Supporting Information

Electrochemical-promoted nickel-catalyzed reductive allylation of aryl halides

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Table of Contents

I. General Methods ........................................................................................................................................... 1
II. Synthesis of Starting Materials ...................................................................................................................... 1
III. Optimization of conditions for electrochemical coupling of trifluoroalkenes and aryl halides ..6
IV. Optimization of electrochemical coupling conditions between MBH ester and aryl halides ...10
V. Experimental procedures ................................................................................................................................. 12
VI. Characteristic Data ........................................................................................................................................ 15
VII. Spectral data ............................................................................................................................................... 27
I. General Methods
All reactions were performed in flame-dried glassware with magnetic stirring bar and sealed with a rubber septum. The Solvents were distilled by standard methods. Reagents were obtained from commercial suppliers and used without further purification unless otherwise noted. Silica gel column chromatography was carried out using silica Gel 60 (230–400 mesh). Analytical thin layer chromatography (TLC) was done using silica Gel (silica gel 60 F254). TLC plates were analyzed by an exposure to ultraviolet (UV) light. NMR experiments were measured on a Bruker AVANCE III-400 or 500 spectrometer and carried out indeuterochloroform (CDCl3) 1H NMR and 13C NMR spectra were recorded at 400 MHz or 500 MHz and 100MHz or 125 MHz spectrometers, respectively. 19F NMR spectra were recorded at 376 MHz or 470 MHz spectrometers. Chemical shifts are reported as δ values relative to internal TMS (δ 0.00 for 1H NMR), chloroform (δ 7.26 for 1H NMR), chloroform (δ 77.00 for 13C NMR). The following abbreviations are used for the multiplicities: s: singlet, d: doublet, dd: doublet of doublet, t: triplet, q: quadruplet, m: multiplet, br: broad signal for proton spectra; Coupling constants (J) are reported in Hertz (Hz). Melting points were uncorrected. Infrared spectra were obtained on agilent Cary630. HRMS were recorded on a Bruker microTOF-Q111. GC-MS spectra were performed on Shimadzu QP2010 (EI Source).

II. General procedure and Characterization data of Starting Materials
All the catalysts, base, arylboronic acid, alkyl halide and aryl halide were purchased from commercial sources (Alfa, TCI, Energy and Macklin) and used as received. They are all known compounds.

List of trifluoromethyl alkenes

1a

1b

1c

1d

1e

1f

1g

1h

1i

1j
Method A

General procedure for the synthesis of trifluoroalkenes (1a - 1h)

\[
\begin{align*}
\text{B(OH)}_2 &\quad \text{Br} &\quad \text{CF}_3 \\
\text{R} &\quad \text{R} &\quad \text{CF}_3 \\
\text{Pd(PPh}_3\text{)}_2\text{Cl}_2 &\quad \text{K}_2\text{CO}_3 (2.0 \text{ M, aq}) &\quad \text{H}_2\text{O / THF 60°C}
\end{align*}
\]

To a Schlenk tube equipped a magnetic stir bar, boronic acid (5 mmol, 1.0 equiv), and Pd(PPh₃)₂Cl₂ (63.2 mg, 3 mol%) were added. The vessel was evacuated and filled with argon (three times), and then THF (15 mL, pre-degased) and aqueous K₂CO₃ (2.0 M, 10 mL, pre-degased) were added. After the addition of 2-bromo-3,3,3-trifluoropropene (1.04 mL, 10 mmol, 2.0 equiv), the reaction mixture was stirred at 60 °C overnight under an argon atmosphere. The resultant mixture was cooled to room temperature, quenched with saturated aqueous NH₄Cl, and extracted with ethyl acetate (EA). The combined organic phases were dried over anhydrous Na₂SO₄, filtered, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel to give the desired corresponding trifluoroalkenes (54% - 83%).

Method B

Synthetic of other trifluoroalkenes (1c, 1i – 1j)

According to Method A, gram-scale preparation of the desired 4-(3,3,3-trifluoroprop-1-en-2-yl)phenol 1c was accomplished. To a 250 mL two-neck flask equipped with a magnetic stir bar, 4-Hydroxyphenylboronic acid (2.07 g, 15 mmol, 1.0 equiv) and Pd(PPh₃)₂Cl₂ (0.32 g, 3 mol%, 0.45 mmol) were added. The flask was evacuated and filled with argon (three cycles), then THF (45 mL, pre-degased) and aqueous K₂CO₃ (2.0 M, 30 mL, pre-degased) were added. After the addition of 2-bromo-3,3,3-trifluoropropene (3.1 mL, 30 mmol, 2.0 equiv), the reaction mixture was stirred at 60 °C for 12 hours (TLC tracking detection). The resultant mixture was cooled to room temperature, quenched with saturated aqueous NH₄Cl, and extracted with EA. The combined organic phases were dried over anhydrous Na₂SO₄, filtered, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel eluting with 10:1 petroleum ether (PE)/EA to give the desired trifluoroalkenes 1c as a brown oil. (2.063 g, 73%)

\[
\begin{align*}
\text{HO} &\quad \text{CF}_3 \\
\text{TsCl, DMAP, Et}_3\text{N} &\quad \text{DCM, 0°C to rt} &\quad \text{TsO} &\quad \text{CF}_3
\end{align*}
\]

To a stirred solution of 4-(3,3,3-trifluoroprop-1-en-2-yl)phenol (0.564 g, 3.0 mmol, 1.0 equiv), 4-dimethylaminopyridine (DMAP) (37.0 mg, 10 mol%), and Et₃N (0.835 mL, 6.0 mmol, 2.0 equiv) in dichloromethane (DCM) (15 mL) was added dropwise a solution of TsCl (0.860 g, 4.5 mmol, 1.5 equiv) in DCM (10 mL) 0 °C over 10 minutes. Then the reaction mixture was allowed to stir at room temperature for 5
hours before it was quenched with water. The organic layer was separated, and the aqueous layer was extracted with DCM. The combined organic phases were dried over anhydrous Na₂SO₄, filtered, and concentrated in vacuo. The residue was purified by column chromatography on silica gel eluting with 10:1 PE/EA to give the desired trifluoroalkenes 1i as a colorless oil. (0.896 g, 87%)

A mixture of 4-(3,3,3-trifluoroprop-1-en-2-yl)phenol (0.564 g, 3.0 mmol, 1.0 equiv), K₂CO₃ (0.828 g, 6.0 mmol, 2.0 equiv), and NaI (45.0 mg, 10 mol%) in DMF (15 mL) was stirred at 60 °C for 30 minutes before 5-bromopent-1-ene (0.533 mL, 4.5 mmol, 1.5 equiv) was added. The reaction mixture was stirred at 60 °C for further 5 hours. The resultant mixture was cooled to room temperature, diluted with water, and extracted with EA. The combined organic phases were washed with brine, dried over anhydrous Na₂SO₄, filtered, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel eluting with 40:1 PE/EA to give the desired trifluoroalkenes 1j as a colorless oil. (0.586 g, 76%)

Method C

**Synthetic of other trifluoroalkenes**

To a two-necked round-bottom flask equipped with a magnetic stir bar and charged with aldehyde (1 equiv), PPh₃ (1.2 equiv), and DMF (0.5 M for aldehyde) was added a solution of sodium chlorodifluoroacetate (1.5 equiv) in DMF (2.0 M) dropwisely at 100 °C over 30 min. After the addition was completed, the reaction mixture was heated additionally at the same temperature for 30 min. After cooling to 0 °C, to the reaction mixture was added water and extracted with Et₂O. The combined organic was washed with water, brine, and then dried over Na₂SO₄. After filtration, the filtrate was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel eluting with PE to give the corresponding gem-difluoroalkene as a solid.

Method D

**Synthetic of MBH alcohol and MBH ester**

![Chemical structure](image-url)
In a round bottom flask fitted with a magnetic stir-bar, aldehyde (1.0 equiv.) and ethyl acrylate (4.0 equiv.) were taken. Required amount of DABCO (1.0 equiv.) was added to the neat reaction mixture and the resulting reaction mixture was stirred at 25 °C vigorously. After specified reaction time, the reaction mixture was diluted with DCM and then washed with HCl (1.0 M), then NaHCO$_3$ and brine. Organic layer was separated and the aqueous layer was extracted with DCM. Combined organic layer was dried over Na$_2$SO$_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica-gel eluting with 5:1 PE/EA to give the corresponding MBH alcohol as a solid.

MBH alcohol (10mmol, 1.0 equiv.) was taken in a flame dried round bottom flask and dissolved it by dry DCM (50 mL) then catalytic amount of DMAP (0.12 g, 1.0 mmol, 10 mol%) was added followed by Ac$_2$O (1.4mL, 15mmol, 1.5 equiv.) was added. The reaction mixture was diluted with additional amount of DCM then washed with water. The organic fractions were combined dried over Na$_2$SO$_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica-gel eluting with 10:1 PE/EA to give the corresponding MBH ester as a solid.

Method D [6]

**Synthetic of Sulfonate**

![Chemical Structure](image1)

To a solution of Allyl Bromide (1.4 mL, 10.0 mmol, 1.0 equiv.) in dry methanol (20 mL) was added sodium phenylsulfinate (2.7 g, 15.0 mmol, 1.5 equiv.). After 2 h of reflux, the mixture was concentrated under reduced pressure, the obtained residue was dissolved in EA and the mixture was washed with water, brine, dried with Na$_2$SO$_4$, filtered and the filtrate was evaporated. The residue was purified by flash column chromatography on silica-gel eluting with 10:1 PE/EA to give the corresponding sulfonate as a colorless oil.

Method E [7]

**Synthetic of oxalates**

![Chemical Structure](image2)

To a solution of alcohol (1.2 g, 10.0 mmol, 1.0 equiv.) in DCM (50 mL) was added Et$_3$N (1.81 mL, 12.0 mmol, 1.2 equiv.), DMAP (0.12 g, 1.0 mmol, 10 mol%) at 0 °C in an ice bath. Following this, ethyl oxalyl chloride (1.10 mL, 12.0 mmol, 1.2 equiv.)
was added dropwise. The reaction mixture was allowed to warm to r.t. and stirred overnight. The reaction mixture was diluted with Et₂O, washed with water, NaHCO₃, and brine. The organic phase was collected, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica-gel eluting with 20:1 PE/EA to give the corresponding oxalate as a solid.

