Supporting Information

Rapid Synthesis of Polysubstituted Phenanthridines from Simple Aliphatic/Aromatic Nitriles and Iodo Arenes via Pd(II) Catalyzed Domino C-C/C-C/N Bonds Formation

Yogesh Jaiswal, Yogesh Kumar, Jagannath Pal, Ranga Subramanian and Amit Kumar*

Department of Chemistry, Indian Institute of Technology Patna, Bihta 801106, Bihar, India

*E-mail: amitkt@iitp.ac.in or amitktiitk@gmail.com
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1. General Considerations:

Unless otherwise noted, all reagents were purchased from a commercial supplier and used without further purification. All the reactions were run under inert atmosphere in the pressure tubes and indicated temperature was that of oil bath. $^1$H NMR spectra were recorded at 400 MHz and $^{13}$C($^1$H) NMR spectra were recorded at 100 MHz, CDCl$_3$ was used as solvent. Chemical shift are reported in δ ppm referenced to CDCl$_3$ (δ 7.26), for $^1$H NMR and CDCl$_3$ (δ 77.0)for $^{13}$C NMR. The following abbreviations were used to explain multiplicities: (s, singlet; d, doublet; t, triplet; q, quartet; m, multiple, br.s, broad singlet), coupling constant (Hertz). Infrared spectra were recorded by FT-IR apparatus. High-resolution mass spectra (HRMS) spectra were obtained on ESI-TOF (electron spray ionization-time of flight) spectrometer and acetonitrile was used to dissolve the sample. Column chromatography was performed on silica gel (100-200) mesh using ethyl acetate/hexanes or DCM/hexanes as eluent in different ratio.

2. General procedure and data for reaction optimization:

*Optimization of reaction conditions*

Table S1. Optimization by varying solvents*

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Solvent</th>
<th>Yield$^b$ of 3a (%)</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Toluene</td>
<td>17</td>
</tr>
<tr>
<td>2.</td>
<td>Chlorobenzene</td>
<td>10</td>
</tr>
<tr>
<td>3.</td>
<td>CH$_3$CN</td>
<td>n.r.</td>
</tr>
<tr>
<td>4.</td>
<td>HFIP</td>
<td>30</td>
</tr>
<tr>
<td>5.</td>
<td>DCE</td>
<td>70</td>
</tr>
<tr>
<td>6.</td>
<td>DCE</td>
<td>42</td>
</tr>
<tr>
<td>7.</td>
<td>TFE</td>
<td>8</td>
</tr>
</tbody>
</table>
Reaction conditions: All reactions were performed with 1a (0.2 mmol), 2a (0.6 mmol), Pd(OAc)₂ (10 mol %), AgBF₄ (3.0 equiv), TFA (20 mol%), in 2.0 mL of solvent for 48 h at 130 °C. Isolated yield of 3a. 2.0 equiv. of iodobenzene was used. n. r. = no reaction. DCE = Dichloroethane, TFE = 2,2,2-Trifluoroethanol, THF = Tetrahydrofuran.

Table S2. Optimization by varying oxidants

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Oxidant</th>
<th>Yield of 3a (%)</th>
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<tbody>
<tr>
<td>1.</td>
<td>Ag₂CO₃</td>
<td>n.r.</td>
</tr>
<tr>
<td>2.</td>
<td>Ag₂O</td>
<td>n.r.</td>
</tr>
<tr>
<td>3.</td>
<td>CH₃CO₂Ag</td>
<td>5</td>
</tr>
<tr>
<td>4.</td>
<td>AgBF₄</td>
<td>70</td>
</tr>
<tr>
<td>5.</td>
<td>AgOTf</td>
<td>n.r.</td>
</tr>
<tr>
<td>6.</td>
<td>AgNO₃</td>
<td>12</td>
</tr>
<tr>
<td>7.</td>
<td>Cu(OAc)₂</td>
<td>n.r.</td>
</tr>
</tbody>
</table>

Reaction conditions: All reactions were performed with 1a (0.2 mmol), 2a (0.6 mmol), Pd(OAc)₂ (10 mol %), oxidant (3.0 equiv), TFA (20 mol%), in 2.0 mL of DCE for 48 h at 130 °C. Isolated yield of 3a. n. r. = no reaction.

Table S3. Optimization by varying ligands

<table>
<thead>
<tr>
<th>S.No.</th>
<th>ligand</th>
<th>Yield of 3a (%)</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>TFA</td>
<td>70</td>
</tr>
<tr>
<td>2.</td>
<td>TfOH</td>
<td>55</td>
</tr>
<tr>
<td>3.</td>
<td>AcOH</td>
<td>65</td>
</tr>
<tr>
<td>5.</td>
<td>SPhos</td>
<td>65</td>
</tr>
<tr>
<td>5.</td>
<td>XPhos</td>
<td>78</td>
</tr>
</tbody>
</table>

Reaction conditions: All reactions were performed with 1a (0.2 mmol), 2a (0.6 mmol), Pd(OAc)₂ (10 mol %), AgBF₄ (3 equiv), TFA (20 mol%), in 2.0 mL of DCE for 48 h at 130 °C. Isolated yield of 3a. n. r. = no reaction.
Reaction conditions: All reactions were performed with 1a (0.2 mmol), 2a (0.6 mmol), Pd(OAc)$_2$ (10 mol%), AgBF$_4$ (3.0 equiv), ligand (20 mol%), in 2.0 mL of DCE for 48 h at 130 °C. *Isolated yield of 3a. *4.0 equiv of iodobenzene was used. n. r. = no reaction.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Time (h)</th>
<th>Temperature (°C)</th>
<th>Yield$^b$ of 3a (%)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>130</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>130</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>130</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>100</td>
<td>30</td>
</tr>
</tbody>
</table>

Table S4. Optimization by varying time and temperature$^a$

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$^a$Isolated yield of 3a. $^b$4.0 equiv of iodobenzene was used. n. r. = no reaction.
Table S5. Optimization by varying catalyst

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Catalyst</th>
<th>Yield of 3a (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>PdCl₂</td>
<td>62</td>
</tr>
<tr>
<td>2</td>
<td>PdBr₂</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>Pd(OCOCF₃)₂</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>Pd(PPh₃)₂Cl₂</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>Pd(CH₃CN)₄BF₄</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>Pd(OAc)₂</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>Pd(OAc)₂</td>
<td>58c</td>
</tr>
<tr>
<td>8</td>
<td>Pd(OAc)₂</td>
<td>22d</td>
</tr>
</tbody>
</table>

*aReaction conditions: All reactions were performed with 1a (0.2 mmol), 2a (0.6 mmol), Catalyst (10 mol %), AgBF₄ (3.0 equiv), ligand (20 mol%), in 2.0 mL of DCE for 48 h at 130 °C.

*bIsolated yield of 3a.

*c5 mol% of the metal catalyst was used.

*dReaction was performed under oxygen atmosphere condition.

**General procedure for phenanthridines synthesis:** To a clean oven-dried 15 mL pressure tube equipped with magnetic stir bar was sequentially added aryl nitriles (0.25mmol, 1 equiv.), Pd(OAc)₂(10 mol%, 5.6 mg), JohnPhos (0.05 mmol, 15.0 mg) in dry DCE (2.5 mL). The tube was carefully evacuated and backfilled with nitrogen for three cycles and subsequently aryl iodide (0.75 mmol, 3 equiv.) and silver tetrafluoroborate (0.75 mmol, 3.0 equiv, 145.5 mg) were added to the reaction mixture. The reaction mixture was placed in preheated oil bath of 130°C and vigorously stirred for 48 h. Upon completion as shown by TLC, the reaction mixture was cooled to room temperature and water was added to quench the reaction mixture. DCM (3 x15 mL) was used for extraction. Combined organic layers were passed through short pad of celite.
and dried over Na$_2$SO$_4$. After evaporation of solvent, the crude reaction mixtures were purified by column chromatography using silica-gel (100-200 mess) with an eluent system ethyl acetate/hexanes (5:95) or DCM/hexanes (20:80) to afford the desired products.

