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# Iodine-mediated coupling of cyclic amines with sulfonyl hydrazides: an efficient synthesis of vinyl sulfone derivatives

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**Abstract:** An efficient iodine-mediated coupling of cyclic amines with sulfonyl hydrazides is herein reported. This transformation opens a new route to the synthesis of vinyl sulfones derivatives, which is a common structural motif in natural products and pharmaceuticals. Tentative mechanistic studies suggest that this reaction is likely to involve a radical process.

by several groups.<sup>[5f, 9]</sup> Compared with other sulfonation agents, sulfonyl hydrazides are insensitive to air and moisture, are easy to prepare, and yield eco-friendly by-products. Herein, we report a method for the synthesis of vinyl sulfones via the iodine-mediated coupling of cyclic amines with sulfonyl hydrazides (Scheme 1).

## Introduction

Vinyl sulfone derivatives are key functional units with significant synthetic value as building blocks in organic transformations<sup>[1]</sup> as they show a broad range of useful biological and pharmacological activities.<sup>[2]</sup> Therefore, considerable efforts have been devoted to developing methodologies for the synthesis of vinyl sulfones. Conventional methods for vinyl sulfone synthesis include Knoevenagel condensation<sup>[3]</sup> and the Horner–Emmons reaction.<sup>[4]</sup> In recent years, the direct coupling of alkenes or alkynes with sodium sulphinates has been developed for the synthesis of vinyl sulphones.<sup>[5]</sup> In addition, cinnamic acids or phenylpropiolic acids have also been reacted with sodium sulfinates to form vinyl sulfones.<sup>[6]</sup>

Amines and their derivatives are essential building blocks for the preparation of pharmaceuticals and natural products.<sup>[7]</sup> In particular, many C(3)-functionalized amines have remarkable biological activities. Therefore, the development of synthetic methods for the C(3)-H functionalization of amines has been a hot topic in organic synthesis.<sup>[8]</sup> For example, Yuan and coworkers developed the I<sub>2</sub>/TBHP-mediated  $\beta$ -C–H sulfonylation of triethylamine.<sup>[8h]</sup> Recently, Talbot and co-workers proposed a novel oxidative  $\beta$ -C–H sulfonylation of cyclic amines using *N*iodosuccinimide (NIS) as the oxidant.<sup>[8e]</sup> Lee and co-workers reported the synthesis of  $\beta$ -amidovinyl sulfones by the electrochemical coupling of arylsulfonyl hydrazides and tertiary amines.<sup>[8i]</sup>

Recently, readily accessible sulfonyl hydrazides have received considerable attention as excellent synthons for many organic transformations. Sulfonylation reactions via sulfonyl radicals generated in situ from sulfonyl hydrazides have been developed



Scheme 1. Coupling of cyclic amines with sulfonyl hydrazides

## **Results and Discussion**

We started our investigations with 1-phenylpiperidine 1a and 4methylbenzene p-toluenesulfonyl hydrazide 2a as model substrates. Several parameters, including the iodine source, solvent, and additives, were analysed to investigate their impact on the reaction outcome, and the results are listed in Table 1. Initially, the reaction was carried out using NIS as the iodine source at 80 °C. Gratifyingly, the desired product was obtained in 35% yield after 12 h (Table 1, entry 1). Inspired by this result, the reaction iodine sources were further examined, and a higher yield was obtained when  $I_2$  was used (Table 1, entries 2 and 3). Then, various bases were tested and NaHCO<sub>3</sub> was found to be optimal, giving the desired product in 71% yield (Table 1, entries 4-9). Solvent screening revealed that 1,4-dioxane was the most suitable (entries 10-14). The yield of 3a decreased severely when iodine sources, oxidants, and additives were absent (entries 15-19). Obviously, these factors play a pivotal role in the reaction system. Other temperatures (60 and 100 °C) were further tested, and the yield of 3a increased to 83% at 100 °C (entries 20 and 21). Finally, the effect of the reaction time was also investigated, and 3.0 h was found to be optimal (entries 22 and 23).

#### Table 1. Optimization of Reaction Conditions. [a]



E notan c	lodine	Oxidant	Base	Solvent	Yield
Entry	source				(%)
1	NIS	TBHP	Na <sub>2</sub> CO <sub>3</sub>	THF	35
2	Nal	TBHP	Na <sub>2</sub> CO <sub>3</sub>	THF	trace
3	l <sub>2</sub>	ТВНР	Na <sub>2</sub> CO <sub>3</sub>	THF	51
4	l <sub>2</sub>	TBHP	K <sub>2</sub> CO <sub>3</sub>	THF	57
5	I <sub>2</sub>	TBHP	Cs <sub>2</sub> CO <sub>3</sub>	THF	49
6	l <sub>2</sub>	TBHP	NaHCO₃	THF	71
7	l <sub>2</sub>	TBHP	CH₃COONa	THF	65
8	l <sub>2</sub>	TBHP	NaOH	THF	33
9	l <sub>2</sub>	TBHP	Et₃N	THF	28
10	l <sub>2</sub>	TBHP	NaHCO₃	DCE	47
11	l <sub>2</sub>	TBHP	NaHCO₃	MeCN	65
12	I <sub>2</sub>	TBHP	NaHCO₃	1,4-dioxane	81
13	l <sub>2</sub>	TBHP	NaHCO₃	H <sub>2</sub> O	0
14	l <sub>2</sub>	TBHP	NaHCO₃	toluene	59
15 <sup>[b]</sup>	l <sub>2</sub>	TBHP	NaHCO <sub>3</sub>	1,4-dioxane	37
16	-	TBHP	NaHCO <sub>3</sub>	1,4-dioxane	0
17 <sup>[c]</sup>	l <sub>2</sub>	TBHP	NaHCO₃	1,4-dioxane	55
18	l <sub>2</sub>	-	NaHCO₃	1,4-dioxane	0
19	l <sub>2</sub>	TBHP	-	1,4-dioxane	0
20 <sup>[d]</sup>	l <sub>2</sub>	TBHP	NaHCO₃	1,4-dioxane	61
21 <sup>[e]</sup>	l <sub>2</sub>	TBHP	NaHCO₃	1,4-dioxane	83
22 <sup>[f]</sup>	l <sub>2</sub>	TBHP	NaHCO₃	1,4-dioxane	74
23 <sup>[g]</sup>	l2	твнр	NaHCO₃	1,4-dioxane	91

[a] Reaction conditions: **Ia** (0.2 mmol), **2a** (0.4 mmol), oxidant (0.6 mmol), iodine source (0.3 mmol), addictive (0.4 mmol), solvent (2 mL), 80 °C, 12 h. [b]  $I_2$  0.5equiv. [c] TBHP 1.5 equiv. [d] at 60 °C. [e] at 100 °C. [f] at 100 °C, for 1 h. [g] at 100 °C, for 3 h.

