Visible-Light-Mediated Minisci C–H Alkylation of Heteroarenes with 4-Alkyl-1,4-dihydropyridines Using O₂ as an Oxidant

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Supporting Information

Table of Contents……………………………………………………………………………………………………S1
General Information…………………………………………………………………………………………………S2
Preparation of Photocatalyst ……………………………………………………………………………………S3
Preparation of 4-alkyl-1,4-dihydropyridines……………………………………………………………………S3
Investigation of the Key Reaction Parameters…………………………………………………………………S3–S4
Investigation of the Mechanism………………………………………………………………………………….S4–S7
Experimental Procedures and Product Characterization………………………………………………………S7–S21
Gram-scale Reaction………………………………………………………………………………………………S21
References…………………………………………………………………………………………………………S21
Copies of *H NMR and *C NMR spectra for new compounds……………………………………………S22–S59
1. General Information

Reagents were purchased from commercial sources and were used as received. $^1$H and $^{13}$C Nuclear Magnetic Resonance (NMR) spectra were recorded on Bruker Avance 400 Ultrashield NMR spectrometers. Chemical shifts ($\delta$) were given in parts per million (ppm) and were measured downfield from internal tetramethylsilane. High-resolution mass spectrometry (HRMS) data were obtained on an FTICR-MS instrument (Ionspec 7.0 T). The melting points were determined on an X-4 microscope melting point apparatus and are uncorrected. Conversion was monitored by thin layer chromatography (TLC). Flash column chromatography was performed over silica gel (100-200 mesh). Blue LED (36 W, $\lambda_{\text{max}} = 470$ nm) purchased from JIADENG (LS) was used for blue light irradiation. A fan attached to the apparatus was used to maintain the reaction temperature at room temperature.

Figure S1 Photograph of the Photocatalytic reactor used for reactions conducted under blue LED irradiation.
2. Preparation of Photocatalyst
The photocatalyst was synthesized according to literature report.[1] The spectral data of the photocatalyst is consistent with the literature data. The other photocatalysts (Eosin Y, Fluorescein, [Ru(bpy)$_3$]Cl$_2$6H$_2$O, Ru(bpy)$_3$(PF$_6$)$_2$, Ir(ppy)$_3$ and Mes-Acr) are commercially available.

3. Preparation of 4-alkyl-1,4-dihydropyridines

\[
\begin{align*}
\text{R} & \quad \text{Me} & \quad \text{Me} \\
\text{O} & \quad \text{O} & \quad \text{O} \\
\text{H} & \quad \text{Me} & \quad \text{OEt}
\end{align*}
\]

\[
\text{TBAHS} = \text{tetrabutylammonium}
\]

Figure S2
4-alkyl-1,4-dihydropyridines were synthesized according to literature report.[2] The spectral data is consistent with the literature data.

4. Investigation of the Key Reaction Parameters
Table S1: Screening of photocatalysts

<table>
<thead>
<tr>
<th>entry</th>
<th>photocatalyst</th>
<th>yield (%)$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[Ir(dtbbpy)(ppy)$_2$][PF$_6$]</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td><a href="PF$_6$">Ru(bpy)$_3$</a>$_2$</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>[Ru(bpy)$_3$] 6H$_2$O</td>
<td>14</td>
</tr>
<tr>
<td>4$^c$</td>
<td>4CzIPN</td>
<td>NR</td>
</tr>
<tr>
<td>5$^c$</td>
<td>Eosin-Y</td>
<td>NR</td>
</tr>
<tr>
<td>6</td>
<td>Ir[dF(CF$_3$)ppy)$_2$(dtbbpy)]PF$_6$</td>
<td>23</td>
</tr>
</tbody>
</table>

$^a$General conditions: 1 (0.3 mmol), 2 (0.45 mmol), photocatalyst (0.003 mmol), TFA (0.45 mmol), CH$_3$CN (3.0 mL), r.t, O$_2$ atmosphere, 24 h. $^b$Yields were determined by $^1$H NMR spectroscopy with dibromomethane as an internal standard. $^c$Photocatalyst (0.015 mmol). NR = no reaction.

Table S2: Screening of different solvents

<table>
<thead>
<tr>
<th>entry</th>
<th>solvent</th>
<th>yield (%)$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CH$_3$CN (0.1 M), O$_2$</td>
<td>36 W blue LED, r.t. 24 h</td>
</tr>
</tbody>
</table>

$^a$General conditions: 1 (0.3 mmol), 2 (0.45 mmol), photocatalyst (0.003 mmol), TFA (0.45 mmol), CH$_3$CN (3.0 mL), r.t, O$_2$ atmosphere, 24 h. $^b$Yields were determined by $^1$H NMR spectroscopy with dibromomethane as an internal standard.
Table S3: Screening of the amount of i-Pr-DHP (2) and TFA

<table>
<thead>
<tr>
<th>entry</th>
<th>solvent</th>
<th>yield (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CH&lt;sub&gt;3&lt;/sub&gt;CN</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>DMSO</td>
<td>89 (85)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>acetone</td>
<td>NR</td>
</tr>
<tr>
<td>4</td>
<td>DCM</td>
<td>NR</td>
</tr>
<tr>
<td>5</td>
<td>CH&lt;sub&gt;3&lt;/sub&gt;CN/H&lt;sub&gt;2&lt;/sub&gt;O = 1:1</td>
<td>35</td>
</tr>
</tbody>
</table>

<sup>a</sup>General conditions: 1 (0.3 mmol), 2 (0.45 mmol), Ir[dF(CF<sub>3</sub>)ppy]<sub>2</sub>(dtbbpy)PF<sub>6</sub> (0.003 mmol), TFA (0.45 mmol), solvent (3.0 mL), r.t, O<sub>2</sub> atmosphere, 24 h. <sup>b</sup>Yields were determined by <sup>1</sup>H NMR spectroscopy with dibromomethane as an internal standard. <sup>c</sup>Isolated yield.

5. Investigation of the Mechanism

5.1 Control experiments

Table S4

<table>
<thead>
<tr>
<th>entry</th>
<th>control conditions</th>
<th>yield (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>w/o photocatalyst</td>
<td>&lt;5</td>
</tr>
<tr>
<td>2</td>
<td>w/o light</td>
<td>NR</td>
</tr>
<tr>
<td>3</td>
<td>w/o TFA</td>
<td>NR</td>
</tr>
<tr>
<td>4</td>
<td>Ar</td>
<td>&lt;5</td>
</tr>
<tr>
<td>5</td>
<td>standard conditions, w/all</td>
<td>89</td>
</tr>
</tbody>
</table>

Yields were determined by <sup>1</sup>H NMR spectroscopy with dibromomethane as an internal standard.
5.2 TEMPO, BHT and 1,1-diphenylethylene were used as radical scavengers

