Supplementary Information

Metal-free I$_2$O$_5$-mediated direct construction of sulfonamides from thiols and amines

Minghui Zhu, Wei Wei,* Daoshan Yang, Huanhuan Cui, Leilei Wang, Hua Wang*

The Key Laboratory of Life-Organic Analysis and Key Laboratory of Pharmaceutical Intermediates and Analysis of Natural Medicine, School of Chemistry and Chemical Engineering, Qufu Normal University, Qufu 273165, Shandong, China

*Phone:+86 537 4458317; Fax:+86 537 4458317.
E-mail: weiweiqfnu@163.com; huawang_qfnu@126.com

Contents

1. General information .....................................................S2
2. General procedure for I$_2$O$_5$-mediated direct synthesis of sulfonamides from thiols and amines.................................................................S3
3. Preliminary mechanistic studies ........................................ S3-S4
4. Characterization data of products 3a–3x................................ S5-S10
5. Copies of NMR spectra for 3a–3x........................................ S11-S34
1. General information

All commercially available reagent grade chemicals were purchased from Aldrich, Acros, Alfa Aesar and Beijing Ouhe Chemical Company and used as received without further purification unless otherwise stated. $^1$H NMR, and $^{13}$C NMR were recorded in CDCl$_3$ on a Bruker Avance 500 spectrometer with TMS as internal standard (500 MHz $^1$H, 125 MHz $^{13}$C ) at room temperature, the chemical shifts ($\delta$) were expressed in ppm and $J$ values were given in Hz. The following abbreviations are used to indicate the multiplicity: singlet (s), doublet (d), triplet (t), quartet (q), doublet of doublets (dd), doublet of triplets (dt), and multiplet (m). All first order splitting patterns were assigned on the basis of the appearance of the multiplet. Splitting patterns that could not be easily interpreted were designated as multiplet (m). Mass analyses and HRMS were obtained on a Finnigan-LCQDECA mass spectrometer and a Bruker Daltonics Bio-TOF-Q mass spectrometer by the ESI method, respectively. Column chromatography was performed on silica gel (200-300 mesh).
2. General procedure for I$_2$O$_5$-mediated direct construction of sulfonamides from thiols and amines.

2.1

\[
\begin{align*}
\text{R}^1 \equiv \text{SH} + \text{HN}_2 \equiv \text{R}^2 \equiv \text{R}^3 & \quad \overset{\text{I}_2\text{O}_5 (1 \text{ equiv})}{\text{CH}_3\text{CN, 60}^\circ\text{C, 12 h}}} \quad \text{R}^1 \equiv \text{SO} \equiv \text{N} \equiv \text{R}^2 \equiv \text{R}^3 \\
\end{align*}
\]

In a tube (25ml), arylthiol 1 (0.2 mmol), amine 2 (0.4 mmol), I$_2$O$_5$ (0.2 mmol), and CH$_3$CN (2 mL) were added. Subsequently, the tube was sealed and the reaction vessel was allowed to stir at 60 °C for 12 h. After completion of the reaction, the reaction mixture was concentrated in vacuum. The resulting mixture purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product 3.

2.2. Gram-scale reaction

\[
\begin{align*}
\text{H}_3\text{C} \equiv \text{SH} + \text{HN}_2 \equiv \text{R}^2 \equiv \text{R}^3 & \quad \overset{\text{I}_2\text{O}_5 (1 \text{ equiv})}{\text{CH}_3\text{CN, 60}^\circ\text{C, 12 h}}} \quad \text{H}_3\text{C} \equiv \text{SO} \equiv \text{O} \equiv \text{N} \equiv \text{O} \equiv \text{R}^2 \equiv \text{R}^3 \\
\end{align*}
\]

In a tube (100 ml), 4-methylbenzenethiol 1a (10 mmol), morpholine 2a (20 mmol) I$_2$O$_5$ (10 mmol), and CH$_3$CN (20 mL) were added. Then, the tube was sealed and the reaction vessel was allowed to stir at 60 °C for 12h. After completion of the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product 3a in 81% yield (1.95g).