With the optimized reaction conditions in hand, we next explored the substrate scope of the reaction (Scheme 2). Arylsulfonyl hydrazides bearing either electron-donating or electron-withdrawing substituents readily reacted with 1a to afford the desired products in moderate to good yields (3a-3j). Generally, arylsulfonyl hydrazides with electron-withdrawing groups (3e-3h) gave higher yields than those with electron-donating groups (3i and 3j). To our delight, biphenyl sulfonyl hydrazide, 1-naphthyl sulfonyl hydrazide, and 2-naphthyl sulfonyl hydrazide with fused rings were also suitable reactants and gave the corresponding products in moderate yields (3k-3m). Moreover, an alkyl sulfonyl hydrazide afforded the corresponding product in 29% yield (3n).





Scheme 2. Reaction of *N*-Benzyl piperidine **1a** with various Sulfonyl Hydrazide. Reaction conditions: **1a** (0.2 mmol), **2** (0.4 mmo1), TBHP (0.6 mmol), I2 (0.3 mmol), NaHCO<sub>3</sub> (0.4 mmol), 1,4-dioxane (2 mL), 100 °C, 3 h.

The scope of this reaction with a variety of piperidines was also investigated, as illustrated in Scheme 3. A variety of N-aryl piperidine derivatives, including methyl, tert-butyl, n-butyl, and trimethyl groups on the aromatic ring, readily participated in the reaction (4a-4d). N-Aryl piperidines with halogen substituents (-F, -Cl, -Br) could also serve as practical substrates for the reaction (4e-4h). N-Aryl piperidines bearing electron-donating substituents also delivered vinyl sulfones in moderate yields (4i-4k). The more bulky substrates 1-biphenyl-4-yl-piperidine and 1naphthalen-1-yl-piperidine also efficiently reacted with 2a, affording products in 79% and 76% yields, respectively (4I and 4m). Heteroaryl piperidines gave the corresponding products in low yields (4n). The piperidine ring bearing a substituent in the 4-position increases the steric hindrance for sulfonylation. However, 4-methyl-1-phenyl-piperidine was also an effective substrate in this transformation, furnishing the corresponding product 4o in good yields up to 83%. When we increased the ring size of the cyclic amine, a poor yield of 31% was obtained (4p). To our delight, the reaction was also compatible with Nbenzyl piperidines and gave the corresponding products in moderate yields (4q-4v). Moreover, the reaction was also tolerant and selective towards N-alkyl substituents on the amine, where the cyclohexyl example performed well with a yield of 47% (4w). Thus, the overall reaction offers excellent functional group tolerance.

Furthermore, a scale-up reaction was performed to demonstrate the practicability of the developed protocol (10 mmol scale). To our satisfaction, the reaction proceeded smoothly under the optimized conditions to provide product **3a** in 68% yield (Scheme 4).

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Scheme 3. Substrate scope with various piperidines. Reaction conditions: I (0.2 mmol), **2a** (0.4 mmol), TBHP (0.6 mmol), I<sub>2</sub> (0.3 mmol), NaHCO<sub>3</sub> (0.4 mmol), 1,4-dioxane (2 mL), 100  $^{\circ}$ C, 3 h.



Scheme 4. Gram scale application.

To gain more insight into the reaction mechanism, some control experiments were explored (Scheme 5). When the reaction was performed in the presence of the free radical scavenger 2,2,6,6-tetramethylpiperidin-1-oxyl (TEMPO, 1.0 equiv.), product **3a** was obtained in 13% yield. When TEMPO (2.5 equiv.) was added to the reaction, no conversion of product **3a** was observed. These results indicate that the transformation may proceed via a radical process.





Scheme 5. Reaction in the presence of a free-radical scavenger.

Based on our experimental results and previous reports, a proposed reaction pathway is proposed in Scheme 6. Initially, TBHP decomposes to generate *tert*-butoxyl and *tert*-butylperoxy radicals with the assistance of an iodide anion. Subsequently, the hydrogen atom at the  $\alpha$ -carbon of substrate **1a** is abstracted by the *tert*-butoxyl radical to form  $\alpha$ -amino radical **A**. Then, the single-electron oxidation of radical **A** by iodine provides iminium ion **B**, which is deprotonated to afford enamine **C**.<sup>[10]</sup> In the meantime, the *tert*-butoxyl radical abstracts a hydrogen atom from sulfonyl hydrazide **2a**, which initiates the generation of sulfonyl radicals (**D**) and the release of molecular nitrogen.<sup>[5f, 9d, 11]</sup> Afterwards, the radical addition reaction of **D** and enamine **C** generates carbon radical **E**. Finally, radical **E** reacts with iodine to generate iodosulfone **F**, which undergoes HI elimination assisted by NaHCO<sub>3</sub> to afford the final product **3a**.



Scheme 6. Proposed Mechanism

## Conclusion

In summary, an iodine-mediated coupling of cyclic amines with sulfonyl hydrazides was developed. In this work, for the first time, sulfonyl hydrazides were used for the sulfonylation of cyclic amines. This system provides a both mild and easy-to-handle method for the synthesis of biologically active vinyl sulfones and shows potential as a new avenue for the further development of sulfonylation transformations.

