Supporting Information

Production of Acrylic Acid from Biomass-Derived Allyl Alcohol by Selective Oxidation Using Au/Ceria Catalysts

Sungpil Yang\textsuperscript{a†}, Minsu Kim\textsuperscript{b†}, Sungeun Yang\textsuperscript{b}, Dae Sung Kim\textsuperscript{c}, Won Jae Lee\textsuperscript{c}, and Hyunjoo Lee\textsuperscript{b*}

\textsuperscript{a}Department of Chemical and Biomolecular Engineering, Yonsei University, Seoul 120-749, Republic of Korea; \textsuperscript{b}Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology, Daejeon 305-701, Republic of Korea; \textsuperscript{c}Corporate R&D, LG Chem Research Park, Daejeon 305-738, Republic of Korea.

Additional Data; Figure S1 ~ Figure S5, Table S1

\textbf{Figure S1.} Au nanoparticle size distribution for (a) 1.5, (b) 2.2, and (c) 4.1 nm-sized Au/ceria (DP) catalysts.

\textsuperscript{†} These authors contributed equally.
Figure S2. XPS data presenting Au 4f peaks for (a) 1.5 nm Au/CeO$_2$ (DP), (b) 2.2 nm Au/CeO$_2$ (DP), (c) 4.1 nm Au/CeO$_2$ (DP), and (d) 2.7 nm Au/CeO$_2$ (CD).

Figure S3. XPS data of Au/Ceria (DP) catalysts presenting (a) Ce 3p peaks and (b) O 1s peaks. The ratio of Ce(III) and Ce(IV) was estimated as 19.1% and 80.9% from the ratio of $V_0$, $V'$ and $V$, $V''$, $V'''$, and the ratio of O$_{l(lattice)}$ and O$_{l(defect)}$ was estimated as 72.6% and 27.4%, respectively. Tian’s work was used for assigning each peak.$^{81}$
**Figure S4.** Different pathways for the formation of 3-HPA and acrylic acid.

**Figure S5.** $^{13}$C NMR of the product solution after allyl alcohol oxidation using Au$_{82.4}$Pd /ceria (DP) catalyst. The reaction condition was the same as Au/ceria (DP) catalyst.
Table S1. Allyl alcohol oxidation results when Au-M/ceria (DP) catalysts were used.a

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Conv. (%)</th>
<th>AcA</th>
<th>3-HPA</th>
<th>Propionic acid</th>
<th>3-APA</th>
<th>GA</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au_{82.4}Pd_{1}/CeO_{2} b</td>
<td>100</td>
<td>5.2</td>
<td>8.0</td>
<td>64.6</td>
<td>0</td>
<td>0</td>
<td>22.2</td>
</tr>
<tr>
<td>Au_{168.8}Pd_{1}/CeO_{2} c</td>
<td>100</td>
<td>9.9</td>
<td>15.3</td>
<td>48.3</td>
<td>0</td>
<td>0</td>
<td>26.5</td>
</tr>
<tr>
<td>Au_{452.8}Pt_{1}/CeO_{2} d</td>
<td>100</td>
<td>35.2</td>
<td>27.3</td>
<td>11.1</td>
<td>2.9</td>
<td>0.9</td>
<td>19.7</td>
</tr>
<tr>
<td>Au_{23.6}Cu_{1}/CeO_{2} e</td>
<td>94.2</td>
<td>35.1</td>
<td>27.2</td>
<td>7.8</td>
<td>2.8</td>
<td>0.9</td>
<td>23.4</td>
</tr>
</tbody>
</table>

aThe reaction was performed at 50°C, O₂ 3 bar, 12 hrs, 3 M NaOH, and a mole ratio of allyl alcohol/Au was 4000. b 0.352 μmol or c 0.176 μmol of PdCl₂ dissolved in 0.2 M of HCl solution was added together with Au precursor. d 0.587 μmol of H₂PtCl₆ was added together with Au precursor. e 0.352 μmol of CuCl₂ was added together with Au precursor. The remaining synthetic procedure was the same as the Au/ceria (DP) catalyst. The actual molar ratio of Au versus secondary metal was measured by ICP-MS after the synthesis.

References