Supporting Information

Pd-Catalyzed Heck-type Coupling Via C–N Cleavage

Weizheng Fan\textsuperscript{a}, Faming Liu\textsuperscript{a}, Bainian Feng\textsuperscript{*}

\textsuperscript{*}School of Pharmaceutical Science, Jiangnan University, Wuxi 214122, China

\textsuperscript{a}The author contributed equally to this work

\textit{E-Mail: fengbainian@jiangnan.edu.cn}

I. General remarks 2

II. Experimental section 2

1. Optimization of the transformation from 1a to 3a 2

2. Supporting experiments for the proposed mechanism 4

3. 1 mmol scale experiment 4

4. Analytical data 4

5. Spectrum of new compounds 8
I. General remarks

All starting materials and reagents were purchased from commercial sources and used as received unless otherwise noted. Analytical thin layer chromatography (TLC) was performed on silica gel 60 F254 plates. Flash column chromatography was undertaken on silica gel (200–300 mesh). $^1$H NMR was recorded on Bruker DRX 500 and chemical shifts were referenced to the appropriate solvent peak or 7.24 ppm for residual $d$–chloroform. $^{13}$C NMR was recorded on 125 MHz and fully decoupled by broad band proton decoupling. Chemical shifts were reported in ppm referenced to the center line of a triplet at 77.0 ppm of $d$–chloroform. High resolution mass spectra were measured on Agilent-G6540 UHD Accurate-MassQ-TOF.

II. Experimental section

1. Optimization of the transformation from 1a to 3a

**SI-Table 1.** Optimization the catalysts and oxidants for the transformation

<table>
<thead>
<tr>
<th>Entry</th>
<th>Pd-Catalysts</th>
<th>Oxidants (1.5 equiv)</th>
<th>Yields $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(5 mol%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pd(OAc)$_2$</td>
<td>Ag$_2$CO$_3$</td>
<td>65%</td>
</tr>
<tr>
<td>2</td>
<td>PdCl$_2$</td>
<td>Ag$_2$CO$_3$</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>Pd(OTf)$_2$</td>
<td>Ag$_2$CO$_3$</td>
<td>43%</td>
</tr>
<tr>
<td>4</td>
<td>Pd$_2$(dba)$_3$</td>
<td>Ag$_2$CO$_3$</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Entry</td>
<td>Reactant 1</td>
<td>Reactant 2</td>
<td>Yield (%)</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>------------</td>
<td>-----------</td>
</tr>
<tr>
<td>5</td>
<td>Pd(PPh₃)₄</td>
<td>Ag₂CO₃</td>
<td>28%</td>
</tr>
<tr>
<td>6</td>
<td>PdCl₂(Bpy)</td>
<td>Ag₂CO₃</td>
<td>23%</td>
</tr>
<tr>
<td>7</td>
<td>Pd(OAc)₂</td>
<td>Ag₂O</td>
<td>51%</td>
</tr>
<tr>
<td>8</td>
<td>Pd(OAc)₂</td>
<td>O₂</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>9</td>
<td>Pd(OAc)₂</td>
<td>Phl(OAc)₂</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Pd(OAc)₂</td>
<td>DDQ</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Pd(OAc)₂</td>
<td>TBHP (70%)</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Pd(OAc)₂</td>
<td>TBP</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Pd(OAc)₂</td>
<td>AgOAc</td>
<td>28%</td>
</tr>
<tr>
<td>10</td>
<td>Pd(OAc)₂</td>
<td>Ag₂CO₃+Ag₂O (1:1)</td>
<td>81%</td>
</tr>
<tr>
<td>11</td>
<td>Pd(OAc)₂</td>
<td>No</td>
<td>&lt;5%</td>
</tr>
</tbody>
</table>

Reaction conditions: 1a (0.2 mmol), 2a (0.6 mmol), catalyst (5 mol%), Oxidant (1.5 equiv), DMSO (3 mL), under air, 120°C for 24h; (b) isolated yield; (c) catalyst (10 mol%); (d) catalyst (2 mol%); (e) Oxidant (1 equiv); (f) Oxidant (2 equiv); (g) 2a (0.4 mmol); (h) 2a (0.8 mmol); (i) under Ar.

SI-Table 2. Screening solvents and temperatures

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent/T (°C)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMSO/120</td>
<td>81%</td>
</tr>
</tbody>
</table>
2. Supporting experiments for the proposed mechanism

![Chemical reaction diagram]

A. First, the reaction of 1a was stirred under standard conditions and 78% yield of phenyl vinyl ketone (1a') was detected by $^1$H NMR in 5 hours. (*J. Am. Chem. Soc.* **2010**, *132*, 4506–4507).