Characterization data of Starting Materials trifluoroalkenes

4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1a)

Solid; ¹H NMR (400 MHz, Chloroform-d) δ 7.65 – 7.58 (m, 4H), 7.58 – 7.52 (m, 2H), 7.50 – 7.43 (m, 2H), 7.41 – 7.33 (m, 1H), 5.99 (q, J = 1.4 Hz, 1H), 5.84 (q, J = 1.7 Hz, 1H). ¹³C NMR (101 MHz, Chloroform-d) δ 141.99, 140.40, 138.72 (q, J = 30.1 Hz), 132.59, 129.02, 127.88, 127.84, 127.41, 127.23, 123.54 (q, J = 274.1 Hz), 120.35 (q, J = 5.8 Hz). ¹⁹F NMR (376 MHz, Chloroform-d) δ -64.64. All data matched that reported in the literature. \[2\]

isopropyl(4-(3,3,3-trifluoroprop-1-en-2-yl)phenyl)sulfane (1e)

Oil; ¹H NMR (400 MHz, Chloroform-d) δ 7.38 (s, 4H), 5.94 (q, J = 1.4 Hz, 1H), 5.77 (q, J = 1.7 Hz, 1H), 3.44 (hept, J = 6.7 Hz, 1H), 1.33 (d, J = 6.7 Hz, 6H). ¹³C NMR (101 MHz, Chloroform-d) δ 138.5 (q, J = 30.3 Hz), 137.6, 131.6, 131.06, 127.8, 123.4 (q, J = 274.7 Hz), 120.2 (q, J = 5.8 Hz), 37.9, 23.2. ¹⁹F NMR (376 MHz, Chloroform-d) δ -64.91. All data matched that reported in the literature. \[2\]

4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1i)

Solid; ¹H NMR (400 MHz, Chloroform-d) δ 7.72 (dd, J = 10.8, 8.4 Hz, 2H), 7.43 – 7.20 (m, 4H), 7.05 – 6.96 (m, 2H), 5.97 (q, J = 1.4 Hz, 1H), 5.75 (q, J = 1.7 Hz, 1H), 2.46 (s, 3H). ¹⁹F NMR (376 MHz, Chloroform-d) δ -64.91. All data matched that reported in the literature. \[2\]

4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1j)

Solid; ¹H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.34 (m, 2H), 6.93 – 6.77 (m, 2H), 5.93 – 5.78 (m, 2H), 5.68 (q, J = 1.7 Hz, 1H), 5.11 – 4.96 (m, 2H), 3.98 (t, J = 6.4 Hz, 2H), 2.37 – 2.10 (m, 2H), 1.97 – 1.79 (m, 2H). ¹³C NMR (101 MHz, Chloroform-d) δ 159.8, 138.5 (q, J = 29.6 Hz), 137.8, 128.7, 126.0, 120.7, 118.9 (q, J = 5.8 Hz), 115.4, 114.6, 67.4, 30.2, 28.5. ¹⁹F NMR (376 MHz, Chloroform-d) δ -64.82. All data matched that reported in the literature. \[2\]
III. Optimization of conditions for electrochemical coupling of trifluoroalkenes and aryl halides

Table S1: Optimization of different Solvents

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent</th>
<th>3aa Yield (%)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>3aa/3ab (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMF</td>
<td>45%</td>
<td>1:1</td>
</tr>
<tr>
<td>2</td>
<td>DMA</td>
<td>trace</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>DMSO</td>
<td>33%</td>
<td>&gt;99:1</td>
</tr>
<tr>
<td>4</td>
<td>MeCN</td>
<td>trace</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>THF</td>
<td>n.r</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>DCM</td>
<td>n.r</td>
<td>-</td>
</tr>
</tbody>
</table>

<sup>a</sup> All reactions were carried out with 1a (0.1 mmol, 1.0 eq), 2ab (0.2 mmol, 2.0 eq), n-BuNPF<sub>6</sub> (0.3 mmol, 1.0M), diglyme NiBr<sub>2</sub> (20 mol%) and L1 (20 mol%) in Solvent (3.0 mL) at rt under Ar and 5.0 mA for 8h. <sup>b</sup>GC yield. (Dodecane as internal standard)
<table>
<thead>
<tr>
<th>Entry</th>
<th>L</th>
<th>Ni</th>
<th>Yield (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L1</td>
<td>diglyme NiBr₂</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>L1</td>
<td>glyme NiCl₂</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>L1</td>
<td>Ni(acac)₂</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>L1</td>
<td>NiI₂</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>L1</td>
<td>Ni(COD)₂</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>L1</td>
<td>Ni(Pcy₃)₂Cl₂</td>
<td>trace</td>
</tr>
<tr>
<td>7</td>
<td>L2</td>
<td>diglyme NiBr₂</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>L3</td>
<td>diglyme NiBr₂</td>
<td>trace</td>
</tr>
<tr>
<td>9</td>
<td>L4</td>
<td>diglyme NiBr₂</td>
<td>trace</td>
</tr>
<tr>
<td>10</td>
<td>L5</td>
<td>diglyme NiBr₂</td>
<td>14</td>
</tr>
</tbody>
</table>

<sup>a</sup> All reactions were carried out with 1a (0.1 mmol, 1.0 eq), 2ab (0.2 mmol, 2.0 eq), t-BuNPF₆ (0.3 mmol, 1.0M), Nickel catalysts (20 mol%) and Ligands (20 mol%) in DMSO (3.0 mL) at rt under Ar and 5.0 mA for 8h. <sup>b</sup> GC yield. (Dodecane as internal standard)
Table S3: Optimization of Electrolytes anode and cathode

![Chemical structure of compounds 1a, 2ab, and 3aa]

<table>
<thead>
<tr>
<th>Entry</th>
<th>Electrolytes</th>
<th>Anode (+)</th>
<th>Cathode (-)</th>
<th>Yield (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;Bu₄NPf₆</td>
<td>Zn</td>
<td>Ni form</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>&quot;Bu₄NBr</td>
<td>Zn</td>
<td>Ni form</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>&quot;Bu₄NOAc</td>
<td>Zn</td>
<td>Ni form</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>LiClO₄</td>
<td>Zn</td>
<td>Ni form</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Et₄NPf₆</td>
<td>Zn</td>
<td>Ni form</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>&quot;Bu₄NBr</td>
<td>Zn</td>
<td>Zn</td>
<td>n.r</td>
</tr>
<tr>
<td>7</td>
<td>&quot;Bu₄NBr</td>
<td>Zn</td>
<td>Cu</td>
<td>n.r</td>
</tr>
<tr>
<td>8</td>
<td>&quot;Bu₄NBr</td>
<td>Zn</td>
<td>Fe</td>
<td>n.r</td>
</tr>
<tr>
<td>9</td>
<td>&quot;Bu₄NBr</td>
<td>Zn</td>
<td>C</td>
<td>n.r</td>
</tr>
<tr>
<td>10</td>
<td>&quot;Bu₄NBr</td>
<td>Al</td>
<td>Ni form</td>
<td>n.r</td>
</tr>
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<td>&quot;Bu₄NBr</td>
<td>Cu</td>
<td>Ni form</td>
<td>trace</td>
</tr>
<tr>
<td>12</td>
<td>&quot;Bu₄NBr</td>
<td>Fe</td>
<td>Ni form</td>
<td>54</td>
</tr>
</tbody>
</table>

<sup>a</sup> All reactions were carried out with 1a (0.1 mmol, 1.0 eq), 2ab (0.2 mmol, 2.0 eq), Electrolyte (0.3mmol, 1.0M), diglyme NiBr₂ (20 mol%) and L1 (20 mol%) in DMSO (3.0 mL) at rt under Ar and 5.0 mA for 8h. <sup>b</sup> GC yield. (Dodecane as internal standard)
Table S4: Optimization of Leaving group, current and time \(^a\)

![Chemical Structure](image)

<table>
<thead>
<tr>
<th>Entry</th>
<th>X</th>
<th>I(mA)</th>
<th>t(h)</th>
<th>Yield (%) (^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Br</td>
<td>5</td>
<td>8</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>5</td>
<td>8</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>4</td>
<td>9</td>
<td>58</td>
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<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
<td>I</td>
<td>7</td>
<td>8</td>
<td>56</td>
</tr>
<tr>
<td>6</td>
<td>I</td>
<td>6</td>
<td>8</td>
<td>80</td>
</tr>
</tbody>
</table>

\(^a\) All reactions were carried out with \(1a\) (0.1 mmol, 1.0 eq), \(2\) (0.2 mmol, 2.0 eq), \(t\text{Bu}_4\text{NBr}\) (0.3 mmol, 1.0 M), diglyme NiBr\(_2\) (20 mol%) and L1 (20 mol%) in DMSO (3.0 mL) at rt under Ar and I mA for t h. \(^b\) GC yield.

