Ni vs. Pd in Suzuki-Miyaura sp<sup>2</sup>-sp<sup>2</sup> cross-coupling:

A head-to-head study in a comparable precatalyst/ligand system

Matthew J. West and Allan J. B. Watson*

EaStCHEM, School of Chemistry, University of St Andrews, North Haugh, St Andrews, KY16 9ST, UK.

Email: aw260@st-andrews.ac.uk

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1. General

All reagents and solvents were obtained from commercial suppliers and were used without further purification unless otherwise stated. Purification was carried out according to standard laboratory methods.¹

1.1. Purification of solvents

All solvents used for dry reactions (PhMe, CH₂Cl₂, THF, and Et₂O) were obtained from a PureSolv SPS-400-5 solvent purification system. These solvents were transferred to and stored in a septum-sealed oven-dried flask over previously activated 4 Å molecular sieves and purged with and stored under N₂. All Ni and Pd precatalysts used are commercially available and can be sourced from Sigma Aldrich. Ni(dppf)(o-tol)Cl was also prepared via a known method.² Dry 1,4-dioxane was obtained by distillation over LiAlH₄ and transferred to and stored in a septum-sealed oven-dried flask over previously activated 4 Å molecular sieves and purged with and stored under N₂. EtOAc, Et₂O, MeOH, CH₂Cl₂, and petroleum ether 40–60 °C for purification purposes were used as obtained from suppliers without further purification.

1.2. Drying of inorganic bases

Inorganic bases were dried in a Heraeus Vacutherm oven at 60 °C under static vacuum for a minimum of 24 hours before use.

1.3. Experimental details

Reactions were carried out using conventional glassware (preparation of intermediates) or in 5 mL capped microwave vials (optimization reactions and substrates). The glassware was oven-dried (150 °C) and cooled under vacuum before use. Purging refers to a vacuum/N₂-refilling procedure. Room temperature was generally 20 °C. Reactions were carried out at elevated temperatures using a temperature-regulated hotplate/stirrer and a sandbath. Temperature quoted is a measurement of the sandbath heating block. Reactions were carried out at 0 °C using an ice bath. Reactions were carried out at −78 °C using an acetone/dry ice bath.

1.4. Purification of products

Thin layer chromatography (TLC) was carried out using Merck silica plates coated with fluorescent indicator UV254. These were analyzed under 254 nm UV light or developed using potassium permanganate, vanillin, or anisaldehyde solutions. Column chromatography was carried out using ZEOprep 60 HYD 40–63 μm silica gel.

1.5. Analysis of products

¹⁹F NMR spectra were obtained on either a Bruker AV 400 spectrometer at 376 MHz or Bruker AV 500 at 470 MHz. ¹H and ¹³C NMR spectra were obtained on either a Bruker AV 400 at 400 MHz and 125 MHz, Bruker AV 500 at 500 MHz and 126 MHz, respectively. Chemical shifts are reported in ppm and coupling constants are reported in Hz: CDCl₃ referenced at 7.26 (¹H) and 77.0 ppm (¹³C); DMSO-d₆ referenced at 2.50 (¹H) and 39.5 ppm (¹³C). For fluorine containing molecules NMR conversion was obtained through the addition of a known standard (trifluorotoluene (30.7 µL, 0.25 mmol)), referenced at −63.0 ppm). After 10 min of stirring, an aliquot of the mixture was filtered through celite and conversion against the internal standard was determined by ¹⁹F NMR. NMR conversion was obtained through addition of a known standard (1,4-dinitrobenzene) to the crude reaction mixture. Solvent was removed under reduced pressure and conversion against the internal standard was determined by ¹H NMR.

Reverse phase HPLC data was obtained on an Agilent 1200 series HPLC using an Agilent Eclipse XDB-C18 column. Analysis was performed using a gradient method, eluting with 5–85% MeCN/H₂O over 8 minutes at a flow rate of 2 mL/min. Samples for HPLC analysis were prepared through the addition of 1.0 mL of naphthalene standard solution (0.03125 M) to the reaction mixture (0.25 mmol). The resulting solution was then stirred before the removal of a 200 µL aliquot. The aliquot was diluted to 1 mL with MeCN. A 200 µL aliquot of the diluted solution was then filtered through Celite and further diluted with 800 µL MeCN and 500 µL H₂O for HPLC analysis against established conversion factors.
2. General experimental procedures


For example, synthesis of compound 3a

To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpdpf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to room temperature, decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the desired product was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

2.2 Method A: Ni-catalyzed Suzuki-Miyaura cross coupling.

For example, synthesis of compound 3a

To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpdpf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The vial was then allowed to cool to room temperature, decapped, diluted with EtOAc (10 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H$_2$O (3 x 10 mL) followed by brine (10 mL) and the organic phases collected. The organic phase was dried over Na$_2$SO$_4$, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (42.4 mg, 98%).

2.3 Method B: Pd-catalyzed Suzuki-Miyaura cross coupling.

For example, synthesis of compound 3a

To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpdpf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The vial was then allowed to cool to room temperature, decapped, diluted with EtOAc (10 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H$_2$O (3 x 10 mL) followed by brine (10 mL) and the organic phases collected. The organic phase was dried over Na$_2$SO$_4$, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (42.4 mg, 98%).
To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M), followed by H$_2$O (22.5 µL, 1.25 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C with stirring. The vial was then allowed to cool to room temperature, decapped, diluted with EtOAc (10 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H$_2$O (3 x 10 mL) followed by brine (10 mL) and the organic phases collected. The organic phase was dried over Na$_2$SO$_4$, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (42.1 mg, 98%).

3. Reaction optimization data

3.1 Time study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for x h at 80 °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Time (h)</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>96</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Quant.</td>
</tr>
</tbody>
</table>

3.2 Catalyst Loading study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (x mg, y mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst loading (x mg, y mol%)</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.4 mg, 4 mol%</td>
<td>Quant.</td>
</tr>
<tr>
<td>2</td>
<td>3.8 mg, 2 mol%</td>
<td>Quant.</td>
</tr>
<tr>
<td>3</td>
<td>1.9 mg, 1 mol%</td>
<td>96</td>
</tr>
</tbody>
</table>

3.3 Base study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), Base (3 equiv, x mg), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Base (3 equiv, x mg)</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K$_3$PO$_4$ (159 mg)</td>
<td>Quant.</td>
</tr>
<tr>
<td>2</td>
<td>Cs$_2$CO$_3$ (244 mg)</td>
<td>18</td>
</tr>
</tbody>
</table>
3.4 Water study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpff)(o-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), 1,4-dioxane (1 mL, 0.25 M), and H$_2$O (x equiv, y µL). The reaction was stirred for 4 h at 80 °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>H$_2$O (x equiv, y µL)</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 equiv, 0 µL</td>
<td>Quant.</td>
</tr>
<tr>
<td>2</td>
<td>1 equiv, 4.5 µL</td>
<td>99</td>
</tr>
<tr>
<td>3</td>
<td>2 equiv, 9 µL</td>
<td>93</td>
</tr>
<tr>
<td>4</td>
<td>3 equiv, 13.5 µL</td>
<td>92</td>
</tr>
<tr>
<td>5</td>
<td>5 equiv, 22.5 µL</td>
<td>68</td>
</tr>
</tbody>
</table>

