catalysts

Supporting Information: The Promoting Effect of Ce on the Performance of Au/CexZr1−xO2 for γ-Valerolactone Production from Biomass-Based Levulinic Acid and Formic Acid

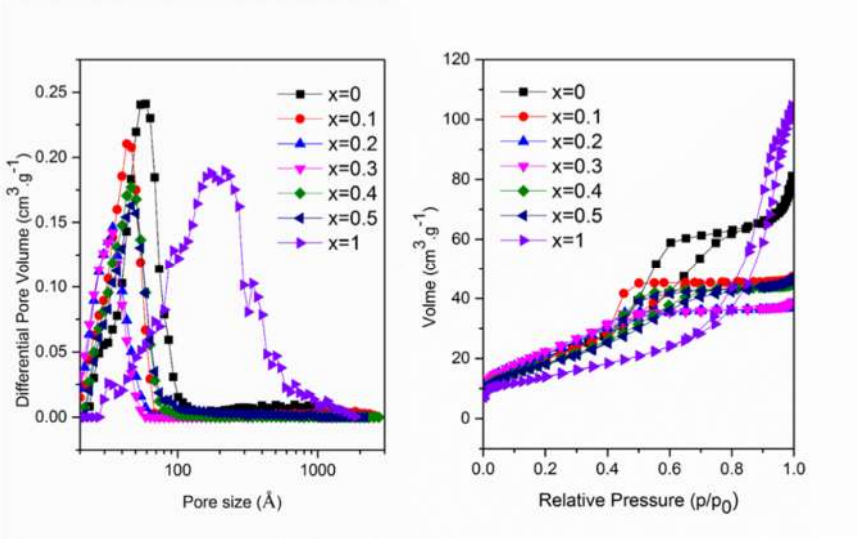

Figure. S1 Pore size distribution and N_2 adsorption-desorption isotherms for samples of 0.6 wt% Au catalyst supported on $Ce_xZr_{1-x}O_2$.

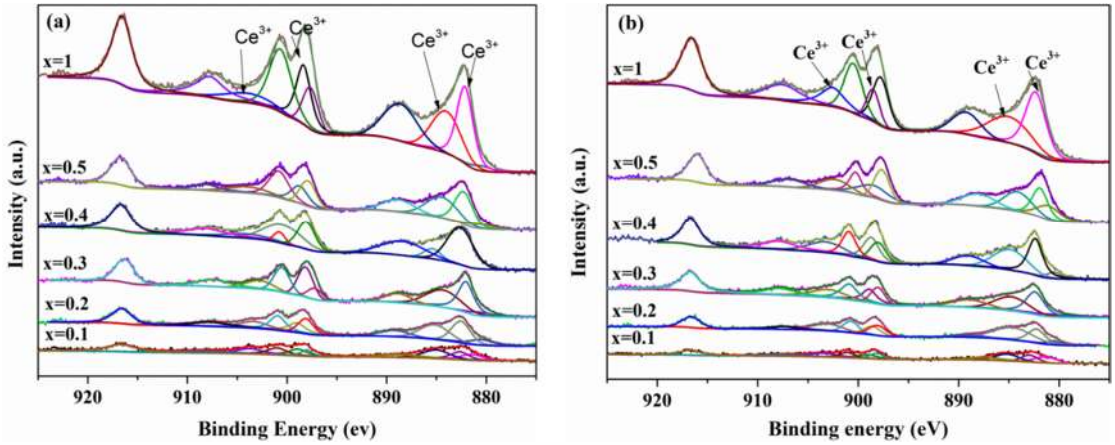

Figure. S2 XP spectra of the (3d) of (a) $Ce_xZr_{1-x}O_2$ and (b) 0.6 wt% Au/$Ce_xZr_{1-x}O_2$.

