Supporting Information

Silver-Mediated Radical Phosphorylation/Cyclization of N-Allylbenzamides to Access Phosphoryl-Substituted Dihydroisoquinolones

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1. General information

All reagents were purchased and used without further purification. All reactions were monitored by thin layer chromatography (TLC), and column chromatography was performed on 200–300 mesh of silica gel purchased from Qing Dao Hai Yang Chemical Industry Co. $^1$H, $^{13}$C, $^{31}$P spectra were record on a Bruker Avance 400 MHz spectrometer operating at 400 MHz, 101 MHz, and 162 MHz, respectively. All NMR spectra were recorded in CDCl$_3$ at room temperature (20 ± 2 °C). Proton chemical shifts $\delta$ were given in ppm relative to tetramethylsilane (0.00 ppm) in CDCl$_3$. High resolution mass spectra (HRMS) were obtained with a Waters Micromass Q-Tof Micro instrument using the ESI technique.

Experiment procedure

General experimental procedures for phosphoryl-substituted dihydroisoquinolones (3)

A mixture of $N$-methyl-$N$-(2-methylally)benzamides (0.5 mmol, 1 equiv), phosphine oxides (1 mmol, 2 equiv), AgNO$_3$ (2 equiv) were sequentially added in a 10-mL reaction vial. Then, CH$_3$CN (3 mL) was added into this reaction system. The reaction vial was sealed and stirred at 80 °C until TLC (petroleum ether: ethyl acetate= 1:1) revealed that conversion of the starting material 1 was completed. Next, the solvent was quenched with water (10 mL), extracted with ethyl acetate (3 × 10 mL). The combined organic layers were washed with brine (25 mL) and dried over anhydrous Na$_2$SO$_4$. After filtration, the solvent was evaporated in vacuo. The crude product was purified by silica gel chromatography (petroleum ether: ethyl acetate = 1:1) to give the desired products.

<table>
<thead>
<tr>
<th>entry</th>
<th>AgNO$_3$ (mol%)</th>
<th>[O] (3 equiv)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AgNO$_3$ (20)</td>
<td>BPO</td>
<td>trace</td>
</tr>
<tr>
<td>2</td>
<td>AgNO$_3$ (20)</td>
<td>Mg(NO$_3$)$_2$</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>AgNO$_3$ (20)</td>
<td>Zn(NO$_3$)$_2$</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>AgNO$_3$ (20)</td>
<td>K$_2$S$_2$O$_8$</td>
<td>trace</td>
</tr>
</tbody>
</table>

*Reaction conditions: 1a (0.5 mmol), 2a (1 mmol), AgNO$_3$ (20 mol%), oxidant (3 equiv), CH$_3$CN (3 mL) under 80 °C for 8 h. BPO = benzyol peroxide. Yields were determined by $^{31}$P NMR using trioctylphosphine oxide as internal standard.
2. Mechanistic studies

\[
\text{1a} + \text{2a} \xrightarrow{\text{BHT (3 equiv)}} \text{3a (trace)} + \text{4} \text{ detected by HRMS}
\]

3. Characterization of products

4-((diphenylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3a)

\[
\begin{align*}
{^1}H \text{ NMR (400 MHz, Chloroform-}\text{d}) & \delta 8.02 (dd, J = 7.7, 1.2 Hz, 1H), 7.69 - 7.63 (m, 4H), 7.48 - 7.39 (m, 6H), 7.35 - 7.31 (m, 1H), 7.29 - 7.24 (m, 2H), 3.80 (d, J = 12.7 Hz, 1H), 3.50 (d, J = 12.7 Hz, 1H), 3.01 (s, 3H), 2.74 - 2.67 (m, 1H), 2.58 - 2.52 (m, 1H), 1.59 (s, 3H); \\
{^{13}}C \text{ NMR (101 MHz, Chloroform-}\text{d}) & \delta 164.6, 145.3 (d, J = 10.4 Hz), 134.8 (d, J = 98.7 Hz), 133.4 (d, J = 98.1 Hz), 132.1, 131.7 (d, J = 2.7 Hz), 131.4 (d, J = 2.8 Hz), 130.5 (d, J = 9.1 Hz), 130.2 (d, J = 9.2 Hz), 128.8 (d, J = 11.5 Hz), 128.59 (d, J = 11.5 Hz), 128.58, 127.8, 127.3, 123.9, 58.1 (d, J = 5.1 Hz), 37.9 (d, J = 67.6 Hz), 37.4 (d, J = 3.5 Hz), 34.9, 23.2 (d, J = 2.0 Hz); \\
{^{31}}P \text{ NMR (162 MHz, Chloroform-}\text{d}) & \delta 27.48; \\
\text{HRMS Calcd for C}_{24}H_{25}NO_2P [M + H]^+: 390.1617, \text{ found: 390.1612.}
\end{align*}
\]
4-((diphenylphosphoryl)methyl)-6-methoxy-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3b)

\[
\begin{align*}
\text{MeO} & \quad \text{N} \\
\text{O} & \quad \text{P-Ph} \\
\end{align*}
\]

$^1$H NMR (400 MHz, Chloroform-\(d\)) \(\delta\) 7.95 (d, \(J = 8.6\) Hz, 1H), 7.67 - 7.59 (m, 4H), 7.48 - 7.34 (m, 6H), 6.76 (d, \(J = 2.5\) Hz, 1H), 6.67 (dd, \(J = 8.7, 2.5\) Hz, 1H), 3.77 (s, 3H), 3.66 (d, \(J = 12.7\) Hz, 1H), 3.47 (d, \(J = 12.6\) Hz, 1H), 2.98 (s, 3H), 2.66 - 2.55 (m, 2H), 1.59 (s, 3H); $^{13}$C NMR (101 MHz, Chloroform-\(d\)) \(\delta\) 164.6, 162.4, 147.0 (d, \(J = 9.6\) Hz), 134.9 (d, \(J = 98.7\) Hz), 133.2 (d, \(J = 98.1\) Hz), 131.6 (d, \(J = 2.8\) Hz), 131.3 (d, \(J = 9.1\) Hz), 130.1 (d, \(J = 9.2\) Hz), 128.7 (d, \(J = 11.7\) Hz), 128.5 (d, \(J = 11.7\) Hz), 120.7, 112.1, 109.9, 58.7 (d, \(J = 6.1\) Hz), 55.3, 37.8, (d, \(J = 68.7\) Hz), 37.5 (d, \(J = 3.6\) Hz), 34.7, 23.1 (d, \(J = 1.8\) Hz); $^{31}$P NMR (162 MHz, Chloroform-\(d\)) \(\delta\) 27.46; HRMS Calcd for C$_{25}$H$_{27}$NO$_3$P [M + H]$^+$: 420.1723, found: 420.1718.

