Supporting Information

Visible-light-induced oxidative cyclization of N-propargylanilines with sulfinic acids to 3-sulfonated quinoline derivatives without external photocatalyst

Yicheng Zhang, Wei Chen, Xueshun Jia, Lei Wang, and Pinhua Li

Department of Chemistry, Huaibei Normal University, Huaibei, Anhui 235000, P. R. China, Tel: +86-561-3802-069 Fax: +86-561-3090-518
E-mail: lake688123@163.com; pphuali@126.com

State Key Laboratory of Organometallic Chemistry, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, P. R. China

School of Environmental and Chemical Engineering, Shanghai University, Shanghai 200444, P. R. China

Table of Contents

1. General considerations S2
2. General procedure for the reaction S2
3. Preliminary mechanistic study S3
4. Characterization data for the products S10
5. 1H and 13C NMR spectra of the products S26
1. General considerations

All $^1$H NMR and $^{13}$C NMR spectra were recorded on a 400 MHz Bruker FT-NMR spectrometer (400 MHz or 100 MHz, respectively). All chemical shifts are given as $\delta$ value (ppm) with reference to tetramethylsilane (TMS) as internal reference. The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; m, multiplet; q, quartet. The coupling constants, $J$, are reported in Hertz (Hz). High resolution mass spectroscopy data of the product were collected on a Waters Micromass GCT instrument. High resolution mass spectroscopy data of the product were collected on an Agilent Technologies 6540 UHD Accurate-Mass Q-TOF LC/MS (ESI). The chemicals and solvents were purchased from commercial suppliers either from Aldrich (USA) or Shanghai Chemical Company (China) without further purification. The starting material propargylamine ($1a-1x$) were prepared according to the reported method (See: L. Zhang, S. Chen, Y. Gao, P. Zhang, Y. Wu, G. Tang and Y. Zhao, *Org. Lett.*, 2016, **18**, 1286). The chemicals and solvents were purchased from commercial suppliers either from Aldrich (USA) or Shanghai Chemical Company (China) without further purification. All the solvents were dried and freshly distilled prior to use. Products were purified by flash chromatography packed with 200–300 mesh silica gels, SiO$_2$.

2. General procedure for the reaction

2.1 General procedure for the reaction in 0.20 mmol scale

\[
\text{HN} R^1 \text{R}^2 + \text{SO} R^3 \text{N} R^1 \text{R}^2 \xrightarrow{\text{LED (380-385 nm)}} \text{HO} \xrightarrow{\text{pyridine (2.0 equiv)}} \text{DCE, r.t., 8 h, air} \xrightarrow{\text{R}^1} \text{R}^2 \text{SO} R^3
\]

$N$-(3-Phenyl-2-propynyl)aniline derivative ($1$, 0.20 mmol), sulfinic acid ($2$, 0.40 mmol), pyridine (0.40 mmol) and DCE (2.0 mL) were sequentially added to a 5 mL oven-dried reaction vessel equipped with a magnetic stirrer bar. The reaction mixture
was exposed to blue LED (380–385 nm, 1.5 W) irradiation at room temperature in air with stirring for 8 h. When the reaction was complete, the reaction solution was concentrated in vacuum. The resulting crude mixture was purified by flash column chromatography (petroleum ether/ethyl acetate = 3:1 to 5:1) to give the desired product (3).

2.2 The representative procedure for the reaction of 1a in 10.0 mmol scale

\[
\begin{align*}
\text{HN} & \text{Ph} \\
\text{Me} & \\
\text{HN} \quad \text{Ph} & \text{Me} \quad \text{Pyridine (2.0 equiv)} \quad \text{DCE, r.t.,16 h, air} \\
1a & \quad 10.0 \text{mmol (2.07 g)} & 2a & \quad 20.0 \text{mmol} & 3a & \quad 2.91 \text{g (81%)}
\end{align*}
\]

\(N\)-(3-phenyl-2-propynyl)aniline \(1a\), 10.0 mmol, 4-methylbenzenesulfinic acid \(2a\), 20.0 mmol, pyridine (20.0 mmol) and DCE (100.0 mL) were sequentially added to a 250 mL oven-dried reaction vessel equipped with a magnetic stirrer bar. The reaction mixture was exposed to blue LED (380–385 nm, 1.5 W×4, four lamps) irradiation at room temperature in air with stirring for 16 h. After the reaction was completed (monitored by TLC), the reaction solution was concentrated in vacuum. Then ethyl acetate (120 mL) was added and the mixture was washed with saturated sodium carbonate (\(\text{Na}_2\text{CO}_3\)) solution, water and brine solution. The organic layer was collected and dried over \(\text{Na}_2\text{SO}_4\). After the solvent was removed under reduced pressure, the residue was purified by column chromatography using a mixture of petroleum ether and ethyl acetate (5:1, V/V) as an eluent to afford the desired product \(3a\) as light yellow solid (2.91g, 81% yield).

3. Preliminary mechanistic study

3.1 Free radical-inhibiting experiment

\[
\begin{align*}
\text{HN} & \quad \text{Ph} \\
\text{Me} & \quad \text{Ts} \\
\text{HN} \quad \text{Ph} & \quad \text{Me} \\
1a & \quad 0.20 \text{mmol} & 2a & \quad \text{standard conditions, TEMPO (2 equiv)} & 3a & \quad \text{trace}
\end{align*}
\]

\(N\)-(3-Phenyl-2-propynyl)aniline \(1a\), 0.20 mmol, 4-methylbenzenesulfinic acid
(2a, 0.40 mmol), pyridine (0.40 mmol), 2,2,6,6-tetramethyl-1-oxylpiperidine (TEMPO, 0.40 mmol) and DCE (2.0 mL) were sequentially added to a 5 mL oven-dried reaction vessel equipped with a magnetic stirrer bar. The reaction mixture was exposed to blue LED (380–385 nm, 1.5 W) irradiation at room temperature in air with stirring for 8 h. After the reaction was completed, only trace amount of product 3a was detected by TLC and HPLC-HRMS, indicating that the reaction was almost inhibited.

