Supporting information

Lattice engineering of AuPd@Pt core-shell icosahedra for highly efficient electrocatalytic ethanol oxidation

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The calculation of the layers of Pt in $Au_{73}Pd_{27}$@Pt, $Au_{66}Pd_{34}$@Pt and Pd@Pt icosahedra.

We define the distance between two opposite planes of $Au_{73}Pd_{27}$, $Au_{66}Pd_{34}$ and Pd icosahedra as *d*. The volume (*V*) of these icosahedral seeds can be calculated from the formulate: $V = 0.631\ d^3$. We assume that each atom occupies the same space, that is, the proportions of the volume occupied by Au and Pd atoms is equal to the atomic percentage of Au and Pd, respectively. Thus, the densities of $Au_{73}Pd_{27}$ and $Au_{66}Pd_{34}$ icosahedra can be denoted as $\rho_{Au73Pd27} = 0.73\rho_{Au} + 0.27\rho_{Pd}$ and $\rho_{Au66Pd34} = 0.66\rho_{Au} + 0.34\rho_{Pd}$. After epitaxial growth of Pt, the volume (V') of $Au_{73}Pd_{27}$@Pt, $Au_{66}Pd_{34}$@Pt and Pd@Pt icosahedra is $V' = 0.631\ d'^3$. Considering that the lattice spacing of Pt(111) planes is 0.2265 nm, the volume $V' = 0.631\ (d + 0.2265 \times 2n)^3$, n is the number of Pt layers (n = 1, 2, 3). Take $Au_{73}Pd_{27}$@Pt as an example, the weight percentages of Pt can be calculated by the following formulate:

$$Pt\ wt\% = \frac{(V' - V)\rho_{Pt}}{V\rho_{Au73Pd27} + (V' - V)\rho_{Pt}}$$

Table S1 The atomic ratios of Au:Pd, weight percentages of Pt determined by ICP-AES and the calculated Pt layers of $Au_{73}Pd_{27}$@Pt, $Au_{66}Pd_{34}$@Pt and Pd@Pt icosahedra.

Samples	Atomic ratios of Au:Pd determined by ICP-AES	Weight percentages of Pt determined by ICP-AES	Weight percentages of Pt calculated from different Pt layers (n = 1, 2, 3)		Estimated Pt layers
$Au_{73}Pd_{27}$@Pt	73:27	10.03%	n = 1	6.2%	1~2
			n = 2	11.8%	
			n = 3	16.9%	
$Au_{66}Pd_{34}$@Pt	66:34	8.97%	n = 1	6.3%	1~2
			n = 2	12.0%	
			n = 3	17.3%	
Pd@Pt	/	13.46%	n = 1	11.1%	1~2
			n = 2	20.4%	
			n = 3	28.2%	

Table S2 The binding energies of Pt 4f of $Au_{73}Pd_{27}$@Pt, $Au_{66}Pd_{34}$@Pt, Pd@Pt icosahedra and commercial Pt/C determined by XPS.

Samples	Pt^0 $4f_{7/2}$	Pt^0 $4f_{5/2}$	Pt^{2+} $4f_{7/2}$	Pt^{2+} $4f_{5/2}$
$Au_{73}Pd_{27}$@Pt	71.64	74.97	72.69	76.02
$Au_{66}Pd_{34}$@Pt	71.78	75.11	73.19	76.52
Pd@Pt	71.74	75.07	73.29	76.62
Pt/C	71.90	75.23	73.42	76.75

Table S3 The ECSAs of $Au_{73}Pd_{27}$@Pt, $Au_{66}Pd_{34}$@Pt, Pd@Pt icosahedra and commercial Pt/C determined by CO stripping measurements.