4-((diphenylphosphoryl)methyl)-2,4,6-trimethyl-3,4-dihydroisoquinolin-1(2H)-one (3c)

\[
\begin{align*}
\text{N} & \quad \text{O} \\
\text{P-Ph} & \quad \text{Cl} \\
\end{align*}
\]

$^1$H NMR (400 MHz, Chloroform-\(d\)) \(\delta\) 7.88 (d, \(J = 7.9\) Hz, 1H), 7.67 - 7.60 (m, 4H), 7.47 - 7.34 (m, 6H), 7.04 - 6.97 (m, 2H), 3.68 (d, \(J = 12.7\) Hz, 1H), 3.47 (d, \(J = 12.6\) Hz, 1H), 2.99 (s, 3H), 2.67 - 2.55 (m, 2H), 2.25 (s, 3H), 1.60 (s, 3H); $^{13}$C NMR (101 MHz, Chloroform-\(d\)) \(\delta\) 164.8, 144.9 (d, \(J = 9.6\) Hz), 142.5, 134.9 (d, \(J = 98.7\) Hz), 131.6 (d, \(J = 2.8\) Hz), 131.3 (d, \(J = 9.1\) Hz), 130.1 (d, \(J = 9.2\) Hz), 128.73 (d, \(J = 11.7\) Hz), 128.67, 128.5 (d, \(J = 11.7\) Hz), 128.1, 125.2, 124.7, 58.7 (d, \(J = 6.0\) Hz), 37.9 (d, \(J = 68.1\) Hz), 37.4 (d, \(J = 3.7\) Hz), 34.8, 23.1, 21.7; $^{31}$P NMR (162 MHz, Chloroform-\(d\)) \(\delta\) 27.50; HRMS Calcd for C$_{25}$H$_{27}$NO$_3$P [M + H]$^+$: 404.1774, found: 404.1767.

6-chloro-4-((diphenylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3d)

\[
\begin{align*}
\text{Cl} & \quad \text{N} \\
\text{O} & \quad \text{P-Ph} \\
\end{align*}
\]

$^1$H NMR (400 MHz, Chloroform-\(d\)) \(\delta\) 7.92 (d, \(J = 8.3\) Hz, 1H), 7.69 - 7.64 (m, 4H), 7.51 - 7.39 (m, 6H), 7.25 (d, \(J = 2.0\) Hz, 1H), 7.16 (dd, \(J = 8.3, 2.0\) Hz, 1H), 3.78 (d, \(J = 12.0\) Hz, 1H), 3.51 (d, \(J = 12.8\) Hz, 1H), 3.04 (s, 3H), 2.68 - 2.54 (m, 2H), 1.59 (s, 3H); $^{13}$C NMR (101 MHz, Chloroform-\(d\)) \(\delta\) 163.8, 146.6 (d, \(J = 9.7\) Hz), 138.3, 134.7 (d, \(J = 99.1\) Hz), 132.9 (d, \(J = 98.1\) Hz), 131.8 (d, \(J = 2.8\) Hz), 131.5 (d, \(J = 2.8\) Hz), 130.5, 130.3 (d, \(J = 9.7\) Hz), 130.1 (d, \(J = 9.3\) Hz), 128.8 (d, \(J = 11.7\) Hz), 128.6 (d, \(J = 11.8\) Hz), 127.7, 126.4, 124.6, 58.4 (d, \(J = 5.8\) Hz), 37.7 (d, \(J = 68.7\) Hz), 37.6 (d, \(J = 3.4\) Hz), 34.9, 23.0 (d, \(J = 2.1\) Hz); $^{31}$P NMR (162 MHz, Chloroform-\(d\)) \(\delta\) 27.16; HRMS Calcd for C$_{24}$H$_{25}$ClNO$_3$P [M + H]$^+$: 424.1228, found: 424.1224.
6-bromo-4-((diphenylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3e)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 7.83 (d, J = 8.3 \text{ Hz, 1H}), 7.68 - 7.63 (m, 4H), 7.49 - 7.39 (m, 7H), 7.32 (dd, J = 8.3, 1.9 \text{ Hz, 1H}), 3.76 (d, J = 12.8 \text{ Hz, 1H}), 3.51 (d, J = 12.8 \text{ Hz, 1H}), 3.03 (s, 3H), 2.67 - 2.54 (m, 2H), 1.58 (s, 3H); \\
\text{C NMR (101 MHz, Chloroform-}d\text{) } & \delta 163.8, 146.7 (d, J = 9.7 \text{ Hz}), 134.7 (d, J = 99.0 \text{ Hz}), 132.8 (d, J = 98.3 \text{ Hz}), 131.8 (d, J = 2.7 \text{ Hz}), 131.5 (d, J = 2.8 \text{ Hz}), 130.7, 130.4 (d, J = 8.9 \text{ Hz}), 130.1 (d, J = 9.2 \text{ Hz}), 128.8 (d, J = 11.6 \text{ Hz}), 128.6 (d, J = 11.8 \text{ Hz}), 127.5, 127.0, 126.8, 58.4 (d, J = 5.8 \text{ Hz}), 37.7 (d, J = 67.7 \text{ Hz}), 37.5 (d, J = 5.5 \text{ Hz}), 34.9, 23.0 (d, J = 2.0 \text{ Hz}); \\
\text{P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.22; \\
\text{HRMS Calcd for } C_{24}H_{23}BrNO_2P [M + H]^+: 468.0723, \text{ found: 468.0723.}
\end{align*}
\]

4-((diphenylphosphoryl)methyl)-6-iodo-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3f)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 7.68 - 7.61 (m, 6H), 7.55 (dd, J = 8.2, 1.7 \text{ Hz, 1H}), 7.50 - 7.39 (m, 6H), 3.73 (d, J = 12.8 \text{ Hz, 1H}), 3.50 (dd, J = 12.8, 1.6 \text{ Hz, 1H}), 3.03 (s, 3H), 2.65 - 2.54 (m, 2H), 1.58 (s, 3H); \\
\text{C NMR (101 MHz, Chloroform-}d\text{) } & \delta 164.0, 146.5 (d, J = 9.6 \text{ Hz}), 136.7, 134.7 (d, J = 99.0 \text{ Hz}), 133.5, 132.8 (d, J = 98.2 \text{ Hz}), 131.7 (d, J = 2.5 \text{ Hz}), 131.5 (d, J = 2.9 \text{ Hz}), 130.4 (d, J = 9.1 \text{ Hz}), 130.2, 130.1 (d, J = 9.2 \text{ Hz}), 128.8 (d, J = 11.9 \text{ Hz}), 128.7 (d, J = 11.9 \text{ Hz}), 127.4, 99.9, 58.5 (d, J = 5.9 \text{ Hz}), 38.1, 37.7 (d, J = 67.7 \text{ Hz}), 37.4, 34.9, 23.0; \\
\text{P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.23; \\
\text{HRMS Calcd for } C_{24}H_{24}INO_2P [M + H]^+: 516.0584, \text{ found: 516.0588.}
\end{align*}
\]