(Dodecane as internal standard)
IV. Optimization of electrochemical coupling conditions between MBH ester and aryl halides

Table S5: Optimization of Solvent, catalyst, electrolyte

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent</th>
<th>Electrolyte</th>
<th>[Ni] / L</th>
<th>Yield (%) b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMSO</td>
<td>&quot;Bu4NBr</td>
<td>NiBr2 diglyme / L1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>DMA</td>
<td>&quot;Bu4NBr</td>
<td>NiBr2 diglyme / L1</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>MeCN</td>
<td>&quot;Bu4NBr</td>
<td>NiBr2 diglyme / L1</td>
<td>trace</td>
</tr>
<tr>
<td>4</td>
<td>NMP</td>
<td>&quot;Bu4NBr</td>
<td>NiBr2 diglyme / L1</td>
<td>trace</td>
</tr>
<tr>
<td>5</td>
<td>DMA</td>
<td>&quot;Bu4NPF6</td>
<td>NiBr2 diglyme / L1</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>DMA</td>
<td>&quot;Bu4NPF6</td>
<td>Ni(acac)2 / L1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>DMA</td>
<td>&quot;Bu4NPF6</td>
<td>Ni(acac)2 / L2</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>DMA</td>
<td>&quot;Bu4NPF6</td>
<td>NiBr2 diglyme / L2</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>DMA</td>
<td>&quot;Bu4NPF6</td>
<td>NiBr2 diglyme / L5</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>DMA</td>
<td>&quot;Bu4NBr</td>
<td>NiBr2 diglyme / L1</td>
<td>20</td>
</tr>
</tbody>
</table>

a Reaction condition: 10 (0.1 mmol, 1.0 eq.), 2aa (0.2 mmol, 2.0 eq), Electrolyte (0.3 mmol, 1.0 M), Ni (20 mol %) and L (20 mol %) in Solvent (3.0 mL) at rt under Ar and 5.0 mA for 6 h. b GC yield. (Dodecane as internal standard).
Table S6: Optimization of Solvent, catalyst, electrolyte

<table>
<thead>
<tr>
<th>Entry</th>
<th>T</th>
<th>Anode(+) / Cathode(-)</th>
<th>Additive</th>
<th>Yield (%) $^b$</th>
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<tbody>
<tr>
<td>1</td>
<td>rt</td>
<td>Fe (+) / Ni form (-)</td>
<td>-</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>rt</td>
<td>Zn (+) / Ni form (-)</td>
<td>-</td>
<td>trace</td>
</tr>
<tr>
<td>3</td>
<td>rt</td>
<td>Fe (+) / C form (-)</td>
<td>-</td>
<td>30</td>
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<tr>
<td>4</td>
<td>rt</td>
<td>C (+) / C form (-)</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>60℃</td>
<td>Fe (+) / C form (-)</td>
<td>-</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>60℃</td>
<td>Fe (+) / C form (-)</td>
<td>K$_2$CO$_3$ (2.0 eq)</td>
<td>49(46) $^c$</td>
</tr>
<tr>
<td>7</td>
<td>60℃</td>
<td>Fe (+) / C form (-)</td>
<td>K$_2$CO$_3$ (2.0 eq)</td>
<td>40</td>
</tr>
</tbody>
</table>

$^a$ Reaction condition: 10 (0.1 mmol, 1.0 eq.), 2aa (0.2 mmol, 2.0 eq.), $^b$Bu$_4$NPF$_6$ (0.05 M), Ni (20 mol%) and L (20 mol%) in Solvent at T under Ar and 5.0 mA for 6 h. $^b$GC yield. (Dodecane as internal standard). $^c$ Isolated yield.
V. Experimental procedures

**Condition A: General procedure for the electrochemical reductive cross-coupling between trifluoroalkenes and alkyl or aryl halide.**
An oven-dried undivided reactor (5 mL) equipped with trifluoroalkenes (0.1 mmol), alkyl aryl halide (0.2 mmol), "Bu₄NBr (99.7 mg, 0.3 mmol, 0.1 M), diglyme NiBr₂ (7.0 mg, 0.02 mmol), L₁ (4.7 mg, 0.02 mmol) and a stir bar before adding DMSO (3 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and foamed nickel electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 6 mA (The dual display potentiostat was operating in constant current mode) under Ar and room temperature for 8 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO₃ and brine, dried over Na₂SO₄ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.

**Condition B: General procedure for the electrochemical reductive cross-coupling between Difluoroethylene and alkyl or aryl halide.**
An oven-dried undivided reactor (5 mL) equipped with Difluoroethylene (0.1 mmol), alkyl aryl halide (0.2 mmol), "Bu₄NPF₆ (116.4 mg, 0.3 mmol, 0.1 M), Ni(acac)₂ (5.1 mg, 0.02 mmol), L₁ (4.7 mg, 0.02 mmol) and a stir bar before adding DMA (3 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and foamed nickel electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 5 mA (The dual display potentiostat was operating in constant current mode) under Ar and room temperature for 6 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO₃ and brine, dried over Na₂SO₄ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.

**Condition C: General procedure for the electrochemical reductive cross-coupling between disulfides and aryl halide.**
An oven-dried undivided reactor (5 mL) equipped with disulfides (0.2 mmol), alkyl halide (0.1 mmol), "Bu₄NBr (99.7 mg, 0.3 mmol, 0.1 M), diglyme NiBr₂ (7.0 mg, 0.02 mmol), L₂ (5.2 mg, 0.02 mmol) and a stir bar before adding DMSO (3 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and foamed nickel electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 5 mA (The dual display potentiostat was operating in constant current mode) under Ar at rt for 6 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO₃ and brine, dried over Na₂SO₄ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.
Condition D: General procedure for the electrochemical reductive cross-coupling between MBH esters or alcohol and alkyl or aryl halide.
An oven-dried undivided reactor (10 mL) equipped with MBH ester or alcohol (0.1 mmol), alkyl aryl halide (0.2 mmol), tBu$_4$NPF$_6$ (77.6 mg, 0.2 mmol, 0.05 M), diglyme NiBr$_2$ (7.0 mg, 0.02 mmol), L2 (5.2 mg, 0.02 mmol), K$_2$CO$_3$ (27.6 mg, 0.2 mmol) and a stir bar before adding DMA (4 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and graphite electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 5 mA (The dual display potentiostat was operating in constant current mode) under Ar at 60℃ for 6 h (heating mantle). When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO$_3$ and brine, dried over Na$_2$SO$_4$ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.

Condition E: General procedure for the electrochemical reductive cross-coupling between acetals and aryl halide.
An oven-dried undivided reactor (10 mL) equipped with acetale (0.1 mmol), alkyl aryl halide (0.2 mmol), tBu$_4$NPF$_6$ (77.6 mg, 0.2 mmol, 0.05 M), diglyme NiBr$_2$ (7.0 mg, 0.02 mmol), L1 (4.7 mg, 0.02 mmol) and a stir bar before adding DMA (4 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and graphite electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 5 mA (The dual display potentiostat was operating in constant current mode) under Ar at 60℃ for 6 h (heating mantle). When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO$_3$ and brine, dried over Na$_2$SO$_4$ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.

Condition F: General procedure for the electrochemical reductive cross-coupling between oxalates and aryl halide.
An oven-dried undivided reactor (5 mL) equipped with oxalates (0.1 mmol), alkyl halide (0.2 mmol), tBu$_4$NPF$_6$ (116.4 mg, 0.3 mmol, 1.0 M), diglyme NiBr$_2$ (7.0 mg, 0.02 mmol), L2 (5.2 mg, 0.02 mmol) and a stir bar before adding DMA (3 mL). The reactor was equipped with Fe electrode (52.5×8×2 mm) as the anode and foamed nickel electrode (52.5×8×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 5 mA (The dual display potentiostat was operating in constant current mode) under Ar at rt for 6 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO$_3$ and brine, dried over Na$_2$SO$_4$ and organic layers were
combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel.

**Condition G: General procedure for the gram scale experiments.**

An oven-dried undivided reactor (25 mL) equipped with trifluoromethyl alkenes 1a (248.0 mg, 1.0 mmol), alkyl halide (0.223 mL, 2.0 mmol), tBu4NBr (996.0 mg, 3 mmol, 0.2M), diglyme NiBr$_2$ (70.2 mg, 0.2 mmol), L1 (5.2 mg, 0.2 mmol) and a stir bar before adding DMSO (15 mL). The reactor was equipped with Fe electrode (52.5×16×2 mm) as the anode and foamed nickel electrode (52.5×16×2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 6 mA (The dual display potentiostat was operating in constant current mode) under Ar at rt for 36 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO$_3$ and brine, dried over Na$_2$SO$_4$ and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel. (166.0 mg, 54%)
VI. Characteristic Data

4-(1,1-difluoro-3-phenylprop-1-en-2-yl)-1,1'-biphenyl (3aa)

Following the general procedure condition A. An oven-dried undivided reactor (5 mL) equipped with 1a (0.1 mmol), PhI (0.2 mmol), n-Bu4NBr (99.7 mg, 0.3 mmol, 1.0 M), diglyme NiBr2 (7.0 mg, 0.02 mmol), L1 (4.7 mg, 0.02 mmol), and a stir bar before adding DMSO (3 mL). The reactor was equipped with iron electrode (52.5× 8× 2 mm) as the anode and foamed nickel electrode (52.5× 8× 2 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current of 6.0 mA (The dual display potentiostat was operating in constant current mode) under Ar and room temperature for 8 h. When the reaction was completed, the reaction mixture was diluted with ethyl acetate, washed with HCl (1M), then washed with NaHCO3, and brine, dried over Na2SO4, and organic layers were combined and concentrated in vacuo. The product was purified by flash column chromatography on silica gel. Solid, (23.0 mg, 75%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.58 – 7.53 (m, 2H), 7.53 – 7.49 (m, 2H), 7.41 (t, J = 7.6 Hz, 2H), 7.37 – 7.30 (m, 3H), 7.29 – 7.24 (m, 2H), 7.22 – 7.16 (m, 3H), 3.77 (s, 2H).

13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 292.5, 287.6 Hz), 140.6, 140.1, 138.6 – 138.5 (t, J = 2.5 Hz), 132.6 (t, J = 3.9 Hz), 129.0, 128.7, 128.4, 127.5, 127.1 (d, J = 9.7 Hz), 126.6, 91.5 (dd, J = 21.5, 13.2 Hz), 33.9. 19F NMR (471 MHz, CDCl3) δ -89.91 (dd, J = 267.9, 39.1 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C21H17F2 307.1298; found 307.1295.

4-(1,1-difluoro-3-(m-tolyl)prop-1-en-2-yl)-1,1'-biphenyl (3b)

Following the general procedure condition A. Solid, (25.8 mg, 81%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.60 – 7.52 (m, 4H), 7.44 (t, J = 7.7 Hz, 2H), 7.40 – 7.33 (m, 3H), 7.17 (t, J = 7.5 Hz, 1H), 7.03 (m, 3H), 3.76 (s, 2H), 2.32 (s, 3H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 292.5, 287.6 Hz), 140.6, 140.1, 138.6 – 138.5 (t, J = 2.5 Hz), 138.2, 132.7 (t, J = 3.9 Hz), 129.1, 128.9, 128.8 – 128.6 (t, J = 3.9 Hz), 128.5, 127.5, 127.3, 127.2, 127.1, 125.4, 91.5 (dd, J = 21.6, 13.0 Hz), 33.8, 21.6. 19F NMR (471 MHz, CDCl3) δ -89.88 (dd, J = 267.9, 39.1 Hz). HRMS(ESI) m/z: [M + Na]+ Calcd for C22H18F2Na 343.1274; found 343.1274.