3.2 Free radical-trapping experiment

\[
\begin{align*}
1a + 2a & \rightarrow \text{standard conditions} \\
& \xrightarrow{\text{Ph}} \xrightarrow{\text{Ph}} \xrightarrow{\text{Ph, 2 equiv}} 3a, 60\% + 6 \\
& \text{detected by HRMS}
\end{align*}
\]

N-(3-Phenyl-2-propynyl)aniline (1a, 0.20 mmol), 4-methylbenzenesulfinic acid (2a, 0.40 mmol), pyridine (0.40 mmol), 1,1-diphenylethylene (5, 0.40 mmol) and DCE (2.0 mL) were sequentially added to a 5 mL oven-dried reaction vessel equipped with a magnetic stirrer bar. The reaction mixture was exposed to blue LED (380–385 nm, 1.5 W) irradiation at room temperature in air with stirring for 8 h. After the reaction was completed, the products were detected by TLC and HPLC-HRMS. The product 3a was isolated in 60% yield, and small amount of compound 6 was detected by HPLC-HRMS analysis, as shown in Figure S1, which is a radical trapping product.
3.3 Determination of electron spin resonance (ESR)

3.3.1 Determination of superoxide radicals

In order to determine the active species of oxygen involved in the present reaction, 5,5-dimethyl-pyrroline-N-oxide (DMPO) was employed to capture O$_2$$^\bullet^-$.

There was no signal when DMPO was added into a solution of N-(3-phenyl-2-propynyl)aniline (1a) in air in the absence of light irradiation (Figure S2A). Irradiation of reaction solution of DMPO and N-(3-phenyl-2-propynyl)aniline (1a) in air with LED (380–385 nm, 1.5 W) resulted in the formation of a strong characteristic signal of O$_2$$^\bullet^-$ adduct with DMPO (Figure S2B). When the reaction time was prolonged, a series of stronger characteristic signal of O$_2$$^\bullet^-$ were observed (Figure S2C and S2D), indicating the formation of O$_2$$^\bullet^-$ in the reaction.
**Figure S2.** Electron spin resonance (ESR) spectra of 5,5-dimethyl-pyrrolone-N-oxide (DMPO) with O$_2$$^\cdot$−

(A) A solution of DMPO (0.20 mol/L) with 1a in DCE without light irradiation.

(B) A solution of DMPO (0.20 mol/L) with 1a in DCE under LED (380–385 nm, 1.5 W) irradiation for 30 s.

(C) A solution of DMPO (0.20 mol/L) with 1a in DCE under LED (380–385 nm, 1.5 W) irradiation for 60 s.

(D) A solution of DMPO (0.20 mol/L) with 1a in DCE under LED (380–385 nm, 1.5 W) irradiation for 90 s.

### 3.3.2 Determination of singlet oxygen species

For further explore the active species of singlet oxygen involved during the reaction, 2,2,6,6-tetramethylpiperidine (TEMP) was used to trap $^1$O$_2$. Irradiation of reaction solution of TEMP and N-(3-phenyl-2-propynyl)aniline (1a) in air with LED (380–385 nm, 1.5 W) resulted in the formation of a strong characteristic signal $^1$O$_2$ adduct with TEMP (**Figure S3**b, c, d and e), implying that $^1$O$_2$ is also present during the reaction.
Figure S3. Electron spin resonance (ESR) spectra of 2,2,6,6-tetramethylpiperidine (TEMP) with $^{1}$O$_2$

(a) A solution of TEMP (0.20 mol/L) with 1a in DCE without light irradiation.

(b) A solution of TEMP (0.20 mol/L) with 1a in DCE under LED (380−385 nm, 1.5 W) irradiation for 30 s.

(c) A solution of TEMP (0.20 mol/L) with 1a in DCE under LED (380−385 nm, 1.5 W) irradiation for 60 s.

(d) A solution of TEMP (0.20 mol/L) with 1a in DCE under LED (380−385 nm, 1.5 W) irradiation for 90 s.

(e) A solution of TEMP (0.20 mol/L) with 1a in DCE under LED (380−385 nm, 1.5 W) irradiation for 120 s.
3.4 UV-visible absorption spectra of reactants and product

Figure S4. UV-visible absorption spectra of 1a, 2a, and 3a in DCE

1. Absorption spectrum of 4-methylbenzenesulfonic acid (2a, 0.40 mmol) in DCE (4.0 mL)
2. Absorption spectrum of 4-methylbenzenesulfonic acid (2a, 0.40 mmol) and pyridine (0.20 mmol) in DCE (4.0 mL)
3. Absorption spectrum of N-(3-phenyl-2-propynyl)aniline (1a, 0.20 mmol) in DCE (4.0 mL)
4. Absorption spectrum of N-(3-phenyl-2-propynyl)aniline (1a, 0.20 mmol), 4-methylbenzenesulfonic acid (2a, 0.40 mmol) and pyridine (0.40 mmol) in DCE (4.0 mL)
5. Absorption spectrum of 4-phenyl-3-tosylquinoline (3a, 0.20 mmol) in DCE (4.0 mL)
3.5 Light/Dark experiment

\[
\text{HN} \quad \text{Ph} \quad 1a \\
+ \quad \text{Me} \quad \text{SO} \quad \text{OH} \quad \text{LED (380-385 nm)} \\
\text{DCE, r.t., air} \quad 2a \\
\rightarrow \quad \text{Ph} \quad \text{Ts} \quad 3a
\]

**Figure S5.** Light/Dark experiment
4. Characterization data for the products

4-Phenyl-3-tosylquinoline (3a)
Yield: 70.4 mg (98%). \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 9.78 \text{ (s, 1H)}, 8.20 \text{ (d, } J = 8.4 \text{ Hz, 1H)}, 7.83–7.78 \text{ (m, 1H)}, 7.47–7.42 \text{ (m, 2H)}, 7.35–7.31 \text{ (m, 3H)}, 7.19 \text{ (d, } J = 8.4 \text{ Hz, 2H)}, 7.04 \text{ (d, } J = 8.4 \text{ Hz, 2H}), 6.95 \text{ (d, } J = 7.2 \text{ Hz, 2H)}, 2.34 \text{ (s, 3H)}; \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 149.7, 149.7, 147.7, 144.0, 137.9, 132.6, 132.1, 130.0, 129.6, 129.2, 128.6, 127.9, 127.8, 127.6, 127.4, 21.5\); HRMS (ESI) ([M+H\(^+\)]) Calcd. For C\(_{22}\)H\(_{18}\)NO\(_2\)S: 360.1053, Found: 360.1061.