4-((diphenylphosphoryl)methyl)-2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinoline-6-carbonitrile (3g)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 8.02 (d, J = 8.0 \text{ Hz, 1H}), 7.64 - 7.55 (m, 5H), 7.47 - 7.35 (m, 7H), 3.76 (d, J = 13.0 \text{ Hz, 1H}), 3.53 (dd, J = 12.9, 1.9 \text{ Hz, 1H}), 3.07 (s, 3H), 2.67 - 2.54 (m, 2H), 1.60 (s, 3H); \\
\text{C NMR (101 MHz, Chloroform-}d\text{) } & \delta 162.7, 145.5 (d, J = 9.0 \text{ Hz}), 134.4 (d, J = 99.7 \text{ Hz}), 132.5 (d, J = 98.3 \text{ Hz}), 131.9 (d, J = 2.7 \text{ Hz}), 131.7 (d, J = 2.8 \text{ Hz}), 131.6, 130.9, 130.4 (d, J = 9.1 \text{ Hz}), 130.0 (d, J = 9.4 \text{ Hz}), 129.2, 128.8 (d, J = 10.7 \text{ Hz}), 128.7 (d, J = 10.3 \text{ Hz}), 128.7, 118.0, 115.3, 58.5 (d, J = 6.4 \text{ Hz}), 37.6 (d, J = 68.7 \text{ Hz}), 37.5 (d, J = 3.5 \text{ Hz}), 35.1, 23.0 (d, J = 2.1 \text{ Hz}); \\
\text{P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.10; \\
\text{HRMS Calcd for } C_{25}H_{24}N_2O_2P [M + H]^+: 415.1570, \text{ found: 415.1568.}
\end{align*}
\]
7-chloro-4-((diphenylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3h)

[Chemical Structure]

\[^1H\text{NMR}\ (400\ MHz,\ \text{Chloroform-d})\ \delta\ 7.93\ (d,\ J = 2.2\ Hz,\ 1H),\ 7.68 - 7.56\ (m,\ 4H),\ 7.52 - 7.36\ (m,\ 6H),\ 7.25 - 7.19\ (m,\ 2H),\ 3.69\ (d,\ J = 12.8\ Hz,\ 1H),\ 3.52\ (dd,\ J = 12.8,\ 2.0\ Hz,\ 1H),\ 3.06\ (s,\ 3H),\ 2.65 - 2.56\ (m,\ 2H),\ 1.64\ (s,\ 3H);\ 1^3C\ \text{NMR}\ (101\ MHz,\ \text{Chloroform-d})\ \delta\ 163.3,\ 142.9\ (d,\ J = 9.0\ Hz),\ 134.7\ (d,\ J = 99.1\ Hz),\ 133.6,\ 132.7\ (d,\ J = 98.3\ Hz),\ 131.8,\ 131.7\ (d,\ J = 2.9\ Hz),\ 131.3\ (d,\ J = 2.9\ Hz),\ 130.5\ (d,\ J = 2.9\ Hz),\ 130.1\ (d,\ J = 9.0\ Hz),\ 129.5,\ 128.8\ (d,\ J = 11.6\ Hz),\ 128.6\ (d,\ J = 11.7\ Hz),\ 128.4,\ 126.1,\ 58.8\ (d,\ J = 6.5\ Hz),\ 38.0\ (d,\ J = 68.3\ Hz),\ 37.2\ (d,\ J = 3.5\ Hz),\ 35.1,\ 23.2;\ 31^P\ \text{NMR}\ (162\ MHz,\ \text{Chloroform-d})\ \delta\ 27.33;\ \text{HRMS}\ \text{Calcd\ for}\ C_{24}H_{24}ClNO_2P\ [M + H]^+:\ 424.1228,\ \text{found}:\ 424.1220.\]

7-bromo-4-((diphenylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3i)

[Chemical Structure]

\[^1H\text{NMR}\ (400\ MHz,\ \text{Chloroform-d})\ \delta\ 8.04\ (d,\ J = 2.2\ Hz,\ 1H),\ 7.65 - 7.61\ (m,\ 2H),\ 7.58 - 7.53\ (m,\ 2H),\ 7.48 - 7.31\ (m,\ 7H),\ 7.15\ (d,\ J = 8.3\ Hz,\ 1H),\ 3.65\ (d,\ J = 12.8\ Hz,\ 1H),\ 3.49\ (dd,\ J = 12.8,\ 2.0\ Hz,\ 1H),\ 3.03\ (s,\ 3H),\ 2.65 - 2.53\ (m,\ 2H),\ 1.61\ (s,\ 3H);\ 1^3C\ \text{NMR}\ (101\ MHz,\ \text{Chloroform-d})\ \delta\ 163.2,\ 143.3\ (d,\ J = 9.0\ Hz),\ 135.2,\ 134.67\ (d,\ J = 100.0\ Hz),\ 134.68,\ 132.6\ (d,\ J = 98.4\ Hz),\ 131.7\ (d,\ J = 2.7\ Hz),\ 131.3\ (d,\ J = 1.9\ Hz),\ 130.5\ (d,\ J = 9.1\ Hz),\ 130.1\ (d,\ J = 9.3\ Hz),\ 129.7,\ 128.8\ (d,\ J = 11.6\ Hz),\ 128.6\ (d,\ J = 11.7\ Hz),\ 126.4,\ 121.6,\ 58.7\ (d,\ J = 6.9\ Hz),\ 37.9\ (d,\ J = 68.6\ Hz),\ 37.2\ (d,\ J = 3.5\ Hz),\ 35.1,\ 23.2;\ 31^P\ \text{NMR}\ (162\ MHz,\ \text{Chloroform-d})\ \delta\ 27.40;\ \text{HRMS}\ \text{Calcd\ for}\ C_{24}H_{24}BrNO_2P\ [M + H]^+:\ 468.0723,\ \text{found}:\ 468.0725.\]

4-((diphenylphosphoryl)methyl)-2,4,8-trimethyl-3,4-dihydroisoquinolin-1(2H)-one (3j)