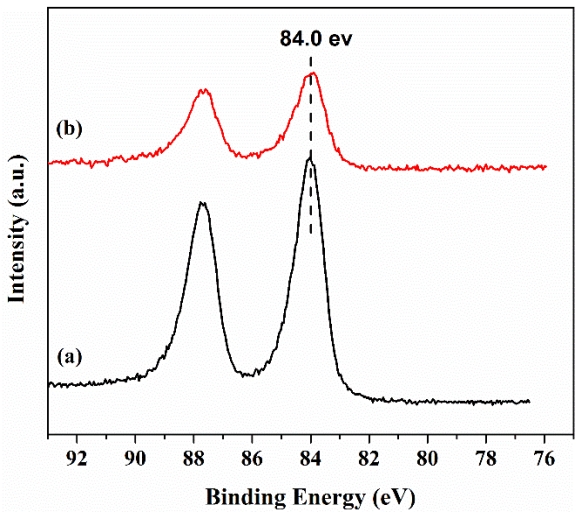

Figure. S3 XP spectra of 2 wt% Au/$Ce_{0.4}Zr_{0.6}O_2$ catalyst: (a) before reaction; (b) after five runs.

Table S1 BET analysis and H_2 consumption from TPR of 0.6 wt% Au/ $Ce_xZr_{1-x}O_2$.

Sample	BET Surface Area (m^2/g)	Total pore volume (cm^3/g)	Average Pore width (nm)	TPR H_2 consumption ($\mu mol\ g^{-1}$)
Au/ZrO_2	77	0.12	4.7	65.6[a]/61[b]
$Au/Ce_{0.1}Zr_{0.9}O_2$	75	0.077	3.3	153.9
$Au/Ce_{0.2}Zr_{0.8}O_2$	81	0.048	2.9	414.3
$Au/Ce_{0.3}Zr_{0.7}O_2$	84	0.048	3.1	552.0
$Au/Ce_{0.4}Zr_{0.6}O_2$	68	0.072	3.5	597.0
$Au/Ce_{0.5}Zr_{0.5}O_2$	66	0.072	3.7	496.6
Au/CeO_2	50	0.15	11.4	500.1[a]/231[b]

[a] Experimental value obtained from TPR analysis

[b] Calculated value for Au^{3+} to Au^0

Table S2 The relative concentration of surface cerium species on different supports and catalysts.

Supporter	Percentage (%)		$Au/Ce_xZr_{1-x}O_2$	Percentage (%)	
	Ce^{4+}	Ce^{3+}		Ce^{4+}	Ce^{3+}
$Ce_{0.1}Zr_{0.8}O_2$	57.6	42.4	$Au/Ce_{0.1}Zr_{0.8}O_2$	54.8	45.2
$Ce_{0.2}Zr_{0.8}\ O_2$	63.2	36.8	$Au/Ce_{0.2}Zr_{0.8}\ O_2$	52.9	47.1
$Ce_{0.3}Zr_{0.7}O_2$	61.4	38.6	$Au/Ce_{0.3}Zr_{0.7}O_2$	63.8	36.2
$Ce_{0.4}Zr_{0.6}O_2$	75.6	24.4	$Au/Ce_{0.4}Zr_{0.6}O_2$	63.6	36.4
$Ce_{0.5}Zr_{0.5}O_2$	67.7	32.3	$Au/Ce_{0.5}Zr_{0.5}O_2$	62.6	37.8
CeO_2	72.5	27.5	Au/CeO_2	67.3	32.7

Table S3 The relative concentration of surface O1s on different supports and catalysts.

Supporter	Percentage (%)		Au /$Ce_xZr_{1-x}O_2$	Percentage (%)	
	O_I [a]	O_{II} [b]		O_I	O_{II}
ZrO_2	68.9	31.1	Au/ZrO_2	51.2	48.8
$Ce_{0.1}Zr_{0.9}O_2$	59.8	40.2	$Au/Ce_{0.1}Zr_{0.9}O_2$	52.9	47.1
$Ce_{0.2}Zr_{0.8}O_2$	66.2	33.8	$Au/Ce_{0.2}Zr_{0.8}O_2$	60.0	40.0
$Ce_{0.3}Zr_{0.7}O_2$	52.9	47.1	$Au/Ce_{0.3}Zr_{0.7}O_2$	49.7	50.3
$Ce_{0.4}Zr_{0.6}O_2$	45.5	54.5	$Au/Ce_{0.4}Zr_{0.6}O_2$	60.3	39.7
$Ce_{0.5}Zr_{0.5}O_2$	49.9	50.1	$Au/Ce_{0.5}Zr_{0.5}O_2$	42.7	57.3
CeO_2	48.9	51.1	Au/CeO_2	44.9	55.1

[a]lattice oxygen, [b] absorbed oxygen.