4-(p-Tolyl)-3-tosylquinoline (3b)
Yield: 73.9 mg (99%). \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 9.76 \text{ (s, 1H)}, 8.18 \text{ (d, } J = 8.4 \text{ Hz, 1H)}, 7.81–7.77 \text{ (m, 1H)}, 7.45–7.41 \text{ (m, 1H)}, 7.38–7.35 \text{ (m, 1H)}, 7.22 \text{ (d, } J = 8.4 \text{ Hz, 2H)}, 7.14 \text{ (d, } J = 8.0 \text{ Hz, 2H)}, 7.04 \text{ (d, } J = 8.0 \text{ Hz, 2H}), 6.84 \text{ (d, } J = 8.0 \text{ Hz, 2H)}, 2.46 \text{ (s, 3H)}, 2.34 \text{ (s, 3H)}; \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 150.1, 149.6, 147.7, 143.9, 138.5, 138.0, 132.7, 132.0, 129.8, 129.6, 129.5, 129.1, 128.2, 127.9, 127.6, 127.4, 21.5, 21.4\); HRMS (ESI) ([M+H\(^+\)]) Calcd. For C\(_{23}\)H\(_{20}\)NO\(_2\)S: 374.1209, Found: 374.1205.
4-(4-Methoxyphenyl)-3-tosylquinoline (3c)
Yield: 73.2 mg (94%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.62$ (s, 1H), 8.07 (d, $J = 9.2$ Hz, 1H), 7.45–7.41 (m, 2H), 7.32 (t, $J = 8.0$ Hz, 2H), 7.18 (d, $J = 8.4$ Hz, 2H), 7.03 (d, $J = 8.0$ Hz, 2H), 6.93 (d, $J = 7.2$ Hz, 2H), 6.49 (d, $J = 2.4$ Hz, 1H), 3.58 (s, 3H), 2.33 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 158.5$, 147.9, 146.0, 145.2, 143.9, 138.0, 132.8, 132.8, 130.9, 129.8, 129.1, 128.7, 128.5, 127.8, 127.7, 124.7, 104.7, 55.2, 21.4; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{23}$H$_{20}$NO$_3$S: 390.1158, Found: 390.1161.

4-(4-(tert-Butyl)phenyl)-3-tosylquinoline (3d)
Yield: 80.6 mg (97%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.80$ (s, 1H), 8.19 (d, $J = 8.8$ Hz, 1H), 7.79 (t, $J = 7.2$ Hz, 1H), 7.44 (t, $J = 8.0$ Hz, 1H), 7.38 (d, $J = 8.4$ Hz, 1H), 7.30 (d, $J = 8.4$ Hz, 2H), 7.12 (d, $J = 8.0$ Hz, 2H), 6.97 (d, $J = 8.0$ Hz, 2H), 6.86 (d, $J = 8.4$ Hz, 2H), 2.33 (s, 3H), 1.41 (s, 9H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 151.7$, 150.1, 149.7, 147.5, 143.7, 137.8, 132.8, 132.0, 129.8, 129.6, 129.4, 129.0, 127.8, 127.6, 127.6, 127.5, 124.4, 34.7, 31.4, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{26}$H$_{26}$NO$_2$S: 416.1679, Found: 416.1675.
4-(3-Tosylquinolin-4-yl)benzonitrile (3e)
Yield: 75.4 mg (98%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.73$ (s, 1H), 8.23 (d, $J = 8.4$ Hz, 1H), 7.85 (t, $J = 7.2$ Hz, 1H), 7.66 (d, $J = 8.4$ Hz, 2H), 7.50 (t, $J = 8.0$ Hz, 1H), 7.26 (d, $J = 8.0$ Hz, 2H), 7.20 (d, $J = 8.4$ Hz, 1H), 7.14–7.12 (m, 4H), 2.38 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.7, 147.7, 147.1, 144.7, 137.8, 137.7, 132.5, 132.3, 131.3, 130.8, 130.0, 129.5, 128.4, 127.7, 126.6, 126.4, 118.2, 112.8, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{23}$H$_{17}$N$_2$O$_2$S: 385.1005, Found: 385.1008.

4-(4-Nitrophenyl)-3-tosylquinoline (3f)
Yield: 76.8 mg (95%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.74$ (s, 1H), 8.26–8.22 (m, 3H), 7.87 (t, $J = 7.2$ Hz, 1H), 7.51 (t, $J = 7.2$ Hz, 1H), 7.30 (d, $J = 8.4$ Hz, 2H), 7.22–7.20 (m, 3H), 7.14 (d, $J = 8.0$ Hz, 2H), 2.39 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.6, 148.0, 147.7, 146.8, 144.9, 139.7, 137.8, 132.6, 132.5, 131.1, 130.0, 129.6, 128.5, 127.8, 126.6, 126.4, 122.8, 21.6; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{17}$N$_2$O$_4$S: 405.0904, Found: 405.0910.
3-Tosyl-4-(4-(trifluoromethyl)phenyl)quinoline (3g)
Yield: 84.6 mg (99%). $^1$H NMR (400 MHz, CDCl$_3$): δ = 9.78 (s, 1H), 8.23 (d, $J$ = 8.4 Hz, 1H), 7.87–7.83 (m, 1H), 7.59 (d, $J$ = 8.0 Hz, 2H), 7.52–7.48 (m, 1H), 7.27–7.25 (m, 1H), 7.20 (d, $J$ = 8.4 Hz, 2H), 7.11 (d, $J$ = 8.0 Hz, 2H), 7.07 (d, $J$ = 8.0 Hz, 2H), 2.37 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): δ = 149.7, 147.7, 147.5, 144.4, 137.6, 136.5, 132.6, 132.3, 130.8 (q, $J$ = 32.0 Hz), 130.5, 129.8, 129.4, 128.2, 127.7, 126.8, 126.7, 124.5 (q, $J$ = 4.0 Hz), 123.8 (q, $J$ = 271.0 Hz), 21.4; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{23}$H$_{17}$F$_3$NO$_2$S: 428.0927, Found: 428.0931.