[Chemical Structure]

\[^1H\text{NMR}\ (400\ MHz,\ \text{Chloroform-d})\ \delta\ 7.68 - 7.62\ (m,\ 4H),\ 7.48 - 7.36\ (m,\ 6H),\ 7.18 - 7.10\ (m,\ 2H),\ 7.00\ (d,\ J = 7.2\ Hz,\ 1H),\ 3.75\ (d,\ J = 12.8\ Hz,\ 1H),\ 3.47\ (d,\ J = 12.8\ Hz,\ 1H),\ 3.08\ (s,\ 3H),\ 2.68 - 2.51\ (m,\ 5H),\ 1.53\ (s,\ 3H);\ 1^3C\ \text{NMR}\ (101\ MHz,\ \text{Chloroform-d})\ \delta\ 165.1,\ 146.3\ (d,\ J = 10.1\ Hz),\ 141.0,\ 135.1\ (d,\ J = 98.7\ Hz),\ 133.2\ (d,\ J = 97.9\ Hz),\ 131.6\ (d,\ J = 2.7\ Hz),\ 131.3\ (d,\ J = 2.2\ Hz),\ 131.0,\ 130.5\ (d,\ J = 9.1\ Hz),\ 130.1\ (d,\ J = 9.2\ Hz),\ 128.7\ (d,\ J = 11.6\ Hz),\ 128.4\ (d,\ J = 11.7\ Hz),\ 126.5,\ 121.9,\ 57.9\ (d,\ J = 5.1\ Hz),\ 38.0\ (d,\ J = 3.5\ Hz),\ 37.2\ (d,\ J = 67.9\ Hz),\ 35.1,\ 23.4\ (d,\ J = 1.9\ Hz),\ 22.7;\ 31^P\ \text{NMR}\ (162\ MHz,\ \text{Chloroform-d})\ \delta\ 27.58;\ \text{HRMS}\ \text{Calcd\ for}\ C_{25}H_{27}NO_2P\ [M + H]^+:\ 404.1774,\ \text{found}:\ 404.1771.\]
4-((diphenylphosphoryl)methyl)-2-ethyl-4-methyl-3,4-dihydroisoquinolin-1(2H)-one (3k)

\[
\begin{align*}
\text{HNMR (400 MHz, Chloroform-}d\text{)} & \delta 8.04 (dd, J = 7.7, 1.4 Hz, 1H), 7.71 - 7.62 (m, 4H), 7.49 - 7.39 \text{ (m, 6H), 7.35 - 7.31 (m, 1H), 7.27 - 7.23 (m, 2H), 3.90 (d, J = 12.7 Hz, 1H), 3.82 - 3.73 (m, 1H), 3.53 (d, J = 12.7 Hz, 1H), 3.43 - 3.35 (m, 1H), 2.75 - 2.67 (m, 1H), 2.59 - 2.53 (m, 1H), 1.57 (s, 3H), 1.23 (t, J = 7.2 Hz, 3H); \\
13C NMR (101 MHz, Chloroform-}d\text{)} & \delta 163.8, 145.2 (d, J = 10.5 Hz), 135.1 (d, J = 99.0 Hz), 133.4 (d, J = 97.7 Hz), 132.0, 131.6 (d, J = 2.7 Hz), 131.4 (d, J = 2.9 Hz), 130.5 (d, J = 9.1 Hz), 130.0 (d, J = 9.2 Hz), 128.7 (d, J = 12.5 Hz), 128.6 (d, J = 10.6 Hz), 128.2, 127.3, 123.8, 55.6 (d, J = 4.8 Hz), 42.1, 37.8, 37.42 (d, J = 67.7 Hz), 37.36 (d, J = 3.6 Hz), 37.1, 23.1, 12.6; \\
31P NMR (162 MHz, Chloroform-}d\text{)} & \delta 27.37; HRMS Calcd for C25H27NO2P [M + H]+: 404.1774, found: 404.1765.
\end{align*}
\]

4-((diphenylphosphoryl)methyl)-2-isopropyl-4-methyl-3,4-dihydroisoquinolin-1(2H)-one (3l)

\[
\begin{align*}
\text{HNMR (400 MHz, Chloroform-}d\text{)} & \delta 8.06 - 7.97 (m, 1H), 7.68 - 7.60 (m, 4H), 7.46 - 7.36 (m, 6H), 7.30 - 7.24 (m, 2H), 7.22 - 7.18 (m, 1H), 5.14 - 5.08 (m, 1H), 3.81 (d, J = 12.7 Hz, 1H), 3.31 (dd, J = 12.8, 1.6 Hz, 1H), 2.69 - 2.57 (m, 2H), 1.59 (s, 3H), 1.28 (d, J = 6.8 Hz, 3H), 1.20 (d, J = 6.8 Hz, 3H); \\
13C NMR (101 MHz, Chloroform-}d\text{)} & \delta 163.5, 144.3 (d, J = 9.2 Hz), 135.4 (d, J = 99.0 Hz), 133.3 (d, J = 97.9 Hz), 131.9, 131.5 (d, J = 2.8 Hz), 131.3 (d, J = 2.9 Hz), 130.5 (d, J = 8.9 Hz), 129.9 (d, J = 9.1 Hz), 128.8, 128.7 (d, J = 11.1 Hz), 128.54 (d, J = 12.1 Hz), 128.45, 127.3, 124.0, 50.4 (d, J = 5.8 Hz), 43.9, 37.1, 37.0 (d, J = 3.5 Hz), 36.7 (d, J = 68.7 Hz), 36.4, 23.4, 20.0, 19.3; \\
31P NMR (162 MHz, Chloroform-}d\text{)} & \delta 27.10; HRMS Calcd for C25H29NO2P [M + H]+: 418.1930, found: 418.1922.
\end{align*}
\]

6-chloro-4-((diphenylphosphoryl)methyl)-2-ethyl-4-methyl-3,4-dihydroisoquinolin-1(2H)-one (3m)