3. Characterization data for all products:

**6-Benzyl-phenanthridine (3a):** Yellow solid (54 mg, 80%); Mp 100-102°C (Reported: 105-107 °C); $R_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; IR (ATR): 3073, 2925, 1448, 1248, 755 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 8.63 (d, $J$ = 8.0 Hz, 1H), 8.56 (d, $J$ = 8.0 Hz, 1H), 8.22 (t, $J$ = 8.0 Hz, 2H), 7.77 (q, $J$ = 8.0 Hz, 2H), 7.67 (t, $J$ = 8.0 Hz, 1H), 7.59 (t, $J$ = 8.0 Hz, 1H), 7.33 (d, $J$ = 6.8 Hz, 2H), 7.27-7.23 (m, 2H), 7.19-7.16 (m, 1H), 4.78 (s, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 160.1, 143.5, 139.0, 133.3, 130.5, 129.7, 128.7, 128.5, 127.4, 127.1, 126.7, 126.3, 125.3, 123.9, 122.4, 121.9, 42.9.

**6-(4-Methoxy-benzyl)-phenanthridine (3b):** White solid (54 mg, 73%); $R_f$ (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 92-94 °C (Reported: 91-92 °C); IR(ATR): 2953, 1602, 1508, 1240, 766 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ = 8.62 (d, $J$ = 8.0 Hz, 1H), 8.56 (d, $J$ = 8.0 Hz, 1H), 8.22-8.19 (m, 2H), 8.80-7.72 (m, 2H), 7.67-7.63 (m, 1H), 7.61-7.57 (m, 1H), 7.24 (d, $J$ = 8.0 Hz, 2H), 6.78 (d, $J$ = 8.7 Hz, 2H), 4.70 (s, 2H), 3.73 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ = 160.4, 158.1, 143.7, 133.3, 131.2, 130.3, 129.8, 129.5, 127.3, 127.1, 126.6, 125.4, 123.9, 122.4, 121.9, 114.0, 55.2, 42.2.
6-(4-Methyl-benzyl)-phenanthridine (3c): White solid (55 mg, 78%); R_f (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 68-70 °C (Reported: 69-70 °C); IR (ATR): 2920, 2860, 1513, 726 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 8.61 (d, J = 8.3 Hz, 1H), 8.56 (d, J = 8.2 Hz, 1H), 8.21 (d, J = 8.2 Hz, 2H), 7.79-7.73 (m, 2H), 7.67 – 7.63 (m, 1H), 7.60-7.56 (m, 1H), 7.22 (d, J = 8.0 Hz, 2H), 7.06 (d, J = 7.9 Hz, 2H). 4.73 (s, 2H), 2.27 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 160.3, 143.7, 136.0, 135.8, 133.2, 130.3, 129.8, 129.2, 128.6, 128.4, 127.3, 127.0, 126.6, 125.3, 123.9, 122.3, 121.9, 42.6, 20.9.

6-(2-Methoxy-benzyl)-phenanthridine (3d): White solid (40 mg, 53% ); R_f (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 105-107 °C; IR (ATR): 3066, 2923, 1456, 760 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 8.63 (d, J = 8.1 Hz, 1H), 8.20 (t, J = 8.8 Hz, 2H), 7.82 – 7.69 (m, 2H), 7.65 (t, J = 7.2 Hz, 1H), 7.57 (t, J = 7.2 Hz, 1H), 7.16 (t, J = 7.7 Hz, 1H), 6.94 (s, 2H), 6.72 (t, J = 7.1 Hz, 1H), 4.74 (s, 2H), 3.97 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 161.0, 156.3, 133.1, 130.6, 129.6, 129.5, 128.7, 127.5, 127.4, 127.3, 126.6, 125.5, 123.9, 122.2, 121.9, 120.6, 110.3, 55.6, 35.6; HRMS (ESI-TOF) m/z Calcd for C₂₁H₁₈NO [ M + H]^⁺ 300.1383, found 300.1388.

6-(3-Methyl-benzyl)-phenanthridine (3e): Yellow sticky solid (46 mg, 65%); R_f (95:5 Hexanes/Ethyl acetate) = 0.5; IR (ATR): 3066, 2923, 1483, 760 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 8.63 (d, J = 8.3 Hz, 1H), 8.57 (d, J = 8.1 Hz, 1H), 8.21 (d, J = 8.2, 2H), 7.81 – 7.72 (m, 2H), 7.68-7.64 (m, 1H), 7.61 – 7.57 (m, 1H), 7.14-7.12 (m, 3H), 6.99 – 6.97 (m, 1H), 4.73 (s, 2H), 2.26 (s, 3H). δ = 160.2, 143.8, 139.0, 138.1, 133.3, 130.3, 129.9, 129.2, 128.6, 128.4, 127.3, 127.1, 127.0, 126.6, 125.6, 125.5, 123.9, 122.4, 121.9, 43.8, 21.4.
6-(4-Chloro-benzyl)-phenanthridine (3f): White solid (46 mg, 60%); R\(_f\) (95:5 Hexanes/Ethyl acetate) = 0.4; Mp 135-137 °C; IR (ATR): 2926, 1483, 1086, 723 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.64\) (d, \(J = 8.0\) Hz, 1H), 8.57 (d, \(J = 8.0\) Hz, 1H), 8.18 (d, \(J = 7.6\) Hz, 1H), 8.13 (d, \(J = 8.0\) Hz, 1H), 7.82-7.74 (m, 2H), 7.67 (t, \(J = 8.0\) Hz, 1H), 7.60 (d, \(J = 7.6\) Hz, 1H), 7.26-7.20 (m, 4H), 4.72 (s, 2H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 159.6, 143.7, 137.6, 133.3, 132.1, 130.5, 129.9, 128.7, 128.6, 127.4, 126.8, 126.7, 125.2, 123.9, 122.5, 122.0, 42.3\); HRMS (ESI-TOF): m/z Calcd for C\(_{20}\)H\(_{15}\)ClN [M + H]\(^+\) 304.0888, found 304.0892.

6-(4-Bromo-benzyl)-phenanthridine (3g): White solid (39 mg, 45%); R\(_f\) (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 130-131 °C; IR (ATR) 2921, 1483, 1007, 759 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.64\) (d, \(J = 8.0\) Hz, 1H), 8.57 (d, \(J = 8.0\) Hz, 1H), 8.19 (d, \(J = 8.0\) Hz, 1H), 8.12 (d, \(J = 8.0\) Hz, 1H), 7.81-7.74 (m, 2H), 7.67 (t, \(J = 8.0\) Hz, 1H), 7.59 (t, \(J = 8.0\) Hz, 1H), 7.36 (d, \(J = 8.0\) Hz, 2H), 7.19 (d, \(J = 8.0\) Hz, 2H), 4.70 (s, 2H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 159.5, 143.6, 138.1, 133.3, 131.6, 130.5, 130.3, 129.8, 128.7, 127.4, 126.8, 126.7, 125.1, 123.9, 122.5, 122.0, 120.2, 42.4\); HRMS (ESI-TOF): m/z Calcd for C\(_{20}\)H\(_{15}\)BrN [M + H]\(^+\) 348.0382, found 348.0392.

6-(4-Fluoro-benzyl)-phenanthridine (3h): White solid (45 mg, 63%); R\(_f\) (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 115-117 °C; IR (ATR): 3060, 2923, 1500, 1206, 740 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.64\) (d, \(J = 8.0\) Hz, 1H), 8.59 (d, \(J = 8.0\) Hz, 1H), 8.22 (d, \(J = 8.0\) Hz, 1H), 8.17 (d, \(J = 8.0\) Hz, 1H), 7.82-7.74 (m, 2H), 7.67 (t, \(J = 7.6\) Hz, 1H), 7.60 (t, \(J = 8.0\) Hz, 1H), 7.30-7.27 (m, 2H), 6.93 (t, \(J = 8.0\) Hz, 2H), 4.74 (s, 2H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 162.5\) (d, \(J = 243\) Hz), 159.9, 143.4, 134.58 (d, \(J = 3.0\) Hz), 133.34, 130.56, 129.9 (d, \(J = 8.0\) Hz), 129.6, 128.8, 127.40,
126.9, 126.8, 125.1, 123.9, 122.50, 121.97, 115.3 (d, J = 21.0 Hz), 41.9; HRMS (ESI-TOF): m/z Calcd for C_{20}H_{15}FN [M + H]^+ 288.1183, found 288.1179.