Scheme S1
To a 10 mL glass vial was added Ir[dF(CF3)ppy]2(dtbbpy)PF6 (3.36 mg, 0.003 mmol, 1 mol %), 1 (0.3 mmol, 1.0 equiv), 2 (0.45 mmol, 1.5 equiv), TEMPO (117 mg, 0.75 mmol, 2.5 equiv) or BHT (165 mg, 0.75 mmol, 2.5 equiv) or 1,1-diphenylethylene (135 mg, 0.75 mmol, 2.5 equiv), TFA (34 μL, 0.45 mmol, 1.5 equiv) and 3.0 mL of DMSO. The reaction mixture was degassed by bubbling with O2 for 15 s with an outlet needle and the vial was sealed with PTFE cap. The mixture was then stirred rapidly and irradiated with a 36 W Blue LED (approximately 2 cm away from the light source) at room temperature for 24 h. The corresponding alkylated product 3 was not observed based on 1H NMR analysis, and instead the corresponding product of radical trapping, 1-isopropoxy-2,2,6,6-tetramethylpiperidine (36), was detected by HR-MS (positive mode ESI).
Figure S3 HR-ESI mass spectra of 1-isopropoxy-2,2,6,6-tetramethylpiperidine (36)

5.3 Light/dark experiment

Eight standard reaction mixtures in 10 mL glass vials were charged with Ir[dF(CF₃)ppy]₂(dtbbpy)PF₆ (3.36 mg, 0.003 mmol, 1 mol %), 1 (0.3 mmol, 1.0 equiv), 2 (0.45 mmol, 1.5 equiv), TFA (34 μL, 0.45 mmol, 1.5 equiv) and 3.0 mL of DMSO. The reaction
mixtures were degassed by bubbling with O₂ for 15 s with an outlet needle and the vials were sealed with PTFE caps. The mixtures were then stirred rapidly and irradiated with a 36 W Blue LED (approximately 2 cm away from the light source) at room temperature. After 2 h, the Blue LED was turned off, and one vial was removed from the irradiation setup for analysis. The remaining seven vials were stirred in the absence of light for an additional 2 h. Then, one vial was removed for analysis, and the Blue LED was turned back on to irradiate the remaining six reaction mixtures. After an additional 2 h of irradiation, the Blue LED was turned off, and one vial was removed for analysis. The remaining five vials were stirred in the absence of light for an additional 2 h. Then, a vial was removed for analysis, and the Blue LED was turned back on to irradiate the remaining four reaction mixtures. After 2 h, the Blue LED was turned off, and one vial was removed for analysis. The remaining three vials were stirred in the absence of light for an additional 2 h, then, a vial was removed for analysis and the Blue LED was turned back on to irradiate the remaining two reaction mixtures. After 2 h, the Blue LED was turned off, and one vial was removed for analysis. The last vial was stirred in the absence of light for an additional 2 h, and then it was analyzed. The yield was determined by ¹H NMR spectroscopy using dibromomethane as the internal standard.

6. Experimental Procedures and Product Characterization

6.1 General Procedure for the alkylation of N-heteroarenes.
To a 10 mL glass vial was added Ir[dF(CF₃)ppy]₂(dtbbpy)PF₆ (3.36 mg, 0.003 mmol, 1 mol %), N-heteroarene (0.3 mmol, 1.0 equiv), 4-alkyl-1,4-dihydropyridines (0.45 mmol, 1.5 equiv), TFA (34 μL, 0.45 mmol, 1.5 equiv) and 3.0 mL of DMSO. The reaction mixture was degassed by bubbling with O₂ for 15 s with an outlet needle and the vial was sealed with PTFE cap. The mixture was then stirred rapidly and irradiated with a 36 W Blue LED (approximately 2 cm away from the light source) at room temperature for 24 h. The reaction mixture was diluted with 10 mL of aqueous 1 M NaHCO₃ solution, and extracted with DCM (3 × 20 mL). The combined organic extracts were washed with brine (40 mL), dried over Na₂SO₄, and concentrated in vacuo.

Figure S4 Light/dark experiment.
Purification of the crude product by flash chromatography on silica gel using the indicated solvent system afforded the desired product.

6.2. Product Characterization

2-isopropylquinazolin-4(3H)-one (3).

![Chemical Structure](image)

According to the **general procedure**. The spectral data is consistent with the literature data.\(^3\)

White solid (47.9 mg, 85%). M.p. = 190 – 191 °C.

\(R_f\) 0.60 (Petroleum ether/EtOAc, 2/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 11.40 (s, 1H), 8.30 (dd, \(J = 8.0, 1.2\) Hz, 1H), 7.86 – 7.67 (m, 2H), 7.56 – 7.42 (m, 1H), 3.05 (hept, \(J = 7.2\) Hz, 1H), 1.45 (d, \(J = 7.2\) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 164.4, 161.0, 149.6, 134.8, 127.5, 126.4, 126.4, 120.9, 35.1, 20.6.

HRMS (ESI) calcd for C\(_{11}\)H\(_{13}\)N\(_2\)O \([M + H]^+\) 189.1022, found 189.1024.

2-isopropyl-6-methylquinazolin-4(3H)-one (4).

![Chemical Structure](image)

According to the **general procedure**. The spectral data is consistent with the literature data.\(^{3a}\)

White solid (50.9 mg, 84%). M.p. = 220 – 221 °C.

\(R_f\) 0.50 (Petroleum ether/EtOAc, 2/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 11.99 (s, 1H), 8.06 (s, 1H), 7.72 (d, \(J = 8.4\) Hz, 1H), 7.63 (d, \(J = 8.4\) Hz, 1H), 3.29 – 3.11 (m, 1H), 2.51 (s, 3H), 1.50 (d, \(J = 6.8\) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 163.9, 161.3, 145.4, 137.5, 136.9, 126.1, 125.9, 120.1, 34.5, 21.4, 20.4.

HRMS (ESI) calcd for C\(_{12}\)H\(_{15}\)N\(_2\)O \([M + H]^+\) 203.1179, found 203.1181.

6-chloro-2-isopropylquinazolin-4(3H)-one (5).

![Chemical Structure](image)

According to the **general procedure**. The spectral data is consistent with the literature data.\(^{3a}\)

White solid (53.9 mg, 81%). M.p. = 198 – 199 °C.

\(R_f\) 0.50 (Petroleum ether/EtOAc, 2/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 11.34 (s, 1H), 8.24 (d, \(J = 2.0\) Hz, 1H), 7.75 – 7.62 (m, 2H), 3.14 – 2.95 (m, 1H), 1.44 (d, \(J = 6.8\) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 164.8, 159.4, 148.2, 136.2, 135.3, 125.8, 123.9, 120.7, 34.9, 20.7.
HRMS (ESI) calcd for C_{11}H_{12}ClN_{2}O [M + H]^+ 223.0633, found 223.0633.

2-isopropyl-4-methylquinoline (6).

According to the general procedure. The spectral data is consistent with the literature data.\(^2\)a

Yellow oil (42.2 mg, 76%).

R\(_f\) 0.70 (Petroleum ether/EtOAc, 10/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.05 (d, \(J = 8.4\) Hz, 1H), 7.93 (d, \(J = 8.4\) Hz, 1H), 7.72 – 7.61 (m, 1H), 7.53 – 7.44 (m, 1H), 7.17 (s, 1H), 3.29 – 3.13 (m, 1H), 2.67 (s, 3H), 1.38 (d, \(J = 7.2\) Hz, 6H).

\(^1\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 167.4, 147.6, 144.5, 129.6, 129.0, 127.1, 125.6, 123.6, 119.8, 37.3, 22.6, 18.9.

HRMS (ESI) calcd for C_{13}H_{16}N [M + H]^+ 186.1277, found 186.1279.