\[
\begin{align*}
\text{HNMR (400 MHz, Chloroform-}d\text{)} & \delta 7.91 (d, J = 8.3 Hz, 1H), 7.70 - 7.61 (m, 4H), 7.48-7.38 (m, 6H), 7.22 (d, J = 2.0 Hz, 1H), 7.15 (dd, J = 8.3, 2.0 Hz, 1H), 3.85 - 3.69 (m, 2H), 3.53 - 3.38 (m, 2H), 2.67 - 2.54 (m, 2H), 1.55 (s, 3H), 1.22 (t, J = 7.2 Hz, 3H); \\
13C NMR (101 MHz, Chloroform-}d\text{)} & \delta 163.0, 146.4 (d, J = 9.6 Hz), 138.2, 134.9 (d, J = 99.5 Hz), 132.8 (d, J = 98.0 Hz), 131.7 (d, J = 2.7 Hz), 131.5 (d, J = 2.9 Hz), 130.5 (d, J = 9.2 Hz), 130.3, 130.0 (d, J = 9.2 Hz), 128.8 (d, J = 12.0 Hz), 128.6, (d, J = 12.1 Hz), 127.6, 126.7, 124.5, 56.2 (d, J = 5.8 Hz), 42.1, 37.5 (d, J = 3.4 Hz), 37.2 (d, J = 67.7 Hz), 23.0 (d, J = 2.1 Hz), 12.5; \\
31P NMR (162 MHz, Chloroform-}d\text{)} & \delta 27.16; HRMS Calcd for C25H26ClNO2P [M + H]+: 438.1384, found: 438.1388.
\end{align*}
\]
6-bromo-4-((diphenylphosphoryl)methyl)-2-ethyl-4-methyl-3,4-dihydroisoquinolin-1(2H)-one (3n)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 7.84 (d, J = 8.2 \text{ Hz}, 1\text{H}), 7.69 - 7.61 (m, 2\text{H}), 7.53 - 3.37 (m, 2\text{H}), 2.66 - 2.56 (m, 2\text{H}), 1.56 (s, 3\text{H}), 1.22 (t, J = 7.2 \text{ Hz}, 3\text{H}); \\
\text{13C NMR (101 MHz, Chloroform-}d\text{) } & \delta 163.1, 146.6 (d, J = 9.7 \text{ Hz}), 134.9 (d, J = 99.6 \text{ Hz}), 132.8 (d, J = 97.9 \text{ Hz}), 131.7 (d, J = 2.7 \text{ Hz}), 131.5 (d, J = 2.8 \text{ Hz}), 130.6, 130.47. (d, J = 99.6 Hz), 130.44, 130.0 (d, J = 9.2 Hz), 128.8 (d, J = 11.1 Hz), 128.6 (d, J = 11.1 Hz), 127.5, 127.1, 127.0, 56.3 (d, J = 5.9 Hz), 42.1, 37.6, 37.4 (d, J = 3.3 Hz), 37.2 (d, J = 3.3 Hz), 36.9, 23.0 (d, J = 2.1 Hz), 12.5; \\
\text{31P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.17; \\
\text{HRMS Calcd for C}_{25}H_{26}BrNO_2P [M + H]^+: 482.0879, found: 482.0876.
\end{align*}
\]

2-cyclopropyl-4-((diphenylphosphoryl)methyl)- 4-methyl-3,4-dihydroisoquinolin-1(2H)-one (3o)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 8.02 (dd, J = 7.7, 1.4 \text{ Hz}, 1\text{H}), 7.69 - 7.58 (m, 4\text{H}), 7.47 - 7.37 (m, 6\text{H}), 7.32 - 7.28 (m, 1\text{H}), 7.25 - 7.19 (m, 2\text{H}), 3.90 (d, J = 12.6 \text{ Hz}, 1\text{H}), 3.43 (d, J = 12.6 \text{ Hz}, 1\text{H}), 2.92 - 2.87 (m, 1\text{H}), 2.64 - 2.48 (m, 2\text{H}), 1.53 (s, 3\text{H}), 1.04 - 0.75 (m, 4\text{H}); \\
\text{13C NMR (101 MHz, Chloroform-}d\text{) } & \delta 166.0, 145.0 (d, J = 10.0 \text{ Hz}), 135.2 (d, J = 99.0 \text{ Hz}), 133.1 (d, J = 97.8 \text{ Hz}), 132.2, 131.6 (d, J = 2.7 \text{ Hz}), 131.4 (d, J = 2.7 \text{ Hz}), 130.6 (d, J = 9.0 \text{ Hz}), 129.9 (d, J = 9.2 \text{ Hz}), 128.8, 128.7 (d, J = 2.0 \text{ Hz}), 128.5 (d, J = 1.7 \text{ Hz}), 128.3, 127.3, 123.9, 57.0 (d, J = 5.0 \text{ Hz}), 37.5 (d, J = 3.6 \text{ Hz}), 37.1 (d, J = 68.3 Hz), 30.1, 23.1 (d, J = 2.4 Hz), 7.2, 6.1; \\
\text{31P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.17; \\
\text{HRMS Calcd for C}_{26}H_{27}NO_2P [M + H]^+: 416.1774, found: 416.1780.
\end{align*}
\]

4-((di-p-tolylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3p)

\[
\begin{align*}
\text{H NMR (400 MHz, Chloroform-}d\text{) } & \delta 8.04 (dd, J = 8.0, 1.5 \text{ Hz}, 1\text{H}), 7.69 - 7.58 (m, 4\text{H}), 7.47 - 7.37 (m, 1\text{H}), 7.29 - 7.25 (m, 2\text{H}), 7.24 - 7.20 (m, 4\text{H}), 3.85 (d, J = 12.7 \text{ Hz}, 1\text{H}), 3.49 (d, J = 12.7 \text{ Hz}, 1\text{H}), 3.00 (s, 3\text{H}), 2.72 - 2.65 (m, 1\text{H}), 2.50 - 2.44 (m, 1\text{H}), 2.37 (s, 3\text{H}), 2.35 (s, 3\text{H}), 1.56 (s, 3\text{H}); \\
\text{13C NMR (101 MHz, Chloroform-}d\text{) } & \delta 164.6, 145.8 (d, J = 10.9 \text{ Hz}), 142.1 (d, J = 2.8 \text{ Hz}), 141.8 (d, J = 2.8 \text{ Hz}), 132.1, 130.5 (d, J = 9.4 \text{ Hz}), 130.5 (d, J = 101.0 \text{ Hz}), 130.2 (d, J = 9.6 \text{ Hz}), 131.7 (d, J = 102.0 \text{ Hz}), 129.4 (d, J = 12.1 \text{ Hz}), 129.3, 128.6, 127.8, 127.1, 123.7, 57.9 (d, J = 4.4 \text{ Hz}), 38.1 (d, J = 67.4 Hz), 37.4 (d, J = 3.6 Hz), 34.8, 23.1 (d, J = 2.1 Hz), 21.5; \\
\text{31P NMR (162 MHz, Chloroform-}d\text{) } & \delta 27.80; \\
\text{HRMS Calcd for C}_{26}H_{29}NO_2P [M + H]^+: 418.1930, found: 418.1920.
\end{align*}
\]
4-((bis(4-methoxyphenyl)phosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3q)