## **Experimental Section**

**General information.** All of the reagents and solvents were purchased from commercial suppliers and used without further purification. All experiments were carried out under air, and

oven-dried glassware was used in all cases. <sup>1</sup>H and <sup>13</sup>C NMR spectra were recorded at 500 and 125 MHz, respectively. <sup>1</sup>H NMR and <sup>13</sup>C NMR chemical shifts are reported in ppm using tetramethylsilane (TMS) as an internal standard or residual nondeuterated solvent peak as an internal standard. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer.

General procedures D the preparation of 3a-4w. An ovendried Schlenk tube equipped with a magnetic stir bar was charged with piperidines 1 (0.2 mmol), sulfonyl hydrazides 2 (0.4mmol),  $l_2$  (0.3 mmol), NaHCO<sub>3</sub> (0.4 mmol), TBHP (0.6 mmol) and 1,4-dioxane (2 mL). The mixture was stirred at 100 °C for 3 h under air. After completion of the reaction, the mixture was then cooled to room temperature, diluted with 30 mL of H<sub>2</sub>O, and extracted with EtOAc (3×20 mL). The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub>, filtered, and concentrated under vacuum. The residue was purified by column chromatography on silica gel to give the products.

**1-phenyl-5-tosyl-1,2,3,4-tetrahydropyridine (3a).** Light yellow solid, 91% yield, M.p. 133-135 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.85 (s, 1H), 7.75 (d, *J* = 8.2 Hz, 2H), 7.37-7.32 (m, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 7.10-7.07 (m, 3H), 3.58-3.53 (m, 2H), 2.41 (s, 3H), 2.27 (t, *J* = 6.2 Hz, 2H), 2.00-1.93 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  145.39, 142.84, 139.07, 139.04, 129.56, 129.49, 127.17, 123.37, 117.74 , 108.13, 45.85, 21.51, 21.18, 20.04; HRMS (ESI) calcd for C<sub>18</sub>H<sub>19</sub>NO<sub>2</sub>S [M+Na]<sup>+</sup>: 336.1029. Found: 336.1046.

**1-phenyl-5-(phenylsulfonyl)-1,2,3,4-tetrahydropyridine** (3b). White solid, 80% yield, M.p. 146-148 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.88-.7.86 (m, 3H), 7.56-7.46 (m, 3H), 7.35 (t, J = 7.9 Hz, 2H), 7.09 (t, J = 7.9 Hz, 3H), 3.58-3.53 (m, 2H), 2.28 (t, J = 6.2 Hz, 2H), 2.01-1.94 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.33, 141.93, 139.46, 132.18, 129.51, 128.96, 127.09, 123.50, 117.80, 107.62, 45.89, 21.14, 20.02; HRMS (ESI) for C<sub>17</sub>H<sub>17</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 300.1053. Found: 300.1049.

**1-phenyl-5-(o-tolylsulfonyl)-1,2,3,4-tetrahydropyridine** (3c). White solid, 69% yield, M.p. 124-126 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.03 (d, *J* = 7.9 Hz, 1H), 7.87 (s, 1H), 7.44 (t, *J* = 7.5 Hz, 1H), 7.38-7.33 (m, 3H), 7.27 (d, *J* = 7.1 Hz, 1H), 7.12-7.06 (m, 3H), 3.61-3.57 (m, 2H), 2.61 (s, 3H), 2.19 (t, *J* = 6.3 Hz, 2H), 1.99-1.92 (m, 2H). <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.41, 139.78, 138.60, 137.31, 132.56, 132.54, 129.80, 129.55, 126.20, 123.46, 117.81, 106.99, 46.02, 21.22, 20.17, 19.99; HRMS (ESI) calcd for C<sub>18</sub>H<sub>19</sub>NO<sub>2</sub>S [M+Na]<sup>+</sup>: 336.1029. Found: 336.1035.

#### 5-((4-(tert-butyl)phenyl)sulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3d). Dark yellow oil, 70% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.78 (s, 1H), 7.70 (d, *J* = 8.5 Hz, 2H), 7.42 (d, *J* = 8.5 Hz, 2H), 7.30-7.24 (m, 2H), 7.00 (d, *J* = 8.1 Hz, 3H), 3.52-3.45 (m, 2H), 2.23 (t, *J* = 6.2 Hz, 2H), 1.95-1.85 (m, 2H), 1.26 (s, 9H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 155.82, 145.41, 139.12, 138.95, 129.49, 126.94, 125.92, 123.36, 117.74, 108.12, 45.85, 35.09, 31.15, 21.19, 20.05; HRMS (ESI) calcd for C<sub>21</sub>H<sub>25</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 356.1679. Found: 356.1680.

#### 5-((4-fluorophenyl)sulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3e). Light yellow solid, 60% yield, M.p. 153-155 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.89-7.84 (m, 3H),

7.36 (t, J = 8.0 Hz, 2H), 7.20-7.13 (m, 2H), 7.09 (d, J = 13.4, 7.5 Hz, 3H), 3.60-3.53 (m, 2H), 2.27 (t, J = 6.2 Hz, 2H), 2.02-1.95 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  164.88 (d,  $J_{C-F} = 254.0$  Hz), 145.30, 139.60, 138.11 (d,  $J_{C-F} = 2.8$  Hz), 129.78 (d,  $J_{C-F} = 9.5$  Hz), 129.53, 123.63, 117.90, 116.10 (d,  $J_{C-F} = 22.4$  Hz), 107.42, 45.94, 21.13, 20.00; HRMS (ESI) calcd for C<sub>17</sub>H<sub>16</sub>FNO<sub>2</sub>S [M+H]<sup>+</sup>: 318.0959. Found: 318.0959.

#### 5-((4-chlorophenyl)sulfonyl)-1-phenyl-1,2,3,4-

**tetrahydropyridine (3f).** Light yellow solid, 87% yield, M.p. 122-124 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.85 (s, 1H), 7.82-7.77 (m, 2H), 7.48-7.43 (m, 2H), 7.36 (m, *J* = 8.4, 7.6 Hz, 2H), 7.12-7.07 (m, 7.6 Hz, 3H), 3.60-3.53 (m, 2H), 2.27 (t, *J* = 6.2 Hz, 2H), 2.02-1.95 (m, 2H); <sup>13</sup>C NMR (126 MHz,CDCl<sub>3</sub>) δ 145.26, 140.59, 139.87, 138.58, 129.55, 129.22, 128.61, 123.72, 117.95, 107.10, 45.98, 21.11, 19.99; HRMS (ESI) calcd for  $C_{17}H_{19}CINO_2S$ [M+H]\*: 334.0663. Found: 334.0668.

