Supporting Information

Palladium Meets Copper: One-Pot Tandem Synthesis of Pyrido Fused Heterocycle via Sonogashira conjoined Electrophilic Cyclization

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<td>Copies of $^1$H NMR, $^{13}$C NMR and HRMS</td>
<td>5-104</td>
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X-ray crystallographic studies

Figure 1. ORTEP drawing of compound 4b drawn at 50% probability level.

The crystal of compound 4b (CCDC No: 1486060) was generated in CH$_2$Cl$_2$/Hexane. The intensity data for SON-387 was collected on an Bruker Kappa Apex-CCD diffractometer equipped with graphite monochromatic Mo-K$_{\alpha}$ radiation ($\lambda = 0.71073$ Å) at 100(2) K. A multi-scan correction was applied. The structure was solved by the direct methods using SIR-92 and refined by full-matrix least-squares refinement techniques on $F^2$ using SHELXL97$^2$. The hydrogen atoms were placed into the calculated positions and included in the last cycles of the refinement. All calculations were done using Wingx software package$^3$. 
Table 1. Crystal data collection and structure refinement parameters for 4b

<table>
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<th>Property</th>
<th>Value</th>
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</thead>
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<tr>
<td><strong>Empirical formula</strong></td>
<td>C&lt;sub&gt;19&lt;/sub&gt;H&lt;sub&gt;14&lt;/sub&gt;N&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>Formula weight</strong></td>
<td>270.32</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>293(2) K</td>
</tr>
<tr>
<td><strong>Wavelength</strong></td>
<td>0.71073 Å</td>
</tr>
<tr>
<td><strong>Crystal system</strong></td>
<td>Monoclinic</td>
</tr>
<tr>
<td><strong>Space group</strong></td>
<td>P 2&lt;sub&gt;1&lt;/sub&gt;/c</td>
</tr>
<tr>
<td><strong>A</strong></td>
<td>13.739(5) Å</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>5.908(5) Å</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>17.319(5) Å</td>
</tr>
<tr>
<td><strong>α (°)</strong></td>
<td>90.000(5)°</td>
</tr>
<tr>
<td><strong>β (°)</strong></td>
<td>91.208(5)°</td>
</tr>
<tr>
<td><strong>γ (°)</strong></td>
<td>90.000(5)°</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td>1405.5(14) Å</td>
</tr>
<tr>
<td><strong>Z</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Density (calculated)</strong></td>
<td>1.278 Mg/m³</td>
</tr>
<tr>
<td><strong>Absorption coefficient</strong></td>
<td>0.076 mm&lt;sup&gt;−1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>F(000)</strong></td>
<td>568</td>
</tr>
<tr>
<td><strong>Crystal size</strong></td>
<td>0.20 x 0.19 x 0.17 mm³</td>
</tr>
<tr>
<td><strong>Theta range for data collection</strong></td>
<td>3.64 to 25.00°</td>
</tr>
<tr>
<td><strong>Index ranges</strong></td>
<td>-16 ≤ h ≤ 16, -7 ≤ k ≤ 7, -20 ≤ l ≤ 20</td>
</tr>
<tr>
<td><strong>Reflections collected</strong></td>
<td>15507</td>
</tr>
<tr>
<td><strong>Independent reflections</strong></td>
<td>2465 [R(int) = 0.0390]</td>
</tr>
<tr>
<td><strong>Completeness to theta = 25.00°</strong></td>
<td>99.8 %</td>
</tr>
<tr>
<td><strong>Absorption correction</strong></td>
<td>Multi-scan</td>
</tr>
<tr>
<td><strong>Max. and min. transmission</strong></td>
<td>0.9872 and 0.9850</td>
</tr>
<tr>
<td><strong>Reefinement method</strong></td>
<td>Full-matrix least-squares on F&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Data / restraints / parameters</strong></td>
<td>2465 / 0 / 190</td>
</tr>
<tr>
<td><strong>Goodness-of-fit on F&lt;sup&gt;2&lt;/sup&gt;</strong></td>
<td>1.038</td>
</tr>
<tr>
<td><strong>Final R indices [I&gt;2sigma(I)]&lt;sup&gt;a,b&lt;/sup&gt;</strong></td>
<td>R&lt;sub&gt;1&lt;/sub&gt; = 0.0514, wR&lt;sub&gt;2&lt;/sub&gt; = 0.1235</td>
</tr>
<tr>
<td><strong>R indices (all data)</strong></td>
<td>R&lt;sub&gt;1&lt;/sub&gt; = 0.0823, wR&lt;sub&gt;2&lt;/sub&gt; = 0.1365</td>
</tr>
<tr>
<td><strong>Largest diff. peak and hole</strong></td>
<td>0.168 and -0.149 e.Å&lt;sup&gt;−3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>R = Σ(∥Fo∥ − ∥Fc∥)/Σ ∥Fo∥;  
<sup>b</sup>wR = {Σ[w(Fo<sup>2</sup> − Fc<sup>2</sup>)<sup>2</sup>]}/Σ[w(Fo<sup>2</sup>)<sup>2</sup>]<sup>1/2</sup>
References


