Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Supporting Information

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

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Additional Data; Figure S1 ~ Figure S5, Table S1

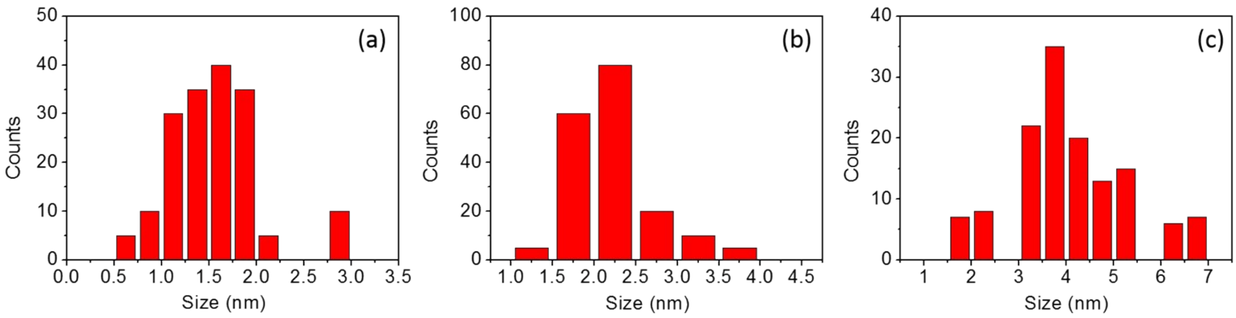

Figure S1. Au nanoparticle size distribution for (a) 1.5, (b) 2.2, and (c) 4.1 nm-sized Au/ceria (DP) catalysts.

† These authors contributed equally.

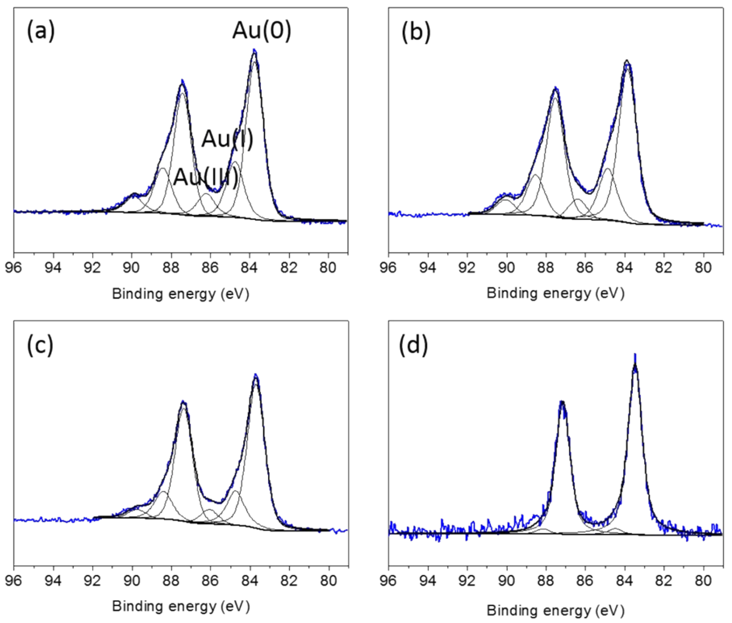

Figure S2. XPS data presenting Au 4f peaks for (a) 1.5 nm Au/CeO_2 (DP), (b) 2.2 nm Au/CeO_2 (DP), (c) 4.1 nm Au/CeO_2 (DP), and (d) 2.7 nm Au/CeO_2 (CD).

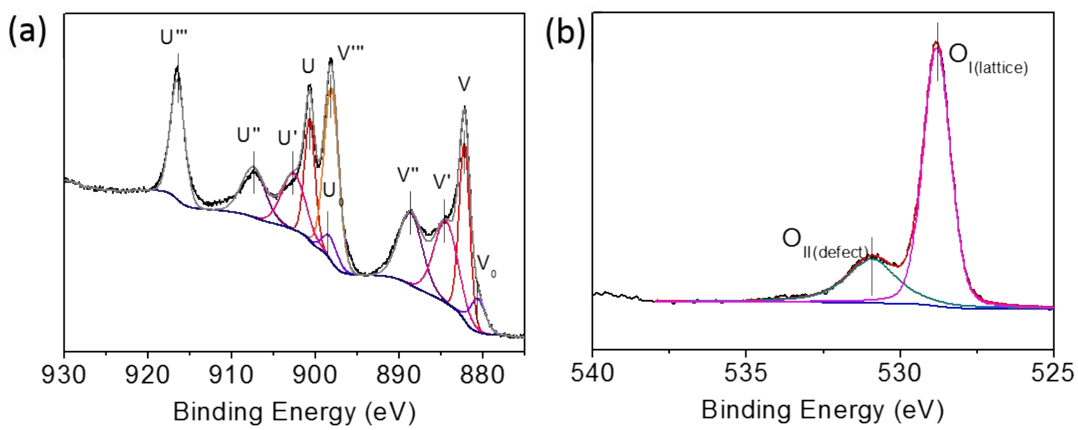

Figure S3. XPS data of Au/Ceria (DP) catalysts presenting (a) Ce 3p peaks and (b) O 1s peaks. The ratio of Ce(III) and Ce(IV) was estimated as 19.1% and 80.9% from the ratio of V_0, V' and V, V'', V''', and the ratio of $O_{I(lattice)}$ and $O_{II(defect)}$ was estimated as 72.6% and 27.4%, respectively. Tian's work was used for assigning each peak [S1].

