0; HRMS (ESI) calcd for $\text{C}_{16}\text{H}_{25}\text{N}_2\text{O}_3\text{S}$: 325.1580 ($\text{M} + \text{H}^+$), found: 325.1584.



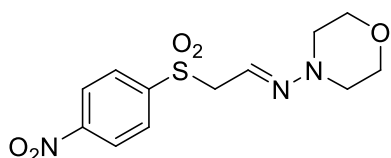
(*E*)-*N*-(2-(4-Bromophenylsulfonyl)ethylidene)morpholin-4-amine (**3f**): ^1H NMR (400 MHz, CDCl_3) δ 7.68-7.75 (m, 4H), 6.73 (t, $J = 5.6$ Hz, 1H), 4.02 (d, $J = 6.0$ Hz, 2H), 3.78 (t, $J = 4.8$ Hz, 4H), 2.93 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 137.4, 133.0, 132.3, 130.0, 123.7, 66.0, 60.0, 51.2; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{BrN}_2\text{O}_3\text{S}$: 347.0060 ($\text{M} + \text{H}^+$), found: 347.0067.



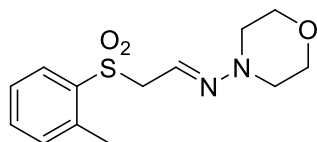
(*E*)-*N*-(2-(4-Fluorophenylsulfonyl)ethylidene)morpholin-4-amine (**3g**): ^1H NMR (400 MHz, CDCl_3) δ 7.86-7.89 (m, 2H), 7.22-7.27 (m, 2H), 6.74 (t, $J = 5.6$ Hz, 1H), 4.02 (d, $J = 5.6$ Hz, 2H), 3.78 (t, $J = 4.8$ Hz, 4H), 2.92 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 165.8 (d, $J_{\text{F}} = 255.2$ Hz), 134.4, 131.3 (d, $J_{\text{F}} = 9.5$ Hz), 123.9, 116.3 (d, $J_{\text{F}} = 22.6$ Hz), 66.0, 60.1, 51.2; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{FN}_2\text{O}_3\text{S}$: 278.0860 ($\text{M} + \text{H}^+$), found: 278.0864.



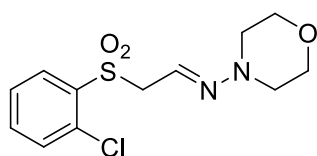
(*E*)-Ethyl 4-(2-(Morpholinoimino)ethylsulfonyl)benzoate (**3h**): ^1H NMR (400 MHz, CDCl_3) δ 8.21 (d, $J = 8.4$ Hz, 2H), 7.93 (d, $J = 8.8$ Hz, 2H), 6.73 (t, $J = 5.6$ Hz, 1H), 4.42 (m, 2H), 4.05 (d, $J = 5.6$ Hz, 2H), 3.76 (t, $J = 4.8$ Hz, 4H), 2.90 (t, $J = 4.8$ Hz, 4H), 1.42 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 164.9, 142.1, 135.2, 130.0, 128.5, 123.5, 65.9, 61.8, 59.9, 51.2, 14.1; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{FN}_2\text{O}_3\text{S}$: 341.1166 ($\text{M} + \text{H}^+$), found: 341.1162.



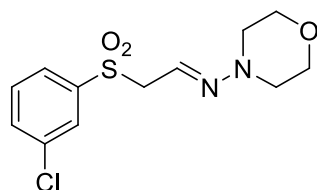
(*E*)-*N*-(2-(4-Nitrophenylsulfonyl)ethylidene)morpholin-4-amine (**3i**): ^1H NMR (400 MHz, CDCl_3) δ 8.42 (d, $J = 8.0$ Hz, 2H), 8.06 (d, $J = 8.0$ Hz, 2H), 6.74 (t, $J = 5.6$ Hz, 1H), 4.09 (d, $J = 6.0$ Hz, 2H), 3.78 (t, $J = 4.8$ Hz, 4H), 2.92 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 144.0, 130.0, 129.3, 124.1, 122.6, 65.9, 59.8, 51.1; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{N}_3\text{O}_5\text{S}$: 314.0805 ($\text{M} + \text{H}^+$), found: 314.0797.