#### 5-((4-nitrophenyl)sulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3g). Orange-red solid, 83% yield, M.p. 148-150 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.05 (d, *J* = 8.8 Hz, 2H), 7.90 (s, 1H), 7.39 (t, *J* = 8.0 Hz, 2H), 7.15 (t, *J* = 7.4 Hz, 1H), 7.13 – 7.08 (m, 2H), 3.64 – 3.58 (m, 2H), 2.31 (t, *J* = 6.2 Hz, 2H), 2.04 – 1.99 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 149.77, 148.01, 145.08, 141.25, 129.64, 128.29, 124.29, 124.25, 118.26, 105.64, 46.18, 21.02, 19.96; HRMS (ESI) calcd for C<sub>17</sub>H<sub>16</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 345.0904. Found: 345.0909.

#### 1-phenyl-5-((4-(trifluoromethyl)phenyl)sulfonyl)-1,2,3,4-

**tetrahydropyridine (3h).** White solid, 85% yield, M.p. 148-150 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.99 (d, J = 8.2 Hz, 2H), 7.89 (s, 1H), 7.76 (d, J = 8.3 Hz, 2H), 7.37 (t, J = 8.0 Hz, 2H), 7.15 – 7.05 (m, 3H), 3.63 – 3.56 (m, 2H), 2.30 (t, J = 6.1 Hz, 2H), 2.06 – 1.94 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.69, 145.19, 140.59, 133.82 (q,  $J_{C-F} = 32.8$  Hz), 129.58, 127.59, 126.11 (q,  $J_{C-F} = 3.6$  Hz), 123.95, 123.41 (q,  $J_{C-F} = 273.2$  Hz), 118.10, 106.35, 46.07, 21.07, 19.98; HRMS (ESI) calcd for C<sub>18</sub>H<sub>16</sub>F<sub>3</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 368.0927. Found: 368.0933.

#### 5-((4-methoxyphenyl)sulfonyl)-1-phenyl-1,2,3,4-

**tetrahydropyridine (3i).** Light yellow oil, 60% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.84 (s, 1H), 7.79 (d, *J* = 8.5 Hz, 2H), 7.34 (t, *J* = 7.8 Hz, 2H), 7.08 (t, *J* = 7.1 Hz, 3H), 6.96 (d, *J* = 8.5 Hz, 2H), 3.85 (s, 3H), 3.57 – 3.52 (m, 2H), 2.27 (t, *J* = 6.1 Hz, 2H), 1.98 – 1.95 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 162.62, 145.43, 138.72, 133.69, 129.47, 129.22, 123.30, 117.71, 114.13, 108.55, 55.57, 45.84, 21.21, 20.03; HRMS (ESI) calcd for C<sub>18</sub>H<sub>19</sub>NO<sub>3</sub>S [M+H]\*: 330.1158. Found: 330.1167.

#### 5-((3,4-dimethoxyphenyl)sulfonyl)-1-phenyl-1,2,3,4-

**tetrahydropyridine (3j).** Yellow oil, 67% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.85 (s, 1H), 7.48 – 7.46 (m, 1H), 7.37 – 7.33 (m, 3H), 7.09 (t, *J* = 7.4 Hz, 3H), 6.93 (d, *J* = 8.4 Hz, 1H), 3.93 (d, *J* = 2.0 Hz, 6H), 3.59 – 3.55 (m, 2H), 2.29 (t, *J* = 6.2 Hz, 2H), 2.02 – 1.96 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 152.26, 149.06, 145.41, 138.75, 133.79, 129.49, 123.35, 121.05, 117.71, 110.66, 109.79, 108.36, 56.27, 56.16, 45.84, 21.20, 20.07; HRMS (ESI) calcd for C<sub>19</sub>H<sub>21</sub>NO<sub>4</sub>S [M+H]<sup>+</sup>: 360.1264. Found: 360.1268.

#### 5-([1,1'-biphenyl]-4-ylsulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3k). Light yellow oil, 70% yield; <sup>1</sup>H NMR

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(500 MHz, CDCl<sub>3</sub>) δ 7.95 – 7.89 (m, 3H), 7.70 (d, J = 8.2 Hz, 2H), 7.60 (d, J = 7.4 Hz, 2H), 7.47 (t, J = 7.5 Hz, 2H), 7.42 - 7.33 (m, 3H), 7.09 (d, J = 8.1 Hz, 3H), 3.60 – 3.55 (m, 2H), 2.34 (t, J =6.0 Hz, 2H), 2.03 – 1.97 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.38, 145.09, 140.63, 139.58, 139.49, 129.52, 129.00, 128.32, 127.64, 127.61, 127.32, 123.52, 117.86, 107.84, 45.94, 21.20, 20.08; HRMS (ESI): m/z calcd for C<sub>23</sub>H<sub>21</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 376.1366. Found: 376.1396.

#### 5-(naphthalen-1-ylsulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3I). Light yellow solid, 65% yield, M.p. 144-146 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  8.76 (d, J = 8.6 Hz, 1H), 8.32 (d, J = 7.3 Hz, 1H), 8.05 (d, J = 9.5 Hz, 2H), 7.93 (d, J = 8.1 Hz, 1H), 7.63 (t, J = 7.6 Hz, 1H), 7.56 (t, J = 7.8 Hz, 2H), 7.38 (t, J = 7.9 Hz, 2H), 7.11 (t, J = 9.0 Hz, 3H), 3.55 – 3.48 (m, 2H), 2.18 (t, J = 6.2 Hz, 2H), 1.92 – 1.84 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.48, 139.61, 135.89, 134.33, 134.04, 129.90, 129.56, 129.00, 128.47, 127.89, 126.61, 124.62, 124.35, 123.53, 117.97, 108.13, 46.01, 21.11, 20.12; HRMS (ESI) calcd for  $C_{21}H_{19}NO_2S [M+H]^+$ : 350.1209. Found: 350.1223.