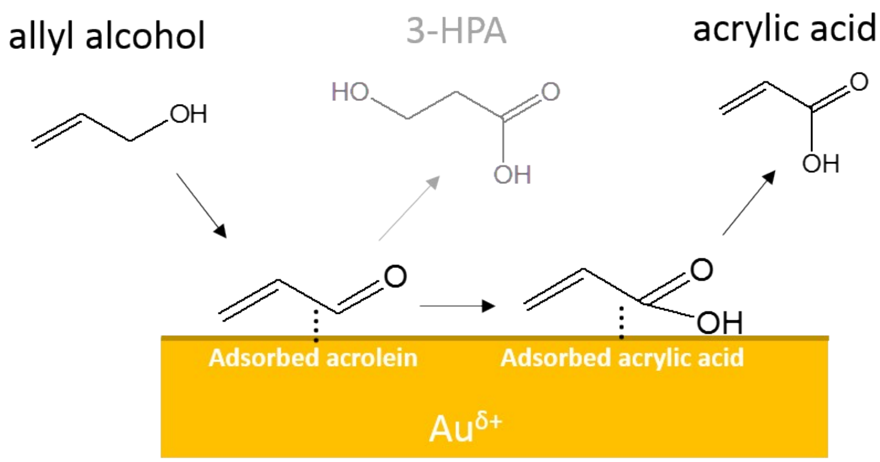

Figure S4. Different pathways for the formation of 3-HPA and acrylic acid.

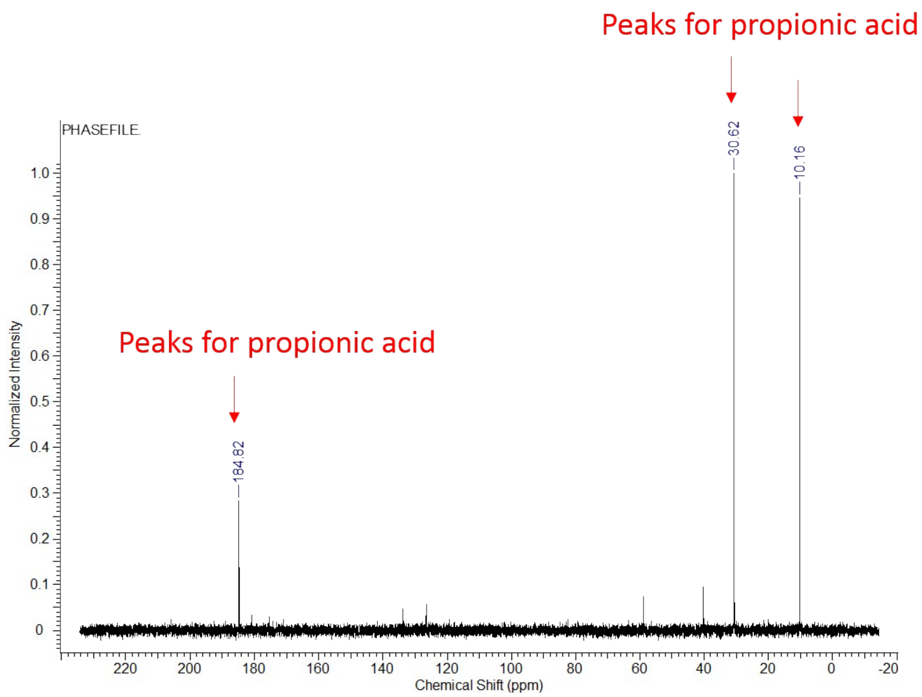

Figure S5. ^{13}C NMR of the product solution after allyl alcohol oxidation using $Au_{82.4}Pd$ /ceria (DP) catalyst. The reaction condition was the same as Au/ceria (DP) catalyst.

Table S1. Allyl alcohol oxidation results when Au-M/ceria (DP) catalysts were used.[a]

Catalyst	Conv. (%)	Yield(%)					
		AcA	3-HPA	Propionic acid	3-APA	GA	Others
$Au_{82.4}Pd_1/CeO_2$[b]	100	5.2	8.0	64.6	0	0	22.2
$Au_{168.8}Pd_1/CeO_2$[c]	100	9.9	15.3	48.3	0	0	26.5
$Au_{452.8}Pt_1/CeO_2$[d]	100	35.2	27.3	11.1	2.9	0.9	19.7
$Au_{23.6}Cu_1/CeO_2$[e]	94.2	35.1	27.2	7.8	2.8	0.9	23.4

[a]The reaction was performed at 50˚C, O_2 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 $PdCl_2$ dissolved in 0.2 M of HCl solution was added together with Au precursor. [d] 0.587 µmol of H_2PtCl_6 was added together with Au precursor. [e] 0.352 µmol of $CuCl_2$ 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

S1. Z. M. Tian, X. Xiang, L. S. Xie and F. Li, *Ind. Eng. Chem. Res.*, 2013, 52, 288-296.