3. Preliminary mechanistic studies

3.1 The reaction of 4-methylbenzenothiol (2a) with I$_2$O$_5$ (15 min).

\[
\begin{align*}
\text{SH} & \quad \overset{\text{I}_2\text{O}_5 (1 \text{ equiv})}{\text{CH}_3\text{CN, 60}^\circ\text{C, 15 min}}} \quad \text{SS} + \text{4a (40%) + 5a (29%)} \\
\end{align*}
\]

In a seal tube (15 mL), 4-methylbenzenothiol 2a (0.4 mmol), I$_2$O$_5$ (0.2 mmol), and CH$_3$CN (2 mL) were added. Then, the tube was sealed and the reaction vessel was
allowed to stir at 60 °C for 15 min. After completion of the reaction, the solution was concentrated in vacuum, the product 4a and 5a were isolated in 40% and 29% yields, respectively.

3.2 The reaction of 4-methylbenzenethiol (2a) with I$_2$O$_5$ (3h).

In a seal tube (15 mL), 4-methylbenzenethiol 2a (0.4 mmol), I$_2$O$_5$ (0.2 mmol), and CH$_3$CN (2 mL) were added. Then, the tube was sealed and the reaction vessel was allowed to stir at 60 °C for 3h. After completion of the reaction, the solution was concentrated in vacuum, the product 5a was isolated in 62% yield.

3.3 The reaction of 1,2-dip-tolyldisulfane (4a) with I$_2$O$_5$.

In a seal tube (15 mL), 1,2-dip-tolyldisulfane 4a (0.2 mmol), I$_2$O$_5$ (0.2 mmol), and CH$_3$CN (2 mL) were added. Then, the tube was sealed and the reaction vessel was allowed to stir at 60 °C for 3h. After completion of the reaction, the solution was concentrated in vacuum, the product 5a were isolated in 65% yield.

3.4 The reaction of sulfonyl iodide 6a with morpholine 2a.

In a seal tube (15 mL), 4-methylbenzene-1-sulfonyl iodide (0.2 mmol), morpholine 2a (0.4 mmol) and CH$_3$CN (2 mL) were added. The reaction vessel was allowed to stir at 60 °C for 12h. After completion of the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give
the desired product 3a in 86% yield.

4. Characterization data of products

4-tosylmorpholine

Compound 3a was obtained in 82% yield according to the general procedure. 

$^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.66 (d, $J = 8.3$ Hz, 2H), 7.37 (d, $J = 8.0$ Hz, 2H), 3.76 (t, $J = 4.7$ Hz, 4H), 3.00 (t, $J = 4.8$ Hz, 4H), 2.47 (s, 3H); 

$^{13}$C NMR (CDCl$_3$, 125MHz, ppm): δ 143.9, 132.1, 129.7, 127.9, 66.1, 46.0, 21.6; HRMS calc. for C$_{11}$H$_{15}$NO$_3$SNa (M+Na)$^+$, 264.0670; found, 264.0675.

4-(phenylsulfonyl)morpholine

Compound 3b was obtained in 81% yield according to the general procedure. 

$^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.77-7.75 (m, 2H), 7.65-7.62 (m, 1H), 7.58-7.55 (m, 2H), 3.75 (t, $J = 4.7$ Hz, 4H), 3.01 (t, $J = 4.8$ Hz, 4H); 

$^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): δ 135.1, 133.1, 129.1, 127.8, 66.1, 46.0; HRMS calc. for C$_{10}$H$_{13}$NO$_3$SNa (M+Na)$^+$, 250.0514; found, 250.0517.

4-(4-methoxyphenylsulfonyl)morpholine

Compound 3c was obtained in 85% yield according to the general procedure. 

$^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.70-7.69 (m, 2H), 7.02-7.01 (m, 2H), 3.89 (s, 3H), 3.74 (t, $J = 4.7$ Hz, 4H), 2.98 (t, $J = 4.8$ Hz, 4H); 

$^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): δ 163.2, 130.0, 126.7, 114.3, 66.1, 55.7, 46.0; HRMS calc. for C$_{11}$H$_{15}$NO$_4$SNa (M+Na)$^+$, 280.0619; found, 280.0622.