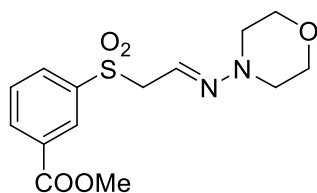
(*E*)-*N*-(2-(*o*-Tolylsulfonyl)ethylidene)morpholin-4-amine (**3j**): ^1H NMR (400 MHz, CDCl_3) δ 7.93 (d, $J = 8.0$ Hz, 1H), 7.52 (t, $J = 7.6$ Hz, 1H), 7.33-7.37 (m, 2H), 6.71 (t, $J = 5.6$ Hz, 1H), 4.07 (d, $J = 6.0$ Hz, 2H), 3.74 (t, $J = 4.8$ Hz, 4H), 2.85 (t, $J = 4.8$ Hz, 4H), 2.71 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 138.3, 136.7, 133.7, 132.5, 130.5, 126.2, 124.3, 65.9, 59.3, 51.2, 20.4; HRMS (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_3\text{S}$: 283.1111 ($\text{M} + \text{H}^+$), found: 283.1113.



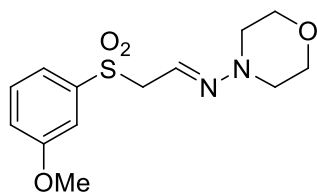
(*E*)-*N*-(2-(2-Chlorophenylsulfonyl)ethylidene)morpholin-4-amine (**3k**): ^1H NMR (400 MHz, CDCl_3) δ 8.05 (d, $J = 8.0$ Hz, 1H), 7.55-7.60 (m, 2H), 7.43-7.48 (m, 1H), 6.69 (t, $J = 5.6$ Hz, 1H), 4.34 (d, $J = 6.0$ Hz, 2H), 3.73 (t, $J = 4.8$ Hz, 4H), 2.84 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 134.7, 133.1, 132.0, 131.7, 127.0, 123.6, 65.9, 58.0, 51.1; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{ClN}_2\text{O}_3\text{S}$: 303.0565 ($\text{M} + \text{H}^+$), found: 303.0561.



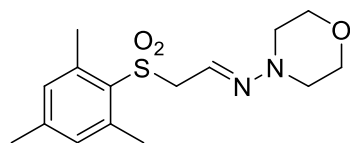
(*E*)-*N*-(2-(3-Chlorophenylsulfonyl)ethylidene)morpholin-4-amine (**3l**): ^1H NMR (400 MHz, CDCl_3) δ 7.83 (t, $J = 2.0$ Hz, 1H), 7.75 (d, $J = 8.0$ Hz, 1H), 7.61-7.64 (m, 1H), 7.51 (t, $J = 8.0$ Hz, 1H), 6.73 (t, $J = 5.6$ Hz, 1H), 4.03 (d, $J = 6.0$ Hz, 2H), 3.78 (t, $J = 4.8$ Hz, 4H), 2.93 (t, $J = 4.8$ Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 140.0, 135.2, 133.9, 130.3, 128.6, 126.5, 123.4, 66.0, 60.0, 51.2; HRMS (ESI) calcd for $\text{C}_{12}\text{H}_{16}\text{ClN}_2\text{O}_3\text{S}$: 303.0565 ($\text{M} + \text{H}^+$), found: 303.0564.



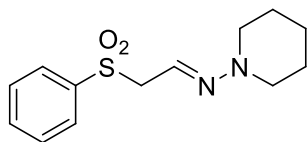
(*E*)-Methyl 3-(2-(Morpholinoimino)ethylsulfonyl)benzoate (**3m**): ^1H NMR (400 MHz, CDCl_3) δ 8.50 (t, J = 1.6 Hz, 1H), 8.30-8.33 (m, 1H), 8.03-8.06 (m, 1H), 7.66 (t, J = 8.0 Hz, 1H), 6.75 (t, J = 5.6 Hz, 1H), 4.04 (d, J = 5.6 Hz, 2H), 3.97 (s, 3H), 3.76 (t, J = 4.8 Hz, 4H), 2.90 (t, J = 4.8 Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 165.1, 138.9, 134.6, 132.4, 131.2, 129.7, 129.3, 123.6, 66.0, 60.0, 52.6, 51.1; HRMS (ESI) calcd for $\text{C}_{14}\text{H}_{19}\text{N}_2\text{O}_5\text{S}$: 327.1009 ($\text{M} + \text{H}^+$), found: 327.1019.