Samples	ECSA / $m^2\ g_{Pt}^{-1}$
$Au_{73}Pd_{27}$@Pt	80.35
$Au_{66}Pd_{34}$@Pt	95.00
Pd@Pt	141.68
Pt/C	39.93

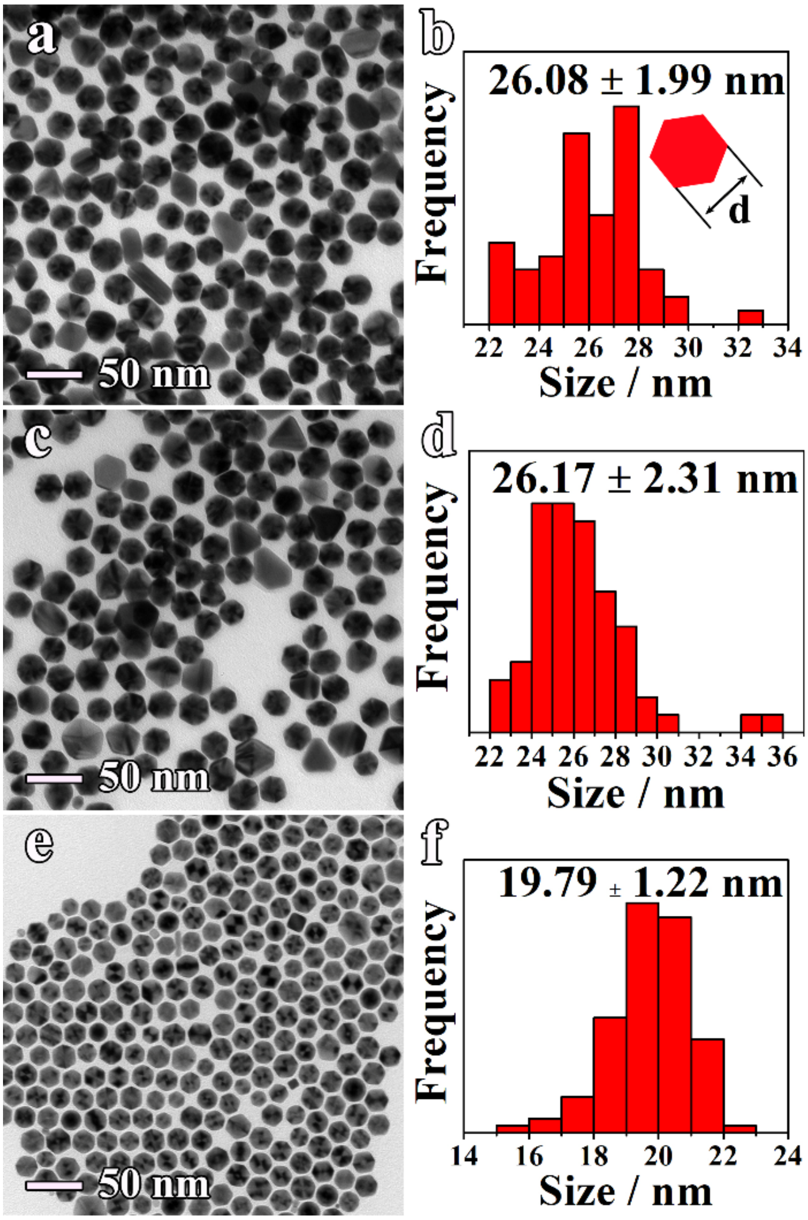

Fig. S1 (a, c, e) TEM images and (b, d ,f) size distributions of $Au_{73}Pd_{27}$, $Au_{66}Pd_{34}$ and Pd icosahedra, respectively.