6-(4-Nitro-benzyl)-phenanthridine (3i): Yellow solid (51 mg, 65%); R_f (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 158-160 °C; IR (ATR): 2829, 2850, 1505, 1336, 747 cm^{-1}; ^1H NMR (400 MHz, CDCl_3): δ = 8.65 (d, J = 8.0 Hz, 1H), 8.57 (d, J = 8.0 Hz, 1H), 8.19 (d, J = 8.0 Hz, 1H), 8.09 (t, J = 7.6 Hz, 3H), 8.82 (t, J = 7.6 Hz, 1H), 7.77 (t, J = 8.0 Hz, 1H), 7.69 (t, J = 8.0 Hz, 1H), 7.62 (t, J = 8.0 Hz, 1H), 7.48 (d, J = 12.0 Hz, 2H), 4.85 (s, 2H); ^13C NMR (100 MHz, CDCl_3): δ = 158.4, 146.62, 146.60, 143.4, 133.4, 130.8, 129.7, 129.5, 128.9, 127.6, 127.1, 126.3, 125.0, 123.9, 123.6, 122.7, 122.0, 42.4; HRMS (ESI-TOF): m/z Calcd for C_{20}H_{15}N_2O_2 [M + H]^+ 315.1128, found 315.1133.

6-(4-Trifluoromethyl-benzyl)-phenanthridine (3j): White solid (51 mg, 61%); R_f (95:5 Hexanes/Ethyl acetate) = 0.4; Mp 120-122 °C; IR (ATR): 3070, 2923, 1323, 1110, 766 cm^{-1}; ^1H NMR (400 MHz, CDCl_3): δ = 8.65 (d, J = 8.0 Hz, 1H), 8.58 (d, J = 8.0 Hz, 1H), 8.21 (d, J = 7.6 Hz, 1H), 8.13 (d, J = 8.0 Hz, 1H), 7.81-7.77 (m, 2H), 7.68 (t, J = 8.0 Hz, 1H), 7.61 (t, J = 8.0 Hz, 1H), 7.52-7.45 (m, 4H), 4.82 (s, 2H); ^13C NMR (100 MHz, CDCl_3): δ = 159.1, 143.5, 143.1, 133.3, 130.6, 129.8, 128.9, 128.8, 128.5, 127.5, 127.0, 126.6, 125.45 (q, J = 4.0 Hz), 125.1, 123.9, 122.8, 122.6, 122.0, 42.6; HRMS (ESI-TOF): m/z Calcd for C_{21}H_{13}F_3N [M + H]^+ 338.1151, found 338.1162.
6-Biphenyl-4-ylmethyl-phenanthridine (3k): White solid (53 mg, 62%);
Rₐ (8:2 Hexanes/DCM) = 0.5; Mp 159-161 °C; IR (ATR): 3066, 2930, 1483, 750 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.64 (d, J = 8.0 Hz, 1H), 8.58 (d, J = 8.0 Hz, 1H), 8.24 (t, J = 7.6 Hz, 2H), 7.81-7.75 (m, 2H), 7.67 (d, J = 8.0 Hz, 1H), 7.61(d, J = 8.0 Hz, 1H), 7.54-7.48 (m, 4H), 7.40 (d, J = 8.0 Hz, 4H), 7.30 (d, J = 7.6 Hz, 1H), 4.81 (s, 2H); ¹³C NMR (100 MHz, CDCl₃): δ = 160.0, 143.7, 140.8, 139.2, 138.2, 133.3, 130.4, 129.9, 128.9, 128.7, 127.4, 127.2, 127.1, 127.0, 126.9, 126.7, 125.4, 123.9, 122.4, 122.0, 42.7; HRMS (ESI-TOF): m/z Calcd for C₂₆H₂₀N [M + H]⁺ 346.1590, found 346.1597.

6-(3,4-Dichloro-benzyl)-phenanthridine (3l): White solid (55 mg, 64%); Rₐ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 86-88 °C; IR (ATR): 2923, 1466, 746 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.66 (d, J = 8.0 Hz, 1H), 8.58 (d, J = 8.0 Hz, 1H), 8.22 (d, J = 7.6 Hz, 1H), 8.12 (d, J = 8.0 Hz, 1H), 7.83 (t, J = 8.0 Hz, 1H), 7.77 (t, J = 8.0 Hz, 1H), 7.69-7.64 (m, 2H), 7.43 (s, 1H), 7.31 (d, J = 8.0 Hz, 1H), 7.16 (d, J = 8.0 Hz, 1H), 4.72 (s, 2H); ¹³C NMR (100 MHz, CDCl₃): δ = 158.8, 143.3, 130.1, 133.4, 132.5, 130.8, 130.5, 130.4, 129.7, 128.9, 128.0, 127.6, 127.1, 126.6, 125.0, 123.9, 122.7, 122.0, 41.7; HRMS (ESI-TOF): m/z Calcd for C₂₀H₁₄Cl₂N [ M + H]⁺ 338.0498, found 338.0505.

4-Phenanthridin-6-ylmethyl-benzoic acid methyl ester (3m): White solid (51 mg, 61%); Rₐ (95:5 Hexanes/Ethyl acetate) = 0.4; Mp 135-137 °C; IR(ATR): 2949, 1711, 1278, 750 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.64 (d, J = 7.6 Hz, 1H), 8.57 (d, J = 8.0 Hz, 1H), 8.19 (d, J = 8.0 Hz, 1H), 8.11 (d, J = 8.0 Hz, 1H), 7.92(d, J = 8.0 Hz, 2H), 7.78(q, J = 8.0 Hz, 2H), 7.67
(t, J = 8.0 Hz, 1H), 7.58 (d, J = 7.6 Hz, 1H), 7.38 (d, J = 8.0 Hz, 2H), 4.80 (s, 2H), 3.86 (s, 3H);

$^1$C NMR (100 MHz, CDCl$_3$): $\delta = 166.9, 159.2, 144.5, 143.6, 133.3, 130.5, 129.8, 128.8, 128.6, 127.4, 126.8, 126.7, 125.2, 123.9, 122.5, 122.0, 52.0, 43.0; HRMS (ESI-TOF): m/z Calcd for C$_{22}$H$_{18}$NO$_2$ [M + H]$^+$ 328.1332, found 328.1331.

6-(Biphenyl-2-ylmethyl)-phenanthridine (3n): White solid (50 mg, 58%);

R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 105-107 °C; IR (ATR): 3056, 2921, 1480, 747 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 8.60$-$8.54$ (m, 2H), 8.18 (d, $J = 8.0$ Hz, 1H), 7.76-7.63 (m, 4H), 7.56-7.49 (m, 4H), 7.47-7.42 (m, 2H), 7.35 (d, $J = 8.0$ Hz, 1H), 7.24 (t, $J = 7.6$ Hz, 1H), 7.13-7.09 (m, 2H), 4.71 (s, 2H); $^1$C NMR (100 MHz, CDCl$_3$): $\delta = 160.7, 141.4, 136.6, 133.1, 130.0, 129.9, 129.5, 129.0, 128.6, 128.4, 127.5, 127.2, 127.1, 127.0, 126.6, 126.3, 125.2, 123.8, 122.2, 121.9, 40.6; HRMS (ESI-TOF): m/z Calcd for C$_{26}$H$_{20}$N [M + H]$^+$ 346.1590, found 346.1598.

6-Benzhydryl-phenanthridine (3o): White solid (58 mg, 68%); R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 114-116 °C; IR (ATR): 3030, 2926, 1490, 696 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 8.66$ (d, $J = 8.0$ Hz, 1H), 8.56 (d, $J = 8.0$ Hz, 1H), 8.32 (d, $J = 8.0$ Hz, 1H), 8.06 (d, $J = 8.0$ Hz, 1H), 7.79 (t, $J = 7.6$ Hz, 1H), 7.69-7.58 (m, 3H), 7.6-7.29 (m, 8H), 7.24 (d, $J = 8.0$ Hz, 2H), 6.51 (s, 1H); $^1$C NMR (100 MHz, CDCl$_3$): $\delta = 161.2, 143.5, 142.6, 133.3, 130.6, 130.0, 129.7, 128.4, 128.2, 127.3, 126.7, 126.3, 125.5, 123.5, 122.5, 121.7, 55.6; HRMS (ESI-TOF): m/z Calcd for C$_{26}$H$_{20}$N [M + H]$^+$ 346.1590, found 346.1599.
6-(1-Phenyl-ethyl)-phenanthridine (3p): Yellow sticky solid (46 mg, 65%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; IR(ATR): 2973, 2926, 1450, 1366, 753 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.61\) (d, \(J = 8.0\) Hz, 1H), 8.55 (d, \(J = 8.0\) Hz, 1H), 8.28-8.22 (m, 2H), 7.78-7.71 (m, 2H), 7.67–7.63 (m, 1H), 7.58–7.53 (m, 1H), 7.38–7.36 (m, 2H), 7.27–7.23 (m, 2H), 7.18–7.13 (m, 1H), 5.12 (q, \(J = 6.9\) Hz, 1H), 1.94 (d, \(J = 6.9\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 162.3, 145.8, 143.6, 133.1, 129.8, 128.5, 128.4, 127.6, 127.1, 126.5, 126.4, 126.2, 125.2, 123.7, 122.4, 121.8, 44.0, 22.0; HRMS (ESI-TOF): m/z Calcd for C\(_{21}\)H\(_{18}\)N [M + H]\(^+\) 284.1434, found 284.1441.

