Electronic Supplementary Information

A universal approach to the synthesis of nanodendrites of noble metals

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Table S1. Synthetic parameters, size, and size distribution of noble metal nanodendrites (NMNDs) prepared in this study.

NMNDs	Precursors	Molar ratio	$\overline{d}$ (nm)	σ (nm)	$\overline{\sigma}$ (%)
Pt	$Pt(acac)_2$	/	25.6	3.74	14.6
Pd	$Pd(acac)_2$	/	30.5	5.95	19.5
Ru	$Ru(acac)_3$	/	16.7	7.45	44.8
Rh	$Rh(acac)_3$	/	24.4	5.71	23.4
Ir	$Ir(acac)_3$	/	22.2	3.60	16.2
Os	$Os(acac)_3$	/	17.8	3.26	18.3
PtPd	$Pt(acac)_2$/$Pd(acac)_2$	1/1	57.1	21.9	38.4
PtRh	$Pt(acac)_2$/$Rh(acac)_3$	1/1	24.8	7.64	30.8
PtIr	$Pt(acac)_2$/$Ir(acac)_3$	1/1	46.2	18.1	39.2
PtOs	$Pt(acac)_2$/$Os(acac)_3$	1/1	14.3	3.02	21.1
PtPdRu	$Pt(acac)_2$/$Pd(acac)_2$/$Ru(acac)_3$	2/1/1	181.8	81.1	44.6
PtPdRh	$Pt(acac)_2$/$Pd(acac)_2$/$Rh(acac)_3$	2/1/1	64.3	14.5	22.5
PtRuOs	$Pt(acac)_2$/$Ru(acac)_3$/$Os(acac)_3$	2/1/1	20.8	3.45	16.6
PtRhOs	$Pt(acac)_2$/$Rh(acac)_3$/$Os(acac)_3$	2/1/1	26.7	4.22	15.8

$$\overline{d} = \frac{\sum_{i=1}^{N} x_i}{N}, \quad \sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \mu)^2}{N}}, \quad \overline{\sigma} = \frac{\sigma}{\overline{d}}$$

where $\overline{d}$ = mean particle size, *x* = the size of one particle, *N* = the total number of the particles counted, σ = standard deviation, $\overline{\sigma}$ = relative standard deviation.

Table S2. The molar ratios of corresponding noble metals in alloy NMNDs produced by EDX analyses and in starting precursors.

NMNDs	Molar ratio in NMNDs by EDX	Molar ratio in starting precursors
PtPd	49/51	1/1
PtOs	53/47	1/1
PtPdRu	48/27/25	2/1/1
PtPdRh	49/25/26	2/1/1
PtRuOs	52/27/21	2/1/1
PtRhOs	53/22/26	2/1/1

