Supporting Information

Intramolecular Carbopalladation/Cross-coupling and DDQ-mediated Cross-Dehydrogenative coupling: An efficient and New strategy to Diverse Indolo[2,3-b]quinolines Derivatives

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Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.
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**General:** All NMR spectral data were recorded by Bruker 300, 400, 500 (300, 400, 500 MHz) spectrometer in CDCl$_3$ solutions expressing chemical shifts in parts per million (ppm, \( \delta \)) and are referenced to CHCl$_3$ (\( \delta = 7.26 \) ppm) as an internal standard. All coupling constants are absolute values and are expressed in Hz. The description of the signals include: s = singlet, d = doublet, t = triplet, m = multiplet, dd = doublet of doublets and brs = broad singlet. $^{13}$C NMR spectra were recorded with a Bruker 300, 400, 500 (75, 100, 125 respectively MHz) spectrometer as solutions in CDCl$_3$ with complete proton decoupling. Chemical shifts are expressed in parts per million (ppm, \( \delta \)) and are referenced to CDCl$_3$ (\( \delta = 77.0 \) ppm) as an internal standard. High-Resolution Mass Spectra (HRMS) were performed with a Qtof Micro YA263 spectrometer in dichloromethane solvent. The molecular fragments are quoted as the relation between mass and charge (m/z). The routine monitoring of reactions was performed with silica gel coated glass slides (Merck, silica gel G for TLC), and pre-coated Al plate, which were analyzed with iodine and uv light respectively. Solvents, reagents and chemicals were purchased from Aldrich, Fluka, Merck, SRL, Spectrochem and Process Chemicals. All reactions involving moisture-sensitive reactants were executed with oven-dried glassware.
Ortep diagram for the crystal structure of the compound 3e (Thermal ellipsoid contour at 50% probability level)

CCDC no. 1848645
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Representative experimental procedure for the synthesis of \( N\)-(3-(2-aminophenyl)prop-2-yn-1-yl)-\( N\)-(2-bromophenyl)-4-methylbenzenesulfonamide (1a):

\[
\begin{align*}
\text{Br} & \quad \text{NH}_2 \\
\text{N} & \quad \text{Ts}
\end{align*}
\]

To a solution of \( N\)-(2-bromophenyl)-4-methyl-\( N\)-(prop-2-yn-1-yl)benzenesulfonamide (363 mg, 1 mmol) in dimethyl sulfoxide (2 mL) and 2-iodoaniline (241 mg, 1.1 mmol), triethylamine (202 mg, 2 mmol), Cul (4 mg, 0.02 mmol) and Pd(PPh\(_3\))\(_4\) (12 mg, 0.01 mmol) were added successively. The resulting solution was stirred at room temperature under argon atmosphere for overnight. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na\(_2\)SO\(_4\) and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 1a as a yellow semisolid (341 mg, 0.75 mmol, 75%).

\(^1\)H NMR (CDCl\(_3\), 300 MHz) \( \delta \) 2.41 (s, 3H), 3.55 (brs, 2H), 4.41 (d, \( J \) = 17.4 Hz, 1H), 4.94 (d, \( J \) = 18.0 Hz, 1H), 6.61–6.64 (m, 2H), 7.02–7.08 (m, 2H), 7.23–7.33 (m, 5H), 7.63 (d, \( J \) = 1.8 Hz, 1H), 7.76 (d, \( J \) = 8.4 Hz, 2H) ppm. \(^{13}\)C NMR (CDCl\(_3\), 75 MHz) \( \delta \) 21.6, 41.4, 82.6, 88.3, 106.7, 114.2, 117.5, 125.6, 128.0, 129.5, 130.3, 132.1, 132.2, 133.8, 136.6, 137.6, 143.9, 148.3.

Compounds 1b-1h were synthesised by the above similar procedure.

\((Z)\)-2-(phenyl(1-tosylindolin-3-ylidene)methyl)aniline (2a):

\[
\begin{align*}
\text{N} & \quad \text{H}_2\text{N} \\
\text{Ts}
\end{align*}
\]

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K\(_2\)CO\(_3\) (1 mL) and 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy\(_3\) (8 mg, 0.03 mmol) and Pd(OAc)\(_2\) (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 70-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na\(_2\)SO\(_4\) and
concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2a as a yellow solid (112 mg, 0.25 mmol, 82%); m. p. 136-138 °C. 1H NMR (CDCl₃, 300 MHz) δ 2.39 (s, 3H), 3.69 (brs, 2H), 4.50 (s, 2H), 6.64-6.73 (m, 4H), 6.88 (d, J = 7.2 Hz, 1H), 7.08-7.29 (m, 9H), 7.68 (dd, J = 8.1, 9.0 Hz, 3H) ppm. 13C NMR (CDCl₃, 75 MHz) δ 21.5, 55.8, 115.5, 116.9, 123.2, 124.3, 127.2, 127.4, 127.8, 128.6, 128.8, 128.9, 129.1, 129.2, 129.5, 129.6, 131.3, 132.0, 133.9, 140.0, 142.7, 144.1, 145.7 ppm. HRMS (ESI) calcd for C₂₈H₂₅N₂O₂S [M+H]+ 453.1637; found 453.1621.