6-Benzyl-phenanthridine (3q): Yellow solid (42 mg, 50%); Rf (8:2 Hexanes/Ethyl acetate) = 0.2; Mp 180-182 °C (Reported: 188-189 °C); IR (ATR): 2920, 2853, 1730, 1306, 1146, 740 (ATR) cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.64\) (d, \(J = 7.6\) Hz, 1H), 8.55 (s, 1H), 8.36 (d, \(J = 7.6\) Hz, 1H), 7.88 (s, 1H), 7.81 (s, 1H), 7.74 (t, \(J = 8.0\) Hz, 1H), 7.68 (s, 4H), 7.56 (s, 1H), 7.39 (t, \(J = 7.2\) Hz, 2H), 5.19 (s, 2H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 149.6, 143.1, 138.3, 133.7, 133.2, 131.1, 129.8, 128.82, 128.77, 128.69, 127.7, 127.0, 125.5, 124.0, 122.3, 122.0, 62.4.

6-Methyl-phenanthridine (3r): Yellow oil (22 mg, 45%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; IR(ATR): 3067, 2924, 1582, 1449, 752 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.66\) (d, \(J = 7.9\) Hz, 1H), 8.57 (d, \(J = 7.7\) Hz, 1H), 8.27 (d, \(J = 7.6\) Hz, 2H), 7.91 (t, \(J = 7.1\) Hz, 1H), 7.75 (t, \(J = 6.9\) Hz, 2H), 7.68 (d, \(J = 7.4\) Hz, 1H), 3.13 (s, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 159.0, 132.9, 131.3, 129.1, 129.1, 128.0, 127.7, 127.5, 126.9, 125.7, 123.8, 123.1, 122.5, 122.0, 29.7.
6-Methyl-4-phenyl-phenanthridine (3rr): Yellow oil (10 mg, 15%); \( \text{R}_f \) (95:5 Hexanes/Ethyl acetate) = 0.6; IR (ATR): 3059, 2922, 1573, 1442, 752 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.70 \) (d, \( J = 8.0 \) Hz, 1H), 8.59 (d, \( J = 8.0 \) Hz, 1H), 8.11 (d, \( J = 7.2 \) Hz, 1H), 7.83 (d, \( J = 8.0 \) Hz, 1H), 7.73 (d, \( J = 8.0 \) Hz, 1H), 7.65 (d, \( J = 6.8 \) Hz, 1H), 7.56 (d, \( J = 6.8 \) Hz, 1H), 7.46 (s, 3H), 7.39 (s, 2H), 2.35 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 159.2, 143.9, 134.1, 131.1, 129.3, 128.9, 127.6, 124.4, 123.5, 122.3, 121.8, 22.6; \) HRMS (ESI-TOF): m/z Calcd for C\(_{20}\)H\(_{16}\)N [M + H]\(^+\) 270.1277, found 270.1281.

6-Isobutyl-phenanthridine (3s): Yellow oil (34 mg, 58%); \( \text{R}_f \) (95:5 Hexanes/Ethyl acetate) = 0.5; IR (ATR): 3070, 2956, 1579, 752 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.65 \) (d, \( J = 8.1 \) Hz, 1H), 8.56 (d, \( J = 7.7 \) Hz, 1H), 8.26 (d, \( J = 7.9 \) Hz, 1H), 8.14 (d, \( J = 7.8 \) Hz, 1H), 7.84 (t, \( J = 7.2 \) Hz, 1H), 7.74-7.67 (m, 2H), 7.62 (t, \( J = 7.0 \) Hz, 1H), 3.26 (d, \( J = 7.2 \) Hz, 2H), 2.39 (m, 1H), 1.05 (d, \( J = 6.5 \) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 161.6, 143.7, 132.9, 130.2, 129.6, 128.5, 127.1, 126.5, 126.2, 125.7, 123.6, 122.4, 121.9, 44.9, 29.2, 22.9; \) HRMS (ESI-TOF): m/z Calcd for C\(_{17}\)H\(_{18}\)N [M + H]\(^+\) 236.1434, found 236.1439.

6-Isobutyl-4-phenyl-phenanthridine (3ss): White sticky solid (14 mg, 18%); \( \text{R}_f \) (95:5 Hexanes/Ethyl acetate) = 0.6; IR (ATR): 3064, 2953, 1570, 1448, 752 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.68 \) (d, \( J = 8.0 \) Hz, 1H), 8.58 (d, \( J = 7.8 \) Hz, 1H), 8.10 (d, \( J = 7.5 \) Hz, 1H), 7.80 (t, \( J = 7.6 \) Hz, 1H), 7.72 (t, \( J = 7.1 \) Hz, 1H), 7.63 (t, \( J = 7.3 \) Hz, 1H), 7.54 (d, \( J = 6.9 \) Hz, 1H), 7.45 (s, 3H), 7.41 (s, 2H), 2.54 (d, \( J = 7.0 \) Hz, 2H), 1.81-1.65 (m, 1H), 0.44 (d, \( J = 6.4 \) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 162.2, 143.7, 141.9, 134.3, 131.2, 129.4, 129.2, 128.9, 128.6, 128.3, 127.4, 126.2, 123.8, 123.3, 122.2, 121.7, 48.3, 28.8, 22.2; \) HRMS (ESI-TOF): m/z Calcd for C\(_{23}\)H\(_{22}\)N [M + H]\(^+\) 312.1747, found 312.1754.
6-Propyl-phenanthridine (3t): Sticky solid (34 mg, 61%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; IR(ATR): 3073, 2960, 1580, 756 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.63\) (d, \(J = 8.0\) Hz, 1H), 8.54 (d, \(J = 7.8\) Hz, 1H), 8.25 (d, \(J = 7.9\) Hz, 1H), 8.13 (d, \(J = 7.9\) Hz, 1H), 7.82 (t, \(J = 7.2\) Hz, 1H), 7.77 – 7.65 (m, 2H), 7.61 (t, \(J = 7.3\) Hz, 1H), 3.35 (t, \(J = 7.6\) Hz, 2H), 1.97 (dd, \(J = 15.2, 7.5\) Hz, 2H), 1.13 (t, \(J = 7.2\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 162.3, 143.7, 132.9, 130.2, 129.5, 128.5, 127.2, 126.3, 126.2, 125.2, 123.6, 122.4, 121.9, 38.3, 22.9, 14.4\).

4-Phenyl-6-propyl-phenanthridine (3tt): Yellow sticky solid (15 mg, 20%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; IR(ATR): 3061, 2869, 1448, 753 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.69\) (d, \(J = 8.0\) Hz, 1H), 8.58 (d, \(J = 7.9\) Hz, 1H), 8.08 (d, \(J = 7.5\) Hz, 1H), 7.80 (t, \(J = 7.0\) Hz, 1H), 7.72 (t, \(J = 7.2\) Hz, 1H), 7.63 (d, \(J = 7.3\) Hz, 1H), 7.53 (d, \(J = 6.8\) Hz, 1H), 7.45 (s, 3H), 7.40 (s, 2H), 2.56 (t, \(J = 7.6\) Hz, 2H), 1.43 (dd, \(J = 14.9, 7.2\) Hz, 2H), 0.53 (t, \(J = 7.1\) Hz, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 162.9, 143.9, 141.9, 134.4, 131.1, 129.11, 129.06, 128.9, 128.6, 128.2, 127.5, 126.2, 123.7, 123.3, 122.2, 121.8, 41.7, 23.1, 13.8); HRMS (ESI-TOF): m/z Calcd for C\(_{22}\)H\(_{20}\)N [M + H]\(^{+}\) 298.1590, found 298.1598.