1H NMR (400 MHz, Chloroform-d) δ 8.03 (dd, J = 8.0, 1.5 Hz, 1H), 7.58 - 7.52 (m, 4H), 7.36 - 7.32 (m, 1H), 7.27 - 7.23 (m, 2H), 6.94 - 6.89 (m, 4H), 3.85 - 3.82 (m, 4H), 3.80 (s, 3H), 3.48 (d, J = 12.7 Hz, 1H), 3.02 (s, 3H), 2.64 (m, 1H), 2.43 (m, 1H), 1.56 (s, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.6, 162.2 (d, J = 2.8 Hz), 162.0 (d, J = 3.0 Hz), 145.7 (d, J = 10.7 Hz), 133.8 (d, J = 11.2 Hz), 132.3 (d, J = 10.4 Hz), 132.0 (d, J = 10.1 Hz), 128.6, 127.8, 127.2, 126.3 (d, J = 105.3 Hz), 124.8 (d, J = 104.5 Hz), 123.8, 114.3 (d, J = 9.6 Hz), 114.1 (d, J = 9.6 Hz), 58.0 (d, J = 4.6 Hz), 55.3 (d, J = 1.6 Hz), 38.3 (d, J = 68.2 Hz), 37.4 (d, J = 3.6 Hz), 34.9, 23.1; 31P NMR (162 MHz, Chloroform-d) δ 27.80; HRMS Calcd for C26H29NO4P [M + H]+: 450.1829, found: 450.1826.

4-((bis(3-methoxyphenyl)phosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3r)

1H NMR (400 MHz, Chloroform-d) δ 8.01 (dd, J = 7.7, 1.5 Hz, 1H), 7.35 - 7.15 (m, 9H), 7.00 - 6.94 (m, 2H), 3.81 - 3.77 (m, 7H), 3.50 (d, J = 12.7 Hz, 1H), 3.03 (s, 3H), 2.70 - 2.63 (m, 1H), 2.56 - 2.51 (m, 1H), 1.59 (s, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 159.7 (d, J = 15.2 Hz), 159.3, (d, J = 14.1 Hz), 145.3 (d, J = 9.3 Hz), 136.1 (d, J = 97.9 Hz), 134.7 (d, J = 97.1 Hz), 132.0, 130.0 (d, J = 13.6 Hz), 129.8 (d, J = 13.8 Hz), 128.5, 127.9, 127.3, 123.9, 122.5 (d, J = 9.2 Hz), 122.1 (d, J = 9.3 Hz), 117.7 (d, J = 2.8 Hz), 117.5 (d, J = 2.7 Hz), 115.3 (d, J = 4.5 Hz), 115.2 (d, J = 4.3 Hz), 58.2 (d, J = 5.2 Hz), 55.4 (d, J = 1.8 Hz), 37.9 (d, J = 67.7 Hz), 37.4 (d, J = 3.7 Hz), 34.9, 23.1 (d, J = 2.1 Hz); 31P NMR (162 MHz, Chloroform-d) δ 27.46; HRMS Calcd for C26H29NO4P [M + H]+: 450.1829, found: 450.1825.

4-((bis(4-chlorophenyl)phosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3s)

1H NMR (400 MHz, Chloroform-d) δ 7.99 (dd, J = 7.2, 1.4 Hz, 1H), 7.56 - 7.46 (m, 4H), 7.40 (dd, J = 8.5, 2.4 Hz, 2H), 7.33 (dd, J = 8.5, 2.4 Hz, 2H), 7.28 - 7.23 (m, 3H), 3.66 (d, J = 12.7 Hz, 1H), 3.54 (dd, J = 12.8, 2.0 Hz, 1H), 3.07 (s, 3H), 2.59 (d, J = 10.5 Hz, 2H), 1.62 (s, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 144.2 (d, J = 9.0 Hz), 138.5 (d, J = 3.3 Hz), 138.2 (d, J = 3.5 Hz), 133.0 (d, J =
100.3 Hz), 132.1, 131.8 (d, J = 10.0 Hz), 131.4 (d, J = 10.1 Hz), 131.1 (d, J = 100.0 Hz), 129.2 (d, J = 12.2 Hz), 129.0 (d, J = 12.3 Hz), 128.6, 127.9, 127.5, 124.2, 58.9 (d, J = 6.7 Hz), 37.9 (d, J = 69.4 Hz), 37.4 (d, J = 3.6 Hz), 35.0, 23.2 (d, J = 2.1 Hz); 31P NMR (162 MHz, Chloroform-d) δ 26.64; HRMS Calcd for C24H23Cl2NO2P [M + H]+: 458.0838, found: 458.0831.

4-((di-m-tolylphosphoryl)methyl)-2,4-dimethyl-3,4-dihydroisoquinolin-1(2H)-one (3t)

\[
\text{N} \quad \text{O} \quad \text{P} \quad \text{O}
\]

1H NMR (400 MHz, Chloroform-d) δ 8.04 (dd, J = 7.7, 1.4 Hz, 1H), 7.53 - 7.39 (m, 4H), 7.33 - 7.22 (m, 7H), 3.77 (d, J = 12.7 Hz, 1H), 3.50 (d, J = 12.7 Hz, 1H), 3.01 (s, 3H), 2.70 - 2.63 (m, 1H), 2.58 - 2.52 (m, 1H), 2.36 (s, 3H), 2.35 (s, 3H), 1.61 (s, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.6, 145.3 (d, J = 10.1 Hz), 138.7 (d, J = 11.5 Hz), 138.4 (d, J = 11.5 Hz), 134.8 (d, J = 98.1 Hz), 133.4 (d, J = 97.6 Hz), 132.4 (d, J = 2.9 Hz), 132.2 (d, J = 2.8 Hz), 132.0, 131.0 (d, J = 8.8 Hz), 130.6 (d, J = 9.0 Hz), 128.6 (d, J = 12.3 Hz), 128.5, 128.4 (d, J = 13.1 Hz), 127.9, 127.4 (d, J = 9.4 Hz), 127.3, 127.2 (d, J = 9.5 Hz), 123.9, 58.3 (d, J = 5.1 Hz), 37.9 (d, J = 67.3 Hz), 37.4 (d, J = 3.6 Hz), 34.8, 23.2 (d, J = 2.0 Hz), 21.4 (d, J = 3.1 Hz); 31P NMR (162 MHz, Chloroform-d) δ 27.52; HRMS Calcd for C26H29NO2P [M + H]+: 418.1930, found: 418.1928.

ethyl-((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)(phenyl)phosphinate (3u), dr=1.15:1

\[
\text{N} \quad \text{O} \quad \text{P} \quad \text{O} \quad \text{Ph}
\]