4-(3-(3-chlorophenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3c)

Following the general procedure condition A. Oil, (20.0 mg, 59%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.60 – 7.51 (m, 4H), 7.44 (m, 2H), 7.37 – 7.32 (m, 3H), 7.19 (m, 3H), 7.10 – 7.06 (m, 1H), 3.76 (s, 2H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J =
293.1, 288.3 Hz), 140.6 (t, J = 2.5 Hz), 140.5, 140.3, 134.5, 132.1 (t, J = 3.9 Hz), 129.9, 128.9, 128.6 (t, J = 3.6 Hz), 128.5, 127.6, 127.3, 127.1, 126.9, 126.6, 91.0 (dd, J = 21.3, 13.9 Hz), 33.6. 19F NMR (471 MHz, CDCl3) δ -89.31 (dd, J = 204.1, 37.6 Hz). HRMS(ESI) m/z: [M + Na]+ Calcd for C21H15ClF2Na 363.0728; found 363.0732.

4-(1,1-difluoro-3-(trifluoromethyl)phenyl)prop-1-en-2-yl)-1,1'-biphenyl (3d)

Following the general procedure condition A. Oil, (19.2 mg, 51%); Eluent: EA; 1H NMR (500 MHz, CDCl3) δ 7.60 – 7.52 (m, 4H), 7.49 – 7.40 (m, 4H), 7.39 – 7.32 (m, 5H), 3.84 (s, 2H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 293.0, 288.5 Hz), 140.5, 140.5, 139.5 (t, J = 3.7 Hz), 132.0 (t, J = 3.7 Hz), 131.7, 131.0 (d, J = 32.0 Hz), 129.1, 128.9, 128.7 (t, J = 3.5 Hz), 127.6, 127.3, 127.1, 125.2 (q, J = 3.8 Hz), 124.2 (q, J = 272.4 Hz), 123.6 (q, J = 3.7 Hz), 91.0 (dd, J = 21.3, 14.2 Hz), 33.8. 19F NMR (471 MHz, CDCl3) δ -62.60 (s), -89.29 (dd, J = 169.8, 37.5 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C22H16F5 375.1178; found 375.1175.

4-(3-(4-ethylphenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3e)

Following the general procedure condition A. Oil, (23.0 mg, 69%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.61 – 7.52 (m, 4H), 7.47 – 7.32 (m, 5H), 7.17 – 7.10 (m, 4H), 3.77 (s, 2H), 2.62 (q, J = 7.6 Hz, 2H), 1.23 (t, J = 7.6 Hz, 3H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 292.5, 287.7 Hz), 142.5, 140.6, 140.1, 135.7 (t, J = 2.6 Hz), 132.7 (t, J = 4.0 Hz), 128.9, 128.7 (t, J = 3.6 Hz), 128.3, 128.2, 127.5, 127.2, 127.1, 91.6 (dd, J = 21.6, 12.8 Hz), 33.5, 28.6, 15.7. 19F NMR (471 MHz, CDCl3) δ -62.60 (s), -89.29 (dd, J = 169.8, 37.5 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C23H20F3 335.1611; found 335.1603.

4,4''-(3,3-difluoroprop-2-ene-1,2-diyl)di-1,1'-biphenyl (3f)

Following the general procedure condition A. Solid, (27.9 mg, 73%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.59 – 7.56 (m, 5H), 7.55 – 7.55 (m, 1H), 7.52 – 7.51 (m, 2H), 7.45 – 7.40 (m, 6H), 7.36 – 7.31 (m, 2H), 7.30 – 7.28 (m, 2H), 3.83 (s, 2H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 292.6, 287.8 Hz), 140.9, 140.6, 140.2, 139.5, 137.7 (t, J = 2.6 Hz), 132.6 (t, J = 3.9 Hz), 128.9, 128.9, 128.8, 128.7 (t, J = 3.6 Hz), 127.5, 127.4, 127.3, 127.2, 127.1, 91.4 (dd, J = 21.5, 13.2 Hz), 33.5. 19F NMR (471 MHz, CDCl3) δ -89.71 (dd, J = 251.1, 38.7 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C27H21F2 383.1611; found 383.1612.
4-(1,1-difluoro-3-(4-methoxyphenyl)prop-1-en-2-yl)-1,1'-biphenyl (3g)

Following the general procedure condition A. Oil, (14.9 mg, 44%); Eluent: PE/EA 20:1; 1H NMR (500 MHz, CDCl3) δ 7.59 – 7.53 (m, 4H), 7.43 (t, J = 7.5 Hz, 2H), 7.40 – 7.33 (m, 3H), 7.12 (d, J = 7.5 Hz, 2H), 6.82 (d, J = 7.0 Hz, 2H), 3.77 (s, 3H), 3.73 (s, 2H).

13C NMR (126 MHz, CDCl3) δ 158.4, 156.9, 154.6, 152.3, 140.7, 140.1, 132.7, 130.6, 129.4 (d, J = 3.7 Hz), 129.1 – 128.4 (m, 4H), 127.5 (d, J = 3.9 Hz), 127.1 (dd, J = 6.9, 3.9 Hz), 114.1, 91.9 (dd, J = 19.2, 11.0 Hz), 77.3 (d, J = 31.9 Hz), 77.1 – 77.0 (m), 76.9, 55.4, 33.1. 19F NMR (471 MHz, CDCl3) δ -90.32 (dd, J = 182.1, 39.8 Hz).

HRMS(ESI) m/z: [M + H]+ Calcd for C22H19F2O337.1404; found 337.1404.

4-(3-(4-(tert-butyl)phenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3h)

Following the general procedure condition A. Solid, (20.4 mg, 56%); Eluent: PE; 1H NMR (500 MHz, CDCl3) δ 7.61 – 7.52 (m, 4H), 7.45 – 7.29 (m, 4H), 7.37 – 7.27 (m, 3H), 7.15 (d, J = 8.2 Hz, 2H), 3.76 (s, 2H), 1.30 (s, 9H).

13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 292.6, 287.7 Hz), 144.2 (t, J = 2.5 Hz), 140.6, 140.0, 135.5 (t, J = 2.5 Hz), 132.8 (t, J = 4.0 Hz), 128.9, 128.7 (t, J = 3.8 Hz), 128.0, 127.5, 127.2, 127.1, 125.6, 91.5 (dd, J = 21.6, 12.7 Hz), 34.5, 33.3, 31.5.

19F NMR (471 MHz, CDCl3) δ -89.78 (dd, J = 361.5, 39.0 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C25H25F363.1924; found 363.1926.

4-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)benzonitrile (3i)

Following the general procedure condition A. Oil, (17.2 mg, 52%); Eluent: PE/EA 10:1; 1H NMR (500 MHz, CDCl3) δ 7.59 – 7.54 (m, 5H), 7.53 (s, 1H), 7.43 (t, J = 7.6 Hz, 2H), 7.36 (d, J = 7.4 Hz, 1H), 7.31 (t, J = 8.2 Hz, 4H), 3.84 (s, 2H). 13C NMR (126 MHz, CDCl3) δ 154.7 (dd, J = 293.5, 288.7 Hz), 144.2 (t, J = 2.5 Hz), 140.6, 140.3, 132.5, 131.7 (t, J = 3.8 Hz), 129.2, 129.0, 128.6 (t, J = 3.5 Hz), 127.7, 127.4, 127.4, 118.9, 110.7, 90.7 (dd, J = 21.3, 14.5 Hz), 34.1. 19F NMR (471 MHz, CDCl3) δ -88.86 (dd, J = 187.3, 36.8 Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C22H16F2N 332.1251; found 332.1250.

5-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)benzo[d][1,3]dioxole (3j)

Following the general procedure condition A. Oil, (14.0 mg, 40%); Eluent: PE/EA 20:1; 1H NMR (500 MHz, CDCl3) δ 7.63 – 7.55 (m, 4H), 7.46 (t, J = 7.6 Hz, 2H), 7.39 – 7.36 (m, 3H), 6.75 – 6.67 (m, 3H), 5.94 (s, 2H), 3.72 (s, 2H). 13C NMR (126 MHz, CDCl3) δ 154.6
(dd, J = 292.5, 287.8 Hz), 147.9, 146.3, 140.6, 140.2, 132.5 (t, J = 3.8 Hz), 132.3 (t, J = 2.6 Hz), 128.9, 128.7 (t, J = 3.6 Hz), 127.5, 127.2, 127.1, 121.4, 108.8, 108.4, 101.0, 91.7 (dd, J = 21.2, 13.0 Hz), 33.6. $^{19}$F NMR (471 MHz, CDCl$_3$) δ -90.11 (dd, J = 147.2, 39.3 Hz). HRMS(ESI) m/z: [M + Na]$^+$ Calcd for C$_{22}$H$_{16}$F$_2$O$_2$Na 373.1016; found 373.1014.

2-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)naphthalene (3k)

Following the general procedure condition A. Solid, (12.6 mg, 36%); Eluent: PE; $^1$H NMR (500 MHz, CDCl$_3$) δ 7.78 (m, 3H), 7.64 (s, 1H), 7.57 – 7.49 (m, 4H), 7.47 – 7.30 (m, 8H), 3.94 (s, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 154.8 (dd, J = 292.7, 287.9 Hz), 140.6, 140.2, 136.1 (t, J = 2.6 Hz), 133.7, 132.6 (t, J = 3.9 Hz), 132.4, 128.9, 128.7 (t, J = 3.6 Hz), 128.4, 127.8, 127.7, 127.5, 127.2, 127.1, 126.9, 126.8, 126.2, 125.6, 91.4 (dd, J = 21.4, 13.2 Hz), 34.1. $^{19}$F NMR (471 MHz, CDCl$_3$) δ -89.68 (dd, J = 228.7, 38.7 Hz). HRMS(ESI) m/z: [M + H]$^+$ Calcd for C$_{25}$H$_{19}$F$_2$O$_2$ 357.1455; found 357.1455.