6-Pentyl-phenanthridine (3u): Yellow oil (32 mg, 52%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; IR(ATR): 3070, 2926, 1580, 1456 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 8.64\) (d, \(J = 8.0\) Hz, 1H), 8.54 (d, \(J = 7.8\) Hz, 1H), 8.26 (d, \(J = 8.0\) Hz, 1H), 8.13 (d, \(J = 8.0\) Hz, 1H), 7.83 (t, \(J = 7.1\) Hz, 1H), 7.70 (q, \(J = 7.0\) Hz, 2H), 7.62 (t, \(J = 7.5\) Hz, 1H), 3.37 (t, \(J = 8.0\) Hz, 2H), 1.97 – 1.89 (m, 2H), 1.55 – 1.49 (m, 2H), 1.47- 1.40 (m, 2H), 0.93 (t, \(J = 7.1\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 162.5, 143.8, 141.8, 134.4, 131.1, 129.11, 129.06, 128.9, 128.6, 128.2, 127.5, 126.2, 123.7, 123.3, 122.2, 121.8, 41.7, 23.1, 13.8); HRMS (ESI-TOF): m/z Calcd for C\(_{22}\)H\(_{20}\)N [M + H]\(^{+}\) 298.1590, found 298.1598.
132.9, 130.2, 129.6, 128.5, 127.2, 126.3, 126.2, 125.2, 123.6, 122.5, 121.9, 36.5, 32.2, 29.4, 22.6, 14.1.

**6-Pentyl-4-phenyl-phenanthridine (3uu):** Yellow sticky solid (16 mg, 20%); R$_f$ (95:5 = Hexanes/Ethyl acetate) = 0.5; IR (ATR): 3061, 2926, 1448, 754 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): δ = 8.69 (d, J = 7.3 Hz, 1H), 8.58 (d, J = 8.2 Hz, 1H), 7.83 – 7.77 (m, 1H), 7.71 (t, J = 7.6 Hz, 1H), 7.62 (t, J = 7.6 Hz, 1H), 7.53 (d, J = 7.2 Hz, 1H), 7.45 (q, J = 3.0 Hz, 3H), 7.40 (dd, J = 6.9, 2.8 Hz, 2H), 2.62 – 2.56 (m, 2H), 1.46 – 1.36 (m, 2H), 1.09 (dd, J = 14.7, 7.3 Hz, 2H), 0.86 (dd, J = 15.2, 7.9 Hz, 2H), 0.75 (t, J = 7.3 Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): δ = 163.0, 143.9, 143.4, 141.9, 134.4, 131.2, 129.1, 129.1, 128.9, 128.6, 128.2, 127.5, 126.2, 123.7, 123.3, 122.2, 121.8, 39.9, 31.7, 29.4, 22.40, 13.9; HRMS (ESI-TOF): m/z Calcd for C$_{24}$H$_{24}$N [M + H]$^+$ 326.1903, found 326.1907.

**6-Phenethyl-phenanthridine (3v):** Sticky solid (48 mg, 68%); R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; IR (ATR): 3066, 2923, 1580, 1366, 750 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): δ = 8.70 (d, J = 8.1 Hz, 1H), 8.69 (d, J = 8.0 Hz, 1H), 8.40 (s, 1H), 8.30 (d, J = 8.0 Hz, 1H), 7.93 (t, J = 7.3 Hz, 1H), 7.81-7.69 (m, 3H), 7.40 – 7.30 (m, 4H), 7.23 (t, J = 8.1 Hz, 1H), 3.82 (s, 2H), 3.33-3.29 (m, 2H). $^{13}$C NMR (100 MHz, CDCl$_3$): δ = 161.0, 142.0, 132.9, 130.4, 129.6, 128.9, 128.6, 128.50, 128.48, 128.2, 127.3, 127.1, 126.5, 126.1, 126.0, 125.2, 123.7, 122.5, 121.9, 37.8, 35.0.

**6-(3-Phenyl-propyl)-phenanthridine (3w):** Yellow solid (52 mg, 70%); R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 70-75 °C; IR(ATR): 3066, 2930, 1580, 1453, 753 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): δ = 8.65 (d, J = 8.1 Hz,
1H), 8.56 (d, J = 7.8 Hz, 1H), 8.16 (t, J = 8.7 Hz, 2H), 7.84 (t, J = 7.2 Hz, 1H), 7.75 (t, J = 7.0 Hz, 1H), 7.66 (dd, J = 15.8, 8.1 Hz, 2H), 7.36 - 7.31 (m, 4H), 7.24 (t, J = 7.2 Hz, 1H), 3.44 (t, J = 7.6 Hz, 2H), 2.90 (t, J = 7.5 Hz, 2H), 2.36 – 2.29 (m, 2H). 13C NMR (100 MHz, CDCl$_3$): δ = 161.8, 143.7, 142.1, 132.9, 130.2, 129.6, 128.5, 128.3, 127.2, 126.3, 126.1, 125.8, 125.2, 123.6, 122.4, 121.9, 36.0, 35.6, 30.8; HRMS (ESI-TOF): m/z Calcd for C$_{22}$H$_{20}$N [M + H]$^+$ 298.1590, found 298.1595.

6-Phenyl-phenanthridine (5a):$^1$ Yellow solid (45 mg, 72%); R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 102-104 °C (Reported: 103-105 °C); IR (ATR): 2920, 1563, 1356, 760 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): δ = 8.70 (d, J = 8.0 Hz, 1H), 8.62 (d, J = 8.0 Hz, 1H), 8.26 (d, J = 7.6 Hz, 1H), 8.11 (d, J = 8.0 Hz, 1H), 7.86 (t, J = 8.0 Hz, 1H), 7.79-7.68 (m, 4H), 7.63-7.53 (m, 4H); 13C NMR (100 MHz, CDCl$_3$): δ = 161.2, 143.7, 139.7, 133.4, 130.5, 129.7, 128.9, 128.8, 128.7, 128.4, 127.1, 126.9, 125.2, 123.7, 122.2, 121.9.

6-(p-Tolyl)-phenanthridine (5b):$^6$ Yellow solid (50 mg, 75%); R$_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 103-105 °C; IR (ATR): 2855, 2922, 1358, 725 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.70 (d, J = 8.0 Hz, 1H), 8.61 (d, J = 8.0 Hz, 1H), 8.25 (d, J = 7.6 Hz, 1H), 8.15 (d, J = 8.0 Hz, 1H), 7.85 (t, J = 8.0 Hz, 1H), 7.76 (t, J = 8.0 Hz, 1H), 7.70-7.59 (m, 4H), 7.38 (d, J = 8.0 Hz, 1H), 2.49 (s, 3H); 13C NMR (100 MHz, CDCl$_3$): δ = 161.3, 143.8, 138.5, 136.9, 133.4, 130.3, 129.6, 129.1, 128.9, 128.7, 127.0, 126.7, 125.3, 123.6, 122.1, 121.9, 21.4.
**6-(4-Methoxy-phenyl)-phenanthridine (5c):** White solid (44 mg, 62%); 

\[ \text{R}_f \ (95:5 \ 	ext{Hexanes/Ethyl acetate}) = 0.3; \ Mp \ 125-127 \ ^\circ \text{C}; \ IR(\text{ATR}): 3066, 2933, 1606, 1243, 753 \text{ cm}^{-1}; \ ^1\text{H NMR} (400 \text{ MHz, CDCl}_3) \delta 8.79 (d, J = 8.0 \text{ Hz, 1H}), 8.60 (d, J = 7.6 \text{ Hz, 1H}), 8.24 (d, J = 8.0 \text{ Hz, 1H}), 8.17 (d, J = 8.0 \text{ Hz, 1H}), 7.85 (t, J = 8.0 \text{ Hz, 1H}), 7.77-7.60 (m, 5H), 7.10 (d, J = 8.0 \text{ Hz, 2H}), 3.91 (s, 3H);

\[^{13}\text{C NMR} \ (100 \text{ MHz, CDCl}_3) \delta = 160.8, 160.1, 143.9, 133.5, 132.3, 131.2, 130.4, 130.2, 128.9, 128.8, 127.0, 126.7, 125.3, 123.6, 122.2, 121.9, 113.9, 55.4.\]