#### 5-(naphthalen-2-ylsulfonyl)-1-phenyl-1,2,3,4-

tetrahydropyridine (3m). Light yellow solid, 67% yield, M.p. 140-142 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.46 (s, 1H), 7.97 -7.92 (m, 3H), 7.89 (d, J = 7.8 Hz, 1H), 7.83 - 7.81 (m, 1H), 7.63 - 7.57 (m, 2H), 7.38 - 7.34 (m, 2H), 7.11 - 7.08 (m, 3H), 3.57 -3.51 (m, 2H), 2.30 (t, J = 6.2 Hz, 2H), 1.98 – 1.91 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.36, 139.58, 138.76, 134.70, 132.33, 129.53, 129.26, 128.52, 128.24, 127.89, 127.34, 123.54, 122.73, 117.85, 107.75, 45.93, 21.17, 20.07; HRMS (ESI) calcd for C<sub>21</sub>H<sub>19</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 350.1209. Found: 350.1220.

### 5-(methylsulfonyl)-1-phenyl-1,2,3,4-tetrahydropyridine (3n). Dark yellow oil, 29% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.69 (s, 1H), 7.34 (t, J = 7.7 Hz, 2H), 7.10 – 7.06 (m, 3H), 3.66-3.59 (m, 2H), 2.93 (s, 3H), 2.49 (t, J = 6.2 Hz, 2H), 2.13 – 2.06 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 145.35, 139.72, 129.49, 123.52, 117.84, 107.32, 45.90, 42.21, 21.20, 20.44; HRMS (ESI) calcd for C<sub>12</sub>H<sub>15</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 238.0896. Found: 238.0911.

1-(p-tolyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4a).<sup>[8e]</sup> Yellow solid, 92% yield, M.p. 91-93 °C;  $^1\text{H}$  NMR (500 MHz, CDCl3)  $\delta$ 7.81 (s, 1H), 7.74 (d, J = 8.0 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 7.14 (d, J = 8.0 Hz, 2H), 6.96 (d, J = 8.1 Hz, 2H), 3.52 (d, J = 4.9 Hz, 2H), 2.40 (s, 3H), 2.31 (s, 3H), 2.26 (t, J = 6.0 Hz, 2H), 1.98 - 1.91 (m, 2H);  $^{13}\text{C}$  NMR (126 MHz, CDCl\_3)  $\delta$  143.18, 142.72, 139.43, 139.23, 133.13, 129.98, 129.51, 127.12, 117.94, 107.20, 46.07, 21.47, 21.18, 20.60, 20.03.

#### 1-(4-(tert-butyl)phenyl)-5-tosyl-1,2,3,4-tetrahydropyridine

(4b). Yellow oil, 85% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.84 (s, 1H), 7.74 (d, J = 8.1 Hz, 2H), 7.37 (d, J = 8.6 Hz, 2H), 7.28 (d, J = 7.9 Hz, 2H), 7.02 (d, J = 8.6 Hz, 2H), 3.60 – 3.49 (m, 2H), 2.41 (s, 3H), 2.27 (t, J = 6.0 Hz, 2H), 1.99 - 1.92 (m, 2H), 1.31 (s, 9H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 153.04, 149.48, 149.30, 145.95, 145.64, 136.06, 133.64, 132.83, 124.05, 113.69, 52.45, 40.81, 37.89, 28.01, 27.70, 26.54; HRMS (ESI) calcd for C<sub>21</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>S [M+H]<sup>+</sup>: 370.1835. Found: 370.1838.

1-(4-butylphenyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4c). Yellow oil, 90% yield; Yellow oil, 90% yiled; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.74 (s, 1H), 7.66 (d, J = 7.8 Hz, 2H), 7.20 (d, J = 8.0 Hz, 2H), 7.07 (d, J = 7.9 Hz, 2H), 6.91 (d, J = 7.9 Hz, 2H), 3.47 -3.42 (m, 2H), 2.50 (t, J = 7.7 Hz, 2H), 2.32 (s, 3H), 2.18 (t, J = 6.1 Hz, 2H), 1.91 - 1.83 (m, 2H), 1.53 - 1.44 (m, 2H), 1.31 -1.22 (m, 2H), 0.85 (t, J = 7.3 Hz, 3H); <sup>13</sup>C NMR (126 MHz,  $\mathsf{CDCI}_3) \ \delta \ 143.27, \ 142.79, \ 139.51, \ 139.11, \ 138.26, \ 129.55,$ 129.36, 127.10, 117.89, 106.99, 46.05, 34.82, 33.66, 22.27, 21.49, 21.17, 20.01, 13.93; HRMS (ESI) calcd for C<sub>22</sub>H<sub>27</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 370.1835. Found: 370.1846.

1-mesityl-5-tosyl-1,2,3,4-tetrahydropyridine (4d). Yellow solid, 75% yield, M.p. 166-168 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.72 (d, J = 8.2 Hz, 2H), 7.28 (d, J = 7.6 Hz, 3H), 6.89 (s, 2H), 3.27 -3.23 (m, 2H), 2.41 (s, 3H), 2.31 - 2.25 (m, 5H), 2.17 (s, 6H), 1.99-1.94 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 143.76, 142.31, 141.22, 139.91, 137.52, 135.67, 129.45, 129.41, 126.90, 101.71, 47.27, 21.47, 21.23, 20.90, 19.83, 17.86; HRMS (ESI) calcd for C<sub>21</sub>H<sub>25</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 356.1679. Found: 356.1680.

1-(4-fluorophenyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4e). Yellow solid, 70% yield, M.p. 174-176 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.74 (s, 3H), 7.29 (d, J = 7.6 Hz, 2H), 7.06 - 7.03 (m, 4H), 3.53 - 3.51 (m, 2H), 2.43 - 2.42 (m, 3H), 2.28 - 2.26 (m, 2H), 1.99 – 1.95 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 159.15 (d, J<sub>C-F</sub> = 243.8 Hz), 142.87, 141.92 (d, J<sub>C-F</sub> = 2.3 Hz), 139.27, 138.98, 129.55, 127.17, 119.66 (d, J<sub>C-F</sub> = 7.9 Hz), 116.16 (d, J<sub>C-F</sub> = 22.8 Hz), 108.11, 46.40, 21.48, 21.16, 19.92; HRMS (ESI) calcd for C<sub>18</sub>H<sub>18</sub>FNO<sub>2</sub>S [M+H]<sup>+</sup>: 332.1115. Found: 332.1122.