Copies of $^1$H NMR, $^{13}$C NMR and HRMS
$^1$H NMR

3-Phenylbenzo[b][1,6]naphthyridine (4a)
$^{13}$C NMR

3-Phenylbenzo[b][1,6]naphthyridine (4a)
3-Phenylbenzo[b][1,6]naphthyridine (4a)
\[ ^1 \text{H NMR} \]

3-(p-Tolyl)benzo[b][1,6]naphthyridine (4b)
$^{13}$C NMR

3-($p$-Tolyl)benzo[$b$][1,6]naphthyridine (4b)
HRMS

3-(p-Tolyl)benzo[b][1,6]naphthyridine (4b)

Max. 3968.1 counts.

m/z, Da

Intensity, counts

270.1156
$^1$H NMR

3-(4-Butylphenyl)benzo[b][1,6]naphthyridine (4c)
$^{13}$C NMR

3-(4-Butylphenyl)benzo[b][1,6]naphthyridine (4c)
HRMS

3-(4-Butylphenyl)benzo[b][1,6]naphthyridine (4c)

![Chemical Structure](image)

1 TOF MS: 1.514 to 1.597 min from Sample 1 (TuneSampleID) of 017.wiff

Max. 2713.3 counts.

a=3.49708865074074e-004, b=-0.0127717986953040e+000 (Turbo Spray)
$^1$H NMR

3-(Thiophen-3-yl)benzo[b][1,6]naphthyridine (4d)
$^{13}$C NMR

3-(Thiophen-3-yl)benzo[b][1,6]naphthyridine (4d)
3-(Thiophen-3-yl)benzo[b][1,6]naphthyridine (4d)

Max. 4317.0 counts.

Int. 262.0565
$^1$H NMR

8-Methyl-3-(p-tolyl)benzo[\(b\)][1,6]naphthyridine (4e)
$^{13}$C NMR

8-Methyl-3-(p-tolyl)benzo[b][1,6]naphthyridine (4e)
HRMS

8-Methyl-3-(p-tolyl)benzo[b][1,6]naphthyridine (4e)

Max. 5339.3 counts.
$^1$H NMR

3-(4-Ethylphenyl)-8-methylbenzo[b][1,6]naphthyridine (4f)
$^{13}\text{C NMR}$

3-(4-Ethylphenyl)-8-methylbenzo[b][1,6]naphthyridine (4f)
HRMS

3-(4-Ethylphenyl)-8-methylbenzo[b][1,6]naphthyridine (4f)

TOF MS: 0.781 to 1.131 min from Sample 1 (TuneSampleID) of 500014.wiff

a=3.48102545163860160e-004, t0=-6.01277179989930130e+000 (Turbo Spray)

Max. 6265.2 counts.
$^1$H NMR

8-Methoxy-3-phenylbenzo[b][1,6]naphthyridine (4g)
$^{13}$C NMR

8-Methoxy-3-phenylbenzo[b][1,6]naphthyridine (4g)
HRMS

8-Methoxy-3-phenylbenzo[b][1,6]naphthyridine (4g)