**6-(o-Tolyl)-phenanthridine (5d):** Yellow sticky solid (47 mg, 70%); \[ \text{R}_f \ (95:5 \ 	ext{Hexanes/Ethyl acetate}) = 0.5; \ IR \ (\text{ATR}): 3063, 2923, 1566, 1356, 723 \text{ cm}^{-1}; \ ^1\text{H NMR} \ (400 \text{ MHz, CDCl}_3) \delta = 8.71 (d, J = 8.1 \text{ Hz, 1H}), 8.65 (d, J = 7.8 \text{ Hz, 1H}), 8.26 (d, J = 7.8 \text{ Hz, 1H}), 7.85 (t, J = 7.0 \text{ Hz, 1H}), 7.78 (t, J = 6.9 \text{ Hz, 1H}), 7.75 – 7.70 (m, 2H), 7.58 (t, J = 7.4 \text{ Hz, 1H}), 7.40 – 7.36 (m, 4H), 2.12 (s, 3H); \ ^{13}\text{C NMR} \ (100 \text{ MHz, CDCl}_3) \delta = 161.9, 143.8, 139.2, 136.4, 133.0, 130.6, 130.3, 129.3, 128.8, 128.6, 128.5, 127.3, 126.9, 125.8, 123.8, 122.1, 122.0, 19.8.\]

**6-Benzyl1,3]dioxol-5-yl-phenanthridine (5e):** Yellow sticky solid (49 mg, 65%); \[ \text{R}_f \ (95:5 \ 	ext{Hexanes/Ethyl acetate}) = 0.5; \ IR \ (\text{ATR}): 3070, 2893, 1736, 1490, 1240, 726 \text{ cm}^{-1}; \ ^1\text{H NMR} \ (400 \text{ MHz, CDCl}_3) \delta = 8.68 (d, J = 7.7 \text{ Hz, 1H}), 8.59 (d, J = 7.5 \text{ Hz, 1H}), 8.23 (d, J = 7.2 \text{ Hz, 1H}), 8.18 (d, J = 7.7 \text{ Hz, 1H}), 7.85 (t, J = 7.6 \text{ Hz, 1H}), 7.75 (t, J = 7.6 \text{ Hz, 1H}), 7.69 – 7.60 (m, 2H), 7.26-7.22 (m, 2H), 7.0 (d, J = 8.0 \text{ Hz, 1H}) 6.07 (s, 2H); \ ^{13}\text{C NMR} \ (100 \text{ MHz, CDCl}_3) \delta = 160.5, 148.2, 147.7, 143.5, 133.7, 133.5, 130.5, 130.2, 128.79, 128.78, 127.1, 126.8, 125.2, 123.9, 123.6, 122.2, 121.9, 110.4, 108.3, 101.3; \ HRMS (ESI-TOF): m/z Calcd for C_{20}H_{13}O_{2}N [M + H]^+ 300.1019, found 300.0997.\]
6-(m-Tolyl)-phenanthridine (5f): White solid (46 mg, 68%); R_f (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 92-94 °C; IR 3063, 2920, 1566, 1360, 723 (ATR) cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.70 (d, J = 8.3 Hz, 1H), 8.62 (d, J = 8.1 Hz, 1H), 8.26 (d, J = 8.1 Hz, 1H), 8.11 (d, J = 8.2 Hz, 1H), 7.86 (t, J = 7.6 Hz, 1H), 7.76 (t, J = 7.5 Hz, 1H), 7.69 (t, J = 11.1 Hz, 1H), 7.62 (t, J = 7.6 Hz, 1H), 7.56 (s, 1H), 7.51 (d, J = 7.6 Hz, 1H), 7.44 (t, J = 7.5 Hz, 1H), 7.34 (d, J = 7.5 Hz, 1H), 2.48 (s, 3H). ¹³C NMR (100 MHz, CDCl₃): δ = 161.5, 143.8, 139.7, 138.2, 133.4, 130.5, 130.3, 129.4, 129.0, 128.8, 128.1, 127.0, 126.8, 125.3, 123.7, 122.1, 121.9.

6-(3-Methoxy-phenyl)-phenanthridine (5g): White solid (51 mg, 72%); R_f (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 112-114 °C (Reported: 115-116 °C); IR (ATR): 3053, 2996, 1586, 1253, 1033, 703 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.70 (d, J = 8.1 Hz, 1H), 8.62 (d, J = 7.7 Hz, 1H), 8.26 (d, J = 7.6 Hz, 1H), 8.13 (d, J = 7.9 Hz, 1H), 7.86 (t, J = 7.2 Hz, 1H), 7.77 (t, J = 6.9 Hz, 1H), 7.69 (t, J = 7.0 Hz, 1H), 7.62 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.7 Hz, 1H), 7.30 (d, J = 7.8 Hz, 2H), 7.08 (d, J = 6.5 Hz, 1H), 3.89 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 161.1, 159.6, 143.7, 141.1, 133.4, 130.6, 130.3, 129.4, 128.9, 128.8, 127.1, 126.9, 125.2, 123.8, 122.2, 122.1, 121.9, 115.0, 114.7, 55.4.

6-(3-Chloro-phenyl)-phenanthridine (5h): White solid (46 mg, 63%); R_f (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 131-133 °C (Reported: 122-123 °C); IR(ATE): 2930, 1566, 1356, 720 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.70 (d, J = 8.0 Hz, 1H), 8.61 (d, J = 7.6 Hz, 1H), 8.25 (d, J = 7.6 Hz, 1H), 8.06 (d, J = 7.8 Hz, 1H),
7.87 (t, J = 7.2 Hz, 1H), 7.79 – 7.76 (m, 2H), 7.71 (t, J = 7.2 Hz, 1H), 7.65 – 7.62 (m, 2H), 7.51-7.48 (m, 2H). ¹³C NMR (100 MHz, CDCl₃): δ = 159.6, 143.6, 141.5, 134.5, 133.4, 130.7, 130.3, 129.8, 129.6, 129.0, 128.8, 127.9, 127.3, 127.2, 124.9, 123.8, 122.3, 122.0.

6-(4-Chloro-phenyl)-phenanthridine (5i): White solid (42 mg, 58%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 145-147 °C; IR(ATR): 3046, 2923, 1483, 1086, 720 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.71 (d, J = 8.0 Hz, 1H), 8.62 (d, J = 8.0 Hz, 1H), 8.23 (d, J = 8.0 Hz, 1H), 8.06 (d, J = 8.0 Hz, 1H), 7.87 (t, J = 8.0 Hz, 1H), 7.77 (t, J = 8.0 Hz, 1H), 7.71-7.69 (m, 3H), 7.63 (t, J = 7.6 Hz, 1H), 7.64-7.62 (m, 3H); ¹³C {¹H} NMR (100 MHz, CDCl₃): δ = 159.9, 143.7, 138.7, 133.5, 131.1, 130.7, 130.3, 128.9, 128.6, 128.4, 127.2, 127.1, 124.9, 123.7, 122.3, 121.9.

6-(4-Bromo-phenyl)-phenanthridine (5j): White solid (55 mg, 66%); Rf (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 163-165 °C ( Reported: 152-154 °C); IR(ATR): 2920, 1481, 821, 753 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.72 (d, J = 8.0 Hz, 1H), 8.63 (d, J = 8.0 Hz, 1H), 8.23 (d, J = 8.0 Hz, 1H), 8.06 (d, J = 8.0 Hz, 1H), 7.88 (t, J = 8.0 Hz, 1H), 7.77 (t, J = 7.6 Hz, 1H), 7.71-7.69 (m, 3H), 7.64-7.62 (m, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 160.0, 143.7, 138.7, 133.5, 131.6, 131.4, 130.7, 130.4, 129.0, 128.5, 127.3, 127.2, 125.0, 123.8, 123.1, 122.3, 122.0.

6-(4-Fluoro-phenyl)-phenanthridine (5k): White solid (45 mg, 66%); Rf (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 122-124 °C; IR(ATR): 3066, 2926, 1596, 1216, 826 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.91 (d, J = 8.0 Hz, 1H), 8.82 (d, J = 8.0 Hz, 1H), 8.45 (d, J = 8.0 Hz, 1H), 8.28 (d, J = 8.0 Hz, 1H), 8.07 (t, J = 8.0 Hz, 1H), 7.99-7.88 (m, 4H), 7.83 (t, J = 7.6 Hz, 1H), 7.47 (t, J = 8.0 Hz, 2H); ¹³C NMR (100
$\delta = 163.1$ (d, $J = 247$ Hz), 160.1, 143.7, 135.8 (d, $J = 4.0$ Hz), 133.5, 131.6 (d, $J = 8.0$ Hz), 130.6, 130.3, 128.9, 128.6, 127.2, 127.0, 125.1, 123.7, 122.3, 121.9, 115.4 (d, $J = 21.0$ Hz).