4-(3-(3,5-dimethoxyphenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3l)

Following the general procedure condition A. Oil, (20.8 mg, 57%); Eluent: PE/EA 20:1; $^1$H NMR (500 MHz, CDCl$_3$) δ 7.56 (dd, J = 16.7, 7.8 Hz, 4H), 7.43 (t, J = 7.7 Hz, 2H), 7.40 – 7.32 (m, 3H), 6.37 (d, J = 2.1 Hz, 2H), 6.31 (t, J = 2.1 Hz, 1H), 3.74 (s, 6H), 3.72 (s, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 161.0, 154.7 (dd, J = 292.6, 288.0 Hz), 141.0 (t, J = 2.5 Hz), 140.6, 140.1, 132.6 (t, J = 3.9 Hz), 128.9, 128.7 (t, J = 3.5 Hz), 127.5, 127.2, 127.1, 106.5, 98.4, 91.2 (dd, J = 21.4, 13.4 Hz), 55.4, 34.1. $^{19}$F NMR (471 MHz, CDCl$_3$) δ -89.73 (dd, J = 215.2, 38.5 Hz). HRMS(ESI) m/z: [M + H]$^+$ Calcd for C$_{23}$H$_{21}$F$_2$O$_2$ 367.1510; found 367.1509.

4-(3-cyclohexyl-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (4a)

Following the general procedure condition A. Solid, (28.6 mg, 92%); Eluent: PE; $^1$H NMR (500 MHz, CDCl$_3$) δ 7.63 – 7.59 (m, 4H), 7.46 (t, J = 7.7 Hz, 2H), 7.42 – 7.35 (m, 3H), 2.33 (dt, J = 5.0, 2.3 Hz, 2H), 1.74 – 1.67 (m, 4H), 1.36 – 1.29 (m, 1H), 1.17 – 1.14 (m, 3H), 0.96 (dd, J = 21.1, 11.3 Hz, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 154.21 (dd, J = 290.6, 286.2 Hz), 140.73, 139.99, 133.2 (t, J = 3.7 Hz), 128.9, 128.8 (t, J = 3.3 Hz), 127.5, 127.2, 127.1, 90.9 (dd, J = 22.2, 12.2 Hz), 35.9, 35.3, 33.0, 26.6, 26.2. $^{19}$F NMR (471 MHz, CDCl$_3$) δ -90.95 (dd, J = 260.4, 43.2 Hz). All data matched that reported in the literature $^{10}$

4-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)tetrahydro-2H-pyran (4b)
Following the general procedure condition A. Solid, (26.6mg, 85%); Eluent: PE/EA 20:1; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\) 7.63 – 7.58 (m, 4H), 7.48 – 7.43 (m, 3H), 7.41 – 7.34 (m, 2H), 3.93 (dd, \(J = 11.3, 3.8\) Hz, 2H), 3.29 (td, \(J = 11.9, 1.9\) Hz, 2H), 2.40 (dt, \(J = 6.9, 2.4\) Hz, 2H), 1.72 – 1.48 (m, 3H), 1.40 – 1.29 (m, 2H). \(^{13}\)C NMR (126 MHz, CDCl\(_3\)) \(\delta\) 154.3 (dd, \(J = 291.2, 287.0\) Hz), 140.9, 140.2, 132.7 (t, \(J = 3.8\) Hz), 129.0, 128.7 (t, \(J = 3.2\) Hz), 127.6, 127.3, 127.1, 90.2 (dd, \(J = 22.0, 12.9\) Hz), 67.9, 34.8, 33.4, 32.8. \(^{19}\)F NMR (471 MHz, CDCl\(_3\)) \(\delta\) -90.35 (dd, \(J = 197.4, 42.0\) Hz). HRMS(ESI) \(m/z\): [M + H]+ Calcd for C\(_{20}\)H\(_{21}\)F\(_2\)O 315.1560; found 315.1559.

tert-butyl 4-(2-([1,1'-biphenyl]-4-yl)-3,3-difluoroallyl)piperidine-1-carboxylate (4c)

Following the general procedure condition A. Solid, (28.8mg, 70%); Eluent: PE/EA 20:1; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\) 7.64 – 7.57 (m, 4H), 7.48 – 7.42 (m, 2H), 7.41 – 7.33 (m, 4H), 4.06 (s, 2H), 2.62 – 2.57 (m, 2H), 2.38 (dd, \(J = 5.0, 2.1\) Hz, 1H), 1.65 (d, \(J = 12.5\) Hz, 2H), 1.52 – 1.45 (m, 10H), 1.15 (dd, \(J = 20.9, 11.1\) Hz, 2H). \(^{13}\)C NMR (126 MHz, CDCl\(_3\)) \(\delta\) 154.9, 154.3 (dd, \(J = 290.3, 286.4\) Hz), 140.6, 140.3, 132.7 (J = 3.7 Hz), 129.0, 128.7 (t, \(J = 3.2\) Hz), 127.6, 127.3, 127.1, 90.4 (dd, \(J = 22.0, 12.9\) Hz), 79.4, 43.9, 34.4 (d, \(J = 1.1\) Hz), 31.9, 28.6. \(^{19}\)F NMR (471 MHz, CDCl\(_3\)) \(\delta\) -90.30 (dd, \(J = 221.1, 41.9\) Hz). HRMS(ESI) \(m/z\): [M + H]+ Calcd for C\(_{25}\)H\(_{30}\)F\(_2\)N\(_2\)O\(_2\) 414.2245; found 414.2246.

4-(1,1-difluoro-4-methylhex-1-en-2-yl)-1',biphenyl (4d)

Following the general procedure condition A. Solid, (19.2mg, 67%); Eluent: PE; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.66 – 7.57 (m, 4H), 7.50 – 7.32 (m, 5H), 2.48-2.42 (m, 1H), 2.28-2.22 (m, 1H), 1.46-1.36 (m, 2H), 1.25-1.12 (m, 1H), 0.91-0.86 (m, 6H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 154.2 (dd, \(J = 290.3, 286.4\) Hz), 140.8, 140.1, 133.3 – 132.5 (m), 128.9, 128.8 (t, \(J = 3.2\) Hz), 127.5, 127.2, 127.2, 91.4 (dd, \(J = 21.9, 12.7\) Hz), 34.7 (d, \(J = 0.6\) Hz), 32.8, 29.2, 18.8, 11.4. \(^{19}\)F NMR (377 MHz, CDCl\(_3\)) \(\delta\) -91.22 (dt, \(J = 43.6, 22.4\) Hz). All data matched that reported in the literature \(^9\).

3-(2-([1,1'-biphenyl]-4-yl)-3,3-difluoroallyltetrahydrofuran (4e)

Following the general procedure condition A. Solid, (17.4mg, 58%); Eluent: PE/EA 20:1; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\) 7.63 – 7.58 (m, 4H), 7.48 – 7.42 (m, 2H), 7.41 – 7.34 (m, 3H), 3.88 (td, \(J = 8.2, 5.1\) Hz, 1H), 3.79 (dd, \(J = 8.4, 7.0\) Hz, 1H), 3.75 – 3.68 (m, 1H), 3.43 (dd, \(J = 8.4, 6.5\)
tert-butyl 3-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)azetidine-1-carboxylate (4f)

Following the general procedure condition A. Solid, (18.5mg, 48%); Eluent: PE/EA 20:1; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.61 – 7.57 (m, 4H), 7.47 – 7.43 (m, 2H), 7.39 – 7.34 (m, 1H), 7.32 (d, $J = 7.6$ Hz, 2H), 3.92 (t, $J = 8.4$ Hz, 2H), 3.57 (dd, $J = 21.5$, 13.9 Hz), 30.3, 29.8.

4-(1,1-difluoro-4,4-dimethylpent-1-en-2-yl)-1,1'-biphenyl (4g)

Following the general procedure condition A. Solid, (21.8mg, 76%); Eluent: PE; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.63 – 7.56 (m, 4H), 7.47 – 7.42 (m, 2H), 7.41 – 7.38 (m, 2H), 7.37 – 7.32 (m, 1H), 2.40 – 2.34 (m, 2H), 0.84 (s, 9H). $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 156.5, 154.3 (dd, $J = 290.4$, 287.7 Hz), 140.6, 139.7, 135.2 – 134.1 (m), 128.8 – 128.8 (m), 127.3, 127.0, 126.9, 90.8 (dd, $J = 21.7$, 12.7 Hz), 32.8 (t, $J = 2.4$ Hz), 30.3, 29.8. $^{19}$F NMR (471 MHz, CDCl$_3$) $\delta$ -90.63 (dd, $J = 1251.8$, 40.5 Hz). HRMS(ESI) m/z: [M + H$^+$] Calcd for C$_{23}$H$_{26}$F$_2$NO; 386.1932 found 386.1932.

1-chloro-4-(1,1-difluoro-3-phenylprop-1-en-2-yl)benzene (5a)

Following the general procedure condition A. Oil, (19.4mg, 73%); Eluent: PE; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.26 – 7.23(m, 4H), 7.21 – 7.16 (m, 3H), 7.13 (d, $J = 7.3$ Hz, 2H), 3.71 (s, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 154.5 (dd, $J = 292.2$, 288.1 Hz), 138.3 – 138.1 (m), 133.3, 132.1 (t, $J = 3.9$ Hz), 129.7 (t, $J = 3.5$ Hz), 128.7, 128.7, 128.4, 126.7, 91.1 (dd, $J = 22.1$, 13.5 Hz), 33.9. $^{19}$F NMR (471 MHz, CDCl$_3$) $\delta$ -89.95 (q, $J = 38.7$ Hz). HRMS(ESI) m/z: [M + H$^+$] Calcd for C$_{15}$H$_{11}$ClF$_2$ 265.0596; 265.0588.

3-(1,1-difluoro-3-phenylprop-1-en-2-yl)quinoline (5b)
Following the general procedure condition A. Solid, (16.8 mg, 60%); Eluent: PE/EA 20:1; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 8.84 (s, 1H), 8.05 (d, $J = 8.4$ Hz, 1H), 7.97 (d, $J = 2.1$ Hz, 1H), 7.75 – 7.64 (m, 2H), 7.51 (ddd, $J = 8.1$, 7.0, 1.1 Hz, 1H), 7.27 – 7.15 (m, 5H), 3.85 (s, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 154.9 (dd, $J = 293.0$, 289.7 Hz), 150.4 – 150.0 (m), 147.0 (s), 137.6 (t, $J = 2.5$ Hz), 135.0 (t, $J = 3.6$ Hz), 129.1, 128.7, 128.3, 127.8, 127.0, 126.8, 89.5 (dd, $J = 22.9$, 13.7 Hz), 33.7. $^{19}$F NMR (471 MHz, CDCl$_3$) $\delta$ -88.79 (dd, $J = 416.3$, 36.4 Hz).

HRMS(ESI) m/z: [M + H]+ Calcd for C$_{18}$H$_{14}$F$_2$N$_2$ 282.1094; found 282.1086.