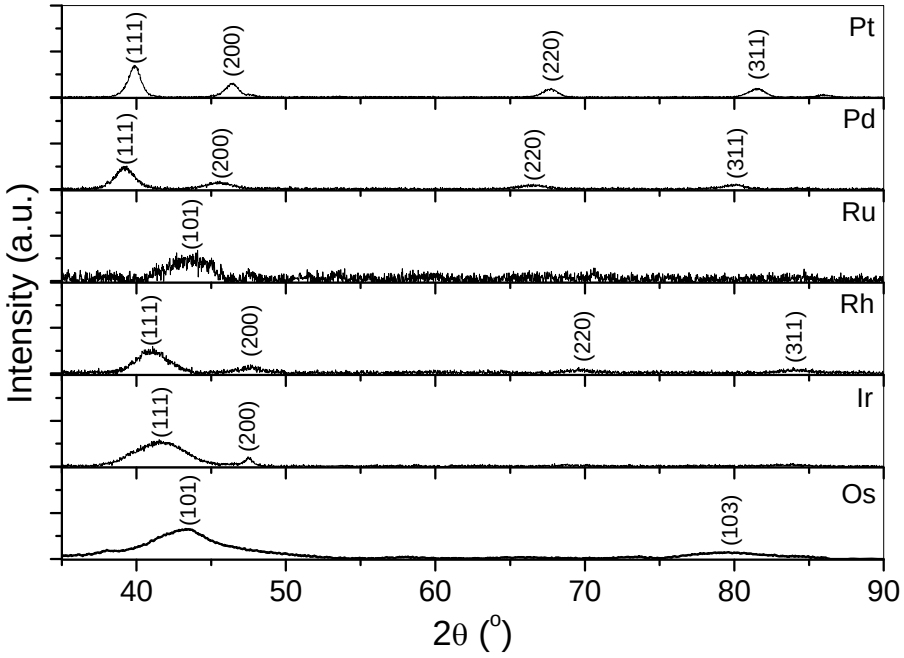

Fig. S1 XRD patterns of hexagonal Ru and Os, and fcc Pt, Pd, Rh, and Ir nanoparticles. The references are JCPDS 893942 for Ru, JCPDS 871704 for Os, JCPDS 882343 for Pt, JCPDS 882335 for Pd, JCPDS 882334 for Rh, and JCPDS 882342 for Ir, respectively.

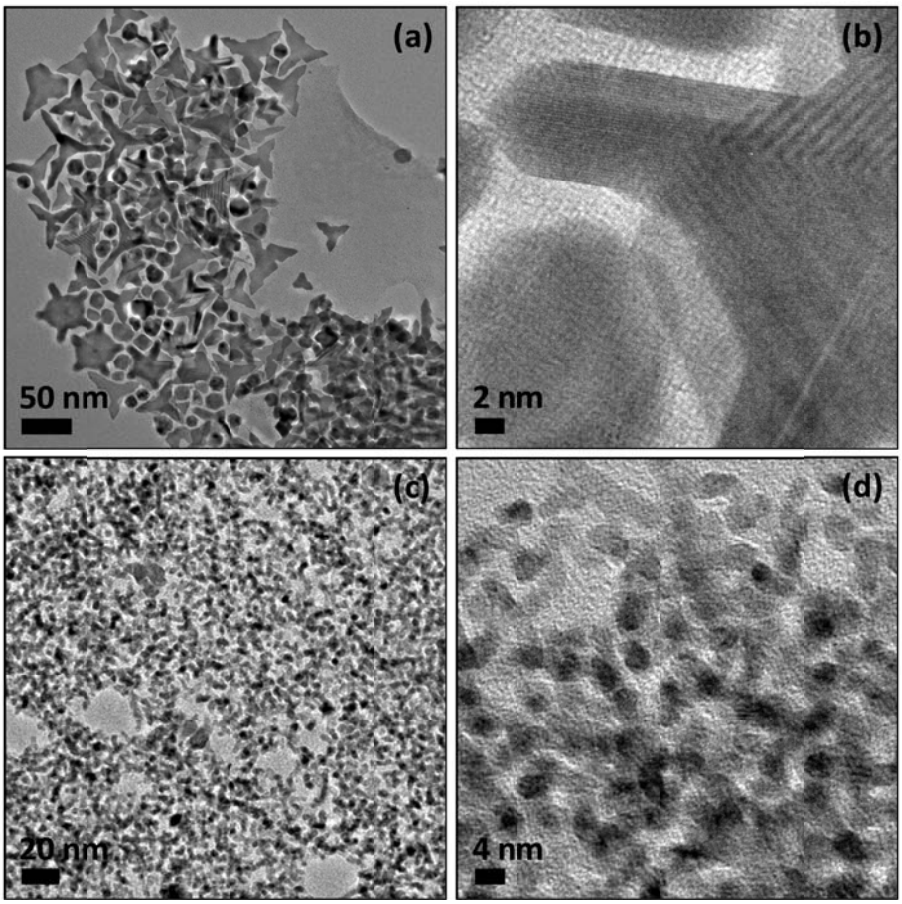

Fig. S2 TEM images (a,c) and HRTEM images (b,d) of Pt (a,b) and Pd nanoparticles (c,d) synthesized in oleylamine at temperature of 160°C using K_2PtCl_4 and $PdCl_2$ as metal precursors, respectively.