(Z)-2-((5-methyl-1-tosylindolin-3-ylidene)(phenyl)methyl)aniline (2b):

![Chemical Structure](image)

To a solution of 1b (140 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2b as a yellow solid (116 mg, 0.25 mmol, 83%); m. p. 142-144 °C. 1H NMR (CDCl₃, 500 MHz) δ 2.01 (s, 3H), 2.38 (s, 3H), 3.66 (brs, 2H), 4.45 (s, 2H), 6.41 (s, 1H), 6.71 (t, J = 4.5 Hz, 2H), 6.85 (d, J = 4.5 Hz, 1H), 6.97 (d, J = 4.8 Hz, 1H), 7.09 (t, J = 4.5 Hz, 1H), 7.15-7.16 (m, 2H), 7.22-7.28 (m, 5H), 7.60 (dd, J = 3.9, 4.5 Hz, 3H) ppm. 13C NMR (CDCl₃, 100 MHz) δ 21.1, 21.6, 56.2, 115.7, 116.2, 118.9, 125.0, 127.4, 127.6, 127.9, 128.4, 128.9, 129.0, 129.3, 129.4, 129.7, 130.4, 131.2, 132.4, 132.9, 134.0, 140.2, 142.9, 143.8, 144.1 ppm. HRMS (ESI) calcd for C₂₉H₂₇N₂O₂S [M+H]+ 467.1793; found 467.1737.

(Z)-2-((5-chloro-1-tosylindolin-3-ylidene)(phenyl)methyl)aniline (2c):

![Chemical Structure](image)
To a solution of 1c (147 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with EtOAc. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2c as a yellow solid (117 mg, 0.24 mmol, 79%); m. p. 154-156 °C.

1H NMR (CDCl₃, 300 MHz) δ 2.41 (s, 3H), 3.67 (brs, 2H), 4.51 (s, 2H), 6.55 (s, 1H), 6.70-6.73 (m, 2H), 6.86 (d, J = 7.5 Hz, 1H), 7.14-7.32 (m, 9H), 7.63 (d, J = 8.1 Hz, 3H) ppm. 13C NMR (CDCl₃, 75 MHz) δ 21.5, 56.1, 116.1, 116.4, 118.8, 124.3, 126.8, 127.4, 128.3, 128.4, 128.6, 128.7, 129.0, 129.1, 129.2, 129.7, 130.9, 133.0, 133.5, 139.4, 142.6, 144.3, 144.4 ppm. HRMS (ESI) calcd for C₂₈H₂₄ClN₂O₂S [M+H]^+ 487.1247; found 487.1232.

(Z)-4-methyl-2-{(phenyl(1-tosylindolin-3-ylidene)methyl)aniline (2d):

To a solution of 1d (140 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2d as a yellow solid (126 mg, 0.27 mmol, 90%); m. p. 158-160 °C. 1H NMR (CDCl₃, 500 MHz) δ 2.12 (s, 3H), 2.32 (s, 3H), 3.48 (s, 2H), 4.42 (s, 2H), 6.55-6.64 (m, 4H), 6.83 (d, J = 8.5 Hz, 1H), 7.07-7.24 (m, 8H), 7.60 (dd, J = 8.0, 17.5 Hz, 3H), ppm. 13C NMR (CDCl₃, 125 MHz) δ 20.5, 21.7, 85.9, 115.6, 116.3, 123.3, 124.7, 127.5, 127.6, 127.9, 128.0, 128.7, 129.0, 129.3, 129.4, 129.5, 129.7, 131.6, 132.0, 134.0, 140.3, 142.2, 145.8 ppm. HRMS (ESI) calcd for C₂₉H₂₅N₂O₂S [M+H]^+ 467.1793; found 467.1752.
(Z)-2-((4-methoxyphenyl)(1-tosylindolin-3-ylidene)methyl)aniline (2e):

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K$_2$CO$_3$ (1 mL), 2 mL ethanol-toluene (1:1), p-methoxyphenyl boronic acid (68 mg, 0.45 mmol), PCy$_3$ (8 mg, 0.03 mmol) and Pd(OAc)$_2$ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 70-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with EtOAc. The organic extract was washed with brine solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2e as a yellow solid (123 mg, 0.26 mmol, 85%); m. p. 200-202 °C. $^1$H NMR (CDCl$_3$, 300 MHz) δ 2.39 (s, 3H), 2.94 (brs, 2H), 3.80 (s, 3H), 4.48 (s, 2H), 6.71- 6.88 (m, 8H), 7.09-7.12 (d, $J = 8.4$ Hz, 3H), 7.17–7.26 (m, 2H), 7.68 (dd, $J = 8.1$, 9.3 Hz, 3H) ppm. $^{13}$C NMR (CDCl$_3$, 75 MHz) δ 21.5, 55.2, 55.9, 114.2, 115.5, 116.1, 118.8, 123.2, 124.3, 127.4, 128.9, 129.2, 129.3, 129.4, 129.6, 129.9, 131.1, 131.3, 132.1, 133.8, 142.7, 144.1, 145.6, 159.2 ppm. HRMS (ESI) calcd for C$_{29}$H$_{27}$N$_2$O$_3$S [M+H]$^+$ 483.1742; found 483.1719.