3.5 Solvent study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpff)(o-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and solvent (1 mL, 0.25 M). The reaction was stirred for 4 h at 80 °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,4-dioxane</td>
<td>Quant.</td>
</tr>
<tr>
<td>2</td>
<td>THF</td>
<td>91</td>
</tr>
<tr>
<td>3</td>
<td>PhMe</td>
<td>83</td>
</tr>
</tbody>
</table>

3.6 Temperature study

Reactions were carried out according to General Procedure using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dpff)(o-tol)Cl (1.9 mg, 0.0025 mmol, 1 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction was stirred for 4 h at x °C, before analysis by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Temperature (°C)</th>
<th>Product conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>Quant.</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>93</td>
</tr>
<tr>
<td>3</td>
<td>room temperature</td>
<td>0</td>
</tr>
</tbody>
</table>
4. Compound characterization data

4.1. Preparation of starting materials

(5-Phenylthiophen-2-yl)boronic acid, 2v

![Image of (5-Phenylthiophen-2-yl)boronic acid]

To an oven dried round bottom flask was added 2-phenylthiophene (2.04 g, 12.7 mmol), the flask was sealed and purged with N₂. Dry THF (40 mL) was added to the flask and the reaction mixture stirred under N₂ at 0 °C for 10 minutes. n-BuLi in THF (5.71 mL, 2.2 M, 1 equiv) was added to the reaction mixture dropwise and the reaction allowed to stir for 1 h at 0 °C. The reaction mixture was then added dropwise to a stirred solution of trimethyl borate (2.84 mL, 25.5 mL, 2 equiv) in THF (20 mL) at −78 °C via cannula, following addition the reaction was stirred overnight under N₂, allowing to warm to room temperature. The mixture was then acidified with HCl (2 M, 20 mL) and stirred for 1 h. The aqueous layer was extracted with diethyl ether (3 × 40 mL) and the organic layer was washed with water and dried over Na₂SO₄. The solvent was removed under vacuum and the resulting crude product was recrystallized from H₂O/EtOH (50/50) to give the product as a grey solid (1.63 g, 62%).

¹H NMR (500 MHz, DMSO-d₆) δ 8.28 (s, 2H), 7.70 – 7.63 (m, 3H), 7.53 (d, J = 3.6 Hz, 1H), 7.44 – 7.39 (m, 2H), 7.34 – 7.28 (m, 1H).

¹³C NMR (126 MHz, DMSO-d₆) δ 148.8, 137.3, 133.9, 129.2, 127.8, 125.6, 124.8.

Spectroscopic data were in agreement with literature values.³

4.2 Products of bromide substrate survey

**Compound 3a**

![Image of Compound 3a]

**Method A:** According to the Method A, using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), and K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.4 mg, 98%).

**Method B:** According to the Method B, using 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.1 mg, 98%).

¹H NMR (400 MHz, CDCl₃) δ 7.59 – 7.54 (m, 4H), 7.48 – 7.43 (m, 2H), 7.39 – 7.34 (m, 1H), 7.18 – 7.11 (m, 2H).

¹³C NMR (101 MHz, CDCl₃) δ 162.5 (d, JCF = 246.1 Hz), 140.3, 137.4, 128.8, 128.7 (d, JCF = 7.7 Hz), 127.2, 127.0, 115.6 (d, JCF = 21.5 Hz).
$^{19}$F NMR (376 MHz, CDCl$_3$) δ –115.80 – –115.88 (m).

Spectroscopic data were in agreement with literature values.$^4$

**Compound 3b**

![Compound 3b](image)

**Method A**: Prepared according to the Method A, using 3-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (33.4 mg, 86%).

**Method B**: Prepared according to the Method B, using 3-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (33.0 mg, 85%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.86 – 8.85 (m, 1H), 8.59 (dd, $J = 4.8$, 1.7 Hz, 1H), 7.87 (ddd, $J = 7.9$, 2.4, 1.6 Hz, 1H), 7.60 – 7.56 (m, 2H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 7.36 (ddd, $J = 7.9$, 4.8, 0.9 Hz, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 148.4, 148.3, 137.8, 136.6, 134.3, 129.0, 128.1, 127.1, 123.5.

Spectroscopic data were in agreement with literature values.$^5$

**Compound 3c**

![Compound 3c](image)

**Method A**: Prepared according to the Method A, using 2-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (3.5 mg, 9%).

**Method B**: According to the Method B, using 2-bromopyridine (39.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5-30% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (22.3 mg, 57%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.75 – 7.99 (m, 1H), 8.04 – 7.97 (m, 2H), 7.77 – 7.70 (m, 2H), 7.52 – 7.45 (m, 2H), 7.44 – 7.39 (m, 1H), 7.25 – 7.20 (m, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 157.5, 149.6, 139.4, 136.7, 128.9, 128.7, 126.9, 122.1, 120.5.
Spectroscopic data were in agreement with literature values.\textsuperscript{5}

**Compound 3d**

\[
\begin{array}{c}
\text{Me}
\end{array}
\]

**Method A:** According to the Method A, using 5-bromo-1-methyl-1\textit{H}-indole (52.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K\textsubscript{3}PO\textsubscript{4} (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60\textdegree) to afford the product as a white solid (49.9 mg, 96%).

**Method B:** According to the Method B, using 5-bromo-1-methyl-1\textit{H}-indole (52.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl\textsubscript{2} (7.3 mg, 0.01 mmol, 4 mol%), K\textsubscript{3}PO\textsubscript{4} (159 mg, 0.75 mmol, 3 equiv), H\textsubscript{2}O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60\textdegree) to afford the product as a white solid (48.1 mg, 93%).

\textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \delta 7.97 – 7.88 (m, 1H), 7.77 – 7.70 (m, 2H), 7.59 – 7.48 (m, 3H), 7.47 – 7.41 (m, 1H), 7.41 – 7.35 (m, 1H), 7.12 (d, \textit{J} = 3.1 Hz, 1H), 6.64 – 6.58 (m, 1H), 3.84 (s, 3H).

\textsuperscript{13}C NMR (101 MHz, CDCl\textsubscript{3}) \delta 142.6, 136.2, 132.8, 129.4, 128.9, 128.6, 127.3, 126.2, 121.3, 119.4, 109.4, 101.3, 32.9.