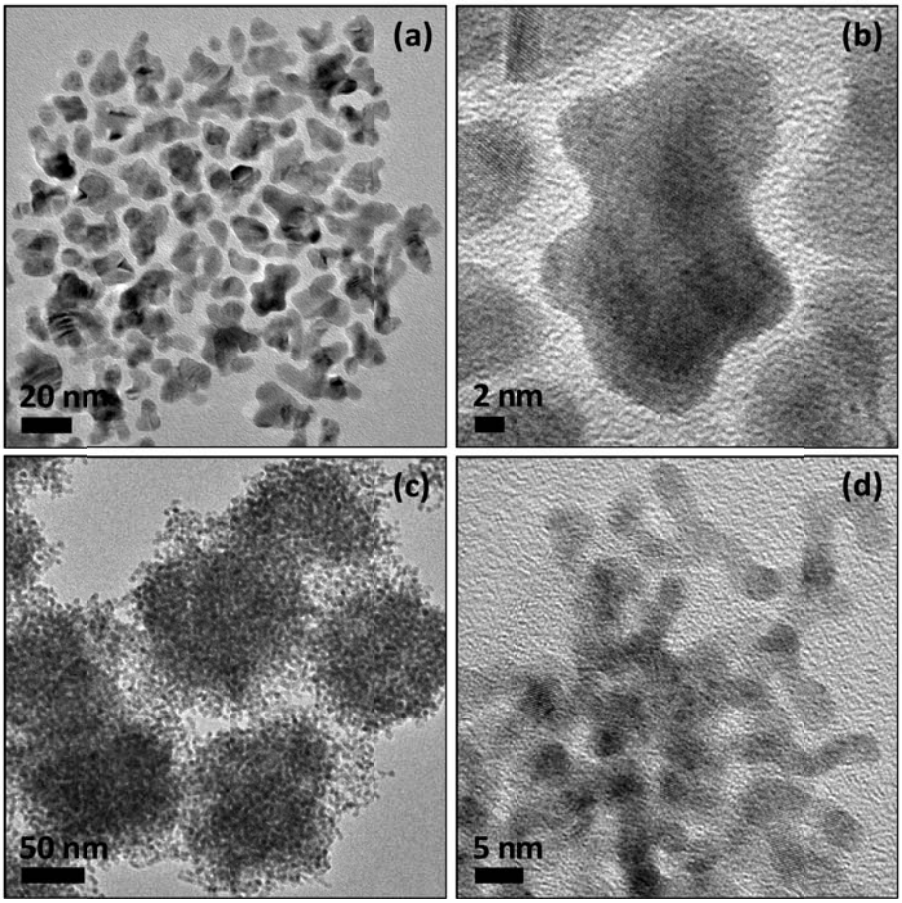

Fig. S3 TEM images (a,c) and HRTEM images (b,d) of Pt (a,b) and Pd nanoparticles (c,d) synthesized in oleylamine at temperature of 180°C using metal acetylacetonates as precursors.