4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl acetate (5c)

Following the general procedure condition A. Oil, (16.5 mg, 57%); Eluent: PE/EA 20:1; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.96 – 7.91 (m, 2H), 7.34 (dd, $J = 8.4$, 0.8 Hz, 2H), 7.26 – 7.22 (m, 2H), 7.20 – 7.12 (m, 3H), 3.88 (s, 3H), 3.76 (s, 2H). $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 166.8, 154.8 (dd, $J = 294.0$, 289.0 Hz), 138.4 (t, $J = 4.2$ Hz), 138.2 – 138.0 (m), 129.8, 129.0, 128.7, 128.3 (t, $J = 3.6$ Hz), 128., 126.7, 91.6 (dd, $J = 22.0$, 12.8 Hz), 52.3, 33.7. $^{19}$F NMR (377 MHz, CDCl$_3$) $\delta$ -89.79 (dd, $J = 244.9$, 35.1 Hz). HRMS(ESI) m/z: [M + H]$^+$ Calcd for C$_{17}$H$_{15}$F$_2$O$_2$ 289.1040; found 289.1033.

(4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl)(isopropyl)sulfane (5d)

Following the general procedure condition A, Eluent: PE; (17.2 mg, 51%); colourless oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.31 – 7.26 (m, 2H), 7.25 – 7.13 (m, 6H), 3.72 (s, 2H), 3.35 (hept, $J = 6.7$ Hz, 1H), 1.28 (d, $J = 6.7$ Hz, 6H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 166.8, 154.8 (dd, $J = 294.0$, 289.0 Hz), 138.5 (t, $J = 4.2$ Hz), 138.2 – 138.0 (m), 129.8, 129.0, 128.7, 128.3 (t, $J = 3.6$ Hz), 128., 126.7, 91.6 (dd, $J = 22.0$, 12.8 Hz), 52.3, 33.7. $^{19}$F NMR (377 MHz, CDCl$_3$) $\delta$ -89.79 (dd, $J = 244.9$, 35.1 Hz). HRMS(ESI) m/z: [M + H]$^+$ Calcd for C$_{18}$H$_{19}$F$_2$S 305.1176; found 305.1168.

2-(1,1-difluoro-3-phenylprop-1-en-2-yl)benzo[b]thiophene (5e)

Following the general procedure condition A, Eluent: PE; (17.0 mg, 59%); colourless oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.74 (ddd, $J = 6.2$, 1.8, 0.7 Hz, 1H), 7.66 – 7.63 (m, 1H), 7.31 – 7.17 (m, 8H), 3.85 – 3.83 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 155.08 (dd, $J = 297.9$, 290.1 Hz), 139.56, 139.48 (dd, $J = 5.5$, 1.6 Hz), 138.05 – 137.89 (m), 135.95 (dd, $J = 7.3$, 3.7 Hz), 128.78, 128.24, 126.85, 124.51, 123.49, 122.75 (dd, $J = 6.0$, 5.1 Hz), 122.00, 88.52 (dd, $J = 25.8$, 12.7 Hz), 33.57 (d, $J = 1.5$ Hz). $^{19}$F NMR
(377 MHz, CDCl₃) δ -85.36 (ddt, J = 27.4, 5.4, 2.0 Hz). HRMS(ESI) m/z: [M + H]^+ Calcd for C₁₇H₁₃F₂S 287.0706; found 287.0696.

1-(1,1-difluoro-3-phenylprop-1-en-2-yl)-4-(pent-4-en-1-yloxy)benzene (5f)

Following the general procedure condition A, Eluent: PE/EA 1/10; (10.3 mg, 33%); colourless oil. ¹H NMR (500 MHz, CDCl₃) δ 7.27 – 7.22 (m, 2H), 7.17 (dt, J = 12.2, 3.7 Hz, 5H), 6.84 – 6.76 (m, 2H), 5.83 (ddt, J = 16.9, 10.2, 6.6 Hz, 1H), 5.10 – 4.96 (m, 2H), 3.92 (t, J = 6.4 Hz, 2H), 3.69 (s, 2H), 2.25 – 2.16 (m, 2H), 1.93 – 1.79 (m, 2H). ¹³C NMR (126 MHz, CDCl₃) δ 158.3, 154.4 (dd, J = 290.6, 286.7 Hz), 138.8 (t, J = 2.7 Hz), 137.9, 129.5 (t, J = 3.5 Hz), 128.6, 128.4, 126.5, 115.3, 114.5, 91.3 (dd, J = 21.3, 13.9 Hz), 67.2, 34.1, 30.2, 28.5. ¹⁹F NMR (471 MHz, CDCl₃) δ -91.73 (dd, J = 188.1, 42.9 Hz). HRMS(ESI) m/z: [M + H]^+ Calcd for C₂₀H₂₁F₂O 315.1560; found 315.1559.

1-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl 4-methylbenzenesulfonate (5g)

Following the general procedure condition A, PE; 15.9mg (58%); colourless oil. ¹H NMR (500 MHz, CDCl₃) δ 7.28 – 7.23 (m, 2H), 7.19 (dd, J = 12.0, 5.5 Hz, 5H), 7.15 – 7.13 (m, 2H), 3.72 (s, 2H), 2.91 – 2.80 (m, 1H), 1.21 (d, J = 6.9 Hz, 6H). ¹³C NMR (126 MHz, CDCl₃) δ 154.6 (dd, J = 291.8, 287.1 Hz), 148.0, 139.7 – 138.0 (m), 131.0 (t, J = 3.8 Hz), 128.6, 128.4, 128.2 (t, J = 3.6 Hz), 126.6, 126.5, 91.5 (dd, J = 21.3, 13.4 Hz), 33.9 (d, J = 15.3 Hz), 24.0. ¹⁹F NMR (471 MHz, CDCl₃) δ -90.72 (dd, J = 256.6, 40.6 Hz). HRMS(ESI) m/z: [M + Na]^+ Calcd for C₁₈H₁₈F₂Na 295.1274; found 295.1265.

4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl 4-methylbenzenesulfonate (5h)

Following the general procedure condition A, PE/EA 1/20; (15.2mg, 38%); colourless oil. ¹H NMR (500 MHz, CDCl₃) δ 7.67 – 7.62 (m, 2H), 7.28 – 7.22 (m, 4H), 7.20 – 7.15 (m, 3H), 7.11 (d, J = 7.2 Hz, 2H), 6.91 – 6.87 (m, 2H), 3.68 (s, 2H), 2.43 (s, 3H). ¹³C NMR (126 MHz, CDCl₃) δ 154.6 (dd, J = 292.6, 288.2 Hz), 148.6, 145.5, 138.1 (t, J = 2.5 Hz), 132.7 (t, J = 4.0 Hz), 132.4, 129.9, 129.6 (t, J = 3.5 Hz), 128.7, 128.6, 128.3, 126.7, 122.5, 91.0 (dd, J = 22.2, 13.3 Hz), 33.9, 21.8. ¹⁹F NMR (471 MHz, CDCl₃) δ -89.67 (dd, J = 264.3, 38.0 Hz). HRMS(ESI) m/z: [M + Na]^+ Calcd for C₂₂H₁₈F₂O₃SNa 423.0842; found 423.0841.
5-(1,1-difluoro-3-phenylprop-1-en-2-yl)-1-methyl-1H-indole (5i)

Following the general procedure condition A, (18.0 mg, 50%), Oil, PE; \(^1H\) NMR (500 MHz, CDCl\(_3\)) \(\delta\) 7.51 (s, 1H), 7.25 – 7.20 (m, 3H), 7.19 – 7.10 (m, 4H), 7.02 (d, \(J = 3.1\) Hz, 1H), 6.42 (dd, \(J = 3.1, 0.6\) Hz, 1H), 3.78 (s, 2H), 3.76 (s, 3H). \(^{13}C\) NMR (126 MHz, CDCl\(_3\)) \(\delta\) 154.4 (dd, \(J = 289.7, 286.4\) Hz), 139.3 – 138.8 (m), 136.0, 133.4, 129.4, 128.5, 128.5, 126.3, 122.3 (t, \(J = 3.2\) Hz), 121.0 (t, \(J = 3.2\) Hz), 109.2, 101.2, 34.9, 33.0. \(^{19}F\) NMR (471 MHz, CDCl\(_3\)) \(\delta\) -92.71 (dd, \(J = 298.6, 44.5\) Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{18}\)H\(_{16}\)F\(_2\)N 284.1251; found 284.1260.

\((Z)-4-(2-fluoro-3,3-dimethylbut-1-en-1-yl)-1,1'-biphenyl (7a)\)

Following the general procedure condition B, Solid (13.7 mg, 54%); Eluent: PE; \(^1H\) NMR (500 MHz, CDCl\(_3\)) 7.63 – 7.61 (m, 2H), 7.58 (s, 4H), 7.47 – 7.42 (m, 2H), 7.37 – 7.33 (m, 1H), 5.59 (d, \(J = 40.7\) Hz, 1H), 1.26 (s, 9H). \(^{13}C\) NMR (126 MHz, CDCl\(_3\)) \(\delta\) 168.4 (d, \(J = 270.0\) Hz), 141.0, 139.4 (d, \(J = 2.3\) Hz), 133.3 (d, \(J = 1.8\) Hz), 129.0 (d, \(J = 7.7\) Hz), 128.9, 127.3, 127.1 (d, \(J = 11.5\) Hz), 102.1 (d, \(J = 9.8\) Hz), 77.4, 77.2, 76.9, 35.7 (d, \(J = 23.9\) Hz), 27.6 (d, \(J = 2.7\) Hz). \(^{19}F\) NMR (471 MHz, CDCl\(_3\)) \(\delta\) -108.86 (s). HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{18}\)H\(_{20}\)F 255.1549; found 255.1547.

\((Z)-4-(2-fluoro-2-phenylvinyl)-1,1'-biphenyl (7b)\)

Following the general procedure condition B, Solid (14.1 mg, 51%); Eluent: PE; \(^1H\) NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.76 – 7.71 (m, 2H), 7.70 – 7.60 (m, 6H), 7.49 – 7.33 (m, 6H), 6.37 (d, \(J = 39.6\) Hz, 1H). \(^{13}C\) NMR (101 MHz, CDCl\(_3\)) \(\delta\) 157.5 (d, \(J = 258.7\) Hz), 140.8, 140.1 (d, \(J = 2.6\) Hz), 133.1, 133.0 – 132.8 (m), 130.5 (d, \(J = 9.4\) Hz), 129.6, 129.5, 129.2, 129.0, 128.8 (d, \(J = 2.1\) Hz), 127.5, 127.4, 127.1, 105.6 (d, \(J = 10.5\) Hz). \(^{19}F\) NMR (377 MHz, CDCl\(_3\)) \(\delta\) -113.78 (d, \(J = 39.6\) Hz). HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{20}\)H\(_{16}\)F 275.1236; found 275.1235.