4-(o-tolylsulfonyl)morpholine

Compound 3d was obtained in 88% yield according to the general procedure. 

$^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.91-7.89 (m, 1H), 7.50-7.47 (m, 1H), 7.35-7.32 (m, 2H), 3.72 (t, $J = 4.7$ Hz, 4H), 3.15 (t, $J = 4.9$ Hz, 4H), 2.65 (s, 3H); 

$^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): δ 138.2, 135.0, 133.1, 132.9, 130.4, 126.2, 66.3, 45.3, 20.9; HRMS calc. for C$_{11}$H$_{15}$NO$_3$SNa (M+Na)$^+$, 264.0670; found, 264.0671.

4-(m-tolylsulfonyl)morpholine
Compound 3e was obtained in 85% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.56-7.55 (m, 2H), 7.46-7.43 (m, 2H), 3.75 (t, $J = 4.8$ Hz, 4H), 3.00 (t, $J = 4.8$ Hz, 4H), 2.45 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 139.4, 134.9, 133.9, 129.0, 128.1, 125.0, 66.1, 46.0, 21.4; HRMS calc. for C$_{11}$H$_{15}$NO$_3$SNa (M+Na)$^+$, 264.0670; found, 264.0673.

4-(3,4-dimethoxyphenylsulfonyl)morpholine

Compound 3f was obtained in 81% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.39-7.36 (m, 1H), 7.21 (d, $J = 2.1$ Hz, 1H), 6.98 (d, $J = 8.5$ Hz, 1H), 3.96 (s, 3H), 3.94 (s, 3H), 3.75 (t, $J = 4.7$ Hz, 4H), 3.00 (t, $J = 4.7$ Hz, 4H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 152.9, 152.9, 149.2, 149.1, 126.8, 121.8, 110.7, 110.7, 110.4, 110.3, 66.1, 56.3, 56.2, 46.0; HRMS calc. for C$_{12}$H$_{17}$NO$_5$SNa (M+Na)$^+$, 310.0725; found, 310.0728.

4-(2,4-dimethylphenylsulfonyl)morpholine

Compound 3g was obtained in 67% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.77 (d, $J = 7.8$ Hz, 1H), 7.13 (d, $J = 8.7$ Hz, 2H), 3.72-3.71 (m, 4H), 3.14-3.12 (m, 4H), 2.60 (s, 3H), 2.38 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 143.9, 138.0, 133.6, 131.8, 130.7, 126.8, 66.3, 45.3, 21.3, 20.8; HRMS calc. for C$_{12}$H$_{17}$NO$_5$SNa (M+Na)$^+$, 278.0827; found, 278.0831.

4-(4-fluorophenylsulfonyl)morpholine

Compound 3h was obtained in 81% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.80-7.77 (m, 2H), 7.26-7.23 (m, 2H), 3.75 (t, $J = 4.7$ Hz, 4H), 3.00 (t, $J = 4.8$ Hz, 4H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 165.4 (d, $J = 254$ Hz), 131.3 (d, $J = 3.3$ Hz), 130.5 (d, $J = 9.2$ Hz), 116.4 (d, $J = 22.5$ Hz), 66.1, 46.0; HRMS calc. for C$_{10}$H$_{12}$FNO$_3$SNa (M+Na)$^+$, 268.0420; found, 268.0423.

4-(4-chlorophenylsulfonyl)morpholine

Compound 3i was obtained in 75% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.70 (d, $J = 8.6$ Hz, 2H), 7.54 (d, $J = 8.6$ Hz, 2H), 3.75 (t,
$J = 4.7 \text{ Hz, } 4\text{H}$, 3.01 (t, $J = 4.7 \text{ Hz, } 4\text{H}$); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 139.7, 133.7, 129.5, 129.2, 66.1, 45.9; HRMS calc. for C$_{10}$H$_{12}$ClNO$_3$SNa (M+Na)$^+$, 284.0124; found, 284.0126.