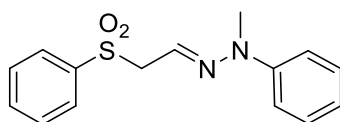
(*E*)-*N*-(2-(3-Methoxyphenylsulfonyl)ethylidene)morpholin-4-amine (**3n**): ^1H NMR (400 MHz, CDCl_3) δ 7.44-7.48 (m, 2H), 7.35 (s, 1H), 7.15-7.18 (m, 1H), 6.75 (t, J = 5.6 Hz, 1H), 4.02 (d, J = 5.6 Hz, 2H), 3.87 (s, 3H), 3.77 (t, J = 4.8 Hz, 4H), 2.93 (t, J = 4.8 Hz, 4H); ^{13}C NMR (100 MHz, CDCl_3) δ 159.8, 139.6, 130.1, 124.2, 120.5, 120.3, 112.7, 66.0, 60.0, 55.6, 51.2; HRMS (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_4\text{S}$: 299.1060 ($\text{M} + \text{H}^+$), found: 299.1062.



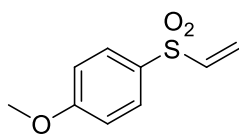
(*E*)-*N*-(2-(Mesitylsulfonyl)ethylidene)morpholin-4-amine (**3o**): ^1H NMR (400 MHz, CDCl_3) δ 6.95 (s, 2H), 6.77 (t, J = 5.6 Hz, 1H), 4.02 (d, J = 5.6 Hz, 2H), 3.76 (t, J = 4.8 Hz, 4H), 2.90 (t, J = 4.8 Hz, 4H), 2.64 (s, 6H), 2.30 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 143.3, 140.1, 132.6, 132.0, 124.2, 66.0, 60.0, 51.1, 23.0, 20.9; HRMS (ESI) calcd for $\text{C}_{15}\text{H}_{23}\text{N}_2\text{O}_3\text{S}$: 311.1424 ($\text{M} + \text{H}^+$), found: 311.1423.



(*E*)-*N*-(2-(Phenylsulfonyl)ethylidene)piperidin-1-amine (**3p**): ^1H NMR (400 MHz, CDCl_3) δ 7.88 (d, $J = 7.2$ Hz, 2H), 7.65 (t, $J = 7.6$ Hz, 1H), 7.56 (t, $J = 7.2$ Hz, 2H), 6.66 (t, $J = 5.6$ Hz, 1H), 4.03 (d, $J = 5.6$ Hz, 2H), 2.91 (t, $J = 5.6$ Hz, 4H), 1.58-1.66 (m, 4H), 1.46-1.50 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 138.6, 133.6, 128.9, 128.4, 122.0, 60.4, 51.5, 24.6, 23.7; HRMS (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_2\text{S}$: 267.1162($\text{M} + \text{H}^+$), found: 267.1167.



(*E*)-1-Methyl-1-phenyl-2-(2-(phenylsulfonyl)ethylidene)hydrazine (**3q**): ^1H NMR (400 MHz, CDCl_3) δ 7.90 (d, $J = 7.2$ Hz, 2H), 7.63 (t, $J = 7.6$ Hz, 1H), 7.54 (t, $J = 8.0$ Hz, 2H), 7.22 (t, $J = 8.0$ Hz, 2H), 6.90-6.95 (m, 3H), 6.65 (t, $J = 5.6$ Hz, 1H), 4.17 (d, $J = 5.6$ Hz, 2H), 3.25 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 147.0, 138.6, 133.6, 129.0, 128.8, 128.4, 121.3, 119.6, 115.6, 60.2, 33.7; HRMS (ESI) calcd for $\text{C}_{15}\text{H}_{17}\text{N}_2\text{O}_2\text{S}$: 289.1005($\text{M} + \text{H}^+$), found: 289.1011.



1-Methoxy-4-(vinylsulfonyl)benzene (**7**): ^1H NMR (400 MHz, CDCl_3) δ 7.82-7.85 (m, 2H), 7.01-7.04 (m, 2H), 6.65 (m, 1H), 6.40 (d, $J = 16.4$ Hz, 1H), 5.98 (d, $J = 10.0$ Hz, 1H), 3.89 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 139.0, 136.9, 130.1, 126.4, 114.5, 55.6; HRMS (ESI) calcd for $\text{C}_9\text{H}_{11}\text{O}_3\text{S}$: 199.0423($\text{M} + \text{H}^+$), found: 199.0429.