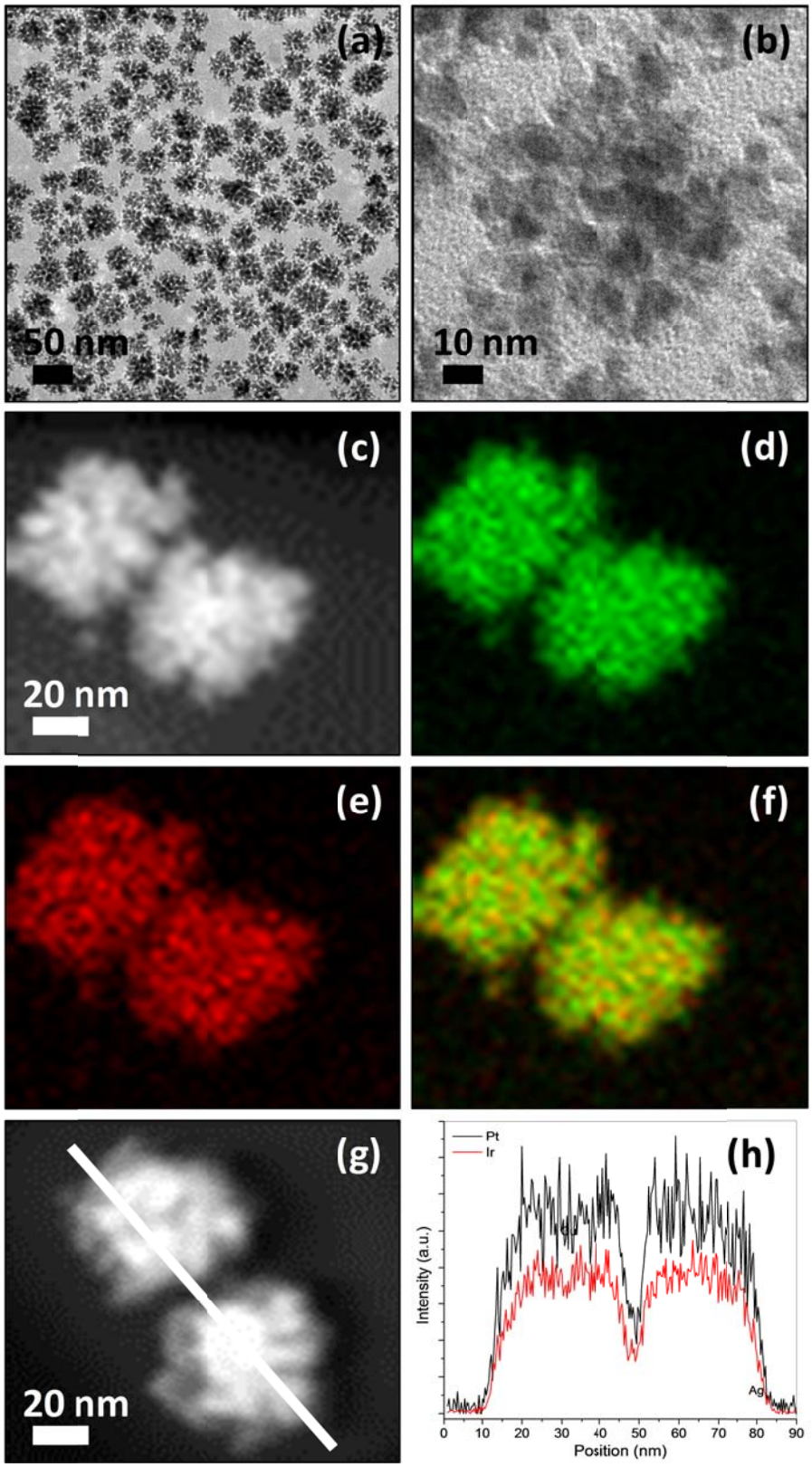

Fig. S4 TEM image (a), HRTEM image (b), elemental mapping (c–f), and line scanning analysis (g,h) of PtIr nanodendrites synthesized in oleylamine at 160°C.

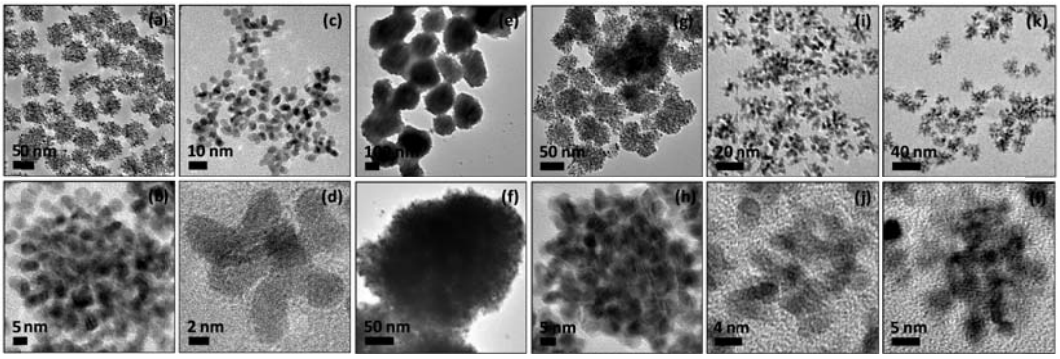

Fig. S5 TEM image (a,c,e,g,i,k) and HRTEM image (b,d,f,h,j,l) of PtPd (a,b), PtOs, (c,d), PtPdRu (e,f), PtPdRh (g,h), PtRuOs (i,j), and PtRhOs (k,l) nanodendrites synthesized in oleylamine at 160°C using metal acetylacetonates as precursors.