(Z)-2-((4-chlorophenyl)(1-tosylindolin-3-ylidene)methyl)aniline (2f):

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K$_2$CO$_3$ (1 mL), 2 mL ethanol-toluene (1:1), p-chlorophenyl boronic acid (70 mg, 0.45 mmol), PCy$_3$ (8 mg, 0.03 mmol) and Pd(OAc)$_2$ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 70-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with EtOAc. The organic extract was washed with brine solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2f as a yellow solid
(117 mg, 0.24 mmol, 81%); m. p. 138-140 °C. $^1$H NMR (CDCl$_3$, 300 MHz) $\delta$ 2.39 (s, 3H), 4.47 (s, 2H), 6.74-6.84 (m, 5H), 7.09-7.17 (m, 3H), 7.20-7.28 (m, 5H), 7.68 (dd, $J = 8.1, 13.5$ Hz, 3H) ppm. $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 21.5, 55.8, 115.6, 116.1, 118.8, 123.3, 124.2, 126.8, 127.4, 128.7, 129.1, 129.6, 129.8, 130.1, 132.6, 133.6, 133.8, 138.5, 142.6, 144.2, 145.9 ppm. HRMS (ESI) calcd for C$_{28}$H$_{24}$N$_2$NaO$_2$S [M+H]$^+$ 487.1247; found 487.1218.

(Z)-2-((1-tosylindolin-3-ylidene)methyl)aniline (2g) :

![Chemical Structure](image)

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K$_2$CO$_3$ (1 mL), 2 mL ethanol-toluene (1:1), PCy$_3$ (8 mg, 0.03 mmol) and Pd(OAc)$_2$ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 70-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2g as a yellow solid (101 mg, 0.27 mmol, 89%); m. p. 146-148 °C. $^1$H NMR (CDCl$_3$, 300 MHz) $\delta$ 2.37 (s, 3H), 4.73 (s, 2H), 6.73-6.81 (m, 3H), 7.05-7.25 (m, 6H), 7.48 (d, $J = 6$ Hz, 1H), 7.70-7.72 (m, 3H) ppm. $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 21.5, 54.2, 113.7, 114.9, 116.3, 118.8, 120.4, 122.1, 123.7, 126.8, 127.2, 127.8, 128.7, 129.8, 130.6, 133.9, 134.1, 143.6, 144.0, 144.3 ppm. HRMS (ESI) calcd for C$_{22}$H$_{21}$N$_2$O$_2$S [M+H]$^+$ 377.1324; found 377.1285.

(Z)-4-chloro-2-((1-tosylindolin-3-ylidene)methyl)aniline (2h) :

![Chemical Structure](image)

To a solution of 1e (143 mg, 0.3 mmol) in 2.5 M K$_2$CO$_3$ (1 mL), 2 mL ethanol-toluene (1:1), PCy$_3$ (8 mg, 0.03 mmol) and Pd(OAc)$_2$ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 70-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with EtOAc. The organic extract was washed with brine solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column
chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 2i as a yellow solid (108 mg, 0.26 mmol, 88%); m. p. 134-136 °C. \(^1\)H NMR (CDCl\(_3\), 300 MHz) \(\delta\) 2.36 (s, 3H), 4.66 (s, 2H), 6.64 (t, \(J = 8.4\) Hz, 2H), 6.97-7.05 (m, 3H), 7.22-7.29 (m, 3H), 7.45 (d, \(J = 6.9\) Hz, 1H), 7.69-7.76 (m, 3H) ppm. \(^{13}\)C NMR (CDCl\(_3\), 75 MHz) \(\delta\) 21.5, 53.9, 112.3, 113.4, 114.9, 120.7, 123.7, 124.6, 126.7, 127.2, 127.4, 128.4, 129.9, 130.0, 130.3, 133.9, 136.1, 144.0, 144.4 ppm. HRMS (ESI) calcd for C\(_{22}\)H\(_{20}\)ClN\(_2\)O\(_2\)S [M+H\(^+\)]\(^+\) 411.0934; found 411.0913.