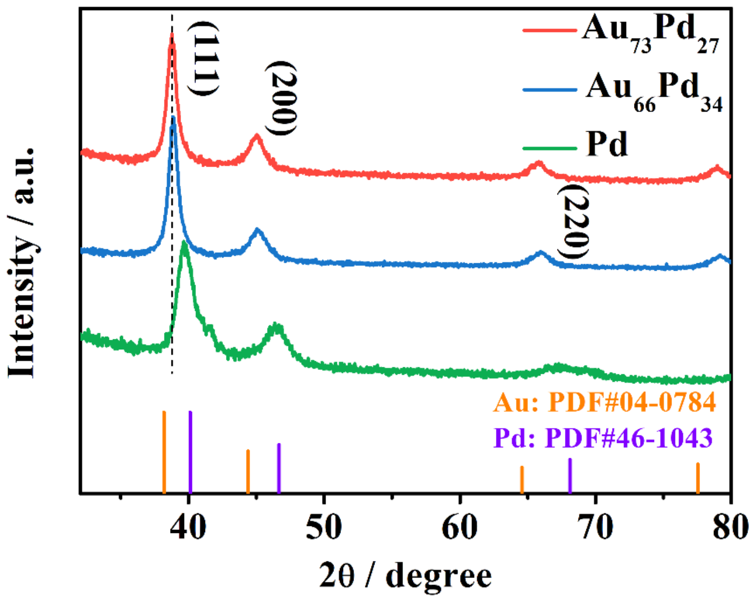

Fig. S2 XRD patterns of $Au_{73}Pd_{27}$, $Au_{66}Pd_{34}$ and Pd icosahedra.

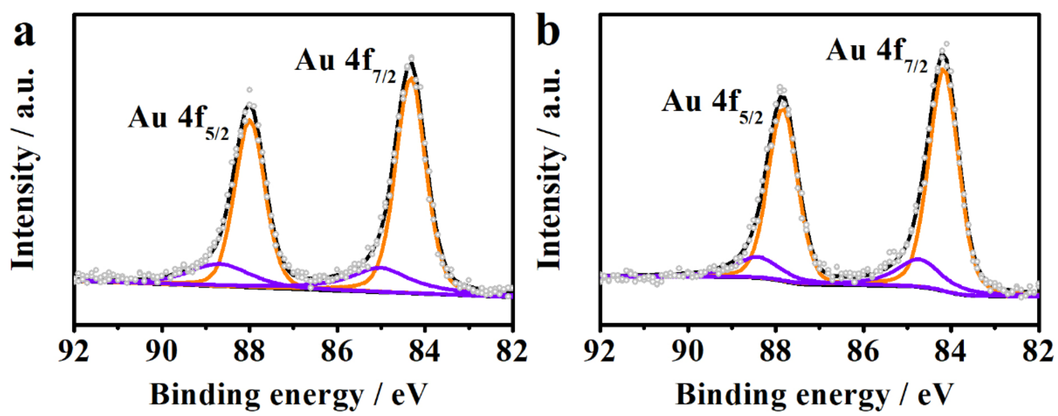

Fig. S3 The Au 4f XPS spectra of (a) $Au_{73}Pd_{27}$@Pt and (b) $Au_{66}Pd_{34}$@Pt icosahedra.

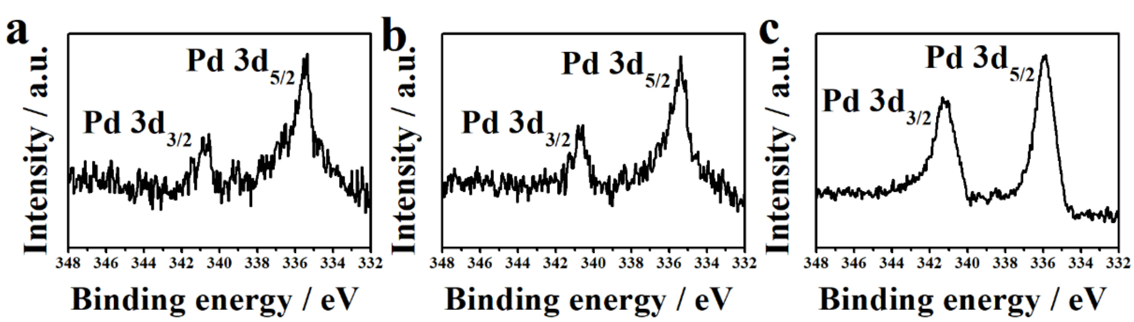

Fig. S4 The Pd 3d XPS spectra of (a) $Au_{73}Pd_{27}$@Pt, (b) $Au_{66}Pd_{34}$@Pt and (c) Pd@Pt icosahedra.