Spectroscopic data were in agreement with literature values.\textsuperscript{5}

**Compound 3e**

\[
\begin{array}{c}
\text{N} = \text{N}
\end{array}
\]

**Method A:** According to the Method A, using 1-benzyl-5-bromo-1\textit{H}-tetrazole (59.1 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K\textsubscript{3}PO\textsubscript{4} (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, using 1-benzyl-5-bromo-1\textit{H}-tetrazole (59.1 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl\textsubscript{2} (7.3 mg, 0.01 mmol, 4 mol%), K\textsubscript{3}PO\textsubscript{4} (159 mg, 0.75 mmol, 3 equiv), H\textsubscript{2}O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.
Compound 3f

Method A: According to the Method A, using 1-(3-bromophenyl)ethan-1-one (49.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 5% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (44.6 mg, 91%).

Method B: According to the Method B, using 1-(3-bromophenyl)ethan-1-one (49.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (47.6 mg, 97%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.23 – 8.17 (m, 1H), 7.96 – 7.92 (m, 1H), 7.79 (ddd, J = 7.7, 1.9, 1.1 Hz, 1H), 7.65 – 7.61 (m, 2H), 7.56 – 7.51 (m, 1H), 7.50 – 7.45 (m, 2H), 7.44 – 7.35 (m, 1H), 2.66 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 198.0, 141.6, 140.1, 137.6, 131.6, 129.0, 128.8, 127.7, 127.1, 126.9, 26.7.

Spectroscopic data were in agreement with literature values.

Compound 3g

Method A: According to the Method A, using 2-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (45.1 mg, 100%).

Method B: According to the Method B, using 2-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as white solid (42.8 mg, 96%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.80 – 7.73 (m, 1H), 7.68 – 7.62 (m, 1H), 7.60 – 7.55 (m, 2H), 7.54 – 7.41 (m, 5H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 145.4, 138.0, 133.6, 132.7, 130.0, 128.7, 128.6, 127.5, 118.6, 111.2.

Spectroscopic data were in agreement with literature values.
**Compound 3h**

![Diagram of Compound 3h]

**Method A:** According to the Method A, using 4-bromobenzaldehyde (46.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (43.3 mg, 95%).

**Method B:** According to the Method B, using 4-bromobenzaldehyde (46.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (42.9 mg, 94%).

1H NMR (500 MHz, CDCl$_3$) δ 10.06 (s, 1H), 7.98 – 7.92 (m, 2H), 7.78 – 7.73 (m, 2H), 7.67 – 7.61 (m, 2H), 7.52 – 7.45 (m, 2H), 7.46 – 7.39 (m, 1H).

13C NMR (126 MHz, CDCl$_3$) δ 192.0, 147.2, 139.7, 135.1, 130.3, 129.0, 128.5, 127.7 127.4.

Spectroscopic data were in agreement with literature values.

**Compound 3i**

![Diagram of Compound 3i]

**Method A:** According to the Method A, using 1-bromo-2-methoxybenzene (46.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (38.3 mg, 83%).

**Method B:** According to the Method B, using 1-bromo-2-methoxybenzene (46.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-2% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (40.9 mg, 89%).

1H NMR (400 MHz, CDCl$_3$) δ 7.59 – 7.55 (m, 2H), 7.49 – 7.41 (m, 2H), 7.41 – 7.33 (m, 3H), 7.12 – 7.03 (m, 1H), 7.04 – 7.01 (m, 1H), 3.84 (s, 3H).

13C NMR (101 MHz, CDCl$_3$) δ 156.4, 138.5, 130.9, 130.7, 129.5, 128.6, 127.9, 126.9, 120.8, 111.2, 55.5.

Spectroscopic data were in agreement with literature values.

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S10
Compound 3j

**Method A:** According to the Method A, using 5-bromofuran-2-carbaldehyde (43.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (39.7 mg, 92%).

**Method B:** According to the Method B, using 5-bromofuran-2-carbaldehyde (43.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (29.6 mg, 69%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 9.65 (s, 1H), 7.86 – 7.80 (m, 2H), 7.48 – 7.37 (m, 3H), 7.32 (d, $J = 3.7$ Hz, 1H), 6.85 (d, $J = 3.7$ Hz, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 177.3, 159.4, 152.0, 129.7, 128.9, 125.3, 107.7.

Spectroscopic data were in agreement with literature values.$^{11}$

Compound 3k

**Method A:** According to the Method A, using 4-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-6% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (44.7 mg, 100%).

**Method B:** According to the Method B, using 4-bromobenzonitrile (45.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as white solid (43.8 mg, 98%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.75 – 7.66 (m, 4H), 7.61 – 7.57 (m, 2H), 7.52 – 7.46 (m, 2H), 7.46 – 7.41 (m, 1H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 145.5, 139.0, 132.5, 129.0, 128.6, 127.6, 127.1, 118.8, 110.7.

Spectroscopic data were in agreement with literature values.$^4$
Compound 3I

**Method A:** According to the Method A, using 5-bromothiophene-2-carbaldehyde (47.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-20% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (47.0 mg, 100%).

**Method B:** According to the Method B, using 5-bromothiophene-2-carbaldehyde (47.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-20% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid (35.0 mg, 74%).

**Compound 3m**

**Method A:** According to the Method A, using 4-bromo-2,6-dimethylpyridine (46.2 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv) and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 96%, determined by ¹H NMR assay.

**Method B:** According to the Method B, using 4-bromo-2,6-dimethylpyridine (46.2 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 70%, determined by ¹H NMR assay. For characterisation purposes, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a yellow solid.

¹H NMR (400 MHz, CDCl₃) δ 7.65 – 7.58 (m, 2H), 7.49 – 7.38 (m, 3H), 7.19 – 7.16 (m, 2H), 2.59 (s, 6H).

¹³C NMR (101 MHz, CDCl₃) δ 158.1, 149.0, 138.7, 128.9, 128.7, 127.0, 118.4, 24.5.

Spectroscopic data were in agreement with literature values.
Compound 3n

**Method A:** According to the Method A, using 5-bromobenzofuran (49.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (44.8 mg, 92%).

**Method B:** According to the Method B, using 5-bromobenzofuran (49.3 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (46.8 mg, 96%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.84 (dd, $J = 1.8$, 0.7 Hz, 1H), 7.70 – 7.65 (m, 3H), 7.63 – 7.55 (m, 2H), 7.52 – 7.47 (m, 2H), 7.41 – 7.36 (m, 1H), 6.85 (dd, $J = 2.2$, 0.9 Hz, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 154.5, 145.5, 141.6, 136.5, 128.7, 127.9, 127.4, 126.8, 124.0, 119.7, 111.5, 106.8.

Spectroscopic data were in agreement with literature values.$^{14}$

Compound 3o

**Method A:** According to the Method A, using methyl 3-bromobenzoate (53.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (45.8 mg, 86%).