1-(4-chlorophenyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4f). Yellow solid, 66% yield, M.p. 200-202 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.78 (s, 1H), 7.74 (d, J = 8.0 Hz, 2H), 7.31 – 7.28 (m, 4H), 6.99 (d, J = 8.7 Hz, 2H), 3.53 - 3.49 (m, 2H), 2.42 (s, 3H), 2.27 (t, J = 6.2 Hz, 2H), 1.99 – 1.94 (m, 2H); <sup>13</sup>C NMR (126 MHz,  $CDCI_3$ )  $\delta$  143.96, 143.02, 138.77, 138.42, 129.60, 129.46, 128.54, 127.21, 118.83, 109.24, 45.91, 21.50, 21.11, 19.95; HRMS (ESI) calcd for C<sub>18</sub>H<sub>18</sub>CINO<sub>2</sub>S [M+H]<sup>+</sup>: 348.0820. Found: 348.0825.

1-(4-bromophenyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4g). Yellow solid, 68% yield, M.p. 200-202 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.78 (s, 1H), 7.74 (d, J = 8.0 Hz, 2H), 7.44 (d, J = 8.6 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 6.94 (d, J = 8.7 Hz, 2H), 3.53 -3.49 (m, 2H), 2.42 (s, 3H), 2.27 (t, J = 6.2 Hz, 2H), 2.00 - 1.93 (m, 2H);  $^{13}C$  NMR (126 MHz, CDCl\_3)  $\delta$  144.41, 143.03, 138.73, 138.27, 132.40, 129.60, 127.23, 119.14, 116.00, 109.46, 45.83, 21.51, 21.11, 19.96; HRMS (ESI) calcd for C18H18BrNO2S [M+H]<sup>+</sup>: 392.0314. Found: 392.0325.

#### 1-(2,6-dichlorophenyl)-5-tosyl-1,2,3,4-tetrahydropyridine(4h).

White solid, 68% yield, M.p. 156-158 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.76 (d, J = 7.9 Hz, 2H), 7.39 (d, J = 8.1 Hz, 2H), 7.30 -7.27 (m, 3H), 7.21 (t, J = 8.1 Hz, 1H), 3.38 - 3.33 (m, 2H), 2.42 (s, 3H), 2.28 (t, J = 6.2 Hz, 2H), 2.05 – 1.96 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 142.67, 142.64, 140.66, 139.28, 134.98, 129.48, 129.13, 129.00, 127.16, 105.41, 47.06, 21.48, 20.93, 19.76; HRMS (ESI) calcd for C18H17Cl2NO2S [M+Na]+: 404.0249. Found: 404.0248.

## 1-(4-methoxyphenyl)-5-tosyl-1,2,3,4-tetrahydropyridine

(4i).<sup>[8e]</sup> Yellow solid, 53% yield, M.p. 176-178 °C; <sup>1</sup>H NMR (500

MHz, CDCl<sub>3</sub>)  $\delta$  7.74 (d, J = 7.5 Hz, 3H), 7.28 (d, J = 10.1 Hz, 2H), 7.01 (d, J = 7.4 Hz, 2H), 6.88 (d, J = 7.4 Hz, 2H), 3.80 (s, 3H), 3.51 (s, 2H), 2.41 (s, 3H), 2.26 (t, J = 5.4 Hz, 2H), 1.95 (s, 2H);  $^{13}\text{C}$  NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  156.25, 142.63, 139.97, 139.39, 129.49, 127.09, 119.93, 114.72, 106.43, 55.61, 46.62, 21.45, 21.20, 19.97.

#### 1-(3,5-dimethoxyphenyl)-5-tosyl-1,2,3,4-tetrahydropyridine

(4j). Yellow oil, 60% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.74 (s, 1H), 7.66 (d, *J* = 7.4 Hz, 2H), 7.21 (d, *J* = 7.5 Hz, 2H), 6.13 (s, 3H), 3.73 (s, 6H), 3.46 – 3.41 (m, 2H), 2.34 (s, 3H), 2.18 (t, *J* = 6.3 Hz, 2H), 1.88 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  161.61, 147.29, 142.89, 138.92, 129.55, 127.18, 108.44, 96.72, 95.14, 55.49, 46.01, 21.47, 21.17, 20.14; HRMS (ESI) calcd for C<sub>20</sub>H<sub>23</sub>NO<sub>4</sub>S [M+H]<sup>+</sup>: 374.1421. Found: 374.1429.

**5-tosyl-1-(3,4,5-trimethoxyphenyl)-1,2,3,4-tetrahydropyridine** (**4k**). Yellow solid, 73% yield, M.p. 152-154 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.78 – 7.72 (m, 3H), 7.29 (d, *J* = 8.0 Hz, 2H), 6.26 (s, 2H), 3.88 (s, 6H), 3.82 (s, 3H), 3.56 – 3.50 (m, 2H), 2.42 (s, 3H), 2.27 (t, *J* = 6.1 Hz, 2H), 2.00 – 1.95 (m, 2H); <sup>13</sup>C NMR (126 MHz,CDCl<sub>3</sub>) δ 153.81, 142.90, 142.11, 139.41, 138.94, 134.75, 129.56, 127.15, 107.70, 96.41, 61.02, 56.34, 46.61, 21.50, 21.18, 20.07; HRMS (ESI) calcd for C<sub>21</sub>H<sub>25</sub>NO<sub>5</sub>S [M+Na]<sup>+</sup>: 426.1346. Found: 426.1360.