4-isopropyl-2-phenylquinoline (7).

According to the general procedure. The spectral data is consistent with the literature data.\(^2\)d

Yellow oil (37.8 mg, 51%).

R\(_f\) 0.40 (Petroleum ether/EtOAc, 20/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.17 (dd, \(J = 21.6, 7.6\) Hz, 3H), 8.08 (d, \(J = 8.4\) Hz, 1H), 7.77 (s, 1H), 7.69 (t, \(J = 7.2\) Hz, 1H), 7.52 (t, \(J = 7.6\) Hz, 3H), 7.45 (t, \(J = 7.2\) Hz, 1H), 3.85 – 3.68 (m, 1H), 1.45 (d, \(J = 6.8\) Hz, 6H).

\(^1\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 157.5, 155.0, 148.7, 140.4, 130.8, 129.3, 129.1, 128.9, 127.7, 126.1, 123.0, 115.0, 28.6, 23.1.

HRMS (ESI) calcd for C_{18}H_{18}N [M + H]^+ 248.1434, found 248.1436.

1-isopropylisoquinoline (8).

According to the general procedure. The spectral data is consistent with the literature data.\(^4\)

Colorless oil (32.3 mg, 63%).

R\(_f\) 0.50 (Petroleum ether/EtOAc, 10/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.49 (d, \(J = 5.6\) Hz, 1H), 8.22 (d, \(J = 8.4\) Hz, 1H), 7.80 (d, \(J = 8.0\) Hz, 1H), 7.70 – 7.61 (m, 1H), 7.61 – 7.54 (m, 1H), 7.48 (d, \(J = 5.6\) Hz, 1H), 4.09 – 3.83 (m, 1H), 1.45 (d, \(J = 6.8\) Hz, 6H).

\(^1\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 166.3, 141.9, 136.4, 129.6, 127.6, 126.9, 126.2, 124.8, 119.0, 30.9, 22.2.

HRMS (ESI) calcd for C_{12}H_{14}N [M + H]^+ 172.1121, found 172.1123.
methyl 1-isopropylisoquinoline-4-carboxylate (9).

\[
\begin{align*}
\text{CO}_2\text{Me} & \\
\end{align*}
\]

According to the *general procedure*. The spectral data is consistent with the literature data.\(^{3b}\)

Colorless oil (37.8 mg, 55%).

\(R_f\) 0.50 (Petroleum ether/EtOAc, 10/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 9.14 (s, 1H), 8.98 (d, \(J = 8.4\) Hz, 1H), 8.29 (d, \(J = 8.4\) Hz, 1H), 7.85 – 7.73 (m, 1H), 7.64 (dd, \(J = 11.2, 4.0\) Hz, 1H), 4.07 – 3.94 (m, 4H), 1.45 (d, \(J = 6.8\) Hz, 6H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 171.5, 167.4, 145.9, 134.4, 131.3, 127.3, 125.9, 125.1, 118.8, 52.3, 31.6, 22.2.

HRMS (ESI) calcd for C\(_{14}\)H\(_{16}\)NO\(_2\) [M + H]\(^+\) 230.1176, found 230.1179.

1-isopropyl-6,7-dimethoxyisoquinoline (10).

\[
\begin{align*}
\text{O} & \text{O} & \text{N} & \\
\end{align*}
\]

According to the *general procedure*. The spectral data is consistent with the literature data.\(^{3c}\)

Yellow oil (33.3 mg, 48%).

\(R_f\) 0.30 (Petroleum ether/EtOAc, 7/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.37 (d, \(J = 5.6\) Hz, 1H), 7.41 (s, 1H), 7.36 (d, \(J = 5.6\) Hz, 1H), 7.06 (s, 1H), 4.04 (s, 3H), 4.02 (s, 3H), 3.90 – 3.73 (m, 1H), 1.44 (d, \(J = 6.8\) Hz, 6H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 163.8, 152.3, 149.9, 141.1, 133.2, 121.9, 117.9, 105.6, 103.2, 56.1, 56.0, 31.2, 22.1.

HRMS (ESI) calcd for C\(_{14}\)H\(_{18}\)NO\(_2\) [M + H]\(^+\) 232.1332, found 232.1334.

6-isopropylphenanthridine (11).

\[
\begin{align*}
\text{N} & \\
\end{align*}
\]

According to the *general procedure*. The spectral data is consistent with the literature data.\(^{4}\)

Colorless oil (47.7 mg, 72%).

\(R_f\) 0.50 (Petroleum ether/EtOAc, 20/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.65 (d, \(J = 8.4\) Hz, 1H), 8.54 (d, \(J = 8.0\) Hz, 1H), 8.33 (d, \(J = 8.4\)Hz, 1H), 8.18 (d, \(J = 8.0\) Hz, 1H), 7.81 (t, \(J = 7.6\) Hz, 1H), 7.71 (dt, \(J = 15.2, 7.6\) Hz, 2H), 7.62 (dd, \(J = 8.0, 7.2\) Hz, 1H), 4.12 – 3.90 (m, 1H), 1.55 (d, \(J = 6.8\) Hz, 6H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 165.9, 143.9, 133.1, 130.0, 128.5, 127.2, 126.3, 125.8, 124.8, 123.5, 122.7, 121.9, 31.6, 22.1.

HRMS (ESI) calcd for C\(_{16}\)H\(_{16}\)N [M + H]\(^+\) 222.1277, found 222.1281.
4-isopropyl-2-phenylpyridine (12).

\[
\begin{align*}
\text{N} & \quad \text{Ph} \\
\text{N} & \quad \text{Ph}
\end{align*}
\]

(2:1 mixture)

According to the general procedure. A 2:1 mixture of mono- and di-substituted compound was obtained. The spectral data is consistent with the literature data.2a

Colorless oil (31.4 mg, 48%).

\[ R_f \text{ 0.50 (Petroleum ether/EtOAc, 10/1).} \]

\[ \text{H NMR (400 MHz, CDCl}_3\text{)} \delta 8.03 (t, J = 7.6 Hz, 3H), 7.65 (t, J = 7.6 Hz, 1H), 7.53 (d, J = 7.6 Hz, 1H), 7.49 - 7.42 (m, 3H), 7.41 - 7.34 (m, 2H), 7.10 (d, J = 7.6 Hz, 1H), 6.96 (s, 1H), 3.22 - 3.04 (m, 2H), 2.98 - 2.85 (m, 1H), 1.36 (dd, J = 6.8, 1.6 Hz, 10H), 1.30 (d, J = 6.8 Hz, 3H). \]

\[ \text{C NMR (100 MHz, CDCl}_3\text{)} \delta 167.3, 158.5, 156.6, 156.5, 140.5, 140.1, 137.1, 128.8, 128.7, 128.6, 127.2, 127.1, 119.0, 117.8, 117.4, 116.3, 36.6, 34.1, 23.4, 22.9, 22.8. \]

\[ \text{HRMS (ESI) calcd for C}_{14}\text{H}_{16}\text{N} [M + H]^+ 198.1277, found 198.1279. And C}_{17}\text{H}_{22}\text{N} [M + H]^+ 240.1747, found 240.1751. \]

2,6-diisopropyl-4-phenylpyridine (13).