\((Z)-4-(2-(4-(tert-buty)phenyl)-2-fluorovinyl)-1,1'-biphenyl (7c)\)

Following the general procedure condition B, Solid (12.0 mg, 36%); Eluent: PE; \(^1H\) NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.74 – 7.72 (m, 1H), 7.66 – 7.60 (m, 6H), 7.49 – 7.43 (m, 4H), 7.39 – 7.33 (m, 1H), 6.33 (d, \(J = 39.7\) Hz, 1H), 1.36 (s, 9H). \(^{13}C\) NMR (101 MHz, CDCl\(_3\)) \(\delta\) 157.8 (d, \(J = 258.5\) Hz), 152.5, 140.8, 139.9 (d, \(J = 2.7\) Hz), 133.1 (d, \(J = 3.0\) Hz), 130.1 – 130.0 (m), 129.4 (d, \(J = 8.0\) Hz), 129.0, 127.5, 127.3, 127.1, 125.7 (d, \(J = 2.0\) Hz), 124.3 (d, \(J = 7.4\) Hz), 104.9 (d, \(J = 10.5\) Hz), 34.9, 31.4. \(^{19}F\) NMR (376 MHz, CDCl\(_3\)) \(\delta\) -113.53 (d, \(J = 39.8\) Hz). HRMS(ESI) m/z: [M + Na]+ Calcd for C\(_{20}\)H\(_{23}\)FNa 353.1681; found 353.1677.
ethyl 2-((1,1'-biphenyl)-4-ylmethyl)acrylate (9a)

Following the general procedure condition C, Solid (16.0 mg, 60%); Eluent: PE/EA 20:1; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.61 – 7.49 (m, 4H), 7.46 – 7.39 (m, 2H), 7.36 – 7.29 (m, 1H), 7.29 – 7.23 (m, 2H), 6.28 – 6.22 (m, 1H), 5.51 (d, \(J = 1.4\) Hz, 1H), 4.20 (q, \(J = 7.1\) Hz, 2H), 3.67 (s, 2H), 1.27 (t, \(J = 7.1\) Hz, 3H).

\(^1\)C NMR (101 MHz, Chloroform-d) \(\delta\) 167.1, 141.1, 140.4, 139.4, 138.1, 129.6, 128.9, 127.3, 127.2, 127.1, 126.2, 60.9, 37.9, 14.3.

HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{18}\)H\(_{19}\)O\(_2\) 276.1385; found 276.1376.

ethyl 2-(phenanthren-9-ylmethyl)acrylate (9b)

Following the general procedure condition C, Solid (15.5 mg, 53%); Eluent: PE/EA 20:1; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.79 – 8.71 (m, 1H), 8.68 (dd, \(J = 8.1, 0.6\) Hz, 1H), 7.96 (dd, \(J = 8.1, 1.2\) Hz, 1H), 7.68 – 7.57 (m, 5H), 6.27 (q, \(J = 1.3\) Hz, 1H), 5.26 – 5.25 (m, 1H), 4.30 (q, \(J = 7.1\) Hz, 2H), 4.15 (s, 2H), 1.34 (t, \(J = 7.1\) Hz, 3H).

\(^1\)C NMR (101 MHz, Chloroform-d) \(\delta\) 167.4, 139.5, 133.2, 131.9, 131.2, 130.9, 130.1, 128.4, 128.3, 126.8, 126.8, 126.5, 126.5, 125.1, 123.3, 122.6, 61.1, 35.3, 14.4. HRMS(ESI) m/z: [M + Na]+ Calcd for C\(_{20}\)H\(_{18}\)O\(_2\) 313.1206; found 313.1206.

ethyl 2-(3-chloro-4-(4-ethoxybenzyl)benzyl)acrylate (9c)

Following the general procedure condition C, Solid (20.9 mg, 58%); Eluent: PE/EA 20:1; \(^1\)H NMR (400 MHz, Chloroform-d) \(\delta\) 7.28 – 7.26 (m, 1H), 7.10 – 7.05 (m, 2H), 6.99 – 6.97 (m, 2H), 6.84 – 6.78 (m, 2H), 6.21 (d, \(J = 1.2\) Hz, 1H), 5.41 (d, \(J = 1.4\) Hz, 1H), 4.15 (q, \(J = 7.1\) Hz, 2H), 4.04 – 3.96 (m, 4H), 3.54 (s, 2H), 1.39 (t, \(J = 7.0\) Hz, 3H), 1.24 (t, \(J = 7.1\) Hz, 4H).

\(^1\)C NMR (101 MHz, Chloroform-d) \(\delta\) 166.9, 157.5, 140.2, 139.1, 137.7, 132.2, 131.8, 131.6, 129.9, 129.6, 128.3, 126.3, 114.6, 63.5, 60.9, 38.5, 37.6, 15.0, 14.3. HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{21}\)H\(_{24}\)ClO\(_3\) 359.1414; found 359.1406.

methyl (E)-3-((1,1'-biphenyl)-4-yl)-2-benzylacrylate (11a)

Following the general procedure condition D, Solid (15.0 mg, 46%); Eluent: PE/EA 20:1; \(^1\)H NMR (400 MHz, Chloroform-d) \(\delta\) 7.97 (s, 1H), 7.61 – 7.55 (m, 4H), 7.50 – 7.40 (m, 4H), 7.39 – 7.27 (m, 3H), 7.23 (d, \(J = 7.6\) Hz, 3H), 4.02 (s, 2H), 3.77 (s, 3H).

\(^1\)C NMR (101 MHz, Chloroform-d) \(\delta\) 168.7, 141.6, 140.6, 140.3, 139.4, 134.3, 130.5, 129.8, 128.9, 128.6, 127.9, 127.7, 127.2, 127.0, 126.2, 52.2, 33.3. HRMS(ESI) m/z: [M + H]+ Calcd for C\(_{23}\)H\(_{21}\)O\(_2\) 329.1542; found 329.1538.
ethyl (E)-3-[[1,1'-biphenyl]-4-yl]-2-benzylacrylate (11b)

Following the general procedure condition D, Solid (10.1 mg, 30%); Eluent: PE/EA 20:1; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.96 (s, 1H), 7.59 (dd, $J = 8.4, 1.7$ Hz, 4H), 7.50 – 7.41 (m, 4H), 7.38 – 7.28 (m, 3H), 7.24 – 7.20 (m, 3H), 4.22 (q, $J = 7.1$ Hz, 2H), 4.01 (s, 2H), 1.25 (t, $J = 7.1$ Hz, 3H).

$^{13}$C NMR (101 MHz, Chloroform-$d$) δ 168.3, 141.6, 140.4, 140.4, 139.7, 134.5, 131.1, 129.9, 129.0, 128.7, 128.1, 127.8, 127.4, 127.2, 126.3, 61.1, 33.5, 14.3.

HRMS(ESI) m/z: [M + H]+ Calcd for C$_{24}$H$_{23}$O$_2$ 343.1698; found 343.1688.

methyl (E)-2-[[1,1'-biphenyl]-4-ylmethylene]-4,4-dimethylpentanoate (11c)

Following the general procedure condition D, Solid (16.0 mg, 52%); Eluent: PE/EA 20:1; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.71 (s, 1H), 7.65 – 7.59 (m, 4H), 7.45 (t, $J = 7.8$ Hz, 4H), 7.38 – 7.34 (m, 1H), 3.82 (s, 3H), 2.72 (s, 2H), 0.80 (s, 9H).

$^{13}$C NMR (101 MHz, Chloroform-$d$) δ 170.3, 140.6, 140.4, 139.5, 135.9, 135.5, 132.6, 129.6, 128.8, 127.5, 127.0, 52.0, 38.4, 33.5, 29.6.

HRMS(ESI) m/z: [M + H]+ Calcd for C$_{21}$H$_{25}$O$_2$ 309.1855; found 309.1863.

ethyl (E)-2-[[1,1'-biphenyl]-4-ylmethylene]-4,4-dimethylpentanoate (11d)

Following the general procedure condition D, Solid (18.3 mg, 57%); Eluent: PE/EA 20:1; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.70 (s, 1H), 7.65 – 7.58 (m, 4H), 7.50 – 7.41 (m, 4H), 7.38 – 7.34 (m, 1H), 4.28 (q, $J = 7.1$ Hz, 2H), 2.71 (s, 2H), 1.36 (t, $J = 7.1$ Hz, 3H), 0.80 (s, 9H).

$^{13}$C NMR (126 MHz, Chloroform-$d$) δ 170.0, 140.6, 140.5, 139.3, 135.8, 133.1, 129.7, 129.0, 127.6, 127.1, 127.1, 61.0, 38.5, 33.7, 29.8, 14.4.

HRMS(ESI) m/z: [M + Na]+ Calcd for C$_{22}$H$_{26}$O$_2$Na 345.1830; found 345.1822.

(E)-4-(3-phenylprop-1-en-1-yl)-1,1'-biphenyl (13a)

Following the general procedure condition E, Solid (16.2 mg, 60%); Eluent: PE; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.63 – 7.50 (m, 5H), 7.45 – 7.39 (m, 4H), 7.35 – 7.19 (m, 5H), 6.53 – 6.35 (m, 2H), 3.57 (d, $J = 6.5$ Hz, 2H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 140.9, 140.3, 140.0, 136.7, 130.8, 129.6, 128.9, 128.8, 128.7, 127.3, 127.0, 126.7, 126.4, 39.6. HRMS(ESI) m/z: [M + H]+ Calcd for C$_{21}$H$_{18}$O$_2$ 271.1487; found 271.1490.