**Method B:** According to the Method B, using methyl 3-bromobenzoate (53.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (48.4 mg, 91%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.31 – 8.29 (m, 1H), 8.06 – 8.02 (m, 1H), 7.79 (ddd, $J = 7.7$, 1.9, 1.2 Hz, 1H), 7.66 – 7.61 (m, 2H), 7.55 – 7.45 (m, 3H), 7.42 – 7.35 (m, 1H), 3.96 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 167.0, 141.4, 140.1, 131.5, 130.7, 128.8, 128.8, 128.3, 128.2, 127.7, 127.1, 52.1.
Spectroscopic data were in agreement with literature values.\textsuperscript{12}

**Compound 3p**

![Structure of Compound 3p]

**Method A:** According to the Method A, using 6-bromoquinoline (52.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-35\% EtOAc in petroleum ether 40-60\(^\circ\)) to afford the product as a yellow solid (49.2 mg, 96%).

**Method B:** According to the Method B, using 6-bromoquinoline (52.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-35\% EtOAc in petroleum ether 40-60\(^\circ\)) to afford the product as a yellow solid (43.2 mg, 84%).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.91 (dd, $J = 4.3, 1.8$ Hz, 1H), 8.22 – 8.15 (m, 2H), 8.03 – 7.95 (m, 2H), 7.75 – 7.67 (m, 2H), 7.55 – 7.46 (m, 2H), 7.43 – 7.37 (m, 2H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 150.3, 147.6, 140.2, 139.2, 129.8, 129.1, 128.9, 128.4, 127.7, 127.4, 125.4, 121.4.

Spectroscopic data were in agreement with literature values.\textsuperscript{15}

**Compound 3q**

![Structure of Compound 3q]

**Method A:** According to the Method A, 1-bromo-4-nitrobenzene (50.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, using 1-bromo-4-nitrobenzene (50.5 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 $\mu$L, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 20-30\% EtOAc in petroleum ether 40-60\(^\circ\)) to afford the product as a white solid (47.6 mg, 96%).

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.34 – 8.23 (m, 2H), 7.78 – 7.69 (m, 2H), 7.67 – 7.59 (m, 2H), 7.55 – 7.41 (m, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 147.6, 147.0, 138.7, 129.1, 128.9, 128.4, 127.7, 127.4, 125.4, 121.4.

Spectroscopic data were in agreement with literature values.\textsuperscript{16}
Compound 3r

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\text{SO}_2\text{Me} \\
\end{array}
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**Method A:** According to the Method A, using 1-bromo-3-(methylsulfonyl)benzene (58.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 57%, determined by $^1$H NMR assay.

**Method B:** According to the Method B, using 1-bromo-3-(methylsulfonyl)benzene (58.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 20-30% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (58.1 mg, 100%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 8.19 – 8.15 (m, 1H), 7.93 – 7.90 (m, 1H), 7.88 – 7.86 (m, 1H), 7.67 – 7.60 (m, 3H), 7.51 – 7.46 (m, 2H), 7.44 – 7.40 (m, 1H), 3.10 (s, 3H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 142.7, 141.1, 138.9, 132.2, 129.8, 129.1, 128.4, 127.2, 125.9, 125.8, 44.5.

Spectroscopic data were in agreement with literature values.

**Compound 3s**

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\text{O} \\
\end{array}
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**Method A:** According to the Method A, using 4-bromo-3,5-dimethylisoxazole (44.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, using 4-bromo-3,5-dimethylisoxazole (44.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (13.2 mg, 30%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.49 – 7.42 (m, 2H), 7.41 – 7.35 (m, 1H), 7.30 – 7.25 (m, 2H), 2.42 (s, 3H), 2.29 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 165.2, 158.7, 130.5, 129.1, 128.8, 127.5, 116.6, 11.5, 10.8.

Spectroscopic data were in agreement with literature values.
**Compound 3t**

![Chemical Structure](image)

**Method A:** According to the Method A, using 5-bromo-1H-indole (49.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°C) to afford the product as a white solid (46.8 mg, 97%).

**Method B:** According to the Method B, using 5-bromo-1H-indole (49.0 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°C) to afford the product as a white solid (44.0 mg, 91%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.08 (s, 1H), 7.93 (d, $J = 2.7$ Hz, 1H), 7.76 – 7.68 (m, 2H), 7.55 – 7.44 (m, 4H), 7.42 – 7.34 (m, 1H), 7.23 (t, $J = 2.8$ Hz, 1H), 6.67 – 6.64 (m, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 142.5, 135.3, 133.4, 128.6, 128.3, 127.4, 126.3, 124.8, 121.9, 119.2, 111.2, 103.0.

Spectroscopic data were in agreement with literature values.$^{19}$

**4.2 Products of boronic acid substrate survey**

**Compound 3u**

![Chemical Structure](image)

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-nitrophenyl)boronic acid (46.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-nitrophenyl)boronic acid (46.7 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°C) to afford the product as a yellow oil (25.5 mg, 51%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.86 (dd, $J = 8.1$, 1.3 Hz, 1H), 7.62 (td, $J = 7.6$, 1.3 Hz, 1H), 7.49 (td, $J = 7.8$, 1.5 Hz, 1H), 7.47 – 7.39 (m, 4H), 7.36 – 7.31 (m, 2H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 149.2, 137.3, 136.3, 132.3, 131.9, 128.7, 128.2, 128.1, 127.8, 124.1.

Spectroscopic data were in agreement with literature values.$^{17}$
Compound 3v

\[
\begin{align*}
\text{SO}_2\text{Me} \\
\text{H} \\
\text{H}
\end{align*}
\]

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylsulfonyl)phenyl)boronic acid (55.0 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-15% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (21.0 mg, 36%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylsulfonyl)phenyl)boronic acid (55.0 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-15% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (45.0 mg, 78%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.04 – 7.97 (m, 2H), 7.79 – 7.75 (m, 2H), 7.63 – 7.59 (m, 2H), 7.51 – 7.46 (m, 2H), 7.45 – 7.40 (m, 1H), 3.09 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 146.6, 139.1, 129.0, 128.6, 127.9, 127.8, 127.3, 44.5.

Spectroscopic data were in agreement with literature values.$^{20}$

Compound 3w

\[
\begin{align*}
\text{NMe}_2 \\
\text{H} \\
\text{H}
\end{align*}
\]

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-(dimethylamino)phenyl)boronic acid (45.4 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-4% EtOAc in petroleum ether 40-60°) to afford the product as a yellow oil (41.7 mg, 85%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-(dimethylamino)phenyl)boronic acid (45.4 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-4% EtOAc in petroleum ether 40-60°) to afford the product as a yellow oil (47.7 mg, 97%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.72 – 7.66 (m, 2H), 7.55 – 7.48 (m, 2H), 7.44 – 7.37 (m, 2H), 7.08 – 7.05 (m, 2H), 6.88 – 6.83 (m, 1H), 3.08 (s, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 150.6, 142.3, 142.1, 129.4, 128.5, 127.3, 127.1, 116.2, 111.8, 111.7, 40.8.