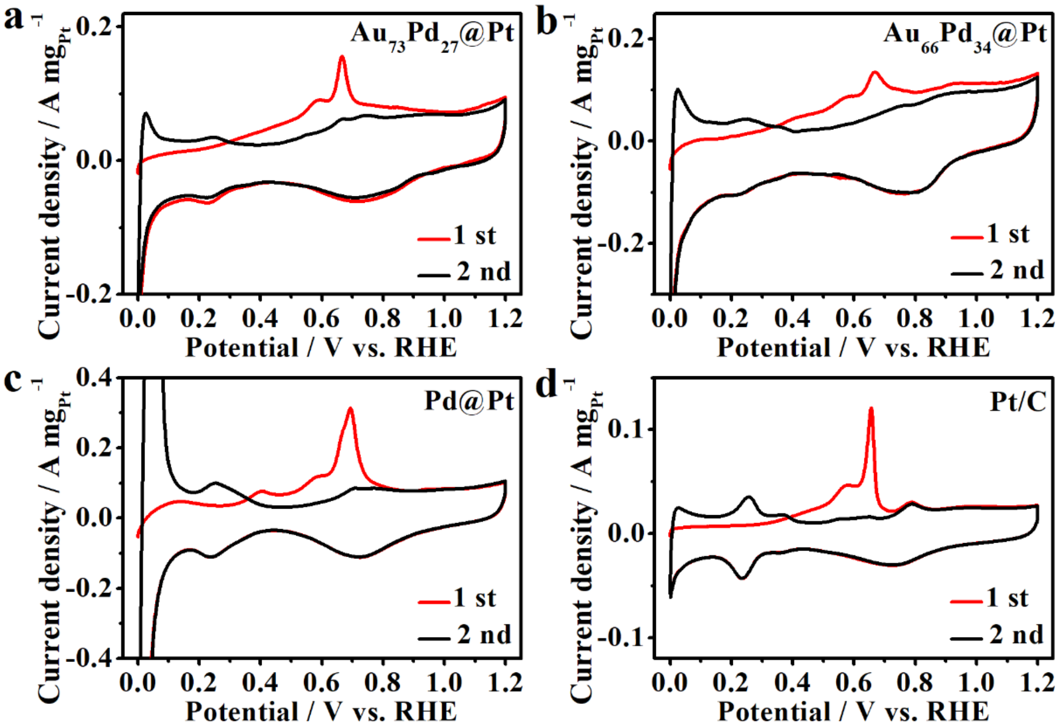

Fig. S5 The CO stripping curves of the catalysts.