![](image)

1-(4-(3-Tosylquinolin-4-yl)phenyl)ethan-1-one (3h)
Yield: 77.1 mg (96%). $^1$H NMR (400 MHz, CDCl$_3$): δ = 9.70 (s, 1H), 8.17 (d, $J$ = 8.4 Hz, 1H), 7.92 (d, $J$ = 8.0 Hz, 2H), 7.79 (t, $J$ = 8.0 Hz, 1H), 7.43 (d, $J$ = 8.0 Hz, 1H), 7.21 (d, $J$ = 8.0 Hz, 3H), 7.08–7.03 (m, 4H), 2.67 (s, 3H), 2.32 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): δ = 197.3, 149.5, 148.2, 147.6, 144.4, 137.8, 137.6, 136.9, 132.3, 132.2, 130.2, 129.7, 129.3, 128.0, 127.7, 127.3, 126.9, 126.7, 26.6, 21.4; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{24}$H$_{20}$NO$_3$S: 402.1158, Found: 402.1161.

![](image)

4-(4-Fluorophenyl)-3-tosylquinoline (3i)
Yield: 73.2 mg (97%). $^1$H NMR (400 MHz, CDCl$_3$): δ = 9.75 (s, 1H), 8.19 (d, $J$ = 8.4 Hz, 1H), 7.83–7.79 (m, 1H), 7.48–7.44 (m, 1H), 7.31 (d, $J$ = 8.4 Hz, 1H), 7.22 (d, $J$ =
8.4 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 7.03 (t, J = 8.8 Hz, 2H), 6.95–6.91 (m, 2H),
2.35 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 162.9 (d, J = 248.0 Hz), 149.7, 148.6,
147.6, 144.2, 137.9, 132.8, 132.2, 131.9 (d, J = 8.0 Hz), 129.7, 129.2, 128.4 (d, J =
4.0 Hz), 127.9, 127.7, 127.4, 127.0, 114.7 (d, J = 17.0 Hz), 21.5; HRMS (ESI) ([M+H]$^+$) Calcd.
For C$_{22}$H$_{17}$FNO$_2$S: 378.0959, Found: 378.0953.

![ClTs]

4-(4-Chlorophenyl)-3-tosylquinoline (3j)
Yield: 77.2 mg (98%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.76 (s, 1H), 8.20 (d, J = 8.4
Hz, 1H), 7.85–7.81 (m, 1H), 7.50–7.46 (m, 1H), 7.33–7.31 (m, 3H), 7.25 (d, J = 8.4
Hz, 2H), 7.11 (d, J = 8.0 Hz, 2H), 6.91 (d, J = 8.4 Hz, 2H), 2.37 (s, 3H); $^{13}$C NMR
(100 MHz, CDCl$_3$): $\delta$ = 149.6, 148.3, 147.6, 144.3, 137.8, 135.0, 132.7, 132.2, 131.3,
131.0, 129.7, 129.3, 128.0, 127.9, 127.8, 127.1, 127.0, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd.
For C$_{22}$H$_{17}$ClNO$_2$S: 394.0663, Found: 394.0661.

![BrTs]

4-(4-Bromophenyl)-3-tosylquinoline (3k)
Yield: 85.0 mg (97%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.73 (s, 1H), 8.18 (d, J = 8.4
Hz, 1H), 7.83–7.78 (m, 1H), 7.48–7.44 (m, 3H), 7.30 (d, J = 8.8 Hz, 1H), 7.23 (d, J =
8.4 Hz, 2H), 7.09 (d, J = 8.0 Hz, 2H), 6.83 (d, J = 8.4 Hz, 2H), 2.35 (s, 3H); $^{13}$C NMR
(100 MHz, CDCl$_3$): $\delta$ = 149.6, 148.2, 147.5, 144.3, 137.7, 132.6, 132.2, 131.5, 131.5,
130.8, 129.7, 129.2, 128.0, 127.7, 126.9, 123.1, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd.
For C\textsubscript{22}H\textsubscript{17}BrNO\textsubscript{2}S: 438.0158, Found: 438.0162.

4-(Thiophen-2-yl)-3-tosylquinoline (3l)

Yield: 65.1 mg (89%). \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta = 9.77\) (s, 1H), 8.15 (d, \(J = 8.4\) Hz, 1H), 7.80–7.76 (m, 1H), 7.55 (d, \(J = 8.0\) Hz, 1H), 7.50–7.45 (m, 2H), 7.29 (d, \(J = 8.4\) Hz, 2H), 7.11–7.07 (m, 3H), 6.97 (d, \(J = 2.8\) Hz, 1H), 2.32 (s, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta = 149.5, 147.5, 144.0, 142.8, 137.3, 134.1, 132.2, 131.6, 131.2, 129.4, 129.2, 128.6, 128.3, 128.0, 127.6, 126.9, 126.6, 21.4\); HRMS (ESI) ([M+H]\textsuperscript{+}): Calcd. For C\textsubscript{20}H\textsubscript{16}NO\textsubscript{2}S: 366.0617, Found: 366.0619.

6-Methyl-4-phenyl-3-tosylquinoline (3m)

Yield: 71.0 mg (95%). \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta = 9.70\) (s, 1H), 8.07 (d, \(J = 8.4\) Hz, 1H), 7.62 (dd, \(J_1 = 8.4\) Hz, \(J_2 = 1.6\) Hz, 1H), 7.45 (t, \(J = 7.6\) Hz, 1H), 7.32 (t, \(J = 7.6\) Hz, 2H), 7.18 (d, \(J = 8.4\) Hz, 2H), 7.04–7.02 (m, 3H), 6.92 (d, \(J = 6.8\) Hz, 2H), 2.34 (s, 3H), 2.33 (s, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta = 148.9, 148.3, 146.7, 143.8, 138.0, 134.4, 132.7, 132.5, 130.0, 129.2, 129.1, 128.5, 127.8, 127.5, 127.4, 125.9, 21.7, 21.4\); HRMS (ESI) ([M+H]\textsuperscript{+}): Calcd. For C\textsubscript{23}H\textsubscript{20}NO\textsubscript{2}S: 374.1209, Found: 374.1210.