**(Z)**-2-(phenyl(1-tosyl-1H-pyrrolo[2,3-b]pyridin-3(2H)-ylidene)methyl)aniline (2i):

To a solution of 1f (136 mg, 0.3 mmol) in 2.5 M K\(_2\)CO\(_3\) (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy\(_3\) (8 mg, 0.03 mmol) and Pd(OAc)\(_2\) (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3.5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na\(_2\)SO\(_4\) and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 90:10 (v/v) to afford the product 2j as a yellow solid (105 mg, 0.23 mmol, 77%); m. p. 204-206 °C. \(^1\)H NMR (CDCl\(_3\), 300 MHz) \(\delta\) 2.39 (s, 3H), 3.14 (brs, 2H), 4.63 (s, 2H), 6.57-6.59 (m, 1H), 6.76 (t, \(J = 7.8\) Hz, 2H), 6.89 (d, \(J = 7.5\) Hz, 1H), 6.96 (d, \(J = 6.9\) Hz, 1H), 7.13 (t, \(J = 7.2\) Hz, 1H), 7.26-7.33 (m, 7H), 7.98 (d, \(J = 7.8\) Hz, 2H), 8.10 (d, \(J = 3.6\) Hz, 1H) ppm. \(^{13}\)C NMR (CDCl\(_3\), 75 MHz) \(\delta\) 21.6, 54.0, 116.3, 117.5, 118.9, 121.9, 126.4, 128.0, 128.2, 128.3, 129.0, 129.1, 129.2, 129.4, 131.7, 134.4, 135.5, 139.7, 142.6, 144.2, 148.3 ppm. HRMS (ESI) calcd for C\(_{27}\)H\(_{24}\)N\(_3\)O\(_2\)S [M+H\(^+\)]\(^+\) 454.1589; found 454.1636.

**(Z)**-5-methyl-3-(phenyl(1-tosylindolin-3-ylidene)methyl)pyridin-2-amine (2j):

![Image](image_url)
To a solution of 1g (141 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3.5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 90:10 (v/v) to afford the product 2k as a yellow solid (112 mg, 0.24 mmol, 80%); m. p. 166-168 °C. ¹H NMR (CDCl₃, 300 MHz) δ 2.17 (s, 3H), 2.39 (s, 3H), 4.33 (s, 2H), 4.49 (s, 2H), 6.63 (d, J = 7.8 Hz, 1H), 6.71 (t, J = 7.8 Hz, 1H), 7.00 (s, 1H), 7.17-7.33 (m, 8H), 7.19 (dd, J = 8.1, 10.2 Hz, 3H), 7.88 (s, 1H) ppm. ¹³C NMR (CDCl₃, 75 MHz) δ 17.3, 21.5, 55.4, 115.5, 121.7, 123.2, 123.4, 124.5, 127.4, 127.7, 128.2, 128.5, 129.1, 129.7, 130.0, 133.1, 133.7, 138.8, 139.2, 144.3, 145.9, 146.5, 152.4 ppm. HRMS (ESI) calcd for C₂₈H₂₆N₃O₂S [M+H]+ 468.1746; found 468.1750.

(Z)-5-methyl-3-((5-methyl-1-tosyl-1H-pyrrolo[2,3-b]pyridin-3(2H)-ylidene)(phenyl)methyl)pyridin-2-amine (2k):

![Chemical structure](image)

To a solution of 1h (145 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), phenyl boronic acid (55 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 4 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 80:20 (v/v) to afford the product 2l as a yellow solid (108 mg, 0.22 mmol, 75%); m. p. >300 °C. ¹H NMR (CDCl₃, 500 MHz) δ 1.98 (s, 3H), 2.18 (s, 3H), 2.38 (s, 3H), 4.40 (s, 2H), 4.59 (s, 2H), 6.66 (s, 1H), 7.06 (s, 1H), 7.26 (d, J = 8.1 Hz, 3H), 7.35-7.37 (m, 3H), 7.90 (s, 1H), 7.96 (d, J = 14.5 Hz, 3H) ppm. ¹³C NMR (CDCl₃, 75 MHz) δ 17.5, 18.0, 21.7, 54.1, 120.6, 121.4, 123.7, 127.0, 128.1, 128.4, 128.7, 129.4, 129.5, 130.0, 132.3, 132.8, 135.4, 138.3, 139.2, 144.3, 148.9, 149.7, 152.6, 156.5 ppm. HRMS (ESI) calcd for C₂₈H₂₇N₄O₂S [M+H]+ 483.1855; found 483.1822.
11-phenyl-6-tosyl-6H-indolo[2,3-b]quinoline (3a):

To a solution of 2a (90 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3a as a yellow solid (89 mg, quantitative); m. p. 208-210 °C. $^1$H NMR (CDCl$_3$, 300 MHz) δ 2.32 (s, 3H), 6.85 (d, J = 7.5 Hz, 1H), 7.08 (t, J = 7.5 Hz, 1H), 7.22 (d, J = 7.8 Hz, 2H), 7.40-7.62 (m, 8H), 7.74 (t, J = 7.2 Hz, 1H), 8.25 (dd, J = 8.1, 12.6 Hz, 3H), 8.51 (d, J = 8.4 Hz, 1H) ppm. $^{13}$C NMR (CDCl$_3$, 75 MHz) δ 21.6, 114.6, 116.6, 122.8, 122.9, 123.4, 125.0, 125.3, 126.0, 128.3, 128.7, 128.8, 129.1, 129.3, 135.6, 135.9, 139.6, 142.6, 144.9, 146.2, 150.5 ppm. HRMS (ESI) calcd for C$_{28}$H$_{21}$N$_2$O$_2$S [M+H]$^+$ 449.1324; found 449.1871.