B. When the reaction finished, adding one equiv of 2h and stirring for 12h afforded 82% yield of 3h.

C. (E)-3-(5-methylthiophen-2-yl)-1-phenylprop-2-en-1-one (3h') reacting under standard conditions for 48h only got 15% yield of 3h.

3. 1 mmol scale experiment: (Taking the transformation of 2a to 3a as an example)

Under standard conditions, we got the 3a in 80% yield (isolated).

4. The Analytical data of 3a–3p:

3a: (81%), $^1$H NMR (500 MHz, CDCl$_3$): δ 8.05 (d, J = 8.0 Hz, 2H), 7.85 (d, J = 15.6 Hz, 1H), 7.78 (d, J = 15.6 Hz, 1H), 7.63 (m, 1H), 7.50 (m, 2H); HRMS: Calculated for C$_{15}$H$_7$OF$_3$: 298.0417; Found: 298.0410 (Zhang, X.-G; Fan, S.-L.; He,

3b: (74%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 7.85 (d, $J = 7.2$ Hz, 2H), 7.78-7.50 (m, 4H), 7.35 (d, $J = 16.8$ Hz, 1H), 7.08 (m, 1H); $^{13}$C NMR (125 MHz, CDCl$_3$) $\delta$ 190.2, 153.0 (dm, $J = 248.0$ Hz), 149.9 (dm, $J = 251.0$ Hz), 148.5 (dm, $J = 249.6$ Hz), 139.2 (dm, $J = 241.2$ Hz), 136.8, 135.9 (m), 131.5, 128.6, 126.9, 115.8, 114.1 (m), 102.9 (m); $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -118.5 (t, $J = 9.6$ Hz, 1F), -134.9 (m, 1F), -138.7 (dd, $J = 19.5$ Hz, 5.5 Hz, 1F), -163.8 (m, 1F); HRMS: Calculated for C$_{15}$H$_8$OF$_4$: 280.0511; Found: 280.0517.

3c: (71%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 7.84 (d, $J = 7.0$ Hz, 2H), 7.62-7.50 (m, 4H), 7.34 (d, $J = 16.6$ Hz, 1H), 6.96 (t, $J = 9.0$ Hz, 2H); $^{13}$C NMR (125 MHz, CDCl$_3$) $\delta$ 189.8, 165.2 (dm, $J = 248.8$ Hz), 139.1, 135.8 (m), 130.5, 128.9, 127.8, 117.1, 111.9 (m), 101.9 (m); $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -105.7 (m, 1F), -113.1 (t, $J = 8.2$ Hz, 2F); HRMS: Calculated for C$_{15}$H$_8$OF$_3$: 262.0605; Found: 262.0613.

3d: (79%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 7.84-7.75 (m, 3H), 7.68-7.59 (m, 3H), 7.35 (d, $J = 17.4$ Hz, 1H), 7.15 (m, 1H); $^{13}$C NMR (125 MHz, CDCl$_3$) $\delta$ 190.3, 149.5 (dm, $J = 256.4$ Hz), 145.8 (dm, $J = 262.5$ Hz), 138.7 (m), 137.1, 128.5, 127.6, 118.3 (m), 114.5, 103.6 (t, $J = 22.8$ Hz); $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -139.7 (m, 2F), -144.8 (m, 2F); HRMS: Calculated for C$_{15}$H$_8$OF$_4$: 280.0511; Found: 280.0508.

3e: (77%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 8.04-8.02 (m, 2H), 7.98 (d, $J = 16.0$ Hz, 1H), 7.78 (d, $J = 16.0$ Hz, 1H), 7.67-7.55 (m, 3H); $^{13}$C NMR (125 MHz, CDCl$_3$) $\delta$ 188.9, 185.0, 148.5 (dm, $J = 246.3$ Hz), 145.3 (dm, $J = 257.9$ Hz), 138.5 (m), 135.4, 129.9, 128.3, 128.4, 127.5, 116.1 (t, $J = 13.7$ Hz), 114.7, 99.3 (m); $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -132.5 (dd, $J = 21.6$ Hz, 8.0 Hz, 2F), -138.4 (dd, $J = 21.6$ Hz, 8.2 Hz, 2F); HRMS: Calculated for C$_{16}$H$_{10}$OF$_4$: 305.0464; Found: 305.0471.