**1-([1,1'-biphenyl]-4-yl)-5-tosyl-1,2,3,4-tetrahydropyridine (4l).** Light yellow solid, 71% yield, M.p. 168-170 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.90 (s, 1H), 7.76 (d, *J* = 7.9 Hz, 2H), 7.57 (t, *J* = 7.7 Hz, 4H), 7.43 (t, *J* = 7.5 Hz, 2H), 7.33 (t, *J* = 7.3 Hz, 1H), 7.29 (d, *J* = 7.9 Hz, 2H), 7.14 (d, *J* = 8.3 Hz, 2H), 3.61-3.55 (m, 2H), 2.41 (s, 3H), 2.29 (t, *J* = 6.1 Hz, 2H), 2.02 – 1.96 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 144.55, 142.88, 140.17, 139.03, 138.73, 136.22, 129.57, 128.85, 128.06, 127.21, 127.18, 126.75, 117.87, 108.62, 45.86, 21.50, 21.20, 20.07; HRMS (ESI) calcd for C<sub>24</sub>H<sub>23</sub>NO<sub>2</sub>S [M+Na]\*: 412.1342. Found: 412.1360.

**1-(naphthalen-1-yl)-5-tosyl-1,2,3,4-tetrahydropyridine** (4m). Light yellow oil, 80% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.89 (d, J = 8.8 Hz, 1H), 7.84 (d, J = 8.7 Hz, 1H), 7.77 (d, J = 8.0 Hz, 3H), 7.63 (s, 1H), 7.55 – 7.51 (m, 2H), 7.44 (t, J = 7.8 Hz, 1H), 7.30 (d, J = 7.9 Hz, 2H), 7.26 (s, 1H), 3.57 (s, 2H), 2.42 (s, 3H), 2.39 (t, J = 6.2 Hz, 2H), 2.09 – 2.02 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 143.47, 143.22, 142.68, 139.43, 134.81, 129.55, 129.20, 128.70, 127.29, 127.13, 126.79, 126.52, 125.64, 122.70, 122.52, 105.90, 49.49, 21.57, 21.51, 20.22; HRMS (ESI) calcd for C<sub>22</sub>H<sub>21</sub>NO<sub>2</sub>S [M+H]\*: 364.1366. Found: 364.1366.

**5-tosyl-3,4-dihydro-2H-1,2'-bipyridine (4n).** Yellow solid, 20% yield, M.p. 170-172 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.50 (s, 1H), 8.32 (d, *J* = 4.3 Hz, 1H), 7.77 (d, *J* = 8.1 Hz, 2H), 7.65 (t, *J* = 7.8 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 6.93 (t, *J* = 7.4 Hz, 2H), 3.74 – 3.67 (m, 2H), 2.41 (s, 3H), 2.30 (t, *J* = 6.2 Hz, 2H), 2.01 – 1.92 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 153.27, 147.17, 142.10, 137.60, 137.32, 135.06, 128.60, 126.37, 116.58, 110.35, 107.68, 42.01, 20.50, 20.13, 19.49; HRMS (ESI) calcd for  $C_{17}H_{18}N_2O_2S$  [M+H]\*: 315.1162. Found: 315.1160.

4-methyl-1-phenyl-5-tosyl-1,2,3,4-tetrahydropyridine (40). Light yellow solid, 83% yield, M.p. 170-172 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.93 (s, 1H), 7.76 (d, J = 8.0 Hz, 2H), 7.37 (t, J = 7.7 Hz, 2H), 7.27 (d, J = 8.3 Hz, 2H), 7.14 – 7.09 (m, 3H), 3.67-3.60 (m, 1H), 3.56 (m, 1H), 2.67 – 2.60 (m, 1H), 2.41 (s, 3H), 1.82-1.70 (m, 2H), 1.06 (d, J = 6.9 Hz, 3H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  145.22, 142.66, 140.27, 139.19, 129.51,129.49, 127.13, 123.52, 117.78, 112.47, 41.92, 28.63, 25.13, 21.48, 21.39; HRMS (ESI) calcd for C<sub>19</sub>H<sub>21</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 328.1366. Found: 328.1373.

**1-phenyl-6-tosyl-2,3,4,5-tetrahydro-1H-azepine (4p).** Light yellow oil, 31% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.78 (s, 1H), 7.75 (d, *J* = 8.1 Hz, 2H), 7.35 (t, *J* = 7.9 Hz, 2H), 7.29 (d, *J* = 7.9 Hz, 2H), 7.11 (s, 2H), 7.09 (s, 1H), 3.85-3.80 (m, 2H), 2.47 – 2.43 (m, 2H), 2.42 (s, 3H), 1.86 (m, 2H), 1.77 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  147.38, 144.63, 142.81, 139.08, 129.52, 129.42, 127.30, 123.84, 119.68, 113.75, 51.70, 27.98, 25.95, 25.56, 21.49; HRMS (ESI) calcd for C<sub>19</sub>H<sub>21</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 328.1366. Found: 328.1374.

**1-benzyl-5-tosyl-1,2,3,4-tetrahydropyridine** (4q).<sup>[Re]</sup> White solid, 68% yield, M.p. 155-157 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.64 (d, J = 8.0 Hz, 2H), 7.41 (s, 1H), 7.26 (d, J = 7.3 Hz, 2H), 7.22 (d, J = 7.0 Hz, 1H), 7.20 – 7.17 (m, 2H), 7.11 (d, J= 7.3 Hz, 2H), 4.21 (s, 2H), 2.91 – 2.80 (m, 2H), 2.32 (s, 3H), 2.07 (t, J = 6.1 Hz, 2H), 1.71 – 1.63 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  144.15, 142.29, 139.89, 136.53, 129.41, 128.83, 127.94, 127.48, 126.88, 101.24, 59.68, 45.02, 21.43, 21.01, 19.67; HRMS (ESI) calcd for C<sub>19</sub>H<sub>21</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 328.1366. Found: 328.1365.