+TOF MS: 0.931 to 1.064 min from Sample 1 (TuneSampleID) of 50007.wiff

a=3.1543272165222890e-004, b=-0.6172717989989940e+000 (Turbo Spray)

Max. 3872.4 counts.
$^1$H NMR

3-(4-(t-Butyl)phenyl)-8-methoxybenzo[b][1,6]naphthyridine (4h)
$^{13}$C NMR

3-(4-(t-Butyl)phenyl)-8-methoxybenzo[b][1,6]naphthyridine (4h)
3-(4-\((t\)-Butyl)phenyl\)-8-methoxybenzo[\(b\)][1,6]naphthyridine (4h)
$^1$H NMR

7-(4-(Tert-butyl)phenyl)-1,6-naphthyridine (4i)
$^{13}$C NMR

7-(4-(Tert-butyl)phenyl)-1,6-naphthyridine (4i)
7-(4-(Tert-butyl)phenyl)-1,6-naphthyridine (4i)

Max. 377.8 counts.

TOF MS: 0.831 to 0.881 min from Sample 1 (TuneSampleID) of 500021.sff
a=3.26410503500352640e-004, t0=-6.01277179989930310e+000 (Turbo Spray)
$^1$H NMR

5-Methyl-3-phenyl-5H-pyrido[4,3-b]indole (6a)
$^{13}$C NMR

5-methyl-3-phenyl-5$H$-pyrido[4,3-$b$]indole (6a)
HRMS

5-methyl-3-phenyl-5H-pyrido[4,3-b]indole (6a)

+TOF MS: 0.698 to 0.798 min from Sample 1 of r10.wiff

a=3.40915898402e-004, t0=-6.01277179989930400e+000 (Turbo Spray)

Max. 1421.6 counts.
$^1$H NMR

5-Methyl-3-(p-tolyl)-5H-pyrido[4,3-b]indole (6b)
$^{13}$C NMR

5-Methyl-3-(p-tolyl)-5H-pyrido[4,3-b]indole (6b)
HRMS

5-Methyl-3-(p-tolyl)-5H-pyrido[4,3-b]indole (6b)

Max. 1338.4 counts.
$^1$H NMR

3-(4-Butylphenyl)-5-methyl-5H-pyrido[4,3-b]indole (6c)
$^{13}$C NMR

3-(4-Butylphenyl)-5-methyl-5$H$-pyrido[4,3-$b$]indole (6c)
3-(4-Butylphenyl)-5-methyl-5H-pyrido[4,3-b]indole (6c)
$^1$H NMR

3-(4-Methoxyphenyl)-5-methyl-5H-pyrido[4,3-b]indole (6d)
$^{13}$C NMR

3-(4-Methoxyphenyl)-5-methyl-$5H$-pyrido[4,3-b]indole (6d)

![Carbon-13 NMR spectrum of 3-(4-Methoxyphenyl)-5-methyl-$5H$-pyrido[4,3-b]indole (6d)]
HRMS

3-(4-Methoxyphenyl)-5-methyl-5H-pyrido[4,3-b]indole (6d)
$^1$H NMR

5-Methyl-3-(thiophen-3-yl)-5$H$-pyrido[4,3-$b$]indole (6e)
$^{13}$C NMR

5-Methyl-3-(thiophen-3-yl)-5H-pyrido[4,3-b]indole (6c)
5-Methyl-3-(thiophen-3-yl)-5H-pyrido[4,3-b]indole (6c)

HRMS

Max. 343.0 counts.
$^1$H NMR

5-Methyl-3-(4-(trifluoromethyl)phenyl)-5$H$-pyrido[4,3-$b$]indole (6f)
$^{13}$C NMR

5-Methyl-3-(4-(trifluoromethyl)phenyl)-5H-pyrido[4,3-b]indole (6f)
HRMS

5-Methyl-3-(4-(trifluoromethyl)phenyl)-5H-pyrido[4,3-b]indole (6f)

Max. 434.3 counts.