Spectroscopic data were in agreement with literature values.$^{21}$
Compound 3x

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-2-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K3PO4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (20.0 mg, 50%).

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-2-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl2 (7.3 mg, 0.01 mmol, 4 mol%), K3PO4 (159 mg, 0.75 mmol, 3 equiv), H2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (32.1 mg, 80%).

1H NMR (400 MHz, CDCl3) δ 7.66 – 7.63 (m, 2H), 7.43 – 7.37 (m, 2H), 7.35 – 7.28 (m, 3H), 7.14 – 7.07 (m, 1H).

13C NMR (101 MHz, CDCl3) δ 144.4, 134.4, 128.9, 128.0, 127.4, 125.9, 124.8, 123.1.

Spectroscopic data were in agreement with literature values.9

Compound 3y

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-3-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K3PO4 (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (22.6 mg, 56%).

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), thiophen-3-ylboronic acid (35.2 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl2 (7.3 mg, 0.01 mmol, 4 mol%), K3PO4 (159 mg, 0.75 mmol, 3 equiv), H2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (37.9 mg, 95%).

1H NMR (400 MHz, CDCl3) δ 7.67 – 7.62 (m, 2H), 7.50 – 7.47 (m, 1H), 7.47 – 7.39 (m, 4H), 7.38 – 7.31 (m, 1H).

13C NMR (101 MHz, CDCl3) δ 142.3, 135.8, 128.8, 127.1, 126.4, 126.3, 126.2, 120.2.

Spectroscopic data were in agreement with literature values.9
Compound 3z

Method A: According to the Method A, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-hydroxyphenyl)boronic acid (37.9 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Method B: According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (2-hydroxyphenyl)boronic acid (37.9 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (28.9 mg, 68%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.54 – 7.46 (m, 4H), 7.42 (d, $J = 2.5$ Hz, 1H), 7.33 – 7.24 (m, 2H), 7.09 – 6.94 (m, 2H), 5.25 (s, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 152.4, 137.1, 130.2, 129.2, 129.1, 128.1, 127.8, 120.8, 115.8.

Spectroscopic data were in agreement with literature values.$^{22}$

Compound 3aa

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), [1,1'-biphenyl]-2-ylboronic acid (54.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (45.3 mg, 79%).

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), [1,1'-biphenyl]-2-ylboronic acid (54.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (46.6 mg, 81%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.57 – 7.50 (m, 4H), 7.35 – 7.29 (m, 6H), 7.28 – 7.25 (m, 4H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 141.5, 140.5, 130.6, 129.9, 127.8, 127.5, 126.4.

Spectroscopic data were in agreement with literature values.$^{23}$
**Compound 3ab**

![Chemical structure of Compound 3ab]

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-vinylphenyl)boronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a clear oil (20.0 mg, 40%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-vinylphenyl)boronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (30.0 mg, 67%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.64 – 7.58 (m, 3H), 7.55 – 7.40 (m, 5H), 7.39 – 7.34 (m, 1H), 6.80 (dd, J = 17.6, 10.9 Hz, 1H), 5.83 (dd, J = 17.6, 1.0 Hz, 1H), 5.30 (dd, J = 10.8, 1.0 Hz, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 141.5, 141.1, 138.0, 136.8, 128.9, 128.7, 127.3, 127.2, 126.7, 125.2, 125.0, 114.2.

Spectroscopic data were in agreement with literature values.

**Compound 3ac**

![Chemical structure of Compound 3ac]

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (E)-styrylboronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (40.0 mg, 89%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (E)-styrylboronic acid (40.7 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (41.2 mg, 91%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.59 – 7.55 (m, 4H), 7.41 (t, J = 7.7 Hz, 4H), 7.31 (td, J = 7.2, 1.4 Hz, 2H), 7.17 (s, 2H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 137.3, 128.7, 128.7, 127.6, 126.5.

Spectroscopic data were in agreement with literature values.
Compound 3ad

\[
\text{\begin{picture}(60,60)
\put(25,30){\Line(0,0)(60,0)}
\put(30,0){\Line(0,60)(60,60)}
\put(30,30){\Line(0,0)(60,60)}
\put(30,30){\Line(0,60)(60,0)}
\end{picture}}
\]

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-aminophenyl)boronic acid (37.7 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-30% EtOAc in petroleum ether 40-60°) to afford the product as a clear oil (30.4 mg, 72%).

**Method B:** According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3-aminophenyl)boronic acid (37.7 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-30% EtOAc in petroleum ether 40-60°) to afford the product as an orange oil (41.8 mg, 99%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.61 – 7.57 (m, 2H), 7.47 – 7.42 (m, 2H), 7.38 – 7.33 (m, 1H), 7.29 – 7.23 (m, 1H), 7.03 – 6.98 (m, 1H), 6.91 (s, 1H), 6.70 – 6.66 (m, 1H), 3.73 (s, 2H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 146.8, 142.5, 141.5, 129.7, 128.7, 127.3, 127.2, 117.7, 114.1, 113.9.

Spectroscopic data were in agreement with literature values.$^{26}$

Compound 3b

\[
\text{\begin{picture}(60,60)
\put(25,30){\Line(0,0)(60,0)}
\put(30,0){\Line(0,60)(60,60)}
\put(30,30){\Line(0,0)(60,60)}
\put(30,30){\Line(0,60)(60,0)}
\end{picture}}
\]

**Method A:** According to the Method A, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 3-pyridinylboronic acid (33.8 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 3-pyridinylboronic acid (33.8 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-40% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (25.8 mg, 67%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.86 – 8.85 (m, 1H), 8.59 (dd, J = 4.8, 1.7 Hz, 1H), 7.87 (ddd, J = 7.9, 2.4, 1.6 Hz, 1H), 7.60 – 7.56 (m, 2H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 7.36 (ddd, J = 7.9, 4.8, 0.9 Hz, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 148.4, 148.3, 137.8, 136.6, 134.3, 129.0, 128.1, 127.1, 123.5.

Spectroscopic data were in agreement with literature values.$^5$
**Compound 3ae**

![Structure of Compound 3ae](image)

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3,4,5-trimethoxyphenyl)boronic acid (58.3 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (41.3 mg, 68%).

**Method B:** According to the Method B, bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (3,4,5-trimethoxyphenyl)boronic acid (58.3 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (55.0 mg, 90%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.61 – 7.55 (m, 2H), 7.50 – 7.42 (m, 2H), 7.37 – 7.33 (m, 1H), 6.80 (s, 2H), 3.93 (s, 6H), 3.92 (s, 3H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 153.3, 141.2, 137.4, 137.1, 128.6, 127.2, 127.0, 104.2, 60.8, 56.0.