3g: (15%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 8.06-8.02 (2H, m), 7.83 (d, $J = 15.6$ Hz, 1H), 7.65 (m, 2H), 7.60 (m, 1H), 7.54 (d, $J = 15.6$ Hz, 1H), 7.50 (m, 2H), 7.42 (m, 3H); HRMS for C$_{15}$H$_{12}$O calc. 208.0888, found 208.0894. (Pennell, M. N.; Sheppard, T. D.; Unthank, M. S.; Turner, P. *J. Org. Chem.* **2011**, *76*, 1479)

3h: (84%), $^1$H NMR (500 MHz, CDCl$_3$): $\delta$ 8.03-7.98 (m, 2H), 7.87 (d, $J = 15.6$ Hz, 1H), 7.66 (d, $J = 3.8$ Hz, 1H), 7.55 (m, 1H), 7.50-7.45 (m, 3H), 7.29 (d, $J = 3.8$ Hz,
1H), 2.43 (s, 3H); HRMS for C_{14}H_{12}OS calcd. 228.0609, found 28.0612. (Musumarri, G; Ballistreri, F. P. *Org. Magn. Reson.* **1980**, *14*, 384)

3i: (75%), ^1^H NMR (500 MHz, CDCl3): δ 8.00-7.98 (m, 2H), 7.85 (d, J = 15.2 Hz, 1H), 7.58-7.55 (m, 1H), 7.51-7.47 (m, 2H), 7.27 (d, J = 9.6 Hz, 1H), 7.18 (d, J = 3.6 Hz, 1H), 6.76 (d, J = 3.6 Hz, 1H), 2.84 (t, J = 7.6 Hz, 2H), 1.68 (q, J = 7.5 Hz, 2H), 1.45-1.36 (m, 2H), 0.98 (t, J = 7.4 Hz, 3H); HRMS for C_{17}H_{18}OS calcd. 270.1078, found 270.1082. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3j: (59%), ^1^H NMR (500 MHz, CDCl3): δ 8.02 (d, J = 7.4 Hz, 2H), 7.86 (d, J = 15.4 Hz, 1H), 7.75 (d, J = 3.8 Hz, 1H), 7.62-7.58 (m, 1H), 7.55-7.49 (m, 2H), 7.44 (d, J = 15.4 Hz, 1H), 7.35 (d, J = 3.8 Hz, 1H), 4.35 (q, J = 7.2 Hz, 2H), 1.39 (t, J = 7.2 Hz, 3H); HRMS for C_{16}H_{14}O_{3}S calcd. 286.0664, found 286.0658. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3k: (63%), ^1^H NMR (500 MHz, CDCl3): δ 7.98 (d, J = 7.8 Hz, 2H), 7.78 (d, J = 15.4 Hz, 1H), 7.60-7.58 (m, 1H), 7.52-7.48 (m, 2H), 7.22 (d, J = 15.4 Hz, 1H), 7.13 (d, J = 3.8 Hz, 1H), 6.91 (d, J = 3.8 Hz, 1H); HRMS for C_{13}H_{9}ClOS calcd. 248.0063, found 248.0065. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3l: (72%), ^1^H NMR (500 MHz, CDCl3): δ 8.04-8.01 (m, 2H), 7.95 (d, J = 15.2 Hz, 1H), 7.66-7.64 (m, 2H), 7.61-7.57 (m, 1H), 7.55-7.50 (m, 2H), 7.44-7.40 (m, 2H), 7.36-7.30 (m, 4H); HRMS for C_{19}H_{14}OS calcd. 290.0765, found 290.0760. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3m: (35%), ^1^H NMR (500 MHz, CDCl3): δ 7.83 (d, J = 7.4 Hz, 2H), 7.76 (d, J = 15.4 Hz, 1H), 7.42-7.32 (m, 3H), 7.30-7.15 (m, 3H), 6.88 (t, J = 5.0 Hz, 1H); HRMS for C_{19}H_{10}OS calcd. 286.0452, found 286.0455. (Ranu, B. C.; Jana, R. *J. Org. Chem.* **2005**, *70*, 8621)

3n: (39%), ^1^H NMR (500 MHz, CDCl3): δ 8.04 (d, J = 7.0 Hz, 2H), 7.66-7.42 (m, 6H), 6.70 (d, J = 3.0 Hz, 1H), 6.55-6.45 (m, 1H); HRMS for C_{13}H_{10}O_{2} calcd. 198.0681, found 198.0675. (Liu, D.-N.; Tian, S.-K. *Chem. Eur. J.* **2009**, *15*, 4538–4542)