1H NMR (400 MHz, Chloroform-d) δ 8.06 (dd, J = 7.7, 1.5 Hz, 1H), 7.74 - 7.68 (m, 2H), 7.56 - 7.46 (m, 4H), 7.35 - 7.29 (m, 2H), 3.98 - 3.92 (m, 1H), 3.77 (d, J = 12.7 Hz, 1H), 3.71 - 3.65 (m, 1H), 3.49 (d, J = 12.7 Hz, 1H), 2.99 (s, 3H), 2.48 - 2.21 (m, 2H), 1.75 (s, 3H), 1.20 (t, J = 7.2 Hz, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.50, 164.45, 146.14, 146.01, 145.58, 145.45, 132.61, 132.38, 132.35, 132.19, 132.16, 132.07, 132.02, 131.99, 131.49, 131.39, 131.36, 131.26, 130.85, 128.86, 128.73, 128.67, 128.58, 128.54, 128.51, 127.81, 127.19, 127.15, 123.63, 123.58, 60.46, 60.43, 60.39, 60.36, 57.94, 57.89, 57.51, 57.47, 39.09, 38.62, 38.12, 37.65, 36.71, 36.67, 36.67, 36.31, 36.29, 35.12, 34.75, 23.11, 23.09, 22.96, 22.94, 16.47, 16.40, 16.38, 16.32; 31P NMR (162 MHz, Chloroform-d) δ 40.54, 40.40; HRMS Calcd for C20H25NO3P [M + H]+: 358.1567, found: 358.1563.

dimethyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3v)
1H NMR (400 MHz, Chloroform-d) δ 8.11 (dd, J = 7.7, 1.4 Hz, 1H), 7.51 - 7.47 (m, 1H), 7.39-7.34 (m, 2H), 3.70 - 3.52 (m, 8H), 3.20 (s, 3H), 2.22 - 2.13 (m, 1H), 2.07 - 1.99 (m, 1H), 1.61 (s, 3H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 145.4 (d, J = 14.8 Hz), 132.1, 128.7, 128.0, 127.4, 123.7, 57.8 (d, J = 5.8 Hz), 52.2 (dd, J = 6.8, 1.6 Hz), 35.5 (d, J = 2.2 Hz), 35.1, 34.4, 33.1, 22.9 (d, J = 2.4 Hz); 31P NMR (162 MHz, Chloroform-d) δ 29.60; HRMS Calcd for C14H21NO4P [M + H]+: 298.1203, found: 298.1194.

diethyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3w)

1H NMR (400 MHz, Chloroform-d) δ 8.11 (dd, J = 8.2, 1.5 Hz, 1H), 7.50 - 7.46 (m, 1H), 7.38 - 7.34 (m, 2H), 4.06 - 3.94 (m, 4H), 3.73 (d, J = 12.7 Hz, 1H), 3.53 (d, J = 12.6 Hz, 1H), 3.20 (s, 3H), 2.21 - 1.98 (m, 2H), 1.61 (s, 3H), 1.28 (t, J = 7.1 Hz, 3H), 1.24 (t, J = 7.1 Hz, 4H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 145.6 (d, J = 14.9 Hz), 132.1, 128.6, 128.0, 127.3, 61.6 (d, J = 5.7 Hz), 61.5 (d, J = 6.1 Hz), 57.7 (d, J = 5.7 Hz), 35.6 (d, J = 36.4 Hz), 23.0 (d, J = 2.4 Hz), 16.43 (d, J = 6.3 Hz), 16.35 (d, J = 6.3 Hz); 31P NMR (162 MHz, Chloroform-d) δ 27.01; HRMS Calcd for C16H25NO4P [M + H]+: 326.1516, found: 326.1502.

diisopropyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3x)

1H NMR (400 MHz, Chloroform-d) δ 8.11 (dd, J = 8.2, 1.5 Hz, 1H), 7.50 - 7.46 (m, 1H), 7.38 - 7.34 (m, 2H), 4.69 - 4.61 (m, 2H), 3.82 (d, J = 12.6 Hz, 1H), 3.50 (d, J = 12.6 Hz, 1H), 3.20 (s, 3H), 2.18 - 2.09 (m, 1H), 1.98 - 1.89 (m, 1H), 1.60 (s, 3H), 1.30 - 1.25 (m, 12H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 146.1 (d, J = 16.0 Hz), 132.1, 128.6, 127.9, 127.2, 123.6, 70.3 (d, J = 6.5 Hz), 70.2 (d, J = 7.0 Hz), 57.4 (d, J = 4.4 Hz), 36.1 (d, J = 137.4 Hz), 35.7 (d, J = 2.5 Hz), 35.1, 24.1 (d, J = 4.1 Hz), 24.1 (d, J = 5.2 Hz), 23.0 (d, J = 2.4 Hz); 31P NMR (162 MHz, Chloroform-d) δ 25.32; HRMS Calcd for C18H29NO4P [M + H]+: 354.1829, found: 354.1830.

diisobutyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3y)

1H NMR (400 MHz, Chloroform-d) δ 8.10 (dd, J = 7.7, 1.5 Hz, 1H), 7.49 - 7.45 (m, 1H), 7.37 - 7.32 (m, 2H), 4.69 - 4.61 (m, 2H), 3.82 (d, J = 12.6 Hz, 1H), 3.50 (d, J = 12.6 Hz, 1H), 3.21 (s, 3H), 2.18 - 2.09 (m, 1H), 1.98 - 1.89 (m, 1H), 1.60 (s, 3H), 1.30 - 1.25 (m, 12H); 13C NMR (101 MHz, Chloroform-d) δ 164.5, 145.6 (d, J = 14.9 Hz), 132.1, 128.6, 127.9, 127.2, 123.6, 70.3 (d, J = 6.5 Hz), 70.2 (d, J = 7.0 Hz), 57.4 (d, J = 4.4 Hz), 36.1 (d, J = 137.4 Hz), 35.7 (d, J = 2.5 Hz), 35.1, 24.1 (d, J = 4.1 Hz), 24.1 (d, J = 5.2 Hz), 23.0 (d, J = 2.4 Hz); 31P NMR (162 MHz, Chloroform-d) δ 35.82; HRMS Calcd for C18H29NO4P [M + H]+: 354.1829, found: 354.1830.

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$^{31}$P NMR (162 MHz, Chloroform-$d$) $\delta$ 27.10; HRMS Calcd for $C_{20}H_{33}NO_4P$ [M + H]$^+$: 382.2142, found: 382.2133.  