Spectroscopic data were in agreement with literature values.\(^{27}\)

**Compound 3af**

![Structure of Compound 3af](image)

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylthio)phenyl)boronic acid (46.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (9.0 mg, 18%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methylthio)phenyl)boronic acid (46.2 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (42.0 mg, 84%).

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.61 – 7.57 (m, 2H), 7.56 – 7.53 (m, 2H), 7.47 – 7.43 (m, 2H), 7.38 – 7.32 (m, 3H), 2.54 (s, 3H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 140.5, 137.9, 137.5, 128.8, 127.4, 126.8, 126.8, 15.8.

Spectroscopic data were in agreement with literature values.\(^{28}\)
Compound 3ag

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 4-methoxyphenylboronic acid (41.8 mg, 0.275 mmol, 1.1 equiv), Ni(dpdpf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether 40-60°) to afford the product as a white solid (42.0 mg, 91%).

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), 4-methoxyphenylboronic acid (41.8 mg, 0.275 mmol, 1.1 equiv), Pd(dpdpf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, petroleum ether) to afford the product as a white solid (42.9 mg, 93%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.61 – 7.51 (m, 4H), 7.47 – 7.40 (m, 2H), 7.36 – 7.29 (m, 1H), 7.04 – 6.97 (m, 2H), 3.87 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 159.1, 140.8, 133.8, 128.7, 128.1, 126.7, 126.6, 114.2, 55.3.

Spectroscopic data were in agreement with literature values.\textsuperscript{29}

Compound 3t

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indol-5-yl)boronic acid (44.3 mg, 0.275 mmol, 1.1 equiv), Ni(dpdpf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

Method B: According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indol-5-yl)boronic acid (44.3 mg, 0.275 mmol, 1.1 equiv), Pd(dpdpf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), H$_2$O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-10% EtOAc in petroleum ether 40-60°) to afford the product as a colourless oil (43.5 mg, 90%).

$^1$H NMR (400 MHz, CDCl$_3$) δ 8.08 (s, 1H), 7.93 (d, $J = 2.7$ Hz, 1H), 7.76 – 7.68 (m, 2H), 7.55 – 7.44 (m, 4H), 7.42 – 7.34 (m, 1H), 7.23 (t, $J = 2.8$ Hz, 1H), 6.67 – 6.64 (m, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 142.5, 135.3, 133.4, 128.6, 128.3, 127.4, 126.3, 124.8, 121.9, 119.2, 111.2, 103.0.

Spectroscopic data were in agreement with literature values.\textsuperscript{19}
Compound 3a

\[
\begin{array}{c}
\text{N} \\
\text{H} \\
\end{array}
\]  

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indazol-4-yl)boronic acid hydrochloride (54.6 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (212 mg, 1.00 mmol, 4 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1H-indazol-4-yl)boronic acid hydrochloride (54.6 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), and K₃PO₄ (212 mg, 1.00 mmol, 4 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction yielded no desired product.

**Compound 3ai**

\[
\begin{array}{c}
\text{Me} \\
\end{array}
\]  

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), o-tolyboronic acid (37.4 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 75%, determined by ¹H NMR assay.

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), o-tolyboronic acid (37.4 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (petroleum ether 40-60°) to afford the product as a colourless oil (33.7 mg, 80%).

¹H NMR (500 MHz, CDCl₃) δ 7.50 – 7.44 (m, 2H), 7.43 – 7.37 (m, 3H), 7.35 – 7.29 (m, 4H), 2.34 (s, 3H).

¹³C NMR (126 MHz, CDCl₃) δ 141.9, 141.9, 135.3, 130.3, 129.8, 129.2, 128.0, 127.2, 126.7, 125.7, 20.5.

Spectroscopic data were in agreement with literature values.

**Compound 3h**

\[
\begin{array}{c}
\text{O} \\
\end{array}
\]  

**Method A:** According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-formylphenyl)boronic acid (41.2 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the
reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-1% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (3.6 mg, 8%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-formylphenyl)boronic acid (41.2 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl₂ (7.3 mg, 0.01 mmol, 4 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), H₂O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was then concentrated under vacuum and was determined to give a yield of 51%, determined by ¹H NMR assay.

¹H NMR (500 MHz, CDCl₃) δ 10.06 (s, 1H), 7.98 – 7.92 (m, 2H), 7.78 – 7.73 (m, 2H), 7.67 – 7.61 (m, 2H), 7.52 – 7.45 (m, 2H), 7.46 – 7.39 (m, 1H).

¹³C NMR (126 MHz, CDCl₃) δ 192.0, 147.2, 139.7, 135.1, 130.3, 129.0, 128.5, 127.7, 127.4.

Spectroscopic data were in agreement with literature values.³⁹

**Compound 3aj**

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (1-benzyl-1H-pyrazol-4-yl)boronic acid (55.6 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)⁻(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 10-15% EtOAc in petroleum ether 40-60°) to afford the product as a pale brown solid (52.8 mg, 90%).

¹H NMR (500 MHz, CDCl₃) δ 7.87 (s, 1H), 7.63 (s, 1H), 7.51 – 7.47 (m, 2H), 7.41 – 7.32 (m, 5H), 7.30 – 7.26 (m, 2H), 7.24 (t, J = 7.7 Hz, 1H), 5.34 (s, 2H).

¹³C NMR (101 MHz, CDCl₃) δ 136.9, 136.3, 132.4, 128.8, 128.7, 128.0, 127.6, 126.3, 126.1, 125.4, 123.4, 56.1.

Spectroscopic data were in agreement with literature values.³⁰

**Compound 3ak**

Method A: According to the Method A, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4-(methoxycarbonyl)phenyl)boronic acid (49.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)⁻(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K₃PO₄ (159 mg, 0.75 mmol, 3 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete,
the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (12.6 mg, 24%).

**Method B:** According to the Method B, using bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), (4- (methoxycarbonyl)phenyl)boronic acid (49.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl_2 (7.3 mg, 0.01 mmol, 4 mol%), K_3PO_4 (159 mg, 0.75 mmol, 3 equiv), H_2O (22.5 µL, 1.25 mmol, 5 equiv), and 1,4-dioxane (1 mL, 0.25 M). After the reaction was complete, the reaction mixture was subjected to the purification method outlined in the Method (silica gel, 0-5% EtOAc in petroleum ether 40-60°) to afford the product as a white solid (48.1 mg, 91%).

^{1}H NMR (400 MHz, CDCl_3) δ 8.14 – 8.11 (m, 2H), 7.69 – 7.61 (m, 4H), 7.50 – 7.45 (m, 2H), 7.43 – 7.38 (m, 1H), 3.95 (s, 3H).

^{13}C NMR (101 MHz, CDCl_3) δ 166.9, 145.5, 139.9, 130.0, 128.8, 128.1, 127.2, 127.0, 52.0.