9-methyl-11-phenyl-6-tosyl-6H-indolo[2,3-b]quinoline (3b):

To a solution of 2b (93 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.2 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3b as a light yellow solid (92 mg, quantitative); m. p. 206-208 °C. $^1$H NMR (CDCl$_3$, 300 MHz) δ 2.22 (s, 3H), 2.31 (s, 3H), 6.60 (s, 1H), 7.20 (d, J = 7.8 Hz, 2H), 7.30 (d, J = 8.4 Hz, 1H), 7.40-7.44 (m, 3H), 7.62 (s, 4H), 7.74 (t, J = 7.2 Hz, 1H), 8.24 (dd, J = 8.4, 22.8 Hz, 3H), 8.37 (d, J = 8.4 Hz, 1H) ppm. $^{13}$C NMR (CDCl$_3$, 75 MHz) δ 21.2, 21.6, 114.4, 116.7, 123.0,
123.1, 124.9, 125.3, 126.0, 128.2, 128.8, 129.1, 129.3, 129.7, 133.0, 135.6, 135.8, 137.6, 142.5, 144.8, 146.1, 150.7 ppm. HRMS (ESI) calcd for C_{29}H_{23}N_{2}O_{2}S [M+H]^+ 463.1480; found 463.1457.

**9-chloro-11-phenyl-6-tosyl-6H-indolo[2,3-b]quinoline (3c):**

![Chemical structure of 3c](image)

To a solution of 2c (97 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na\textsubscript{2}SO\textsubscript{4} and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3c as a yellow solid (91 mg, 0.19 mmol, 98%); m. p. 208-210 °C. \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 500 MHz) δ 2.33 (s, 3H), 6.76 (s, 1H), 7.24 (t, J = 4.8 Hz, 2H), 7.37-7.39 (m, 2H), 7.42-7.45 (m, 2H), 7.63-7.65 (m, 4H), 7.76 (t, J = 3.9 Hz, 1H), 8.19 (d, J = 4.8 Hz, 2H), 8.27 (d, J = 5.1 Hz, 1H), 8.44 (d, J = 5.4 Hz, 1H) ppm. \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 125 MHz) δ 21.7, 115.7, 115.9, 122.7, 124.5, 125.4, 126.3, 128.5, 128.7, 129.0, 129.2, 129.3, 129.4, 129.5, 129.8, 135.1, 135.8, 138.0, 143.5, 145.3, 146.7, 150.7 ppm. HRMS (ESI) calcd for C\textsubscript{28}H\textsubscript{20}ClN\textsubscript{2}O\textsubscript{2}S [M+H]^+ 482.0856; found 482.0980.

**2-methyl-11-phenyl-6-tosyl-6H-indolo[2,3-b]quinoline (3d):**

![Chemical structure of 3d](image)

To a solution of 2d (93 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na\textsubscript{2}SO\textsubscript{4} and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3d as a yellow solid (92 mg, quantitative); m. p. 214-216 °C. \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 300 MHz) δ 2.31 (s, 3H), 2.43 (s, 3H), 6.79 (d, J = 7.8 Hz, 1H), 7.06 (t, J = 7.8
Hz, 1H), 7.19-7.26 (m, 2H), 7.36-7.63 (m, 8H), 8.17-8.21 (m, 3H), 8.49 (d, \( J = 8.4 \) Hz, 1H) ppm. \(^{13}\)C NMR (CDCl\(_3\), 75 MHz) \( \delta \) 21.7, 21.8, 114.8, 116.7, 122.9, 123.2, 123.5, 124.8, 125.4, 128.4, 128.7, 128.9, 129.0, 129.2, 129.3, 129.5, 131.6, 135.0, 135.9, 136.0, 139.7, 142.0, 144.9, 145.0, 150.2 ppm. HRMS (ESI) calcd for C\(_{29}\)H\(_{23}\)N\(_2\)O\(_2\)S [M+H]\(^+\) 463.1480; found 463.1455.

**11-(4-methoxyphenyl)-6-tosyl-6H-indolo[2,3-b]quinoline (3e):**

To a solution of 2e (96 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na\(_2\)SO\(_4\) and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3e as a yellow solid (95 mg, quantitative); m. p. 210-212 °C. \(^1\)H NMR (CDCl\(_3\), 300 MHz) \( \delta \) 2.31 (s, 3H), 3.96 (s, 3H), 6.97 (d, \( J = 7.8 \) Hz, 1H), 7.16 (dq, d, \( J = 8.4 \) Hz, \( J = 13.2 \), 5H), 7.32 (d, \( J = 8.4 \) Hz, 2H), 7.39-7.51 (m, 2H), 7.66-7.75 (m, 2H), 8.23 (dd, \( J = 8.1 \) Hz, \( J = 11.4 \), 3H), 8.50 (d, \( J = 8.4 \) Hz, 1H) ppm. \(^{13}\)C NMR (CDCl\(_3\), 75 MHz) \( \delta \) 21.6, 55.4, 114.6, 116.9, 122.9, 123.1, 123.4, 124.9, 125.7, 126.0, 127.5, 128.3, 128.6, 129.1, 129.3, 130.4, 135.9, 139.5, 142.6, 144.9, 146.2, 150.6, 160.0 ppm. HRMS (ESI) calcd for C\(_{29}\)H\(_{23}\)N\(_2\)O\(_3\)S [M+H]\(^+\) 479.1429 ; found 479.1521.