3p: (85%), ^1^H NMR (500 MHz, CDCl3): δ 8.00 (d, J = 8.8 Hz, 2H), 7.85 (d, J =
15.2 Hz, 1H), 7.20 (d, J = 15.2 Hz, 1H), 7.15 (d, J = 3.3 Hz, 1H), 6.98 (d, J = 8.8 Hz, 2H), 6.74 (d, J = 2.6 Hz, 1H), 3.87 (s, 3H), 2.51 (s, 3H): HRMS for C$_{13}$H$_{14}$O$_2$S calcd. 258.0715, found 258.0721. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3q: (76%), $^1$H NMR (500 MHz, CDCl$_3$): δ 7.94 (d, J = 8.4 Hz, 2H), 7.87 (d, J = 15.2 Hz, 1H), 7.46 (d, J = 8.4 Hz, 2H), 7.17 (d, J = 3.4 Hz, 1H), 7.15 (d, J = 15.2 Hz, 1H), 6.75 (d, J = 3.4 Hz, 1H), 2.54 (s, 3H); HRMS for C$_{14}$H$_{11}$ClOS calcd. 262.0219, found 262.0221. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3r: (79%), $^1$H NMR (500 MHz, CDCl$_3$): δ 8.14 (d, J = 8.0 Hz, 2H), 7.95 (d, J = 15.4 Hz, 1H), 7.68 (d, J = 8.0 Hz, 2H), 7.34 (d, J = 3.6 Hz, 1H), 7.25 (d, J = 15.4 Hz, 1H), 6.88 (d, J = 3.6 Hz, 1H), 2.62 (s, 3H); $^{13}$C NMR (125 MHz, CDCl$_3$): 189.8, 146.8, 140.2, 140.0, 139.3, 137.5, 134.2, 129.9, 128.5, 127.3, 118.4, 16.1; HRMS for C$_{14}$H$_{11}$NO$_3$S calcd. 273.0460, found 273.0465.

3s: (75%), $^1$H NMR (500 MHz, CDCl$_3$): δ 7.85 (d, J = 15.2 Hz, 1H), 7.80-7.78 (m, 2H), 7.39 (d, J = 5.0 Hz, 2H), 7.21-7.15 (m, 2H), 6.75 (d, J = 3.4 Hz, 1H), 2.51 (s, 3H), 2.44 (s, 3H); HRMS for C$_{13}$H$_{14}$OS calcd. 242.0765, found 242.0767. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3t: (76%), $^1$H NMR (500 MHz, CDCl$_3$): δ 7.94 (d, J = 0.94 Hz, 1H), 7.89-7.84 (m, 2H), 7.54-7.52 (m, 1H), 7.44-7.41 (m, 1H), 7.18 (d, J = 3.4 Hz, 1H), 7.10 (d, J = 15.2 Hz, 1H), 6.76-6.75 (m, 1H), 2.55 (s, 3H); HRMS for C$_{14}$H$_{11}$ClOS calcd. 262.0219, found 262.0223. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3u: (71%), $^1$H NMR (500 MHz, CDCl$_3$): δ 7.84 (d, J = 15.2 Hz, 1H), 7.72 (d, J = 7.8 Hz, 1H), 7.64-7.61 (m, 1H), 7.45-7.38 (m, 1H), 7.24-7.19 (m, 1H), 7.14 (d, J = 3.6 Hz, 1H), 7.09 (d, J = 15.2 Hz, 1H), 6.70 (m, 1H), 2.45 (s, 3H); HRMS for C$_{14}$H$_{11}$FOS calcd. 246.0515, found 246.0521. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. *Angew. Chem. Int. Ed.* **2013**, *52*, 1299)

3v: (68%), $^1$H NMR (500 MHz, CDCl$_3$): δ 7.80-7.76 (m, 2H), 7.50-7.46 (m, 1H), 7.26-7.21 (m, 1H), 7.16-7.11 (m, 2H), 7.07-7.02 (m, 1H), 6.73 (d, J = 3.4 Hz, 1H), δ
2.48 (s, 3H); HRMS for \( \text{C}_{14}\text{H}_{11}\text{FOS} \) calcd. 246.0515, found 246.0513. (Shang, Y.-P.; Jie, X.-M.; Zhou, J.; Hu, P.; Huang, S.-J.; Su, W.-P. Angew. Chem. Int. Ed. 2013, 52, 1299)

5. The spectra
3e, 77%