Spectroscopic data were in agreement with literature values.\(^{31}\)

**4.3 Scale-up procedure**

![Diagram](image)

**[Ni]:** To an oven-dried round-bottom flask was added 4-bromofluorobenzene (437.5 mg, 2.5 mmol, 1 equiv), phenylboronic acid (335.5 mg, 2.75 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (37 mg, 0.05 mmol, 2 mol%), and K_3PO_4 (1.59 g, 7.5 mmol, 3 equiv). The vial was sealed and purged with N_2 before the addition of 1,4-dioxane (10 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The flask was then allowed to cool to room temperature, the reaction mixture was then diluted with EtOAc (100 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 100 mL) followed by brine (100 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (390 mg, 91%)

**[Pd]:** To an oven-dried round-bottom flask was added 4-bromofluorobenzene (437.5 mg, 2.5 mmol, 1 equiv), phenylboronic acid (335.5 mg, 2.75 mmol, 1.1 equiv), Pd(dppf)Cl_2 (73.2 mg, 0.1 mmol, 4 mol%), and K_3PO_4 (1.59 g, 7.5 mmol, 3 equiv). The vial was sealed and purged with N_2 before the addition of 1,4-dioxane (10 mL, 0.25 M), followed by H_2O (225 µL, 12.5 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C. The flask was then allowed to cool to room temperature, the reaction mixture was then diluted with EtOAc (100 mL) and filtered through a plug of celite, eluting with EtOAc. The resulting solution was washed with H_2O (3 x 100 mL) followed by brine (100 mL) and the organic phases collected. The organic phase was dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was purified by column chromatography (silica gel, petroleum ether 40-60°) to afford the desired product as a white solid (415 mg, 96%).

**4.4 Quantification of Ni and Pd**

Ni and Pd concentrations were determined using a Thermo Fisher Scientific ICP-OES iCAP 6000 Series, equipped with a CETAC ASX-520 autosampler. Compounds 3a, 3r, and 3aj were tested for quantities of residual Pd and Ni (based on whether they had been prepared via the Ni or Pd method). The samples were prepared by acid digestion using 70% HNO_3, followed by filtration, and dilution with H_2O to give a 5% HNO_3 solution. It was found that the residual concentration for Ni samples was <100 ppm. Residual Pd was found to be consistently below the limit of detection for the instrument.
5.0 Protodeboronation study

5.1 Protodeboronation study for fluorine containing substrates

5.1.1 Protodeboronation study of 2-fluorophenyl boronic acid/2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane

To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), boron reagent (1 equiv), catalyst, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the products was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>2-fluorophenyl boronic acid</td>
<td>-</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>2-fluorophenyl boronic acid</td>
<td>5 equiv</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>No metal</td>
<td>2-fluorophenyl boronic acid</td>
<td>-</td>
<td>-</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>83</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>88</td>
<td>trace</td>
</tr>
<tr>
<td>6</td>
<td>No metal</td>
<td>2-(2-fluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>-</td>
<td>trace</td>
</tr>
</tbody>
</table>
5.1.2 Protodeboronation study of 2,3-difluorophenylboronic acid/2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane

To an oven-dried microwave vial was added 4-fluorobromobenzene (43.8 mg, 0.25 mmol, 1 equiv), boron reagent (1 equiv), catalyst, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the products was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

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<tr>
<th>Entry</th>
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<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>2,3-difluorophenylboronic acid</td>
<td>-</td>
<td>9</td>
<td>89</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>2,3-difluorophenylboronic acid</td>
<td>5 equiv</td>
<td>81</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>No metal</td>
<td>2,3-difluorophenylboronic acid</td>
<td>-</td>
<td>-</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>9</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>74</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>No metal</td>
<td>2-(2,3-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>Trace</td>
<td>15</td>
</tr>
</tbody>
</table>
5.1.3 Protodeboronation study of 2,4-difluorophenylboronic acid/2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane

To an oven-dried microwave vial was added 4-fluorobromobenzene (43.8 mg, 0.25 mmol, 1 equiv), boron reagent (1 equiv), catalyst, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the products was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dpff)(o-tol)Cl (2 mol%)</td>
<td>2,4-difluorophenylboronic acid</td>
<td>-</td>
<td>43</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dpff)Cl$_2$ (4 mol%)</td>
<td>2,4-difluorophenylboronic acid</td>
<td>5 equiv</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>No metal</td>
<td>2,4-difluorophenylboronic acid</td>
<td>-</td>
<td>-</td>
<td>87</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dpff)(o-tol)Cl (2 mol%)</td>
<td>2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>Pd(dpff)Cl$_2$ (4 mol%)</td>
<td>2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>68</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>No metal</td>
<td>2-(2,4-difluorophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>
5.2 Protodeboronation study for non-fluorine containing substrates

5.2.1 Protodeboronation study of (4-(methylsulfonyl)phenyl)boronic acid/4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane

To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), boron reagent (1 equiv), catalyst, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>(4-(methylsulfonyl)phenyl)boronic acid</td>
<td>-</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>(4-(methylsulfonyl)phenyl)boronic acid</td>
<td>5 equiv</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>No metal</td>
<td>(4-(methylsulfonyl)phenyl)boronic acid</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>No metal</td>
<td>4,4,5,5-tetramethyl-2-(4-(methylsulfonyl)phenyl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>
5.2.2 Protodeboronation study of (3,4,5-trimethoxyphenyl)boronic acid/4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane

To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), boron reagent (1 equiv), catalyst, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dppe)(o-tol)Cl (2 mol%)</td>
<td>(3,4,5-trimethoxyphenyl)boronic acid</td>
<td>-</td>
<td>34</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dppe)Cl$_2$ (4 mol%)</td>
<td>(3,4,5-trimethoxyphenyl)boronic acid</td>
<td>5 equiv</td>
<td>47</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>No metal</td>
<td>(3,4,5-trimethoxyphenyl)boronic acid</td>
<td>-</td>
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<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dppe)(o-tol)Cl (2 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Pd(dppe)Cl$_2$ (4 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>61</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>No metal</td>
<td>4,4,5,5-tetramethyl-2-(3,4,5-trimethoxyphenyl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

5.2.3 Protodeboronation study of (5-phenylthiophen-2-yl)boronic acid/4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane
To an oven-dried microwave vial was added bromobenzene (39.3 mg, 0.25 mmol, 1 equiv), **boron reagent (1 equiv), catalyst**, and K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 0.5 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and an aliquot was taken which was analysed by HPLC against an internal standard (naphthalene).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>R-BR$_2$ (1 equiv)</th>
<th>H$_2$O</th>
<th>A(%)</th>
<th>B(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>(5-phenylthiophen-2-yl)boronic acid</td>
<td>-</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>(5-phenylthiophen-2-yl)boronic acid</td>
<td>5 equiv</td>
<td>22</td>
<td>41</td>
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<tr>
<td>3</td>
<td>No metal</td>
<td>(5-phenylthiophen-2-yl)boronic acid</td>
<td>-</td>
<td>-</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Ni(dppf)(o-tol)Cl (2 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>3</td>
<td>31</td>
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<tr>
<td>5</td>
<td>Pd(dppf)Cl$_2$ (4 mol%)</td>
<td>4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane</td>
<td>5 equiv</td>
<td>24</td>
<td>7</td>
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<tr>
<td>6</td>
<td>No metal</td>
<td>4,4,5,5-tetramethyl-2-(5-phenylthiophen-2-yl)-1,3,2-dioxaborolane</td>
<td>-</td>
<td>-</td>
<td>30</td>
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</table>
6.0 Robustness screen