6-Methoxy-4-phenyl-3-tosylquinoline (3n)

Yield: 64.7 mg (83%). \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta = 9.75\) (s, 1H), 8.17 (d, \(J = 8.4\) Hz, 1H), 7.79 (d, \(J = 8.0\) Hz, 1H), 7.68 (d, \(J = 8.4\) Hz, 1H), 7.60 (d, \(J = 8.4\) Hz, 1H), 7.50–7.48 (m, 1H), 7.44 (t, \(J = 7.6\) Hz, 1H), 7.36 (t, \(J = 7.6\) Hz, 2H), 7.11–7.09 (m, 3H), 6.95 (d, \(J = 6.8\) Hz, 2H), 2.32 (s, 3H), 2.31 (s, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta = 149.5, 147.5, 144.0, 142.8, 137.3, 134.1, 132.2, 131.6, 131.2, 129.4, 129.2, 128.6, 128.3, 128.0, 127.6, 126.9, 126.6, 21.4\); HRMS (ESI) ([M+H]\textsuperscript{+}): Calcd. For C\textsubscript{23}H\textsubscript{20}NO\textsubscript{2}S: 374.1209, Found: 374.1210.
Hz, 1H), 7.80–7.76 (m, 1H), 7.45–7.41 (m, 1H), 7.29 (d, \(J = 8.4\) Hz, 1H), 7.20 (d, \(J = 8.4\) Hz, 2H), 7.04 (d, \(J = 8.0\) Hz, 2H), 6.87–6.83 (m, 4H), 3.89 (s, 3H), 2.33 (s, 3H);

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 159.9, 149.8, 149.6, 147.6, 143.9, 137.9, 132.9, 132.0, 131.3, 129.5, 129.1, 127.8, 127.8, 127.6, 127.3, 124.5, 113.0, 55.3, 21.4;

HRMS (ESI) ([M+H]\(^+\)) Calcd. For C\(_{23}\)H\(_{20}\)NO\(_3\)S: 390.1158, Found: 390.1162.

\[ \text{6-Fluoro-4-phenyl-3-tosylquinoline (3o)} \]

Yield: 73.2 mg (97%). \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 9.73\) (s, 1H), 8.19 (dd, \(J_1 = 9.2\) Hz, \(J_2 = 5.6\) Hz, 1H), 7.58–7.53 (m, 1H), 7.46 (t, \(J = 7.2\) Hz, 1H), 7.33 (t, \(J = 8.0\) Hz, 2H), 7.18 (d, \(J = 8.4\) Hz, 2H), 7.04 (d, \(J = 8.4\) Hz, 2H), 6.93–6.89 (m, 3H), 2.33 (s, 3H);

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 160.9\) (d, \(J = 249.0\) Hz), 149.0 (d, \(J = 6.0\) Hz), 147.0 (d, \(J = 2.0\) Hz), 146.8, 144.1, 137.6, 133.3, 132.2, 132.1, 129.8, 129.2, 128.8, 128.6 (d, \(J = 10.0\) Hz), 127.8, 127.8, 122.3 (d, \(J = 26.0\) Hz), 110.6 (d, \(J = 24.0\) Hz), 21.5; HRMS (ESI) ([M+H]\(^+\)) Calcd. For C\(_{22}\)H\(_{17}\)FNO\(_2\)S: 378.0959, Found: 378.0953.

\[ \text{6-Chloro-4-phenyl-3-tosylquinoline (3p)} \]

Yield: 78.0 mg (99%). \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 9.76\) (s, 1H), 8.14 (d, \(J = 8.8\) Hz, 1H), 7.73 (dd, \(J_1 = 9.2\) Hz, \(J_2 = 2.4\) Hz, 1H), 7.48 (t, \(J = 7.6\) Hz, 1H), 7.35 (t, \(J = 7.6\) Hz, 2H), 7.28 (d, \(J = 2.4\) Hz, 1H), 7.19 (d, \(J = 8.4\) Hz, 2H), 7.05 (d, \(J = 8.0\) Hz, 2H), 6.94 (d, \(J = 6.8\) Hz, 2H), 2.35 (s, 3H);

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 148.8, 148.0, 147.9, 144.2, 137.5, 133.9, 133.5, 132.9, 131.9, 131.2, 129.9, 129.2, 128.9, 128.3, 127.9, 127.8, 125.9, 21.5; HRMS (ESI) ([M+H]\(^+\)) Calcd. For C\(_{22}\)H\(_{17}\)ClNO\(_2\)S: 394.0663, Found: 394.0660.
6-Bromo-4-phenyl-3-tosylquinoline (3q)

Yield: 85.0 mg (97%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.76$ (s, 1H), 8.04 ($d, J = 8.8$ Hz, 1H), 7.84 ($dd, J_1 = 9.2$ Hz, $J_2 = 2.4$ Hz, 1H), 7.47 ($t, J = 7.6$ Hz, 1H), 7.43 ($d, J = 2.0$ Hz, 1H), 7.33 ($t, J = 8.0$ Hz, 2H), 7.16 ($d, J = 8.4$ Hz, 2H), 7.03 ($d, J = 8.4$ Hz, 2H), 6.92 ($d, J = 6.8$ Hz, 2H), 2.33 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 148.7$, 148.2, 148.0, 144.2, 137.5, 135.5, 133.4, 131.8, 131.2, 129.8, 129.2, 128.9, 127.8, 127.8, 122.2, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{17}$BrNO$_2$: 438.0158, Found: 438.0161.