ToF MS: 2.364 to 2.447 min from Sample 1 of 0029.wiff

a=3.723352648292669e-004, t0=-6.012771799889930e+000 (Turbo Spray)

326.1030
$^1$H NMR

5-Methyl-3-phenethyl-5$H$-pyrido[4,3-$b$]indole (6g)
$^{13}$C NMR

5-Methyl-3-phenethyl-5H-pyrido[4,3-b]indole (6g)
5-Methyl-3-phenethyl-5H-pyrido[4,3-b]indole (6g)

**Qualitative Compound Report**

**Compound Table**

<table>
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<tr>
<th>Compound Label</th>
<th>RT (min)</th>
<th>Mass (m/z)</th>
<th>Formula</th>
<th>MFI Formula</th>
<th>MFI Form. (ppm)</th>
<th>DB Formula</th>
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<tbody>
<tr>
<td>Cpd 1: C29 H31 N2</td>
<td>11</td>
<td>368.1451</td>
<td>C29 H31 N2</td>
<td>C29 H31 N2</td>
<td>8.53</td>
<td>C29 H31 N2</td>
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**MSE MS Spectrum**

```
Counts vs. Mass-to-Charge (m/z)
```

**MSE HS Ionized Spectrum**

```
Counts vs. Mass-to-Charge (m/z)
```

**MS Spectrum Peak List**

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<th>Abund</th>
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<th>Ion</th>
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<td>267.1524</td>
<td>1</td>
<td>C20 H18 N2</td>
<td>M+1</td>
</tr>
<tr>
<td>262.1508</td>
<td>1</td>
<td>C20 H18 N2</td>
<td>M+2</td>
</tr>
<tr>
<td>261.1504</td>
<td>1</td>
<td>C20 H18 N2</td>
<td>M+3</td>
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<tr>
<td>260.1501</td>
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<td>C20 H18 N2</td>
<td>M+4</td>
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<tr>
<td>259.1498</td>
<td>1</td>
<td>C20 H18 N2</td>
<td>M+5</td>
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</table>

--- End Of Report ---
$^1$H NMR

3-Cyclopropyl-5-methyl-5H-pyrido[4,3-b]indole (6h)
$^{13}$C NMR

3-Cyclopropyl-5-methyl-5H-pyrido[4,3-b]indole (6h)
HRMS

3-Cyclopropyl-5-methyl-5H-pyrido[4,3-b]indole (6h)
$^1$H NMR

3-Butyl-5-methyl-$5H$-pyrido[4,3-$b$]indole (6i)
$^{13}$C NMR

3-Butyl-5-methyl-5H-pyrido[4,3-b]indole (6i)
3-Butyl-5-methyl-5H-pyrido[4,3-b]indole (6i)
$^1$H NMR

3-Phenylisoquinoline (8a)
$^{13}$C NMR

3-Phenylisoquinoline (8a)
3-Phenylisoquinoline (8a)
$^1$H NMR

3-(4-Ethylphenyl)isoquinoline (8b)
$^{13}$C NMR

3-(4-Ethylphenyl)isoquinoline (8b)
3-(4-Ethylphenyl)isoquinoline (8b)
$^1$H NMR

3-(3-Methoxyphenyl)isoquinoline (8c)
$^{13}$C NMR

3-(3-Methoxyphenyl)isoquinoline (8c)
HRMS

3-(3-Methoxyphenyl)isoquinoline (8c)

m/z, Da

50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0 500.0 550.0 600.0 650.0 700.0 750.0 800.0 850.0 900.0 950.0 1000.0 1050.0 1100.0 1150.0 1200.0 1250.0

$nC_0$
$^1$H NMR

3-(4-(Trifluoromethyl)phenyl)isoquinoline (8d)
$^{13}$C NMR

3-(4-(Trifluoromethyl)phenyl)isoquinoline (8d)
HRMS

3-(4-(Trifluoromethyl)phenyl)isoquinoline (8d)
$^1$H NMR

7-(4-Butylphenyl)-[1,3]dioxolo[4,5-g]isoquinoline (8e)
$^{13}$C NMR

7-(4-Butylphenyl)-[1,3]dioxolo[4,5-g]isoquinoline (8e)
HRMS

7-(4-Butylphenyl)-[1,3]dioxolo[4,5-g]isoquinoline (8e)
$^1$H NMR

4-([1,3]Dioxolo[4,5-g]isoquinolin-7-yl)-N,N-dimethylaniline (8f)
$^{13}$C NMR

4-([1,3]Dioxolo[4,5-g]isoquinolin-7-yl)-N,N-dimethylaniline (8f)
4-([1,3]Dioxolo[4,5-g]isoquinolin-7-yl)-N,N-dimethylaniline (8f)
$^1$H NMR