**di-tert-butyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3z)**

\[ \text{di-tert-butyl((2,4-dimethyl-1-oxo-1,2,3,4-tetrahydroisoquinolin-4-yl)methyl)phosphonate (3z)} \]

$^1$H NMR (400 MHz, Chloroform-$d$) $\delta$ 8.10 (dd, $J = 7.6, 1.5$ Hz, 1H), 7.49 - 7.45 (m, 1H), 7.36 - 7.31 (m, 2H), 3.95 (d, $J = 12.6$ Hz, 1H), 3.47 (d, $J = 12.5$ Hz, 1H), 3.21 (s, 3H), 2.16 - 2.08 (m, 1H), 1.91 - 1.82 (m, 1H), 1.58 (s, 3H), 1.49 (s, 9H), 1.45 (s, 9H); $^{13}$C NMR (101 MHz, Chloroform-$d$) $\delta$ 164.6, 146.7 (d, $J = 16.6$ Hz), 132.0, 128.5, 127.9, 127.0, 123.6, 82.6 (d, $J = 9.5$ Hz), 82.2 (d, $J = 8.2$ Hz), 57.0 (d, $J = 3.7$ Hz), 38.7 (d, $J = 141.1$ Hz), 35.9 (d, $J = 2.9$ Hz), 35.0, 30.6 (d, $J = 4.1$ Hz), 30.4 (d, $J = 3.8$ Hz), 23.1 (d, $J = 2.6$ Hz); $^{31}$P NMR (162 MHz, Chloroform-$d$) $\delta$ 19.02; HRMS Calcd for $C_{20}H_{33}NO_4P$ [M + H]$^+$: 382.2142, found: 382.2149.  

**4-((diphenylphosphoryl)methyl)-2-methyl-3,4-dihydroisoquinolin-1(2H)-one (3aa)**

\[ \text{4-((diphenylphosphoryl)methyl)-2-methyl-3,4-dihydroisoquinolin-1(2H)-one (3aa)} \]

$^1$H NMR (400 MHz, Chloroform-$d$) $\delta$ 8.07 – 8.04 (m, 1H), 7.78 - 7.70 (m, 4H), 7.55 - 7.45 (m, 6H), 7.34 - 7.28 (m, 2H), 7.04 - 7.02 (m, 1H), 3.76 (dd, $J = 12.9, 4.0$ Hz, 1H), 3.59 (dd, $J = 12.9, 2.2$ Hz, 1H), 3.52 – 3.44 (m, 1H), 2.91 (s, 3H), 2.85 – 2.73 (m, 1H), 2.46 – 2.39 (m, 1H); $^{13}$C NMR (101 MHz, Chloroform-$d$) $\delta$ 164.5, 141.7 (d, $J = 11.6$ Hz), 133.7 (d, $J = 98.4$ Hz), 132.5 (d, $J = 102.0$ Hz), 132.0 (d, $J = 2.7$ Hz), 131.9 (d, $J = 2.9$ Hz), 130.6 (d, $J = 9.2$ Hz), 130.4 (d, $J = 9.5$ Hz), 128.9 (d, $J = 8.3$ Hz), 128.8 (d, $J = 8.2$ Hz), 128.4 (d, $J = 2.0$ Hz), 127.6, 126.2, 51.7 (d, $J = 3.2$ Hz), 35.1, 33.2 (d, $J = 68.3$ Hz), 32.5 (d, $J = 2.7$ Hz); $^{31}$P NMR (162 MHz, Chloroform-$d$) $\delta$ 29.29; HRMS Calcd for $C_{23}H_{23}NO_4P$ [M + H]$^+$: 376.1461, found: 376.1460
4. $^1$H, $^{13}$C and $^{31}$P NMR spectra

3a, 400 MHz, CDCl$_3$

3a, 101 MHz, CDCl$_3$
3a, 162 MHz, CDCl₃

3b, 400 MHz, CDCl₃
3b, 101 MHz, CDCl₃

3b, 162 MHz, CDCl₃
3e, 400 MHz, CDCl₃

3e, 101 MHz, CDCl₃
3c, 162 MHz, CDCl₃

3d, 400 MHz, CDCl₃
**3d, 101 MHz, CDCl₃**

**3d, 162 MHz, CDCl₃**
$\text{3e, 400 MHz, CDCl}_3$

$\text{3e, 101 MHz, CDCl}_3$
$\\text{3e, 162 MHz, CDCl}_3$

$\\text{3f, 400 MHz, CDCl}_3$
$3f$, 101 MHz, CDCl$_3$

$3f$, 162 MHz, CDCl$_3$
3g, 162 MHz, CDCl₃

3h, 400 MHz, CDCl₃
3h, 101 MHz, CDCl₃

3h, 162 MHz, CDCl₃
3i, 400 MHz, CDCl₃

3i, 101 MHz, CDCl₃
3i, 162 MHz, CDCl₃

3j, 400 MHz, CDCl₃
3j, 101 MHz, CDCl$_3$

3j, 162 MHz, CDCl$_3$
$3k$, 400 MHz, CDCl$_3$

$3k$, 101 MHz, CDCl$_3$
3k, 162 MHz, CDCl₃

3l, 400 MHz, CDCl₃
$\text{31, 101 MHz, CDCl}_3$

$\text{31, 162 MHz, CDCl}_3$
3m, 400 MHz, CDCl₃

3m, 101 MHz, CDCl₃
3m, 162 MHz, CDCl₃

3n, 400 MHz, CDCl₃
3n, 101 MHz, CDCl₃

3n, 162 MHz, CDCl₃
$3o$, 400 MHz, CDCl$_3$

$3o$, 101 MHz, CDCl$_3$
30, 162 MHz, CDCl₃

3p, 400 MHz, CDCl₃
$3p$, 101 MHz, CDCl$_3$

$3p$, 162 MHz, CDCl$_3$
3q. 400 MHz, CDCl₃

3q. 101 MHz, CDCl₃
3q, 162 MHz, CDCl₃

3r, 400 MHz, CDCl₃
$3s$, 400 MHz, CDCl$_3$

$3s$, 101 MHz, CDCl$_3$
3s, 162 MHz, CDCl₃

3t, 400 MHz, CDCl₃
$3t, 101\text{ MHz, CDCl}_3$

$3t, 162\text{ MHz, CDCl}_3$
3u, 400 MHz, CDCl₃

3u, 101 MHz, CDCl₃
3u, 162 MHz, CDCl₃

3v, 400 MHz, CDCl₃
3v, 101 MHz, CDCl₃

3v, 162 MHz, CDCl₃
$\text{3w, 400 MHz, CDCl}_3$

$\text{3w, 101 MHz, CDCl}_3$
$3\text{w}, 162\text{ MHz, CDCl}_3$

$3\text{x, 400 MHz, CDCl}_3$
$3x$, 101 MHz, CDCl$_3$

$3x$, 162 MHz, CDCl$_3$
$\begin{align*}
3y, 400 \text{ MHz, CDCl}_3 \\
\end{align*}$
3y, 162 MHz, CDCl₃

3z, 400 MHz, CDCl₃
3z, 101 MHz, CDCl₃

3z, 162 MHz, CDCl₃
3aa, 400 MHz, CDCl₃

3aa, 101 MHz, CDCl₃
3aa, 162 MHz, CDCl₃