**1-(4-fluorobenzyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4r).** Yellow oil, 65% yield; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.72 (d, J = 7.5 Hz, 2H), 7.47 (s, 1H), 7.27 (s, 2H), 7.20 – 7.15 (m, 2H), 7.04 (t, J = 8.1 Hz, 2H), 4.27 (s, 2H), 2.92 (s, 2H), 2.41 (s, 3H), 2.16 (t, J = 5.6 Hz, 2H), 1.79 – 1.73 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  162.48 (d,  $J_{C-F}$  = 247.0 Hz), 143.89, 142.38, 139.75, 132.25 (d,  $J_{C-F}$  = 2.9 Hz), 129.42, 129.19 (d,  $J_{C-F}$  = 8.2 Hz), 126.90, 115.75 (d,  $J_{C-F}$  = 21.7 Hz), 101.77, 58.94, 44.95, 21.41, 21.00, 19.65; HRMS (ESI) calcd for C<sub>19</sub>H<sub>20</sub>FNO<sub>2</sub>S [M+H]<sup>+</sup>: 346.1272. Found: 346.1286.

**1-(4-chlorobenzyl)-5-tosyl-1,2,3,4-tetrahydropyridine** (4s). Light yellow soild, 57% yield; M.p. 104-106 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.63 (d, *J* = 8.1 Hz, 2H), 7.38 (s, 1H), 7.24 (d, *J* = 8.1 Hz, 2H), 7.24 (d, *J* = 8.1 Hz, 2H), 7.06 (d, *J* = 8.3 Hz, 2H), 4.18 (s, 2H), 2.90 – 2.80 (m, 2H), 2.33 (s, 3H), 2.08 (t, *J* = 6.1 Hz, 2H), 1.71 – 1.64 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  143.87, 142.42, 139.68, 135.07, 133.82, 129.44, 129.01, 128.86, 126.89, 101.91, 58.95, 45.01, 21.44, 20.98, 19.62; HRMS (ESI) calcd for C<sub>19</sub>H<sub>20</sub>CINO<sub>2</sub>S [M+Na]\*: 384.0801. Found: 384.0809.

**1-(4-bromobenzyl)-5-tosyl-1,2,3,4-tetrahydropyridine** (4t). Light yellow soild, 58% yield, M.p. 117-119 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.71 (d, *J* = 8.2 Hz, 2H), 7.48 (s, 1H), 7.46 (s, 2H), 7.28 – 7.27 (m, 2H), 7.08 (d, *J* = 8.3 Hz, 2H), 4.25 (s, 2H), 2.96 – 2.88 (m, 2H), 2.41 (s, 3H), 2.16 (t, *J* = 6.1 Hz, 2H), 1.79 – 1.72 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  143.88, 142.43, 139.65, 135.59, 131.99, 129.45, 129.19, 126.90, 121.90, 101.97, 59.02, 45.03, 21.45, 20.99, 19.62. HRMS (ESI) calcd for C<sub>19</sub>H<sub>20</sub>BrNO<sub>2</sub>S [M+H]<sup>+</sup>: 406.0471. Found: 406.0469.

1-(4-methoxybenzyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4u).  $^{[8e]}$  Light yellow solid, 59% yield, M.p. 88-90 °C;  $^1\text{H}$  NMR (500

MHz, CDCl<sub>3</sub>)  $\delta$  7.72 (d, J = 8.2 Hz, 2H), 7.49 (s, 1H), 7.26 (d, J = 3.7 Hz, 2H), 7.12 (d, J = 8.5 Hz, 2H), 6.88 (d, J = 8.6 Hz, 2H), 4.23 (s, 2H), 3.81 (s, 3H), 2.98 – 2.85 (m, 2H), 2.41 (s, 3H), 2.15 (t, J = 6.1 Hz, 2H), 1.79 – 1.69 (m, 2H);  $^{13}\text{C}$  NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  159.43, 144.08, 142.28, 139.86, 129.40, 128.88, 128.38, 126.88, 114.24, 59.22, 55.32, 44.81, 21.44, 21.00, 19.68.

**1-(4-nitrobenzyl)-5-tosyl-1,2,3,4-tetrahydropyridine** (4v).<sup>[Be]</sup> Light yellow solid, 62% yield, M.p. 103-105 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  8.21 (d, *J* = 8.1 Hz, 2H), 7.72 (d, *J* = 7.8 Hz, 2H), 7.48 (s, 1H), 7.39 (d, *J* = 8.2 Hz, 2H), 7.29 (d, *J* = 8.6 Hz, 2H), 4.42 (s, 2H), 2.97 (s, 2H), 2.42 (s, 3H), 2.19 (t, *J* = 6.0 Hz, 2H), 1.85 - 1.75 (m, 2H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  147.76, 144.15, 143.66, 142.68, 139.35, 129.53, 128.17, 126.96, 124.10, 103.23, 58.82, 45.45, 21.44, 20.99, 19.54.

**1-(cyclohexylmethyl)-5-tosyl-1,2,3,4-tetrahydropyridine (4w).** Light yellow solid, 47% yield, M.p. 136 -138 °C; <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.69 (d, *J* = 7.8 Hz, 2H), 7.27 (s, 1H), 7.26 (s, 2H), 3.05 (d, *J* = 4.5 Hz, 2H), 2.95 (d, *J* = 7.0 Hz, 2H), 2.39 (s, 3H), 2.14 (t, *J* = 6.0 Hz, 2H), 1.78 (dd, *J* = 11.9, 5.9 Hz, 3H), 1.66 (d, *J* = 12.1 Hz, 2H), 1.31 – 1.14 (m, 5H), 0.87 (dd, *J* = 21.3, 11.0 Hz, 3H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)  $\delta$  144.72, 142.08, 140.13, 129.33, 126.79, 100.00, 62.62, 46.10, 36.83, 30.64, 26.33, 25.75, 21.40, 21.10, 19.69; HRMS (ESI) calcd for C<sub>19</sub>H<sub>27</sub>NO<sub>2</sub>S [M+H]<sup>+</sup>: 334.1835. Found: 334.1824.

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## Entry for the Table of Contents



A highly efficient and generally applicable methodology for the construction of vinyl sulfone derivatives from cyclic amines and sulfonyl hydrazides in one step was developed. This protocol could be applied for the C-S bond formation of *N*-Aryl piperidines, *N*-alkyl piperidines and heteroaryl piperidines with sulfonyl hydrazides.