7-(4-(Trifluoromethyl)phenyl-1,3]dioxolo[4,5-g]isoquinoline (8g)
$^{13}$C NMR

7-(4-(Trifluoromethyl)phenyl)-[1,3]dioxolo[4,5-g]isoquinoline (8g)
HRMS

7-(4-(Trifluoromethyl)phenyl)-[1,3]dioxolo[4,5-g]isoquinoline (8g)
$^1$H NMR

3-Phenylbenzo[4,5]thieno[2,3-c]pyridine (10a)
$^{13}$C NMR

3-Phenylbenzo[4,5]thieno[2,3-c]pyridine (10a)
HRMS

3-Phenylbenzo[4,5]thieno[2,3-c]pyridine (10a)
$^1$H NMR

3-(p-Tolyl)benzo[4,5]thieno[2,3-c]pyridine (10b)
$^{13}$C NMR

3-(p-Tolyl)benzo[4,5]thieno[2,3-c]pyridine (10b)
3-(\(p\)-Tolyl)benzo[4,5]thieno[2,3-c]pyridine (10b)

HRMS

\[
\text{Max. 5878.2 counts.}
\]
$^1$H NMR

3-(Thiophen-3-yl)benzo[4,5]thieno[2,3-c]pyridine (10c)
$^{13}$C NMR

3-(Thiophen-3-yl)benzo[4,5]thieno[2,3-c]pyridine (10c)
3-(Thiophen-3-yl)benzo[4,5]thieno[2,3-c]pyridine (10c)

HRMS
$^1$H NMR

3-(4-(Trifluoromethyl)phenyl)benzo[4,5]thieno[2,3-c]pyridine(10d)
$^{13}$C NMR

3-(4-(Trifluoromethyl)phenyl)benzo[4,5]thieno[2,3-c]pyridine(10d)
$^{13}$C NMR

3-(4-(Trifluoromethyl)phenyl)benzo[4,5]thieno[2,3-c]pyridine (10d)

$\text{TOF MS: 0.615 to 0.815 min from Sample 1 (TuneSampleID) of 500012.wiff}$

$a=3.6569778866614525 \times 10^{-4}$, $t_0=-6.0127717998993031 \times 10^0$ (Turbo Spray)

Max. 6056.9 counts.
$^1$H NMR

3-Phenylbenzofuro[3,2-c]pyridine (12a)
$^{13}$C NMR

3-Phenylbenzofuro[3,2-\textit{c}]pyridine (12a)
3-Phenylbenzofuro[3,2-c]pyridine (12a)
$^1$H NMR

3-(4-(Tert-butyl)phenyl)benzofuro[3,2-c]pyridine (12b)
$^{13}$C NMR

3-(4-(Tert-butyl)phenyl)benzofuro[3,2-\(c\)]pyridine (12b)
HRMS

3-(4-(Tert-butyl)phenyl)benzofuro[3,2-c]pyridine (12b)
$^1$H NMR

3-(3-Methoxyphenyl)benzofuro[3,2-c]pyridine (12c)
$^{13}$C NMR

3-(3-Methoxyphenyl)benzofuro[3,2-c]pyridine (12c)
HRMS

3-(3-Methoxyphenyl)benzofuro[3,2-c]pyridine (12c)
$^1$HNMR

3-(4-(Trifluoromethoxy)phenyl)benzofuro[3,2-\textit{c}]pyridine (12d)
$^{13}$C NMR

3-(4-(Trifluoromethoxy)phenyl)benzofuro[3,2-c]pyridine (12d)
HRMS

3-(4-(Trifluoromethoxy)phenyl)benzofuro[3,2-c]pyridine (12d)