\[
\begin{align*}
\text{N} & \quad \text{Ph} \\
\text{N} & \quad \text{Ph}
\end{align*}
\]

According to the general procedure. The spectral data is consistent with the literature data.3c

Colorless oil (25.8 mg, 36%).

\[ R_f \text{ 0.60 (Petroleum ether/EtOAc, 10/1).} \]

\[ \text{H NMR (400 MHz, CDCl}_3\text{)} \delta 7.68 (d, J = 7.6 Hz, 2H), 7.53 (t, J = 7.6 Hz, 2H), 7.50 - 7.43 (m, 1H), 7.24 (s, 2H), 3.27 - 3.05 (m, 2H), 1.40 (d, J = 6.8 Hz, 12H). \]

\[ \text{C NMR (100 MHz, CDCl}_3\text{)} \delta 167.2, 149.3, 139.8, 129.0, 128.0, 128.6, 127.3, 115.8, 36.7, 22.9. \]

\[ \text{HRMS (ESI) calcd for C}_{17}\text{H}_{22}\text{N} [M + H]^+ 240.1747, found 240.1748. \]

6-isopropylpyridine-2,4-dicarbonitile (14).

\[
\begin{align*}
\text{N} & \quad \text{CN} \\
\text{CN}
\end{align*}
\]

According to the general procedure.

Colorless oil (16.9 mg, 33%).

\[ R_f \text{ 0.70 (Petroleum ether/EtOAc, 7/1).} \]

\[ \text{H NMR (400 MHz, CDCl}_3\text{)} \delta 8.86 (s, 1H), 7.86 (s, 1H), 3.57 - 3.27 (m, 1H), 1.44 (d, J = 7.2 Hz,} \]
$^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 150.7, 149.6, 132.4, 129.9, 121.0 115.9, 114.1, 31.7, 22.6.  
HRMS (ESI) calcd for C$_{10}$H$_{10}$N$_3$ [M + H]$^+$ 172.0869, found 172.0870.  
IR (neat) $\nu_{\text{max}}$ = 2971, 2295, 1473, 1370, 1054 cm$^{-1}$.

**methyl 4-isopropyl-6-methylpicolinate (15).**

![Structure of methyl 4-isopropyl-6-methylpicolinate](image)

According to the *general procedure*.  
Colorless oil (30.2 mg, 54%).  
$R_f$ 0.65 (Petroleum ether/EtOAc, 7/1).  
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.87 (s, 1H), 7.17 (s, 1H), 3.91 (s, 3H), 3.83 (dp, $J$ = 13.6, 6.8 Hz, 1H), 2.58 (s, 3H), 1.25 (d, $J$ = 6.8 Hz, 6H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 167.0, 161.8, 159.4, 150.9, 122.7, 120.5, 52.1, 29.0, 24.7, 23.1.  
HRMS (ESI) calcd for C$_{11}$H$_{16}$N$_2$ [M + H]$^+$ 194.1176, found 194.1180.  
IR (neat) $\nu_{\text{max}}$ = 2953, 1721, 1596, 1276, 1071 cm$^{-1}$.

**1,1'-(3-isopropylpyridine-2,6-diyl)bis(ethan-1-one) (16).**

![Structure of 1,1'-(3-isopropylpyridine-2,6-diyl)bis(ethan-1-one)](image)

According to the *general procedure*.  
Colorless oil (30.0 mg, 49%).  
$R_f$ 0.65 (Petroleum ether/EtOAc, 7/1).  
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.10 (d, $J$ = 8.0 Hz, 1H), 7.92 (d, $J$ = 8.0 Hz, 1H), 3.98 – 3.75 (m, 1H), 2.75 (d, $J$ = 10.8 Hz, 6H), 1.27 (d, $J$ = 6.8 Hz, 6H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 202.1, 199.5, 151.2, 150.0, 148.5, 136.1, 123.9, 28.9, 28.3, 25.6, 23.6.  
HRMS (ESI) calcd for C$_{12}$H$_{16}$NO$_2$ [M + H]$^+$ 206.1176, found 206.1178.  
IR (neat) $\nu_{\text{max}}$ = 2957, 2003, 1698, 1357, 1055 cm$^{-1}$.

**diethyl 3-isopropylpyridine-2,6-dicarboxylate (17).**

![Structure of diethyl 3-isopropylpyridine-2,6-dicarboxylate](image)

According to the *general procedure*.  
Colorless oil (42.1 mg, 53%).  
$R_f$ 0.65 (Petroleum ether/EtOAc, 7/1).  
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.16 (d, $J$ = 8.0 Hz, 1H), 7.87 (d, $J$ = 8.0 Hz, 1H), 4.47 (q, $J$ = 7.2 Hz, 4H), 3.54 – 3.37 (m, 1H), 1.43 (t, $J$ = 7.2 Hz, 6H), 1.29 (d, $J$ = 6.8 Hz, 6H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 166.5, 164.8, 149.6, 146.8, 145.7, 135.6, 126.7, 62.1, 29.4, 23.5, 14.4, 14.3.
HRMS (ESI) calcd for C₁₄H₂₀NO₄ [M + H]^+ 266.1387, found 266.1388.
IR (neat) \( \nu_{\text{max}} = 2965, 1719, 1313, 1018, 670 \text{ cm}^{-1} \).

2-isopropylbenzo[d]thiazole (18).

![2-isopropylbenzo[d]thiazole](image)

According to the *general procedure*. The spectral data is consistent with the literature data.³ᵃ

Colorless oil (19.1 mg, 36%).

\( R_f \) 0.60 (Petroleum ether/EtOAc, 15/1).

\(^1\)H NMR (400 MHz, CDCl₃) \( \delta \) 7.98 (d, \( J = 8.0 \) Hz, 1H), 7.85 (d, \( J = 8.0 \) Hz, 1H), 7.45 (t, \( J = 7.6 \) Hz, 1H), 7.34 (t, \( J = 7.6 \) Hz, 1H), 3.54 – 3.34 (m, 1H), 1.49 (d, \( J = 6.8 \) Hz, 6H).

\(^13\)C NMR (100 MHz, CDCl₃) \( \delta \) 178.7, 153.3, 134.8, 125.9, 124.7, 122.7, 121.7, 34.2, 23.0.

HRMS (ESI) calcd for C₁₀H₁₂NS [M + H]^+ 178.0685, found 178.0688.

6-chloro-7-isopropylimidazo[1,2-b]pyridazine (19).

![6-chloro-7-isopropylimidazo[1,2-b]pyridazine](image)

According to the *general procedure*. The spectral data is consistent with the literature data.³ᵃ

Colorless oil (50.9 mg, 87%).

\( R_f \) 0.75 (Petroleum ether/EtOAc, 5/1).

\(^1\)H NMR (400 MHz, CDCl₃) \( \delta \) 7.90 (s, 1H), 7.73 (s, 1H), 6.88 (s, 1H), 3.75 – 3.62 (m, 1H), 1.42 (d, \( J = 6.8 \) Hz, 6H).

\(^13\)C NMR (100 MHz, CDCl₃) \( \delta \) 149.1, 147.4, 137.9, 133.3, 117.3, 114.3, 29.2, 21.6.


3-bromo-6-chloro-7-isopropylimidazo[1,2-b]pyridazine (20).