4-(3-chlorophenylsulfonyl)morpholine

Compound 3j was obtained in 86% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.68 (t, $J = 1.8 \text{ Hz, } 1\text{H}$), 7.59-7.53 (m, 2H), 7.44 (t, $J = 8.0 \text{ Hz, } 1\text{H}$), 3.69 (t, $J = 4.6 \text{ Hz, } 4\text{H}$), 2.96 (t, $J = 4.8 \text{ Hz, } 4\text{H}$); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 136.0, 134.5, 132.2, 129.4, 126.8, 124.9, 65.0, 44.9; HRMS calc. for C$_{10}$H$_{12}$ClNO$_3$SNa (M+Na)$^+$, 284.0124; found, 284.0119.

4-(4-bromophenylsulfonyl)morpholine

Compound 3k was obtained in 62% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.70 (d, $J = 8.6 \text{ Hz, } 2\text{H}$), 7.62 (d, $J = 8.6 \text{ Hz, } 2\text{H}$), 3.75 (t, $J = 4.8 \text{ Hz, } 4\text{H}$), 3.00 (t, $J = 4.8 \text{ Hz, } 4\text{H}$); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 134.2, 132.5, 129.3, 128.2, 66.0, 45.9; HRMS calc. for C$_{10}$H$_{12}$BrNO$_3$SNa (M+Na)$^+$, 327.9619; found, 327.9621.

4-(naphthalen-2-ylsulfonyl)morpholine

Compound 3l was obtained in 75% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 8.34 (d, $J = 1.8 \text{ Hz, } 1\text{H}$), 8.01-7.98 (m, 2H), 7.94 (d, $J = 8.1 \text{ Hz, } 1\text{H}$), 7.76-7.74 (m, 1H), 7.69-7.62 (m, 2H), 3.75 (t, $J = 4.8 \text{ Hz, } 4\text{H}$), 3.07 (t, $J = 4.8 \text{ Hz, } 4\text{H}$); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 135.0, 132.3, 132.2, 129.3, 129.3, 129.2, 129.0, 128.0, 127.7, 123.0, 66.1, 46.1; HRMS calc. for C$_{14}$H$_{15}$NO$_3$SNa (M+Na)$^+$, 300.0670; found, 300.0673.

4-(pyridin-4-ylsulfonyl)morpholine

Compound 3m was obtained in 60% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 8.90 (d, $J = 4.1 \text{ Hz, } 2\text{H}$), 7.60 (d, $J = 5.8 \text{ Hz, } 2\text{H}$), 3.76 (t, $J = 4.8 \text{ Hz, } 4\text{H}$), 3.06 (t, $J = 4.7 \text{ Hz, } 4\text{H}$); $^{13}$C NMR (CDCl$_3$, 125MHz, ppm): $\delta$ 151.2, 143.6, 120.9, 66.0, 45.9; HRMS calc. for C$_{9}$H$_{12}$N$_2$O$_3$SNa (M+Na)$^+$, 251.0466; found, 251.0467.
1-tosylpiperidine

Compound 3n was obtained in 64% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.66 (d, $J = 8.3$ Hz, 2H), 7.34 (d, $J = 8.0$ Hz, 2H), 2.99 (t, $J = 5.5$ Hz, 4H), 2.45 (s, 3H), 1.68-1.63 (m, 4H), 1.45-1.41 (m, 2H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 143.3, 133.3, 129.5, 127.7, 46.9, 25.2, 23.5, 21.5; HRMS calc. for C$_{12}$H$_{17}$NO$_2$SNa (M+Na)$^+$, 262.0878; found, 262.0879.