4-Phenyl-3-tosylquinoline-6-carbonitrile (3r)

Yield: 67.7 mg (88%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.86$ (s, 1H), 8.28 ($d, J = 8.8$ Hz, 1H), 7.92 ($dd, J_1 = 8.8$ Hz, $J_2 = 1.6$ Hz, 1H), 7.70 ($d, J = 1.2$ Hz, 1H), 7.51 ($t, J = 7.6$ Hz, 1H), 7.37 ($t, J = 8.0$ Hz, 2H), 7.17 ($d, J = 8.4$ Hz, 2H), 7.05 ($d, J = 8.4$ Hz, 2H), 6.93 ($d, J = 7.6$ Hz, 2H), 2.34 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 150.4$, 150.3, 150.1, 144.5, 137.1, 134.3, 133.6, 132.2, 131.2, 131.1, 129.7, 129.3, 128.0, 127.9, 127.2, 117.8, 111.6, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For Chemical Formula: C$_{23}$H$_{17}$N$_2$O$_2$: 385.1005, Found: 385.1007.

Ethyl 4-phenyl-3-tosylquinoline-6-carboxylate (3s)

Yield: 84.6 mg (98%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.84$ (s, 1H), 8.37 ($dd, J_1 = 8.8$ Hz, $J_2 = 2.0$ Hz, 1H), 8.23 ($d, J = 8.8$ Hz, 1H), 8.07 ($d, J = 2.0$ Hz, 1H), 7.48 ($t, J = 7.6$ Hz, 1H), 7.35 ($d, J = 8.0$ Hz, 2H), 7.19 ($d, J = 8.4$ Hz, 2H), 7.05 ($d, J = 8.0$ Hz,
7-Methyl-4-phenyl-3-tosylquinoline (3t)
Yield: 70.2 mg (94%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.77 (s, 1H), 8.16 (d, $J$ = 8.4 Hz, 1H), 7.79–7.75 (m, 1H), 7.44–7.40 (m, 1H), 7.33 (dd, $J_1$ = 8.4 Hz, $J_2$ = 0.8 Hz, 1H), 7.27–7.21 (m, 2H), 7.17 (d, $J$ = 8.4 Hz, 2H), 7.03 (d, $J$ = 8.0 Hz, 2H), 6.86 (d, $J$ = 6.8 Hz, 1H), 6.50 (s, 1H), 2.33 (s, 3H), 2.21 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 149.9, 149.5, 147.5, 143.7, 137.8, 137.0, 132.5, 132.3, 132.0, 130.1, 129.4, 129.2, 129.0, 127.8, 127.6, 127.5, 127.4, 127.2, 21.4, 21.1; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{23}$H$_{20}$NO$_2$S: 374.1209, Found: 374.1211.

8-Methyl-4-phenyl-3-tosylquinoline (3u)
Yield: 66.5 mg (89%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.79 (s, 1H), 7.64 (d, $J$ = 7.2 Hz, 1H), 7.44 (t, $J$ = 7.6 Hz, 1H), 7.34–7.30 (m, 3H), 7.21 (d, $J$ = 8.4 Hz, 2H), 7.16 (d, $J$ = 8.4 Hz, 1H), 7.04 (d, $J$ = 8.4 Hz, 2H), 6.94 (d, $J$ = 7.2 Hz, 2H), 2.86 (s, 3H), 2.34 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 149.7, 148.7, 146.4, 143.9, 138.0, 137.5, 133.0, 132.2, 132.1, 130.0, 129.1, 128.4, 127.8, 127.5, 127.4, 125.3, 21.4, 18.1; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{23}$H$_{20}$NO$_2$S: 374.1209, Found: 374.1211.
8-Bromo-4-phenyl-3-tosylquinoline (3v)
Yield: 78.9 mg (90%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.86 (s, 1H), 8.12 (dd, $J_1$ = 6.0 Hz, $J_2$ = 2.4 Hz, 1H), 7.47 (t, $J$ = 7.6 Hz, 1H), 7.34 (t, $J$ = 7.6 Hz, 2H), 7.30–7.28 (m, 2H), 7.19 (d, $J$ = 8.4 Hz, 2H), 7.05 (d, $J$ = 8.0 Hz, 2H), 6.94 (d, $J$ = 7.2 Hz, 2H), 2.34 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 150.3, 148.5, 146.5, 144.2, 137.5, 135.6, 133.6, 132.2, 129.9, 129.3, 129.0, 128.8, 128.0, 127.9, 127.7, 127.3, 125.2, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{17}$/79BrNO$_2$: 438.0158, Found: 438.0155.

5,7-Dichloro-4-phenyl-3-tosylquinoline (3w)
Yield: 74.5 mg (87%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.83 (s, 1H), 8.15 (d, $J$ = 2.0 Hz, 1H), 7.52 (d, $J$ = 2.4 Hz, 1H), 7.38 (t, $J$ = 7.6 Hz, 1H), 7.18 (t, $J$ = 7.6 Hz, 2H), 7.09 (d, $J$ = 8.4 Hz, 2H), 7.02 (d, $J$ = 8.4 Hz, 2H), 6.88 (d, $J$ = 7.6 Hz, 2H), 2.34 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 151.4, 149.7, 149.3, 144.1, 137.6, 137.2, 134.8, 133.6, 132.9, 132.0, 130.5, 129.3, 128.9, 128.7, 127.6, 127.0, 122.9, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{18}$/75Cl$_2$NO$_2$: 428.0273, Found: 428.0277.

Phenyl-2-tosylbenzo[f]quinoline (3x)
Yield: 68.0 mg (83%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.88 (s, 1H), 9.40 (d, $J$ = 7.6 Hz, 1H), 7.87–7.85 (m, 1H), 7.82–7.74 (m, 2H), 7.66 (d, $J$ = 9.2 Hz, 1H), 7.48 (t, $J$ = 7.2 Hz, 1H), 7.35 (t, $J$ = 8.0 Hz, 2H), 7.22 (d, $J$ = 8.4 Hz, 2H), 7.15 (d, $J$ = 9.2 Hz,
1H), 7.05 (d, J = 8.0 Hz, 2H), 6.98 (d, J = 6.8 Hz, 2H), 2.35 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 149.0, 148.7, 146.7, 143.9, 138.0, 134.1, 133.3, 133.1, 130.8, 130.1, 129.7, 129.2, 128.9, 128.5, 127.9, 127.7, 127.6, 125.5, 125.5, 123.0, 21.5; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{26}$H$_{20}$NO$_2$S: 410.1209, Found: 410.1212.