![3-bromo-6-chloro-7-isopropylimidazo[1,2-b]pyridazine](image)

According to the *general procedure*. The spectral data is consistent with the literature data.³ᵃ

Colorless oil (67.1 mg, 82%).

\( R_f \) 0.80 (Petroleum ether/EtOAc, 5/1).

\(^1\)H NMR (400 MHz, CDCl₃) \( \delta \) 7.73 (s, 1H), 6.94 (s, 1H), 3.68 (hept, \( J = 6.8 \) Hz, 1H), 1.42 (d, \( J = 6.8 \) Hz, 6H).

\(^13\)C NMR (100 MHz, CDCl₃) \( \delta \) 149.4, 148.5, 138.6, 133.7, 114.7, 101.3, 28.9, 21.7.


ethyl 6-chloro-7-isopropylimidazo[1,2-b]pyridazine-2-carboxylate (21).

![ethyl 6-chloro-7-isopropylimidazo[1,2-b]pyridazine-2-carboxylate](image)
According to the *general procedure*. The spectral data is consistent with the literature data.\(^{3a}\) Colorless oil (48.9 mg, 61%).

\(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.31 (s, 1H), 7.07 (s, 1H), 4.46 (q, \(J = 7.2\) Hz, 2H), 3.78 – 3.62 (m, 1H), 1.43 (dt, \(J = 7.2, 3.6\) Hz, 9H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 158.5, 149.4, 148.9, 141.1, 139.9, 120.60, 116.9, 61.1, 29.3, 21.6, 14.5.

**HRMS** (ESI) calcd for C\(_{12}\)H\(_{15}\)ClN\(_3\)O\(_2\) [M + H]\(^{+}\) 268.0847, found 268.0848.

**2-isopropyl-1H-benzo[\(\phi\)]imidazole (22).**

According to the *general procedure*. The spectral data is consistent with the literature data.\(^{3d}\) Colorless oil (23.5 mg, 49%).

\(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.55 (dd, \(J = 6.0, 3.2\) Hz, 2H), 7.20 (dd, \(J = 6.0, 3.2\) Hz, 2H), 3.41 – 3.20 (m, 1H), 1.47 (d, \(J = 7.2\) Hz, 6H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 160.2, 138.5, 122.2, 114.8, 29.2, 21.7.

**HRMS** (ESI) calcd for C\(_{10}\)H\(_{13}\)N\(_2\) [M + H]\(^{+}\) 161.1073, found 161.1076.

**2-hydroxy-3-isopropyl-1,4-naphthalene-dione (23).**

According to the *general procedure*. Yellow solid (46.6 mg, 72%). M.p. = 84 – 85 °C.

\(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.11 (d, \(J = 6.0\) Hz, 1H), 8.06 (d, \(J = 6.0\) Hz, 1H), 7.75 (t, \(J = 6.0\) Hz, 1H), 7.68 (d, \(J = 6.0\) Hz, 1H), 7.47 (s, 1H), 3.43 (dd, \(J = 6.8, 4.4\) Hz, 1H), 1.32 (dd, \(J = 6.8, 2.0\) Hz, 6H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 184.6, 182.0, 152.9, 135.0, 133.3, 132.8, 129.3, 128.9, 127.0, 126.1, 24.8, 19.9.

**HRMS** (ESI) calcd for C\(_{13}\)H\(_{13}\)O\(_3\) [M + H]\(^{+}\) 217.0859, found 217.0860.

**IR** (neat) \(\nu_{\text{max}}\) = 3373, 2962, 1658, 1273, 725 cm\(^{-1}\).

**IR** (neat) \(\nu_{\text{max}}\) = 3373, 2962, 1658, 1273, 725 cm\(^{-1}\).

**IR** (neat) \(\nu_{\text{max}}\) = 3373, 2962, 1658, 1273, 725 cm\(^{-1}\).

\((R)-2-(\text{sec-butyl})\text{quinazolin-4(3H)}\)-one (24).

According to the *general procedure*. The spectral data is consistent with the literature data.\(^{2a}\) White solid (49.1 mg, 81%). M.p. = 173 – 174 °C.
$R_f$ 0.50 (Petroleum ether/EtOAc, 2/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 12.01 (s, 1H), 8.31 (d, $J = 7.6$ Hz, 1H), 7.76 (ddd, $J = 15.2$, 11.2, 4.4 Hz, 2H), 7.54 – 7.42 (m, 1H), 2.95 – 2.74 (m, 1H), 1.98 (dt, $J = 14.8$, 7.6 Hz, 1H), 1.84 – 1.67 (m, 1H), 1.45 (d, $J = 7.2$ Hz, 3H), 0.99 (t, $J = 7.2$ Hz, 3H). $^1$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.5, 160.6, 149.6, 134.8, 127.5, 126.3, 120.8, 42.3, 28.2, 18.3, 12.1.

HRMS (ESI) calcd for C$_{12}$H$_{15}$N$_2$O [M + H]$^+$ 203.1179, found 203.1181.

2-(pentan-3-yl)quinazolin-4(3H)-one (25).

According to the general procedure. The spectral data is consistent with the literature data.$^{2a}$

White solid (57.7 mg, 89%). M.p. = 141 – 142 °C.

$R_f$ 0.50 (Petroleum ether/EtOAc, 3/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.46 (s, 1H), 8.30 (d, $J = 7.6$ Hz, 1H), 7.76 (ddd, $J = 14.4$, 10.8, 4.3 Hz, 2H), 7.58 – 7.41 (m, 1H), 2.60 (tt, $J = 9.2$, 5.6 Hz, 1H), 1.97 – 1.77 (m, 4H), 0.95 (t, $J = 7.2$ Hz, 6H). $^1$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.1, 159.5, 149.6, 134.8, 127.6, 126.4, 120.9, 50.2, 26.6, 12.2.

HRMS (ESI) calcd for C$_{13}$H$_{17}$N$_2$O [M + H]$^+$ 217.1335, found 217.1338.

($R$)-2-(1-(4-isopropylphenyl)propan-2-yl)quinazolin-4(3H)-one (26).

According to the general procedure. The spectral data is consistent with the literature data.$^{2a}$

Pale oil (67.0 mg, 73%).

$R_f$ 0.50 (Petroleum ether/EtOAc, 2/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.90 (s, 1H), 8.33 (d, $J = 7.6$ Hz, 1H), 7.78 (ddd, $J = 12.4$, 9.6, 4.4 Hz, 2H), 7.59 – 7.45 (m, 1H), 7.22 (d, $J = 8.0$ Hz, 2H), 7.11 (d, $J = 8.0$ Hz, 2H), 3.25 (dd, $J = 13.2$, 6.4 Hz, 1H), 3.17 (dd, $J = 14.8$, 6.8 Hz, 1H), 2.87 (ddd, $J = 20.8$, 13.6, 7.6 Hz, 2H), 1.41 (d, $J = 6.8$ Hz, 3H), 1.20 (dd, $J = 6.8$, 2.0 Hz, 6H). $^1$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.4, 160.0, 149.7, 147.0, 136.7, 134.8, 129.3, 127.6, 126.6, 126.5, 126.4, 120.9, 42.4, 40.9, 33.8, 24.2, 24.1, 17.9.

HRMS (ESI) calcd for C$_{20}$H$_{23}$N$_2$O [M + H]$^+$ 307.1805, found 307.1807.