6-(4-Trifluoromethyl-phenyl)-phenanthidine (5l):$^{10}$ White solid (60 mg, 75%); $R_f$ (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 162-164 °C (Reported: 171 °C); IR(ATR): 3066, 1316, 1106, 756 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 8.96$ (d, $J = 12.0$ Hz, 1H), 8.88 (d, $J = 8.0$ Hz, 1H), 8.49 (d, $J = 8.0$ Hz, 1H), 8.27 (d, $J = 8.0$ Hz, 1H), 8.15-8.10 (m, 5H), 8.03 (t, $J = 7.6$ Hz, 1H), 7.97 (t, $J = 8.0$ Hz, 1H), 7.88 (t, $J = 7.6$ Hz, 1H); $^{13}$C{^1}H NMR (100 MHz, CDCl$_3$): $\delta = 159.7$, 143.6, 143.3, 133.4, 130.8, 130.4, 130.1, 129.0, 128.6, 127.3, 125.4 (q, $J = 4.0$ Hz), 124.8, 123.8, 122.4, 122.0.

6-Biphenyl-4-yl-phenanthidine (5m):$^{11}$ White solid (51 mg, 62%); $R_f$ (8:2 Hexanes/DCM) = 0.5; Mp 190-192 °C (Reported: 200-201 °C); IR(ATR): 2920, 1482, 692, 727 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 8.72$ (d, $J = 8.0$ Hz, 1H), 8.63 (d, $J = 8.0$ Hz, 1H), 8.29 (d, $J = 8.0$ Hz, 1H), 8.22 (d, $J = 8.0$ Hz, 1H), 7.89-7.77 (m, 6H), 7.72 (d, $J = 8.0$ Hz, 3H), 7.65 (t, $J = 8.0$ Hz, 1H), 7.52 (t, $J = 8.0$ Hz, 2H), 7.42 (t, $J = 8.0$ Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 160.9$, 143.8, 141.6, 140.8, 138.7, 133.5, 130.5, 130.3, 130.2, 128.84, 128.82, 127.5, 127.20, 127.18, 127.1, 126.9, 125.2, 123.7, 122.2, 121.9.

3,9-Dimethyl-6-phenyl-phenanthidine (5n): White solid (52 mg, 73%); $R_f$ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 112-114 °C; IR(ATR): 2963, 1256, 1020, 790 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta = 8.48$ (d, $J = 8.0$ Hz, 1H), 8.43 (s,1H), 8.04 (s, 1H), 7.97 (d, $J = 8.0$ Hz, 1H), 7.73 (d, $J = 8.0$ Hz, 2H), 7.56-7.48 (m, 4H), 7.39 (d, $J = 8.0$ Hz, 1H), 2.64 (s, 3H), 2.60 (s, 3H); $^{13}$C NMR (100 MHz,
CDCl₃: δ = 161.0, 144.1, 140.8, 140.0, 138.8, 129.7, 128.5, 128.4, 128.3, 123.0, 121.7, 121.6, 121.2, 22.2, 21.5; HRMS (ESI-TOF): m/z Calcd for C₂₁H₁₈N [M + H]⁺ 284.1434, found 284.1433.

3,9-Dimethoxy-6-phenyl-phenanthridine (5o): White solid (47 mg, 60%); Rₕ (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 85-87 °C; IR (ATR): 2922, 1611, 1374, 966 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.41 (d, J = 9.2 Hz, 1H), 7.97 (d, J = 8.8 Hz, 1H), 7.88 (s, 1H), 7.70 (d, J = 6.4 Hz, 2H), 7.62 (s, 1H), 7.54 (q, J = 7.2 Hz, 3H), 7.30-7.26 (m, 1H), 7.14-7.12 (m, 1H), 4.0 (s, 3H), 3.97 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 161.3, 161.2, 160.3, 145.8, 140.0, 135.6, 130.9, 129.6, 128.5, 128.4, 123.2, 119.4, 117.7, 116.6, 116.4, 109.8, 102.1, 55.6, 55.5; HRMS (ESI-TOF): m/z Calcd for C₂₁H₁₈NO₂ [M + H]⁺ 316.1332, found 316.1329.

3,9-Dichloro-6-phenyl-phenanthridine (5p): White solid (26 mg, 32%); Rₕ (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 175-177 °C; IR (ATR): 3053, 1599, 1077, 692 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.59 (s, 1H), 8.44 (d, J = 8.0 Hz, 1H), 8.23 (s, 1H), 8.05 (d, J = 8.3 Hz, 1H), 7.69–7.64 (m, 3H), 7.57–7.56 (m, 4H); ¹³C NMR (100 MHz, CDCl₃): δ = 161.9, 144.9, 139.0, 137.6, 135.3, 134.9, 130.7, 129.6, 129.2, 128.6, 128.0, 127.8, 123.41, 123.36, 121.9, 121.2; HRMS (ESI-TOF): m/z Calcd for C₁₉H₁₂Cl₂N [M + H]⁺ 324.0341, found 324.0343.

2,8-Dimethyl-6-phenyl-phenanthridine (5q): White solid (45 mg, 63%); Rₕ (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 178-180 °C; IR(ATR) 2913, 1360, 823, 700 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.57 (d, J = 8.0 Hz, 1H), 8.36 (s, 1H), 8.12 (d, J = 8.0 Hz, 1H), 7.85 (s, 1H), 7.73 (d, J = 6.4 Hz, 2H),
7.66 (d, \( J = 8.0 \) Hz, 1H), 7.57-7.54 (m, 4H), 2.64 (s, 3H), 2.60 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 160.0, 141.8, 140.0, 136.9, 136.7, 132.0, 131.0, 130.1, 129.9, 128.5, 128.4, 128.1, 125.4, 123.6, 122.0, 121.3, 22.0, 21.7.\

2,8-Dimethoxy-6-phenyl-phenanthridine (5r): White solid (39 mg, 50%); \( R_t \) (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 89-91 °C; IR (ATR): 2953, 2833, 1606, 1210, 826 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.54 \) (d, \( J = 8.0 \) Hz, 1H), 8.13 (d, \( J = 8.0 \) Hz, 1H), 7.86 (s, 1H), 7.73 (d, \( J = 6.4 \) Hz, 2H), 7.57-7.45 (m, 5H), 7.34-7.32 (m, 1H), 4.03 (s, 3H), 4.83 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 158.5, 158.48, 157.9, 140.0, 138.4, 131.7, 129.6, 128.5, 128.47, 127.3, 126.7, 124.9, 123.9, 120.6, 117.8, 108.8, 102.3, 55.6, 55.4; HRMS (ESI-TOF): m/z Calcd for C\(_{21}\)H\(_{18}\)NO\(_2\) [ M + H]\(^+\) 316.1332, found 316.1340.

3,9-Dimethyl-6-p-tolyl-phenanthridine (5s):\(^{13}\) White solid (52 mg, 70%); \( R_t \) (95:5 Hexanes/Ethyl acetate) = 0.5; Mp 88-90 °C; IR(ATR): 2919, 1616, 1359, 778 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.47 \) (d, \( J = 8.4 \) Hz, 1H), 8.42 (s, 1H), 8.02 (s, 1H), 8.00 (d, \( J = 8.4 \) Hz, 1H), 7.62 (d, \( J = 8.0 \) Hz, 2H), 7.48 (dd, \( J = 8.3, 1.6 \) Hz, 1H), 7.40 – 7.35 (m, 3H), 2.64 (s, 3H), 2.59 (s, 3H), 2.48 (s, 3H). \(^{13}\)C NMR (10 MHz, CDCl\(_3\)): \( \delta = 161.1, 144.1, 140.7, 138.7, 138.4, 137.2, 133.6, 129.8, 129.6, 129.0, 128.8, 128.3, 123.1, 121.7, 121.6, 121.2, 22.2, 21.5, 21.4.