**11-(4-chlorophenyl)-6-tosyl-6H-indolo[2,3-b]quinoline (3f):**

To a solution of 2f (97 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 1 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na\(_2\)SO\(_4\) and
concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3f as a yellow solid (87 mg, 0.18 mmol, 92%); m. p. 222-224 °C. ¹H NMR (CDCl₃, 300 MHz) δ 2.32 (s, 3H), 6.91 (d, J = 7.5 Hz, 1H), 7.12 (t, J = 7.5 Hz, 1H), 7.22 (d, J = 8.1 Hz, 2H), 7.35 (d, J = 8.4 Hz, 2H), 7.41-7.57 (m, 3H), 7.61 (d, J = 8.1 Hz, 2H), 7.75 (t, J = 7.2 Hz, 1H), 8.25 (dd, J = 8.1, 13.5 Hz, 3H), 8.52 (d, J = 8.4 Hz, 1H) ppm. ¹³C NMR (CDCl₃, 100 MHz) δ 21.7, 114.4, 116.6, 119.2, 125.3, 125.5, 126.1, 126.3, 127.2, 127.6, 128.7, 129.1, 129.2, 129.4, 129.5, 129.6, 129.8, 129.9, 130.7, 135.3, 136.7, 143.8, 145.1, 146.8, 148.0, 149.8, 152.4 ppm. HRMS (ESI) calcd for C₂₈H₂₀ClN₂O₂S [M+H]^+ 482.0856; found 482.0847.

6-tosyl-6H-indolo[2,3-b]quinoline (3g):

![Image](image_url)

To a solution of 2g (75 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 2 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3g as a yellow solid (60 mg, 0.16 mmol, 82%); m. p. 226-228 °C. ¹H NMR (CDCl₃, 300 MHz) δ 2.27 (s, 3H), 7.04-7.16 (m, 5H), 7.25-7.35 (m, 3H), 7.52 (s, 1H), 7.70 (d, J = 8.1 Hz, 2H), 7.89 (d, J = 7.8 Hz, 1H), 8.49 (d, J = 6.6 Hz, 1H) ppm. ¹³C NMR (CDCl₃, 100 MHz) δ 21.6, 113.3, 121.7, 122.3, 123.6, 124.1, 124.3, 125.5, 126.8, 127.1, 127.6, 128.6, 130.0, 131.1, 132.2, 134.9, 135.7, 145.5, 151.6, 164.5 ppm. HRMS (ESI) calcd for C₂₂H₁₇N₂O₂S [M+H]^+ 373.1011; found 373.1014.

2-chloro-6-(phenylsulfonyl)-6H-indolo[2,3-b]quinoline (3h):

![Image](image_url)

To a solution of 3i (82 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (0.4 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 2.5 h. After the completion of the reaction
(monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3i as a yellow solid (61 mg, 0.15 mmol, 75%); m. p. 266-268 °C. $^1$H NMR (CDCl$_3$, 300 MHz) $\delta$ 2.29 (s, 3H), 7.00-7.04 (m, 2H), 7.18 (d, $J$ = 8.1 Hz, 2H), 7.30-7.37 (m, 3H), 7.50 (s, 1H), 7.71 (d, $J$ = 8.1 Hz, 2H), 7.91 (d, $J$ = 7.8 Hz, 1H), 8.42 (d, $J$ = 7.2 Hz, 1H) ppm. $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 21.7, 113.4, 121.8, 123.4, 123.8, 124.5, 125.8, 127.1, 127.4, 128.0, 128.2, 129.2, 130.2, 130.5, 132.5, 134.8, 135.7, 145.7, 149.8, 163.7 ppm. HRMS (ESI) calcd for C$_{22}$H$_{16}$ClN$_2$O$_2$S [M+H]$^+$ 407.0621; found 407.0613.


To a solution of 2j (91 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 2 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na$_2$SO$_4$ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 90:10 (v/v) to afford the product 3j as a yellow solid (76 mg, 0.17 mmol, 85%); m. p. 204-206 °C. $^1$H NMR (CDCl$_3$, 300 MHz) $\delta$ 2.40 (s, 3H), 7.04-7.12 (m, 2H), 7.26 (d, $J$ = 6.6 Hz, 3H), 7.41-7.48 (m, 4H), 7.63-7.68 (m, 3H), 7.78 (t, $J$ = 7.5 Hz, 1H), 8.35 (d, $J$ = 7.8 Hz, 2H), 8.57 (s, 1H) ppm. $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 21.7, 114.9, 116.7, 122.7, 122.8, 123.6, 125.2, 125.3, 125.7, 128.4, 129.1, 129.3, 129.4, 129.5, 129.7, 130.7, 134.1, 135.2, 136.0, 139.8, 141.2, 145.1, 146.3, 150.6 ppm. HRMS (ESI) calcd for C$_{27}$H$_{20}$N$_3$O$_2$S [M+H]$^+$ 450.1276; found 450.1716.

