Supporting Information

Mechanistic Studies on Dynamic Multi-Component Covalent Assemblies of Metal-Mediated Hemi-Aminal Ethers†

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General Information:
NMR spectra were recorded on Agilent MR 400 at The University of Texas at Austin NMR facility. ESI-mass spectra were obtained on Agilent 6100 at The University of Texas at Austin mass spectrometry facility. Circular dichroism (CD) spectra were recorded on a Jasco J-815 spectropolarimeter at The University of Texas facility.
Experimental Procedures:

General Procedures for Multi-component Assembly

All assembly reactions for kinetics and LEFR studies were performed \textit{in situ} in acetonitrile without isolation and purification. Pyridine-2-carboxaldehyde (2-PA, 35 mM, 1 equiv.), zinc triflate (Zn(OTf)$_2$, 35 mM, 1 equiv.), di-(2-picolyl)amine (DPA, 42 mM, 1.2 equiv.), 4-penten-2-ol (ROH, 175 mM, 5 equiv. except for the alcohol dependence studies), and 4-(2-chloroethyl)morpholine hydrochloride (CEM-HCl, 35 mM, 1 equiv.) were stirred together in acetonitrile in the presence of 3Å activated molecular sieves. The mixture was stirred at room temperature.

Synthesis of Pyridinium Salt (5)

\[
\text{2-PA} + \text{DPA} \xrightleftharpoons[CD_3CN, \text{rt}]^{\text{BF}_3\text{OEt}_2} \text{Imminium salt} \xrightarrow{} \text{Pyridinium salt} 5
\]

To pyridine-2-carboxaldehyde (2-PA, 3.21 mg, 0.03 mmol) in dry CD$_3$CN solution (60 mM), dipicolylamine (DPA, 7.17 mg, 0.036 mmol) was added. Then, BF$_3$-OEt$_2$ (5.11 µL, 0.036 mmol) was added dropwise. The reaction mixture was shaken for 3–5 min and then $^1$H NMR, $^{13}$C NMR, and mass spectrum were recorded.
Hammett Plot using $\sigma^+$:

<table>
<thead>
<tr>
<th>X</th>
<th>$K_{eq}$</th>
<th>$\sigma^+$</th>
<th>$\log \left( \frac{k_X}{k_H} \right)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH</td>
<td>16.9</td>
<td>-0.92</td>
<td>-0.21</td>
</tr>
<tr>
<td>Me</td>
<td>23.6</td>
<td>-0.31</td>
<td>-0.062</td>
</tr>
<tr>
<td>H</td>
<td>27.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>38.0</td>
<td>-0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>alkyne</td>
<td>36.3</td>
<td>-</td>
<td>0.13</td>
</tr>
<tr>
<td>Cl</td>
<td>40.1</td>
<td>0.11</td>
<td>0.17</td>
</tr>
<tr>
<td>Br</td>
<td>39.7</td>
<td>0.15</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**Table S2.** $\sigma^+$ values and corresponding $\log \left( \frac{k_X}{k_H} \right)$ values for encountered substituents.

**Figure S2.** Hammett plot ($\sigma^+$) for four-component assembly with para substituted 2-PA.
NMR and Mass Spectra:

**Figure S4.** $^1$H NMR of multi-component assembly varying the concentration of alcohol from 17.5 mM (0.5 equiv.) to 210 mM (6 equiv.). For alcohol, 4-penten-2-ol was chosen for all kinetic studies.
Figure S5. $^1$H NMR of pyridinium salt (5) formed from 2-PA (1.0 equiv.), DPA (1.2 equiv.), and BF$_3$-OEt$_2$ (1.2 equiv.) (top), $^1$H NMR of DPA (middle) and $^1$H NMR of 2-PA (bottom). All nmrs recorded in CD$_3$CN.
Figure S6. $^1$H NMR of pyridinium salt (5) formed from 2-PA (1.0 equiv.), DPA (1.2 equiv.), and BF$_3$-OEt$_2$ (1.2 equiv.) in CD$_3$CN.

Peaks corresponding to pyridinium salt (5): $^1$H NMR (400 MHz, CD$_3$CN) $\delta$ 8.72–8.66 (m, 2H), 8.62–8.50 (m, 3H), 8.15 (d, $J$ = 8.0 Hz, 1H), 8.00–7.91 (m, 4H), 7.79 (d, $J$ = 8.0 Hz, 1H), 7.48 (m, 1H), 6.97 (s, 1H), 4.93 (d, $J$ = 16.8 Hz, 1H), 4.69 (d, $J$ = 16.8 Hz, 1H), 4.58 (d, $J$ = 16.8 Hz, 1H), 4.50 (d, $J$ = 16.8 Hz, 1H).
Figure S7. $^{13}$C NMR of pyridinium salt (5) formed from 2-PA (1.0 equiv.), DPA (1.2 equiv.), and BF$_3$-OEt$_2$ (1.2 equiv.) in CD$_3$CN.

Peaks corresponding to pyridinium salt (5): $^{13}$C NMR (100 MHz, CD$_3$CN) $\delta$ 154.9, 153.6, 152.7, 151.3, 148.4, 148.2, 142.3, 141.1, 139.4, 127.8, 127.7, 127.6, 126.9, 125.2, 124.5, 91.3, 58.2, 54.5.
Figure S8. $^1$H NMR of pyridinium salt (5) formed from 2-PA (1.0 equiv.), DPA (1.2 equiv.) and TMS-OTf (1.2 equiv.) in CD$_3$CN.
Figure S9. $^1$H NMR of pyridinium salt (5) formed from 2-PA (1.0 equiv.), DPA (1.0 equiv.) and BF$_3$-OEt$_2$ (1.0 equiv.) in CD$_3$CN.
Figure S10. Mass spectrum of pyridinium salt (5) generated from 2-PA, DPA and BF$_3$-OEt$_2$. HRMS calcd for C$_{18}$H$_{17}$N$_4$+ (M$^+$) 289.1448. Found 289.1450.
Figure S11. Mass spectrum of pyridinium salt generated from 2-PA, DPA and TMS-OTf. HRMS calcd for $\text{C}_{18}\text{H}_{17}\text{N}_4^+$ ($M^+$) 289.1448. Found 289.1445.