1-tosylpyrrolidine

Compound 3o was obtained in 56% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.74 (d, $J = 8.3$ Hz, 2H), 7.34 (d, $J = 8.0$ Hz, 2H), 3.26-3.24 (m, 4H), 2.45 (s, 3H), 1.78-1.75 (m, 4H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 143.3, 133.9, 129.6, 127.6, 47.9, 25.2, 21.5; HRMS calc. for C$_{11}$H$_{15}$NO$_2$SNa (M+Na)$^+$, 248.0721; found, 248.0727.

N-benzyl-4-methylbenzenesulfonamide

Compound 3p was obtained in 63% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.76 (d, $J = 8.3$ Hz, 2H), 7.32-7.25 (m, 5H), 7.20-7.19 (m, 2H), 4.67 (d, $J = 5.7$ Hz, 1H), 4.12 (d, $J = 6.2$ Hz, 2H), 2.44 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 143.5, 136.9, 136.3, 129.8, 128.7, 127.9, 127.9, 127.2, 47.3, 21.6; HRMS calc. for C$_{14}$H$_{17}$NO$_2$SNa (M+Na)$^+$, 284.0721; found, 284.0723.

4-methyl-N-(4-methylbenzyl)benzenesulfonamide

Compound 3q was obtained in 60% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.64 (d, $J = 8.2$ Hz, 2H), 7.32 (d, $J = 7.9$ Hz, 2H), 7.16 (d, $J = 8.2$ Hz, 2H), 7.12 (d, $J = 8.0$ Hz, 2H), 4.24 (brs, 1H), 4.22-4.19 (m, 1H), 3.87-3.83 (m, 1H), 2.42 (s, 3H), 2.32 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 141.3, 140.9, 137.4, 134.7, 129.6, 129.3, 129.3, 126.0, 44.4, 21.4, 21.1; HRMS calc. for C$_{15}$H$_{17}$NO$_2$SNa (M+Na)$^+$, 298.0878, found, 298.0881.

N-(4-fluorobenzyl)-4-methylbenzenesulfonamide
Compound 3r was obtained in 61% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.63 (d, $J = 8.3$ Hz, 2H), 7.33-7.31 (m, 2H), 7.25-7.22 (m, 2H), 6.99 (t, $J = 8.7$ Hz, 2H), 4.30 (t, $J = 1.6$ Hz, 1H), 4.23-4.19 (m, 1H), 3.90-3.86 (m, 1H), 3.90-3.86 (m, 1H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 162.2 (d, $J = 244.7$ Hz), 141.5, 140.7, 133.6 (d, $J = 3.2$ Hz), 130.0 (d, $J = 8.1$ Hz), 129.7, 126.4, 126.0, 115.6 (d, $J = 21.6$ Hz), 44.0, 21.4; HRMS calc. for C$_{14}$H$_{14}$FNO$_2$SNa (M+Na)$^+$, 302.0627; found, 302.0625.

N-(4-chlorobenzyl)-4-methylbenzenesulfonamide

Compound 3s was obtained in 67% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.63 (d, $J = 7.9$ Hz, 2H), 7.32(d, $J = 8.0$ Hz, 2H) 7.27 (d, $J = 8.3$ Hz, 2H), 7.20 (d, $J = 8.2$ Hz, 2H), 4.32-4.28 (m, 1H), 4.22-4.18 (m, 1H), 3.91-3.87 (m, 1H), 2.42 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 141.5, 140.7, 136.4, 133.5, 129.7, 128.8, 125.9, 44.0, 21.4; HRMS calc. for C$_{14}$H$_{14}$ClNO$_2$SNa (M+Na)$^+$, 318.0331; found, 318.0333.

N-(4-bromobenzyl)-4-methylbenzenesulfonamide

Compound 3t was obtained in 53% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.62 (d, $J = 8.3$ Hz, 2H), 7.43 (d, $J = 8.4$ Hz, 2H), 7.31 (d, $J = 8.0$ Hz, 2H), 7.14 (d, $J = 8.4$ Hz, 2H), 4.31 (t, $J = 6.2$ Hz, 1H), 4.20-4.16 (m, 1H), 3.90-3.85 (m, 1H), 2.42 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 141.6, 140.7, 136.9, 131.7, 130.0, 129.7, 125.9, 121.6, 44.0, 21.4; HRMS calc. for C$_{14}$H$_{14}$BrNO$_2$SNa (M+Na)$^+$, 361.9826; found, 361.9829.