3-methyl-5-phenyl-10-tosyl-10H-indolo[2,3-b][1,8]naphthyridine (3j):
To a solution of 2k (94 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 3.5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 90:10 (v/v) to afford the product 3k as a yellow solid (77 mg, 0.16 mmol, 83%); m. p. 236-238 °C. ¹H NMR (CDCl₃, 400 MHz) δ 2.32 (s, 3H), 2.45 (s, 3H), 6.87 (d, J = 7.6 Hz, 1H), 7.09 (t, J = 7.6 Hz, 1H), 7.24-7.26 (m, 2H), 7.38-7.40 (m, 2H), 7.51 (t, J = 7.6 Hz, 1H), 7.64 (t, J = 3.2 Hz, 3H), 7.74 (s, 1H), 8.32 (d, J = 8 Hz, 2H), 8.51 (d, J = 8.4 Hz, 1H), 8.97 (s, 1H) ppm. ¹³C NMR (CDCl₃, 100 MHz) δ 18.7, 21.7, 114.8, 117.5, 119.7, 122.4, 123.0, 123.6, 128.5, 129.2, 129.3, 129.4, 129.7, 130.3, 134.1, 134.8, 136.0, 140.0, 142.9, 145.2, 152.2, 152.5, 154.9 ppm. HRMS (ESI) calcd for C₂₈H₂₂N₃O₂S [M+H]⁺ 464.1433; found 464.1471.


To a solution of 2l (96 mg, 0.2 mmol) in dichloromethane (2 mL), DDQ (91 mg, 0.4 mmol) was added. The resulting solution was stirred at room temperature for 3.5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 80:20 (v/v) to afford the product 3l as a yellow solid (72 mg, 0.15 mmol, 75%); m. p. 236-238 °C. ¹H NMR (CDCl₃, 300 MHz) δ 2.23 (s, 3H), 2.34 (s, 3H), 2.47 (s, 3H), 6.92 (s, 1H), 7.29 (s, 2H), 7.39 (s, 2H), 7.67 (s, 3H), 7.77 (s, 1H), 8.42 (s, 3H), 9.01 (s, 1H) ppm. ¹³C NMR (CDCl₃, 100 MHz) δ 18.7, 21.7, 114.8, 119.6, 128.5, 128.7, 129.1, 129.5, 129.6, 131.2, 132.0, 132.1, 132.2, 132.3, 134.0, 134.5, 136.6, 143.9, 145.1, 148.9, 150.9, 151.6, 155.3 ppm. HRMS (ESI) calcd for C₂₈H₂₃N₄O₂S [M+H]⁺ 479.1542; found 479.1644.
4-(6-tosyl-6H-indolo[2,3-b]quinolin-11-yl)benzonitrile (3l) :

![Diagram of 4-(6-tosyl-6H-indolo[2,3-b]quinolin-11-yl)benzonitrile (3l)](image)

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), (4-cyanophenyl)boronic acid (66 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. To a solution of this crude product in dichloromethane (2 mL), DDQ (136 mg, 0.6 mmol) was added. The resulting solution was stirred at room temperature for 2 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 95:5 (v/v) to afford the product 3m as a yellow solid (105 mg, 0.22 mmol, 74 %); m. p. 236-238 °C. ¹H NMR (CDCl₃, 300 MHz) δ 2.30 (s, 3H), 7.04-7.13 (m, 4H), 7.18 (d, J = 8.4 Hz, 2H), 7.23-7.41 (m, 3H), 7.50-7.54 (m, 2H), 7.63-7.68 (m, 1H), 7.73 (d, J = 8.4 Hz, 2H), 7.90 (d, J = 7.6 Hz, 1H), 8.50-8.52 (m, 1H) ppm. ¹³C NMR (CDCl₃, 100 MHz) δ 21.6, 113.3, 118.4, 122.2, 123.1, 123.6, 124.1, 125.5, 126.8, 127.1, 127.6, 128.5, 129.8, 130.3, 132.2, 132.7, 134.9, 135.7, 145.5, 151.5, 164.6 ppm. HRMS (ESI) calc'd for C₂₉H₂₀N₃O₂S [M+H]+ 474.1276; found 474.1258.