(E)-4-(3-(4-((tert-butyl)phenyl)prop-1-en-1-yl)-1,1'-biphenyl (13b)

Following the general procedure condition E, Solid (15.2 mg, 47%); Eluent: PE; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.63 – 7.52 (m, 4H), 7.47 – 7.41 (m, 4H), 7.39 – 7.30 (m, 3H), 7.21 (d, $J = 8.3$ Hz, 2H), 6.56 – 6.37 (m, 2H), 3.56 (d, $J$
= 6.6 Hz, 2H), 1.33 (s, 9H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 149.2, 141.0, 139.9, 137.3, 136.8, 130.6, 129.8, 128.9, 128.5, 127.3, 127.0, 126.7, 125.6, 39.1, 34.6, 31.6. HRMS(ESI) m/z: [M + H]+ Calcd for C$_{25}$H$_{27}$ 327.2113; found 327.2122.

(E)-4-(3-(4-methoxyphenyl)prop-1-en-1-yl)-1,1'-biphenyl (13c)

Following the general procedure condition E, Solid (11.0 mg, 37%); Eluent: PE/EA 20:1; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.63 – 7.50 (m, 4H), 7.47 – 7.39 (m, 4H), 7.36 – 7.29 (m, 1H), 7.21 – 7.14 (m, 2H), 6.92 – 6.82 (m, 2H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 158.2, 141.0, 140.0, 136.8, 132.3, 130.4, 130.0, 129.8, 128.9, 127.3, 127.0, 126.7, 114.1, 55.5, 38.7. HRMS(ESI) m/z: [M + H]+ Calcd for C$_{22}$H$_{21}$O$_{3}$ 301.1592; found 301.1586.

(E)-prop-1-ene-1,3-diyl dibenzene (15a)

Following the general procedure condition F, Solid (16.4 mg, 85%); Eluent: PE; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.42 – 7.14 (m, 10H), 6.49 – 6.30 (m, 2H), 3.55 (d, $J$ = 6.8 Hz, 2H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 140.2, 137.5, 131.1, 129.3, 128.7, 128.5, 127.1, 126.2, 126.2, 39.4. HRMS(ESI) m/z: [M + Na]+ Calcd for C$_{15}$H$_{14}$Na 217.0993; found 217.0996.

1-(tert-butyl)-4-cinnamylbenzene (15b)

Following the general procedure condition F, Solid (23.4 mg, 94%); Eluent: PE; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.39 – 7.14 (m, 9H), 6.52 – 6.29 (m, 2H), 3.52 (dd, $J$ = 6.8, 1.1 Hz, 2H), 1.31 (s, 9H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 149.2, 137.7, 137.3, 131.0, 129.6, 128.6, 128.4, 127.2, 126.3, 125.5, 39.0, 34.5, 31.5. HRMS(ESI) m/z: [M + H]+ Calcd for C$_{19}$H$_{23}$ 251.1800; found 251.1801.

1-cinnamyl-4-methoxybenzene (15c)

Following the general procedure condition F, Solid (14.2 mg, 63%); Eluent: PE/EA 20:1; $^1$H NMR (400 MHz, Chloroform-$d$) δ 7.38 – 7.27 (m, 4H), 7.24 – 7.13 (m, 3H), 6.89 – 6.83 (m, 2H), 6.47 – 6.30 (m, 2H), 3.80 (s, 3H), 3.50 (d, $J$ = 6.5 Hz, 2H). $^{13}$C NMR (101 MHz, Chloroform-$d$) δ 158.2, 137.7, 132.3, 130.9, 129.8, 129.7, 128.6, 127.2, 126.3, 114.1, 55.4, 38.6. HRMS(ESI) m/z: [M + Na]+ Calcd for C$_{16}$H$_{16}$ONa 247.1099; found 247.1109.
VII. Spectral data

4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1a)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

isopropyl(4-(3,3,3-trifluoroprop-1-en-2-yl)phenyl)sulfane (1e)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

$^{19}$F NMR (376 MHz CDCl$_3$)
4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1i)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{19}$F NMR (376 MHz, CDCl$_3$)
4-(3,3,3-trifluoroprop-1-en-2-yl)-1,1'-biphenyl (1j)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)
4-(1,1-difluoro-3-phenylprop-1-en-2-yl)-1,1'-biphenyl (3aa)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

4-(1,1-difluoro-3-(m-tolyl)prop-1-en-2-yl)-1,1'-biphenyl (3b)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz CDCl$_3$)
4-(3-(3-chlorophenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3c)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

4-(1,1-difluoro-3-(3-(trifluoromethyl)phenyl)prop-1-en-2-yl)-1,1'-biphenyl (3d)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl₃)

$^{19}$F NMR (471 MHz, CDCl₃)
4-(3-(4-ethylphenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3e)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

4,4''-(3,3-difluoroprop-2-ene-1,2-diyl)di-1,1'-biphenyl (3f)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)
4-(1,1-difluoro-3-(4-methoxyphenyl)prop-1-en-2-yl)-1,1'-biphenyl(3h)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

4-(3-(4-(tert-butyl)phenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3h)
$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)
4-(2-[(1,1'-biphenyl]-4-yl)-3,3-difluoroallyl)benzonitrile (3i)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

5-(2-[[1,1'-'biphenyl]-4-yl]-3,3-difluoroallyl)benzo[d][1,3]dioxole (3j)
$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (376 MHz, CDCl$_3$)
2-(2-([1,1'-biphenyl]-4-yl)-3,3-difluorallyl)naphthalene (3k)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

4-(3-(3,5-dimethoxyphenyl)-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (3l)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}\text{C} \text{NMR}$ (126 MHz, CDCl$_3$)

$^{19}\text{F} \text{NMR}$ (471 MHz, CDCl$_3$)
4-(3-cyclohexyl-1,1-difluoroprop-1-en-2-yl)-1,1'-biphenyl (4a)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^1$H NMR (500 MHz, CDCl$_3$)

4-(2-[[1,1'-biphenyl]-4-yl]-3,3-difluoroallyl)tetrahydro-2H-pyran (4b)

$^{19}$F NMR (471 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (376 MHz, CDCl$_3$)
tert-butyl 4-(2-([1,1'-biphenyl]-4-yl)-3,3-difluoroallyl)piperidine-1-carboxylate (4c)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)

4-(1,1-difluoro-4-methylhex-1-en-2-yl)-1,1'-biphenyl (4d)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

$^{19}$F NMR (377 MHz, CDCl$_3$)
3-(2-([1,1'-biphenyl]-4-yl)-3,3-difluorallyl)tetrahydrofuran (4e)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

tert-butyl 3-(2-[[1,1'-'biphenyl]-4-yl]-3,3-difluoroallyl)azetidine-1-carboxylate (4f)
$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)
4-(1,1-difluoro-4,4-dimethylpent-1-en-2-yl)-1,1'-biphenyl (4h)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

1-chloro-4-(1,1-difluoro-3-phenylprop-1-en-2-yl)benzene (5a)
$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)
3-(1,1-difluoro-3-phenylprop-1-en-2-yl)quinoline (5b)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

$^1$H NMR (400 MHz, CDCl$_3$)

4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl acetate (5c)
${}^{13}C$ NMR (101 MHz, CDCl₃)

${}^{19}F$ NMR (376 MHz, CDCl₃)
(4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl)(isopropyl)sulfane (5d)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (102 MHz, CDCl$_3$)
$^{19}$F NMR (371 MHz, CDCl$_3$)

1-(1,1-difluoro-3-phenylprop-1-en-2-yl)-3,5-dimethylbenzene (5e)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

$^{19}$F NMR (377 MHz, CDCl$_3$)
1-(1,1-difluoro-3-phenylprop-1-en-2-yl)-4-(pent-4-en-1-yloxy)benzene (5f)

$^1$H NMR (500 MHz, CDCl₃)

$^{13}$C NMR (126 MHz, CDCl₃)
$^{19}$F NMR (476 MHz, CDCl$_3$)

1-(1,1-difluoro-3-phenylprop-1-en-2-yl)-4-isopropylbenzene (5g)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

$^{19}$F NMR (471 MHz, CDCl$_3$)
4-(1,1-difluoro-3-phenylprop-1-en-2-yl)phenyl 4-methylbenzenesulfonate (5h)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (126 MHz, CDCl$_3$)
$^{19}$F NMR (471 MHz, CDCl$_3$)

5-(1,1-difluoro-3-phenylprop-1-en-2-yl)-1-methyl-1H-indole (5i)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (126 MHz, CDCl$_3$)

![Carbon-13 NMR spectrum]

$^{19}$F NMR (471 MHz, CDCl$_3$)

![Fluorine-19 NMR spectrum]
(Z)-4-(2-fluoro-3,3-dimethylbut-1-en-1-yl)-1,1'-biphenyl (7a)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

(Z)-4-(2-fluoro-2-phenylvinyl)-1,1'-biphenyl (7b)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

$^{19}$F NMR (376 MHz, CDCl$_3$)
(Z)-4-(2-(4-(tert-butyl)phenyl)-2-fluorovinyl)-1,1'-biphenyl (7c)

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
$^{19}$F NMR (376 MHz, CDCl$_3$)

ethyl 2-([1,1'-biphenyl]-4-ylmethyl)acrylate (9a)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

ethyl 2-(phenanthren-9-ylmethyl)acrylate (9b)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

ethyl 2-(3-chloro-4-(4-ethoxybenzyl)benzyl)acrylate (9c)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

methyl (E)-3-([1,1'-biphenyl]-4-yl)-2-benzylacrylate (11a)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

ethyl (E)-3-([1,1'-biphenyl]-4-yl)-2-benzylacrylate (11b)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

methyl (E)-2-([1,1'-biphenyl]-4-ylmethylene)-4,4-dimethylpentanoate (11c)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

ethyl (E)-2-[[1,1'-biphenyl]-4-ylmethylene]-4,4-dimethylpentanoate (11d)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

(E)-4-(3-phenylprop-1-en-1-yl)-1,1'-biphenyl (13a)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

(E)-4-(3-(4-(tert-butyl)phenyl)prop-1-en-1-yl)-1,1'-biphenyl (13b)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

(E)-4-(3-(4-methoxyphenyl)prop-1-en-1-yl)-1,1'-biphenyl (13c)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

(E)-prop-1-ene-1,3-diyl dibenzene (15a)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

1-(tert-butyl)-4-cinnamylbenzene (15b)

$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)

1-cinnamyl-4-methoxybenzene (15c)
$^1$H NMR (400 MHz, CDCl$_3$)
$^{13}$C NMR (101 MHz, CDCl$_3$)
References

S93