[Ni]: To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Ni(dppf)(o-tol)Cl (3.8 mg, 0.005 mmol, 2 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and additive (1 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the desired product was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

[Pd]: To an oven-dried microwave vial was added 4-bromofluorobenzene (43.8 mg, 0.25 mmol, 1 equiv), phenylboronic acid (33.5 mg, 0.275 mmol, 1.1 equiv), Pd(dppf)Cl$_2$ (7.3 mg, 0.01 mmol, 4 mol%), K$_3$PO$_4$ (159 mg, 0.75 mmol, 3 equiv), and additive (1 equiv). The vial was capped and purged with N$_2$ before the addition of 1,4-dioxane (1 mL, 0.25 M), and H$_2$O (22.5 µL, 1.25 mmol, 5 equiv). The reaction mixture was heated for 4 h at 80 °C. The reaction mixture was then allowed to cool to room temperature and trifluorotoluene (30.7 µL, 0.25 mmol) was added. The vial was then decapped, and the reaction mixture diluted with CDCl$_3$ and filtered through a layer of celite. Conversion to the desired product was measured by $^{19}$F NMR against a known internal standard (trifluorotoluene).

<table>
<thead>
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<th>Entry</th>
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<th>[Ni] Product yield (%)</th>
<th>[Pd] Product yield (%)</th>
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<td>&gt;99</td>
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<td>DMAP</td>
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<td>Pinacol</td>
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<td>Benzoic acid</td>
<td>8</td>
<td>98</td>
</tr>
</tbody>
</table>
7.0 References


8.0 NMR spectra for intermediates and products

**Compound 2v**

$^1$H NMR of 2v, DMSO-$_d_{6}$, 500 MHz

$^{13}$C NMR of 2v, DMSO-$_d_{6}$, 126 MHz
Compound 3a

\(^1\text{H NMR of 3a, CDCl}\textsubscript{3}, 400 MHz\)

\(^{13}\text{C NMR of 3a, CDCl}\textsubscript{3}, 101 MHz\)
$^{19}\text{F NMR of 3a, CDCl}_3$, 376 MHz
Compound 3b

$^1$H NMR of 3b, CDCl$_3$, 400 MHz.

$^{13}$C NMR of 3b, CDCl$_3$, 101 MHz.
Compound 3c

$^1$H NMR of 3c, CDCl$_3$ 400 MHz.

$^{13}$C NMR of 3c, CDCl$_3$, 101 MHz

S40
Compound 3d

$^1$H NMR of 3d, CDCl$_3$, 400 MHz.

$^{13}$C NMR of 3d, CDCl$_3$, 101 MHz.
Compound 3f

$^1$H NMR of 3f, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3f, CDCl$_3$, 101 MHz
Compound 3g

$^1$H NMR of 3g, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3g, CDCl$_3$, 101 MHz
Compound 3h

$^1$H NMR of 3h, CDCl$_3$, 500 MHz

$^{13}$C NMR of 3h, CDCl$_3$, 101 MHz
Compound 3i

$^1$H NMR of 3i, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3i, CDCl$_3$, 101 MHz
Compound 3j

$^1$H NMR of 3j, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3j, CDCl$_3$, 101 MHz
Compound 3k

$^1$H NMR of 3k, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3k, CDCl$_3$, 101 MHz
Compound 3m

$^1$H NMR of 3m, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3m, CDCl$_3$, 101 MHz
Compound 3n

$^1$H NMR of 3n, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3n, CDCl$_3$, 101 MHz
Compound 3o

$^1$H NMR of 3o, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3o, CDCl$_3$, 101 MHz
Compound 3p

$^1$H NMR of 3p, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3p, CDCl$_3$, 400 MHz
Compound 3q

$^1$H NMR of 3q, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3q, CDCl$_3$, 101 MHz
Compound 3r

$^1$H NMR of 3r, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3r, CDCl$_3$, 101 MHz
Compound 3s

$^1$H NMR of 3s, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3s, CDCl$_3$, 101 MHz
Compound 3t

$^1$H NMR of 3t, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3t, CDCl$_3$, 101 MHz
Compound 3u

$^1$H NMR of 3u, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3u, CDCl$_3$, 101 MHz
Compound 3v

$^1$H NMR of 3v, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3v, CDCl$_3$, 101 MHz
Compound 3w

$^1$H NMR of 3w, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3w, CDCl$_3$, 101 MHz
Compound 3x

$^1$H NMR of 3x, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3x, CDCl$_3$, 101 MHz
Compound 3y

$^1$H NMR of 3y, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3y, CDCl$_3$, 101 MHz
Compound 3z

\(^1\text{H NMR of } 3z, \text{CDCl}_3, 400 \text{ MHz}\)

\(^{13}\text{C NMR of } 3z, \text{CDCl}_3, 101 \text{ MHz}\)
Compound 3aa

$^1$H NMR of 3aa, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3aa, CDCl$_3$, 101 MHz
Compound 3ab

$^1$H NMR of 3ab, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3ab, CDCl$_3$, 101 MHz
Compound 3ac

$^1$H NMR of 3ac, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3ac, CDCl$_3$, 101 MHz
Compound 3ad

$^1\text{H}$ NMR of 3ad, CDCl$_3$, 400 MHz

$^{13}\text{C}$ NMR of 3ad, CDCl$_3$, 101 MHz
Compound 3ae

$^1$H NMR of 3ae, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3ae, CDCl$_3$, 126 MHz
Compound 3af

$^1$H NMR of 3af, CDCl$_3$, 500 MHz

$^{13}$C NMR of 3af, CDCl$_3$, 126 MHz
Compound 3ag

$^1$H NMR of 3ag, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3ag, CDCl$_3$, 101 MHz
Compound 3ai

$^1$H NMR of 3ai, CDCl$_3$, 400 MHz

$^{13}$C NMR of 3ai, CDCl$_3$, 101 MHz
Compound 3aj

$^1$H NMR of 3aj, CDCl$_3$, 500 MHz

$^{13}$C NMR of 3aj, CDCl$_3$, 101 MHz
Compound 3ak

$^1$H NMR of 3ak, CDCl$_3$, 400 MHz

13C NMR of 3ak, CDCl$_3$, 101 MHz