4-(6-tosyl-6H-indolo[2,3-b]quinolin-11-yl)benzaldehyde (3m) :

![Diagram of 4-(6-tosyl-6H-indolo[2,3-b]quinolin-11-yl)benzaldehyde (3m)](image)

To a solution of 1a (136 mg, 0.3 mmol) in 2.5 M K₂CO₃ (1 mL), 2 mL ethanol-toluene (1:1), (4-formylphenyl)boronic acid (69 mg, 0.45 mmol), PCy₃ (8 mg, 0.03 mmol) and Pd(OAc)₂ (4 mg, 0.015 mmol) were added successively. The resulting solution was stirred at 75-75 °C under argon
atmosphere for 3 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. To a solution of this crude product in dichloromethane (2 mL), DDQ (136 mg, 0.06 mmol) was added. The resulting solution was stirred at room temperature for 2.5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with dichloromethane. The organic extract was washed with sodium bicarbonate solution, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/EtOAc 90:10 (v/v) to afford the product 3n as a yellow solid (99 mg, 0.21 mmol, 71%); m. p. 236-238 °C. 

\[ \text{H NMR (CDCl}_3, 300 MHz) \delta 2.33 (s, 3H), 6.81 (s, 1H), 7.09 (s, 1H), 7.25 (s, 3H), 7.45-7.62 (m, 5H), 7.77 (s, 1H), 8.17-8.29 (m, 4H), 8.51-8.53 (m, 1H), 10.22 (s, 1H) ppm. } 

\[ \text{C NMR (CDCl}_3, 100 MHz) \delta 21.7, 115.0, 116.4, 122.5, 122.7, 123.7, 124.7, 125.5, 128.5, 129.2, 129.4, 129.5, 129.6, 130.0, 130.2, 130.6, 136.0, 139.9, 140.8, 142.2, 145.2, 146.3, 150.5, 191.8 ppm. } 

HRMS (ESI) calcd for C_{29}H_{21}N_2O_3S [M+H]^+ 477.1273; found 477.1230.

11-phenyl-6H-indolo[2,3-b]quinoline (4):

To a solution of 3a (78 mg, 0.175 mmol) in methanol (2 mL), NaOH (14 mg, 0.35 mmol), water (1 mL) were added successively. The resulting solution was refluxed in a sealed tube for 5 h. After the completion of the reaction (monitored by TLC), the crude reaction mixture was extracted with ethyl acetate. The organic extract was washed with water, dried over anhydrous Na₂SO₄ and concentrated. The product was subjected to column chromatography (silica gel, 60-120 mesh), eluting with pet ether/ EtOAc 95:5 (v/v) to afford the product 4 as a yellow solid (41 mg, 0.14 mmol, 82%).

\[ \text{H NMR (CDCl}_3, 500 MHz) \delta 6.97 (t, J = 7.0 Hz, 1H), 7.06 (d, J = 8.0 Hz, 1H), 7.25-7.45 (m, 2H), 7.48 (d, J = 8 Hz, 1H), 7.49-7.56 (m, 2H), 7.62-7.68 (m, 3H), 7.73-7.78 (m, 2H), 7.77 (d, J = 8.0 Hz, 1H), 9.8 (s, 1H) ppm. } 

\[ \text{C NMR (CDCl}_3, 100 MHz) \delta 110.7, 116.6, 120.2, 121.4, 123.2, 123.3, 124.1, 126.7, 127.1, 128.1, 128.7, 129.1, 129.5, 136.5, 141.2, 143.0, 146.6, 153.0 ppm. } 

HRMS (ESI) calcd for C_{29}H_{15}N_2 [M+H]^+ 295.1235; found 295.1219.
$^1$H NMR spectrum of compound 1a, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 1a, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2a, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2a, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2b, CDCl$_3$, 500 MHz

$^{13}$C NMR spectrum of compound 2b, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 2c, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2c, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2d, CDCl$_3$, 500 MHz

$^{13}$C NMR spectrum of compound 2d, CDCl$_3$, 300 MHz
$^1$H NMR spectrum of compound 2e, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2e, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2f, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2f, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound $2g$, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound $2g$, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2h, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2h, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2i, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2i, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 2j, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 2j, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 2k, CDCl$_3$, 500 MHz

$^{13}$C NMR spectrum of compound 2k, CDCl$_3$, 75 MHz
\(^1\)H NMR spectrum of compound 3a, CDCl₃, 300 MHz

\(^{13}\)C NMR spectrum of compound 3a, CDCl₃, 75 MHz
$^1$H NMR spectrum of compound 3b, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3b, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 3c, CDCl$_3$, 500 MHz

$^{13}$C NMR spectrum of compound 3c, CDCl$_3$, 125 MHz
$^1$H NMR spectrum of compound 3d, CDCl$_3$, 400 MHz

$^{13}$C NMR spectrum of compound 3d, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3e, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3e, CDCl$_3$, 75 MHz
$^1$H NMR spectrum of compound 3f, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3f, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3g, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3g, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3h, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3h, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3i, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3i, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3j, CDCl$_3$, 400 MHz

$^{13}$C NMR spectrum of compound 3j, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3k, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3k, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3l, CDCl$_3$, 400 MHz

$^{13}$C NMR spectrum of compound 3l, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 3m, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 3m, CDCl$_3$, 100 MHz
$^1$H NMR spectrum of compound 4, CDCl$_3$, 300 MHz

$^{13}$C NMR spectrum of compound 4, CDCl$_3$, 100 MHz