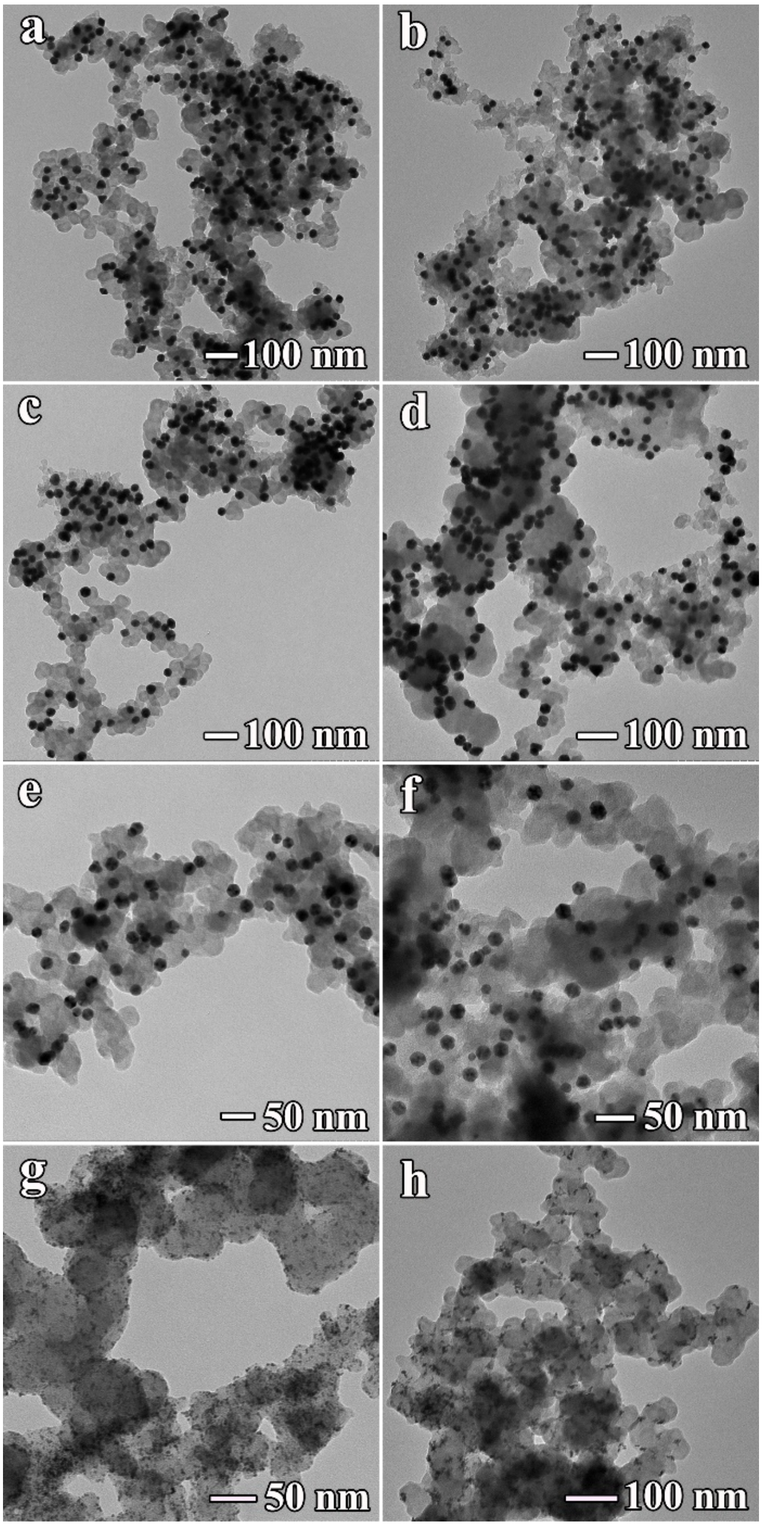

Fig. S6 TEM images (a, c, e, g) before and (b, d, f, h) after I-t tests of $Au_{73}Pd_{27}@Pt$, $Au_{66}Pd_{34}@Pt$, Pd@Pt icosahedra and commercial Pt/C, respectively.

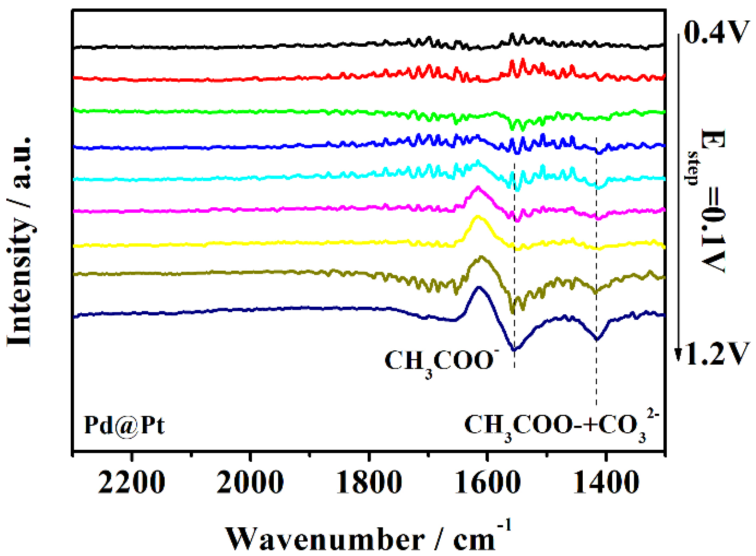

Fig. S7 The *in-situ* FTIR spectra of Pd@Pt icosahedra.