2-cyclopentylquinazolin-4(3H)-one (27).
According to the general procedure. The spectral data is consistent with the literature data.\textsuperscript{3a}

White solid (47.5 mg, 74%). M.p. = 188 – 189 °C.

$R_t$ 0.50 (Petroleum ether/EtOAc, 2/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.35 (s, 1H), 8.27 (d, $J = 7.6$ Hz, 1H), 7.83 – 7.66 (m, 2H), 7.46 (t, $J = 7.6$ Hz, 1H), 3.16 (p, $J = 8.4$ Hz, 1H), 2.25 – 2.11 (m, 2H), 2.09 – 1.98 (m, 2H), 1.96 – 1.85 (m, 2H), 1.77 – 1.70 (m, 2H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.3, 159.8, 149.6, 134.8, 127.5, 126.3, 120.8, 45.7, 31.5, 26.0.

HRMS (ESI) calcd for C$_{13}$H$_{15}$N$_2$O $[\text{M + H}]^+$ 215.1179, found 215.1181.

2-cyclohexylquinazolin-4(3H)-one (28).

According to the general procedure. The spectral data is consistent with the literature data.\textsuperscript{3a}

White solid (53.4 mg, 78%). M.p. = 189 – 190 °C.

$R_t$ 0.40 (Petroleum ether/EtOAc, 2/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.78 (s, 1H), 8.29 (d, $J = 7.6$ Hz, 1H), 7.86 – 7.68 (m, 2H), 7.47 (t, $J = 7.2$ Hz, 1H), 2.74 (dd, $J = 16.4$, 7.6 Hz, 1H), 2.06 (d, $J = 11.6$ Hz, 2H), 1.93 (d, $J = 11.6$ Hz, 2H), 1.78 (dd, $J = 23.6$, 11.2 Hz, 3H), 1.44 (dd, $J = 23.2$, 16.0 Hz, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.4, 160.4, 149.7, 134.8, 127.5, 126.4, 126.3, 120.9, 44.9, 30.6, 26.2, 25.8.

HRMS (ESI) calcd for C$_{14}$H$_{17}$N$_2$O $[\text{M + H}]^+$ 229.1335, found 229.1338.

(R)-2-(tetrahydrofuran-3-yl)quinazolin-4(3H)-one (29).

According to the general procedure. The spectral data is consistent with the literature data.\textsuperscript{3a}

White solid (29.8 mg, 46%). M.p. = 192 – 193 °C.

$R_t$ 0.40 (EtOAc).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.26 (s, 1H), 8.27 (d, $J = 7.2$ Hz, 1H), 7.77 (t, $J = 7.2$ Hz, 1H), 7.70 (d, $J = 8.0$ Hz, 1H), 7.48 (t, $J = 7.2$ Hz, 1H), 4.24 – 4.05 (m, 3H), 3.96 – 3.84 (m, 1H), 3.62 – 3.45 (m, 1H), 2.59 – 2.26 (m, 2H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.0, 156.9, 149.1, 134.9, 127.6, 126.8, 126.4, 120.9, 71.5, 68.4, 44.6, 31.2.

HRMS (ESI) calcd for C$_{12}$H$_{13}$N$_2$O$_2$ $[\text{M + H}]^+$ 217.0972, found 217.0967.

tert-butyl (S)-2-(isoquinolin-1-yl)pyrrolidine-1-carboxylate (30).
According to the general procedure. The spectral data is consistent with the literature data.\(^5\)

Yellow solid (79.6 mg, 89%); M.p. = 70 – 71 °C.

\(R_f\) 0.35 (Petroleum ether/EtOAc, 4/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.46 (d, \(J = 5.3\) Hz, 1H), 8.28 – 8.13 (m, 1H), 7.90 – 7.76 (m, 1H), 7.74 – 7.44 (m, 3H), 5.97 – 5.52 (m, 1H), 3.89 – 3.60 (m, 2H), 2.54 – 2.41 (m, 1H), 2.13 – 1.87 (m, 1H), 1.45 (s, 3H), 0.92 (s, 6H).

\(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 162.2 and 161.1, 154.7 and 154.4, 141.9, 136.5 and 136.3, 129.7, 127.6 and 127.0, 124.4 and 124.1, 119.8 and 119.6, 79.2 and 78.8, 59.6 and 58.7, 47.4 and 47.2, 34.0 and 33.1, 28.1 and 28.0, 24.1 and 23.9.

HRMS (ESI) calcd for C\(_{18}\)H\(_{23}\)N\(_2\)O\(_2\) [M + H]\(^+\) 299.1754, found 299.1757.

1-benzylisoquinoline (31).

According to the general procedure. The spectral data is consistent with the literature data.\(^6\)

Yellow oil (30.4 mg, 51%).

\(R_f\) 0.30 (Petroleum ether/EtOAc, 5/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.49 (d, \(J = 5.6\) Hz, 1H), 8.11 (d, \(J = 8.4\) Hz, 1H), 7.75 (d, \(J = 8.4\) Hz, 1H), 7.57 (t, \(J = 7.6\) Hz, 1H), 7.53 – 7.43 (m, 2H), 7.30 – 7.19 (m, 4H), 7.13 (t, \(J = 7.2\) Hz, 1H), 4.65 (s, 2H).

\(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 160.2, 142.1, 139.5, 136.6, 129.9, 128.6, 128.5, 127.4, 127.2, 126.3, 125.8, 119.8, 42.1.

HRMS (ESI) calcd for C\(_{16}\)H\(_{14}\)N [M + H]\(^+\) 200.1121, found 200.1124.

2-((benzyloxy)methyl)quinazolin-4(3H)-one (32).

According to the general procedure. The spectral data is consistent with the literature data.\(^2\a\)

White solid (41.5 mg, 52%). M.p. = 159 – 160 °C.

\(R_f\) 0.60 (Petroleum ether/EtOAc, 2/1).

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 9.96 (s, 1H), 8.27 (dd, \(J = 8.0, 1.0\) Hz, 1H), 7.82 – 7.71 (m, 1H), 7.64 (d, \(J = 8.0\) Hz, 1H), 7.47 (t, \(J = 7.6\) Hz, 1H), 7.41 – 7.29 (m, 5H), 4.70 (s, 2H), 4.56 (s, 2H).

\(^13\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 161.8, 152.8, 148.7, 136.4, 134.9, 128.8, 128.6, 128.3, 127.1, 126.9, 126.8, 121.7, 73.9, 68.7.

HRMS (ESI) calcd for C\(_{16}\)H\(_{15}\)N\(_2\)O\(_2\) [M + H]\(^+\) 267.1128, found 267.1128.

2-(tert-butyl)quinazolin-4(3H)-one (33).
According to the general procedure. The spectral data is consistent with the literature data.3a
White solid (48.5 mg, 80%). M.p. = 150–151 °C.

$R_f$ 0.70 (Petroleum ether/EtOAc, 2/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 11.37 (s, 1H), 8.29 (d, $J$ = 8.0 Hz, 1H), 7.75 (dt, $J$ = 14.8, 4.8 Hz, 2H), 7.51–7.40 (m, 1H), 1.51 (s, 9H).

$^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 164.1, 162.3, 149.3, 134.6, 127.8, 126.4, 126.3, 120.7, 37.6, 28.4.