N-(2-bromobenzyl)-4-methylbenzenesulfonamide

Compound 3u was obtained in 60% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): $\delta$ 7.63 (d, $J = 8.3$ Hz, 2H), 7.53 (d, $J = 7.6$ Hz, 1H), 7.30 (d, $J = 7.9$ Hz, 2H), 7.25-7.24 (m, 2H), 7.15-7.11 (m, 1H), 4.46 (t, $J = 6.7$ Hz, 1H), 4.37-4.33 (m, 1H), 4.09-4.04 (m, 1H), 2.41 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): $\delta$ 140.4, 139.8, 136.3, 131.9, 129.5, 128.5, 128.3, 126.6, 125.0, 123.0, 44.3, 20.3; HRMS calc. for C$_{14}$H$_{14}$BrNO$_2$SNa (M+Na)$^+$, 361.9826; found, 361.9831.
N-butyl-4-methylbenzenesulfonamide

Compound 3v was obtained in 56% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.75 (t, $J = 8.3$ Hz, 2H), 7.30 (t, $J = 8.0$ Hz, 2H), 4.70 (brs, 1H), 2.94-2.90 (m, 2H), 2.43 (s, 3H), 1.46-1.41 (m, 2H), 1.31-1.26 (m, 2H), 0.84 (t, $J = 7.4$ Hz, 3H); $^{13}$C NMR (CDCl$_3$, 125MHz, ppm): δ 143.3, 137.0, 129.7, 127.1, 42.9, 31.6, 21.5, 19.7, 13.5; HRMS calc. for C$_{11}$H$_{17}$NO$_2$SNa (M+Na)$^+$, 250.0878; found, 250.0877.

N-(ethoxymethyl)-4-methylbenzenesulfonamide

Compound 3w was obtained in 57% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.59 (d, $J = 8.2$ Hz, 2H), 7.29 (t, $J = 8.0$ Hz, 2H), 4.51 (s, 1H), 3.49-3.42 (m, 2H), 3.33 (s, 3H), 3.29-3.24 (m, 1H), 2.96-2.90 (m, 1H), 2.41 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125MHz, ppm): δ 141.2, 136.5, 129.6, 126.0, 71.9, 58.7, 40.3, 21.3; HRMS calc. for C$_{10}$H$_{15}$NO$_3$SNa (M+Na)$^+$, 252.0670; found, 252.0673.

4-methyl-N-p-tolylbenzenesulfonamide

Compound 3x was obtained in 42% yield according to the general procedure. $^1$H NMR (CDCl$_3$, 500 MHz, ppm): δ 7.66 (d, $J = 8.3$ Hz, 2H), 7.24 (d, $J = 8.0$ Hz, 2H), 7.05 (d, $J = 8.2$ Hz, 2H), 6.97 (d, $J = 8.4$ Hz, 2H), 6.73 (s, 1H), 2.40 (s, 3H), 2.29 (s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz, ppm): δ 143.7, 136.1, 135.4, 133.7, 129.8, 129.6, 127.3, 122.3, 21.5, 20.8; HRMS calc. for C$_{14}$H$_{16}$NO$_2$SNa (M+Na)$^+$, 284.0721; found, 284.0723.
5. Copies of NMR spectra for 3a-3x

3a
$3b$

![Chemical structure](image)

![NMR spectrum](image)
$H_3CO$-$\begin{array}{c}
\text{SO}_2
\end{array}$-$N$-$\begin{array}{c}
\text{O}
\end{array}$

$H_3CO$-$\begin{array}{c}
\text{SO}_2
\end{array}$-$N$-$\begin{array}{c}
\text{O}
\end{array}$
$$\text{SO}_{2}\text{NH}$$

[Image of a chemical structure]

$$\text{SO}_{2}\text{NH}$$

[Image of a chemical structure]