3-((4-Methoxyphenyl)sulfonyl)-4-phenylquinoline (4b)
Yield: 66.8 mg (89%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.78 (s, 1H), 8.20 (d, J = 8.4 Hz, 1H), 7.81 (t, J = 8.0 Hz, 1H), 7.48–7.43 (m, 2H), 7.37–7.31 (m, 3H), 7.24–7.21 (m, 2H), 6.98 (d, J = 7.2 Hz, 2H), 6.71 (d, J = 8.8 Hz, 2H), 3.80 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 163.2, 149.6, 149.6, 147.7, 132.9, 132.7, 132.4, 132.0, 130.1, 130.0, 129.6, 128.6, 127.7, 127.6, 127.5, 127.3, 113.8, 55.6; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{18}$NO$_3$S: 376.1002, Found: 376.0999.
4-Phenyl-3-((4-(trifluoromethyl)phenyl)sulfonyl)quinoline (4c)
Yield: 77.7 mg (94%).$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.82 (s, 1H), 8.23 (d, $J$ = 8.4 Hz, 1H), 7.85 (t, $J$ = 8.0 Hz, 1H), 7.51–7.45 (m, 4H), 7.42 (d, $J$ = 8.8 Hz, 2H), 7.35–7.29 (m, 3H), 6.93 (d, $J$ = 7.2 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 150.1, 150.0, 147.3, 144.2, 134.5 (q, $J$ = 33.0 Hz), 132.6, 132.3, 131.7, 130.1, 129.8, 128.9, 128.4, 128.1, 127.8, 127.4, 127.3, 125.6 (q, $J$ = 4.0 Hz), 123.0 (q, $J$ = 272.0 Hz); HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{15}$F$_3$NO$_2$S: 414.0770, Found: 414.0773.

3-((4-Fluorophenyl)sulfonyl)-4-phenylquinoline (4d)
Yield: 66.9 mg (92%).$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 9.79 (s, 1H), 8.21 (d, $J$ = 8.8 Hz, 1H), 7.84–7.80 (m, 1H), 7.49–7.44 (m, 2H), 7.37–7.28 (m, 5H), 6.96 (d, $J$ = 6.8 Hz, 2H), 6.91 (t, $J$ = 8.8 Hz, 2H), 7.03 (s, 1H), 6.93 (d, $J$ = 7.6 Hz, 2H), 2.21 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 165.2 (d, $J$ = 254.0 Hz), 149.8, 147.4, 136.8 (d, $J$ = 3.0 Hz), 132.4, 132.3, 132.2, 130.7 (d, $J$ = 10.0 Hz), 130.0, 129.7, 128.8, 127.9, 127.7, 127.3, 115.8 (d, $J$ = 23.0 Hz); HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{21}$H$_{13}$FNO$_2$S: 364.0802, Found: 364.0806.

3-((4-Chlorophenyl)sulfonyl)-4-phenylquinoline (4e)

521
Yield: 72.2 mg (95%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.76$ (s, 1H), 8.19 (d, $J = 8.4$ Hz, 1H), 7.83–7.79 (m, 1H), 7.48–7.43 (m, 2H), 7.35–7.31 (m, 3H), 7.22–7.17 (m, 4H), 6.94 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.8$, 149.8, 147.3, 139.6, 139.2, 132.3, 131.9, 130.0, 129.6, 129.2, 128.8, 127.9, 127.7, 127.3, 127.2; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{21}$H$_{15}$ClNO$_2$S: 380.0507, Found: 380.0510.

![3-((4-Bromophenyl)sulfonyl)-4-phenylquinoline (4f)](image)

3-((4-Bromophenyl)sulfonyl)-4-phenylquinoline (4f)

Yield: 81.5 mg (96%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.76$ (s, 1H), 8.19 (d, $J = 8.4$ Hz, 1H), 7.81 (t, $J = 7.6$ Hz, 1H), 7.48–7.43 (m, 2H), 7.37–7.31 (m, 5H), 7.12 (d, $J = 8.4$ Hz, 2H), 6.94 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.8$, 149.8, 147.3, 139.7, 132.3, 132.3, 131.9, 131.8, 129.9, 129.6, 129.2, 128.8, 128.2, 127.9, 127.7, 127.3, 127.2; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{21}$H$_{15}$BrNO$_2$S: 424.0001, Found: 424.0002.

![4-Phenyl-3-(m-tolylsulfonyl)quinoline (4g)](image)

4-Phenyl-3-(m-tolylsulfonyl)quinoline (4g)

Yield: 66.9 mg (97%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.80$ (s, 1H), 8.20 (d, $J = 8.8$ Hz, 1H), 7.82–7.78 (m, 1H), 7.47–7.42 (m, 2H), 7.33–7.30 (m, 3H), 7.24–7.21 (m, 1H), 7.15–7.13 (m, 2H), 7.03 (s, 1H), 6.93 (d, $J = 7.6$ Hz, 2H), 2.21 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.8$, 149.7, 147.5, 140.5, 138.6, 133.8, 132.5, 132.4, 132.1, 130.0, 129.6, 128.5, 128.5, 128.3, 127.8, 127.5, 127.4, 127.3, 124.9, 21.1; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{22}$H$_{18}$NO$_2$S: 360.1053, Found: 360.1055.
3-((3-Chlorophenyl)sulfonyl)-4-phenylquinoline (4h)
Yield: 71.4 mg (94%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.79$ (s, 1H), 8.22 (d, $J = 8.8$ Hz, 1H), 7.84 (t, $J = 8.0$ Hz, 1H), 7.53–7.46 (m, 2H), 7.42 (s, $J = 7.6$ Hz, 1H), 7.38–7.35 (m, 3H), 7.27–7.22 (m, 2H), 7.15 (s, 1H), 6.95 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 150.1$, 149.9, 147.3, 142.3, 134.7, 133.1, 132.4, 132.0, 131.9, 130.0, 129.9, 129.7, 129.0, 128.1, 128.0, 127.7, 127.4, 127.3, 125.8; HRMS (ESI) ([M+H$^+$]) Calcd. For C$_{21}$H$_{15}$ClNO$_2$S: 380.0507, Found: 380.0509.