HRMS (ESI) calcd for C$_{12}$H$_{15}$N$_2$O [M + H]$^+$ 203.1179, found 203.1182.

2-(adamantan-1-yl)-4-methylquinoline (34).

According to the general procedure. The spectral data is consistent with the literature data.7
White solid (69.0 mg, 83%). M.p. = 105–106 °C.

$R_f$ 0.65 (Petroleum ether/EtOAc, 40/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.08 (d, $J$ = 8.4 Hz, 1H), 7.94 (d, $J$ = 8.4 Hz, 1H), 7.66 (t, $J$ = 7.6 Hz, 1H), 7.49 (t, $J$ = 7.6 Hz, 1H), 7.33 (s, 1H), 2.69 (s, 3H), 2.20–2.08 (m, 9H), 1.84 (s, 6H).

$^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 168.8, 147.6, 143.6, 130.1, 128.7, 125.4, 123.5, 118.6, 41.93, 39.6, 37.0, 28.9, 19.1.

HRMS (ESI) calcd for C$_{20}$H$_{24}$N [M + H]$^+$ 278.1903, found 278.1900.

5,7-dichloro-4-(4-fluorophenoxy)-2-isopropylquinoline (35).

According to the general procedure.
Red solid (63.9 mg, 61%). M.p. = 54–55 °C.

$R_f$ 0.70 (Petroleum ether/EtOAc, 7/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.99 (d, $J$ = 2.0 Hz, 1H), 7.52 (d, $J$ = 2.0 Hz, 1H), 7.16 (qd, $J$ = 9.2, 3.7 Hz, 4H), 6.56 (s, 1H), 3.12–2.97 (m, 1H), 1.27 (d, $J$ = 6.8 Hz, 6H).

$^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 170.5, 162.5, 159.9 (d, $J$ = 244.2 Hz), 151.5, 150.4, 134.9, 130.0, 128.8, 127.7, 122.1 (d, $J$ = 8.5 Hz), 117.2, 117.0, 105.5, 37.2, 22.2.

HRMS (ESI) calcd for C$_{18}$H$_{15}$Cl$_2$FNO [M + H]$^+$ 350.0509, found 350.0512.
IR (neat) $\nu_{\text{max}} = 2964, 1599, 1551, 1196, 741 \text{ cm}^{-1}$.

$$ \text{υ}_{\text{max}} = 2964, 1599, 1551, 1196, 741 \text{ cm}^{-1}.$$ 

(1S)-(2-(tert-butyl)quinolin-4-yl)((1S,4S)-5-vinylquinuclidin-2-yl)methanol (36).

![Chemical structure](image)

According to the general procedure. The spectral data is consistent with the literature data.$^{2a}$

White solid (42.0 mg, 40%). M.p. = 172 – 173 °C.

$R_f$ 0.50 (CH$_2$Cl$_2$/MeOH, 20/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.06 (dd, $J = 8.4, 0.8$ Hz, 1H), 8.04 – 7.99 (m, 1H), 7.65 (dd, $J = 8.4, 6.8, 1.2$ Hz, 1H), 7.49 (ddd, $J = 8.4, 6.8, 1.2$ Hz, 1H), 7.36 (s, 1H), 6.07 – 5.90 (m, 1H), 5.18 – 5.06 (m, 2H), 3.44 (dd, $J = 13.2, 4.8$ Hz, 1H), 3.20 – 3.10 (m, 1H), 3.08 – 2.88 (m, 5H), 2.36 – 2.22 (m, 1H), 1.60 – 1.49 (m, 3H), 1.46 (s, 9H), 1.37 – 1.29 (m, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 168.7, 147.8, 144.7, 140.6, 130.3, 128.7, 126.1, 125.6, 123.3, 118.8, 114.7, 56.0, 49.4, 47.7, 40.0, 38.0, 37.8, 30.2, 28.0, 27.9, 26.5.

HRMS (ESI) calcd for C$_{23}$H$_{31}$N$_2$O $[\text{M} + \text{H}]^+$ 351.2431, found 351.2432.

$[\alpha]^{25}_{D} = -102.976$ (c = 0.506, CHCl$_3$).

5-((1,4-diazepan-1-yl)sulfonyl)-1-isopropylisoquinoline (37).

![Chemical structure](image)

According to the general procedure. The spectral data is consistent with the literature data.$^{2d}$

Yellow oil (72.9 mg, 73%).

$R_f$ 0.30 (CH$_2$Cl$_2$/MeOH, 10/1).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.63 (d, $J = 6.0$ Hz, 1H), 8.49 (d, $J = 8.4$ Hz, 1H), 8.30 (dd, $J = 10.8, 6.8$ Hz, 2H), 7.66 (t, $J = 8.0$ Hz, 1H), 3.97 (dt, $J = 13.2, 6.8$ Hz, 1H), 3.56 – 3.39 (m, 4H), 3.09 – 2.92 (m, 4H), 2.48 (s, 1H), 1.93 – 1.76 (m, 2H), 1.45 (d, $J = 6.4$ Hz, 6H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 167.3, 143.9, 135.3, 132.4, 130.4, 126.9, 125.3, 115.7, 51.0, 50.3, 47.7, 47.5, 31.6, 31.2, 22.4.

HRMS (ESI) calcd for C$_{17}$H$_{24}$N$_2$O$_2$S $[\text{M} + \text{H}]^+$ 334.1584, found 334.1585.

2-((2-(4-chlorophenoxy)-2-methylpropanoyl)oxy)ethyl 6-(tert-butyl)nicotinate (38).
According to the *general procedure*. The spectral data is consistent with the literature data. Colorless oil (72.9 mg, 58%).

R_{f} 0.65 (Petroleum ether/EtOAc, 5/1).

\[ { }^{1}H \text{ NMR} \] (400 MHz, CDCl\(_{3}\)) \( \delta \) 9.06 (d, \( J = 2.0 \) Hz, 1H), 8.01 (dd, \( J = 8.4, 2.0 \) Hz, 1H), 7.37 (d, \( J = 8.4 \) Hz, 1H), 7.12 – 7.03 (m, 2H), 6.80 – 6.70 (m, 2H), 4.50 (q, \( J = 5.6 \) Hz, 4H), 1.57 (s, 6H), 1.37 (s, 9H).

\[ { }^{13}C \text{ NMR} \] (100 MHz, CDCl\(_{3}\)) \( \delta \) 174.3, 173.9, 165.2, 153.9, 150.0, 137.3, 129.1, 127.26, 122.5, 120.2, 118.8, 79.3, 63.1, 62.5, 38.0, 30.0, 25.3.

HRMS (ESI) calcd for C\(_{22}\)H\(_{27}\)ClNO\(_{5}\) [M + H]\(^{+}\) 420.1572, found 420.1575.

2',6'-diisopropyl-2-methyl-6-oxo-1,6-dihydro-[3,4'-bipyridine]-5-carbonitrile (39).

According to the *general procedure*.

Yellow solid (37.2 mg, 42%). M.p. = 143 – 144 °C.