3,9-Dimethoxy-6-(4-trifluoromethyl-phenyl)-phenanthridine (5t): White solid (65 mg, 68%); \( R_t \) (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 138-140 °C; IR (ATR): 2919, 1613, 1314, 1103 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \( \delta = 8.42 \) (d, \( J = 8.3 \) Hz, 1H), 7.89 – 7.78 (m, 6H), 7.61 (s, 1H), 7.32 (d, \( J = 8.8 \) Hz, 1H), 7.16 (d, \( J = 8.7 \) Hz, 1H), 4.06 (s, 3H), 3.99 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \( \delta = 160.0, 141.8, 140.0, 136.9, 136.7, 132.0, 131.0, 130.1, 129.9, 128.5, 128.4, 128.1, 125.4, 123.6, 122.0, 121.3, 22.0, 21.7.\}
MHz, CDCl₃): δ = 161.5, 160.4, 159.6, 145.7, 143.6, 135.9, 130.6 (q, J = 32 Hz), 130.0, 124.2 (q, J = 271 Hz), 125.4 (q, J = 4.0 Hz), 123.2, 119.0, 118.1, 117.7, 116.8, 109.8, 102.2, 55.6, 55.5; HRMS (ESI-TOF): m/z Calcd for C₂₂H₁₇F₃NO₂[M + H]⁺ 384.1206, found 384.1200.

6-(4-Methoxy-phenyl)-2,9-dimethyl-phenanthridine (5u): White solid (43 mg, 55%); Rₛ (95:5 Hexanes/Ethyl acetate) = 0.3; Mp 134-136 °C; IR (ATR): 2919, 1607, 1245, 823 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 8.56 (d, J = 7.6 Hz, 1H), 8.34 (s, 1H), 8.09 (d, J = 7.4 Hz, 1H), 7.90 (s, 1H), 7.70-7.65 (m, 3H), 7.54 (d, J = 7.3 Hz, 1H), 7.08 (d, J = 6.5 Hz, 2H), 3.92 (s, 3H), 2.63 (s, 3H), 2.51 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ = 159.9, 159.7, 141.9, 136.8, 136.5, 132.6, 130.0, 129.9, 128.2, 125.5, 123.5, 122.1, 121.3, 113.8, 55.4, 22.0, 21.7; HRMS (ESI-TOF): m/z Calcd for C₂₂H₂₀NO [M + H]⁺ 314.1539, found 314.1538.

Benzhydrylideneamine (6): ¹H NMR (400 MHz, CDCl₃): δ = 9.70 (brs, 1H), 9.57-9.55 (m, 4H), 7.47-7.39 (m, 6H); ¹³C NMR (100 MHz, CDCl₃): δ = 178.4, 139.3, 130.3, 128.4, 128.3.

5. Procedure for preparative scale synthesis

To a clean oven-dried 120 mL pressure tube equipped with magnetic stir bar was sequentially added aryl nitrile (4.0 mmol, 1 equiv), Pd(OAc)₂ (10 mol%, 89.6 mg), JohnPhos (0.8mmol, 238.0 mg). Then iodobenzene (12.0 mmol, 1.3 mL) and silvertetrafluoroborate (12.0 mmol, 2.3 g) in dry DCE (40 mL) under nitrogen atmosphere was added. The reaction mixture was placed in preheated oil bath of 130°C and vigorously stirred for 48 h. The reaction was monitored by TLC, after completion, the reaction mixture was cooled to room temperature and water was added to quench the reaction mixture. DCM (3 x 100 mL) was used for extraction. Combined organic
layers were passed through short pad of celite and dried over Na$_2$SO$_4$. After evaporation of solvent, the crude mixture was purified by column chromatography on silica gel using ethyl acetate/hexanes (5:95) as eluent to give the yellow solid.

$$
\begin{align*}
\text{4a (4.0 mmol)} & \quad + \quad \text{2a (12.0 mmol)} \\
\text{Pd(OAc)$_2$ (10 mol\%)} & \quad \text{AgBF$_4$ (3 equiv)} \\
\text{DCE, 130 °C, 48 h} & \quad \text{5a, 560 mg (56\%)}
\end{align*}
$$

6. X-Ray Crystallographic Information for product 5c (CCDC 1817112)

![Ortep diagram of 5c with 50% ellipsoidal probability.]

**Figure S1.** Ortep diagram of 5c with 50% ellipsoidal probability.

- **Chemical formula:** C$_{20}$H$_{15}$NO
- **Formula weight:** 285.33 g/mol
- **Temperature:** 273(2) K
- **Wavelength:** 0.71073 Å
- **Crystal size:** 0.100 x 0.100 x 0.200 mm
- **Crystal system:** monoclinic
- **Space group:** P 1 21/n 1
Unit cell dimensions

\[ a = 13.107(3) \, \text{Å} \quad \alpha = 90^\circ \]
\[ b = 5.8099(12) \, \text{Å} \quad \beta = 102.575(7)^\circ \]
\[ c = 19.648(4) \, \text{Å} \quad \gamma = 90^\circ \]

Volume

\[ V = 1460.3(5) \, \text{Å}^3 \]

Z

4

Density (calculated)

1.298 g/cm³

Absorption coefficient

0.080 mm⁻¹

F(000)

600

Theta range for data collection

3.19 to 27.52°

Index ranges

-16 \leq h \leq 15, -7 \leq k \leq 7, -25 \leq l \leq 25

Reflections collected

29074

Independent reflections

2948 [R(int) = 0.0655]

Max. and min. transmission

0.9920 and 0.9840

Refinement method

Full-matrix least-squares on F2

Refinement program

SHELXL-2014/7 (Sheldrick, 2014)

Function minimized

\[ \Sigma w(F_o^2 - F_c^2)^2 \]

Data / restraints / parameters

2948 / 0 / 201

Goodness-of-fit on F²

0.996

Final R indices

1629 data; I>2σ(I) \quad R1 = 0.0543, wR2 = 0.1112
all data \quad R1 = 0.1355, wR2 = 0.1396

Weighting scheme

w = 1/[σ²(Fo²) + (0.0597P)² + 0.3631P]
where P=(Fo² + 2Fc²)/3

Extinction coefficient

0.0107(18)

Largest diff. peak and hole

0.150 and -0.137 eÅ⁻³

R.M.S. deviation from mean

0.034 eÅ⁻³
8. References:


$^1$H and $^{13}$C spectra of 3a
$^1\text{H}$ and $^{13}\text{C}$ spectra of 3b
$^1$H and $^{13}$C spectra of 3c
$^1$H and $^{13}$C spectra of 3d
$^1$H and $^{13}$C spectra of 3e
$^1$H and $^{13}$C spectra of 3f
$^1$H and $^{13}$C spectra of 3g
$^1$H and $^{13}{C}$ spectra of 3h
$^1$H and $^{13}$C spectra of 3i
$^1$H and $^{13}$(C) spectra of 3j
$^1$H and $^{13}$C spectra of 3k
$^1$H and $^{13}$C spectra of 3l
$^1$H and $^{13}$C spectra of 3m
$^1$H and $^{13}$C spectra of 3n
$^1\text{H}$ and $^{13}\{\text{C}\}$ spectra of 3o
$^1$H and $^{13}$C spectra of 3p
$^1$H and $^{13}$C spectra of 3q
$^1$H and $^{13}$C spectra of 3r
$^1$H and $^{13}C$ spectra of 3rr
$^{1}\text{H}$ and $^{13}\{\text{C}\}$ spectra of 3s
$^1$H and $^{13}$C spectra of 3ss

![NMR spectra of 3ss](image)
$^1$H and $^{13}$C spectra of 3t
$^1$H and $^{13}\{C\}$ spectra of 3tt
$^1$H and $^{13}$C spectra of 3u
$^1\text{H}$ and $^{13}\{\text{C}\}$ spectra of 3uu
$^1$H and $^{13}$C spectra of 3v
$^1$H and $^{13}$C spectra of 3w
$^1$H and $^{13}$C spectra of 5a
$^1$H and $^{13}$C spectra of 5b
$^1$H and $^{13}$C spectra of 5c
$^1\text{H}$ and $^{13}\text{C}$ spectra of 5d
$^1$H and $^{13}$C spectra of 5e
$^1$H and $^{13}$C spectra of 5f
$^1$H and $^{13}$C spectra of 5g
$^1$H and $^{13}$C spectra of 5h
$^1$H and $^{13}$C spectra of 5i
$^1$H and $^{13}$C spectra of 5j
$^1$H and $^{13}$C spectra of 5k
$^1$H and $^{13}$C spectra of 5I
$^1$H and $^{13}$C spectra of 5m
$^1$H and $^{13}$C spectra of 5n
$^1$H and $^{13}$C spectra of 5o
$^1$H and $^{13}$C spectra of 5p

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S70
$^1$H and $^{13}$C spectra of 5q
$^1$H and $^{13}$C spectra of 5r
$^1$H and $^{13}$C spectra of 5s
$^1$H and $^{13}$C spectra of 5t
$^1$H and $^{13}$C spectra of 5u
$^1$H and $^{13}$C spectra of 6