3-((3-Bromophenyl)sulfonyl)-4-phenylquinoline (4i)
Yield: 78.1 mg (92%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.77$ (s, 1H), 8.20 (d, $J = 8.8$ Hz, 1H), 7.82 (t, $J = 8.4$ Hz, 1H), 7.55 (d, $J = 8.0$ Hz, 1H), 7.50 (t, $J = 7.6$ Hz, 1H), 7.45 (t, $J = 8.0$ Hz, 1H), 7.37–7.33 (m, 3H), 7.30–7.27 (m, 2H), 7.13 (t, $J = 7.6$ Hz, 1H), 6.93 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 150.0$, 149.8, 147.2, 142.4, 136.0, 132.4, 131.9, 131.8, 130.8, 130.1, 129.9, 129.6, 129.0, 127.9, 127.7, 127.3, 127.2, 126.2, 122.5; HRMS (ESI) ([M+H$^+$]) Calcd. For C$_{21}$H$_{15}$BrNO$_2$S: 424.0001, Found: 424.0003.

3-((2-Chlorophenyl)sulfonyl)-4-phenylquinoline (4j)
Yield: 59.3 mg (78%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.85$ (s, 1H), 8.24 (d, $J = 8.4$ Hz, 1H), 7.84 (t, $J = 8.0$ Hz, 1H), 7.47 (t, $J = 7.2$ Hz, 1H), 7.39–7.25 (m, 5H), 7.17 (t, $J = 7.6$ Hz, 2H), 7.01 (t, $J = 8.0$ Hz, 1H), 6.90 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.6$, 149.3, 148.5, 138.0, 134.1, 132.2, 132.0, 131.7, 131.4, 131.0, 130.9, 129.7, 129.6, 128.6, 127.8, 127.5, 127.3, 127.1, 126.7; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{21}$H$_{15}$ClNO$_2$S: 380.0507, Found: 380.0509.

![3-((2-bromophenyl)sulfonyl)-4-phenylquinoline (4k)](image)

3-((2-bromophenyl)sulfonyl)-4-phenylquinoline (4k)
Yield: 64.5 mg (76%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.88$ (s, 1H), 8.25 (d, $J = 8.4$ Hz, 1H), 7.85 (t, $J = 7.6$ Hz, 1H), 7.51–7.46 (m, 2H), 7.34–7.25 (m, 4H), 7.16 (t, $J = 7.6$ Hz, 2H), 7.05 (t, $J = 7.6$ Hz, 1H), 6.92 (d, $J = 7.6$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 149.6$, 149.2, 148.9, 139.5, 134.5, 134.0, 132.2, 132.0, 131.3, 131.2, 129.7, 129.6, 128.6, 127.8, 127.5, 127.3, 127.1, 126.0; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{21}$H$_{15}$BrNO$_2$S: 424.0001, Found: 424.0005.

![3-(Naphthalen-2-ylsulfonyl)-4-phenylquinoline (4l)](image)

3-(Naphthalen-2-ylsulfonyl)-4-phenylquinoline (4l)
Yield: 71.2 mg (90%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.88$ (s, 1H), 8.21 (d, $J = 8.4$ Hz, 1H), 7.82–7.79 (m, 2H), 7.74–7.65 (m, 3H), 7.60 (t, $J = 6.8$ Hz, 1H), 7.54 (t, $J = 6.8$ Hz, 1H), 7.44–7.35 (m, 3H), 7.29 (d, $J = 8.4$ Hz, 1H), 7.17 (t, $J = 7.6$ Hz, 2H), 6.86 (d, $J = 7.2$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 150.0$, 149.8, 147.7, 137.2, 134.7, 132.3, 132.2, 132.1, 131.6, 130.1, 129.9, 129.6, 129.4, 129.1, 128.9, 128.8, 127.8, 127.7, 127.5, 127.4, 127.3, 127.3, 122.3; HRMS (ESI) ([M+H]$^+$) Calcd. For
4-Phenyl-3-(thiophen-2-ylsulfonyl)quinoline (4m)
Yield: 66.1 mg (94%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.73$ (s, 1H), 8.20 (d, $J =$ 8.4 Hz, 1H), 7.83 (t, $J =$ 8.0 Hz, 1H), 7.54 (d, $J =$ 6.8 Hz, 1H), 7.49–7.45 (m, 2H), 7.42–7.35 (m, 3H), 7.08 (d, $J =$ 7.2 Hz, 2H), 6.67 (d, $J =$ 4.4 Hz, 1H), 6.85 (t, $J =$ 4.8 Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta =$ 149.8, 149.7, 147.4, 142.0, 134.4, 134.2, 132.8, 132.6, 132.3, 129.8, 129.6, 128.8, 127.9, 127.7, 127.5, 127.4, 127.2; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{19}$H$_{14}$NO$_2$S$_2$: 352.0460, Found: 352.0461.

3-(Butylsulfonyl)-4-phenylquinoline (4n)
Yield: 59.2 mg (91%). $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 9.52$ (s, 1H), 8.21 (d, $J =$ 8.8 Hz, 1H), 7.84 (t, $J =$ 6.8 Hz, 1H), 7.56–7.50 (m, 4H), 7.45 (d, $J =$ 8.4 Hz, 1H), 7.40–7.39 (m, 2H), 2.7 (t, $J =$ 8.0 Hz, 2H), 1.55–1.47 (m, 2H), 1.27–1.18 (m, 2H), 0.76 (t, $J =$ 7.6 Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta =$ 149.8, 149.6, 148.1, 132.9, 132.2, 130.0, 129.8, 129.6, 129.3, 128.0, 127.9, 127.5, 127.1, 55.2, 24.4, 21.3, 13.3; HRMS (ESI) ([M+H]$^+$) Calcd. For C$_{19}$H$_{20}$NO$_2$S: 326.1209, Found: 326.1211.
5. $^1$H and $^{13}$C NMR spectra of the products