R_{f} 0.50 (CH\(_{2}\)Cl\(_{2}\)/MeOH, 20/1).

\[ { }^{1}H \text{ NMR} \] (400 MHz, CDCl\(_{3}\)) \( \delta \) 7.86 (s, 1H), 6.85 (s, 2H), 3.09 (dt, \( J = 13.6, 6.8 \) Hz, 2H), 2.51 (s, 3H), 1.33 (d, \( J = 6.8 \) Hz, 12H).

\[ { }^{13}C \text{ NMR} \] (100 MHz, CDCl\(_{3}\)) \( \delta \) 167.7, 162.7, 150.6, 149.7, 143.9, 119.7, 115.4, 101.9, 36.6, 22.8, 18.9.

HRMS (ESI) calcd for C\(_{18}\)H\(_{22}\)N\(_{3}\)O [M + H]\(^{+}\) 296.1757, found 296.1760.

IR (neat) \( \nu_{\text{max}} \) = 3470, 1643, 1265, 745 cm\(^{-1}\).

2-cyclohexyl-3-hydroxynaphthalene-1,4-dione (40)

According to the *general procedure*. The spectral data is consistent with the literature data.2a

Yellow solid (57.6 mg, 75%). M.p. =128 – 129 °C.

R_{f} 0.60 (Petroleum ether/EtOAc, 7/1).

\[ { }^{1}H \text{ NMR} \] (400 MHz, CDCl\(_{3}\)) \( \delta \) 8.10 (d, \( J = 7.6 \) Hz, 1H), 8.04 (d, \( J = 7.6 \) Hz, 1H), 7.74 (t, \( J = 7.6 \) Hz, 1H), 7.65 (t, \( J = 7.6 \) Hz, 1H), 7.51 (s, 1H), 3.08 (t, \( J = 12.4 \) Hz, 1H), 1.98 (dd, \( J = 24.4, 12.4 \) Hz, 2H), 1.81 (d, \( J = 11.6 \) Hz, 2H), 1.72 (d, \( J = 8.8 \) Hz, 1H), 1.61 (d, \( J = 12.4 \) Hz, 2H), 1.40 – 1.24 (m, 3H).

\[ { }^{13}C \text{ NMR} \] (100 MHz, CDCl\(_{3}\)) \( \delta \) 184.7, 182.0, 153.0, 134.9, 133.3, 132.8, 129.3, 128.0, 127.0, 126.0, 35.3, 29.3, 26.8, 26.1.
HRMS (ESI) calcd for C_{16}H_{17}O_{3} [M + H]^+ 257.1172, found 257.1174.

7. Gram-scale Reaction

\[
\begin{align*}
\text{1, 1.0 equiv.} + & \text{1 mol % Ir[dF(CF_3)ppy]_2(dtbbpy)PF}_6 \quad 1.5 \text{ equiv. TFA} \\
\text{DMSO (0.1 M), O}_2 \quad 36 \text{ W blue LED, r.t. 24 h} \\
\rightarrow \text{3 (73\%)}
\end{align*}
\]

Scheme S2
To an oven dried Schlenk tube was added Ir[dF(CF_3)ppy]_2(dtbbpy)PF_6 (90 mg, 0.08 mmol, 1 mol %), 1 (1.17 g, 8.0 mmol, 1.0 equiv), 2 (3.54 g, 12 mmol, 1.5 equiv), TFA (0.9 mL, 12 mmol, 1.5 equiv) and 80 mL of DMSO. The tube was evacuated and backfilled with O_2 (this process was repeated three times). The mixture was then stirred rapidly and irradiated with two 36 W Blue LEDs (approximately 2 cm away from the light source) at room temperature for 48 h. The reaction mixture was diluted with 60 mL of aqueous 1 M NaHCO_3 solution, and extracted with DCM (3 × 100 mL). The combined organic extracts were washed with brine (200 mL), dried over Na_2SO_4, and concentrated in vacuo. After purification by flash column chromatography on silica gel, the product was obtained in 73\% yield.

References

NMR Spectra

1H NMR spectrum of compound 3
$^{13}$C NMR spectrum of compound 4

$^1$H NMR spectrum of compound 5
$^{13}$C NMR spectrum of compound 5

$^1$H NMR spectrum of compound 6
$^{13}$C NMR spectrum of compound 6

$^1$H NMR spectrum of compound 7
$^{13}$C NMR spectrum of compound 7

$^{1}$H NMR spectrum of compound 8
$^{13}$C NMR spectrum of compound 8

$^{1}$H NMR spectrum of compound 9
$^{13}$C NMR spectrum of compound 9

$^1$H NMR spectrum of compound 10
$^{13}$C NMR spectrum of compound 10

$^1$H NMR spectrum of compound 11
$^{13}$C NMR spectrum of compound 11

$^1$H NMR spectrum of compound 12
$^{13}$C NMR spectrum of compound 12

$^1$H NMR spectrum of compound 13

31
$^{13}$C NMR spectrum of compound 13

$^1$H NMR spectrum of compound 14
$^1$H NMR spectrum of compound 15
$^{13}$C NMR spectrum of compound 15

$^1$H NMR spectrum of compound 16
$^{13}$C NMR spectrum of compound 16

$^1$H NMR spectrum of compound 17
$^{13}$C NMR spectrum of compound 17

$^1$H NMR spectrum of compound 18
$^{13}$C NMR spectrum of compound 18

$^1$H NMR spectrum of compound 19
$^{13}$C NMR spectrum of compound 19

$^1$H NMR spectrum of compound 20
$^{13}$C NMR spectrum of compound 20

$^1$H NMR spectrum of compound 21
$^{13}$C NMR spectrum of compound 21

$^1$H NMR spectrum of compound 22
$^{13}$C NMR spectrum of compound 22

$^1$H NMR spectrum of compound 23
$^{13}$C NMR spectrum of compound 23

$^1$H NMR spectrum of compound 24
$^{13}$C NMR spectrum of compound 24

$^1$H NMR spectrum of compound 25
$^{13}$C NMR spectrum of compound 25

$^1$H NMR spectrum of compound 26
\(^{13}\text{C} \) NMR spectrum of compound 26

\(^{1}\text{H} \) NMR spectrum of compound 27
$^{13}$C NMR spectrum of compound 27

$^1$H NMR spectrum of compound 28
C NMR spectrum of compound 28

$^{13}$C NMR spectrum of compound 28

$^{1}$H NMR spectrum of compound 29

47
C NMR spectrum of compound 29

$\text{H NMR spectrum of compound 30}$
C NMR spectrum of compound 30

H NMR spectrum of compound 31
$^{13}$C NMR spectrum of compound 31

$^1$H NMR spectrum of compound 32
$^{13}$C NMR spectrum of compound 32

$^1$H NMR spectrum of compound 33
$^{13}$C NMR spectrum of compound 33

$^1$H NMR spectrum of compound 34
$^{13}$C NMR spectrum of compound 34

$^1$H NMR spectrum of compound 35
$^{13}$C NMR spectrum of compound 35

$^1$H NMR spectrum of compound 36
$^{13}$C NMR spectrum of compound 36

$^1$H NMR spectrum of compound 37
$^{13}$C NMR spectrum of compound 37

$^1$H NMR spectrum of compound 38
$^{13}$C NMR spectrum of compound 38

$^1$H NMR spectrum of compound 39

57
$^{13}$C NMR spectrum of compound 39

$^1$H NMR spectrum of compound 40
$^{13}$C NMR spectrum of compound 40