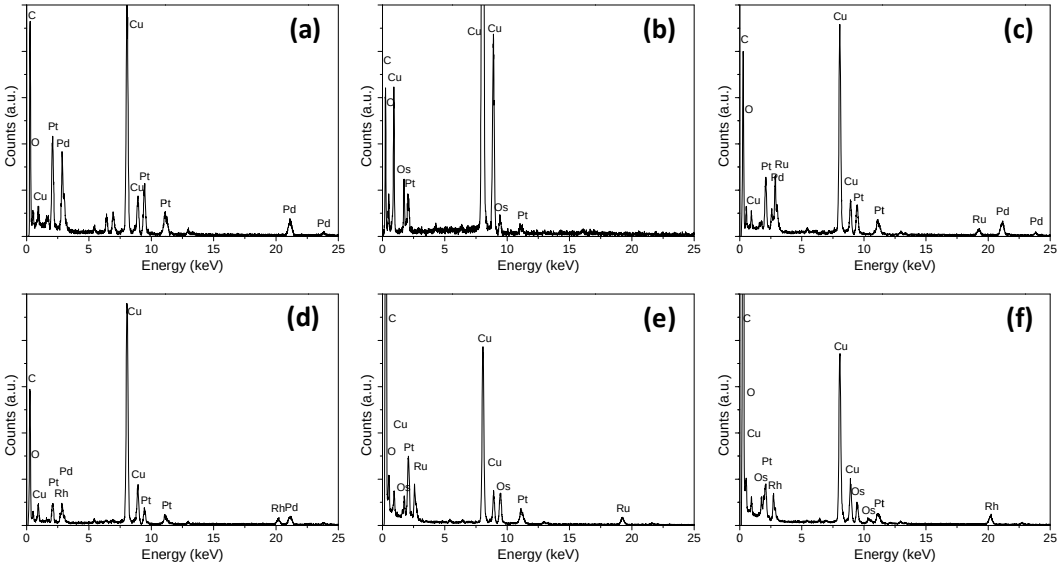

Fig. S6 EDX analyses of PtPd (a), PtOs, (b), PtPdRu (c), PtPdRh (d), PtRuOs (e), and PtRhOs nanodendrites (f) synthesized in oleylamine at 160°C using metal acetylacetonates as precursors.

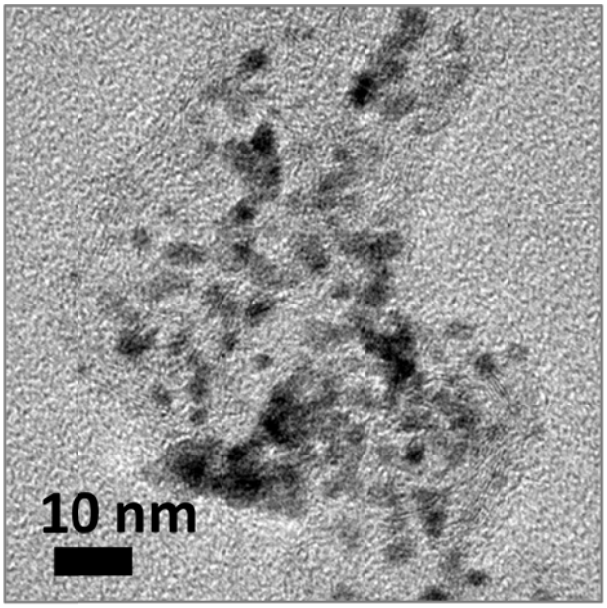

Fig. S7 TEM image of the PtRu/C catalyst (E-TEK), which consisted of alloy PtRu nanoparticles of ~ 3.5 nm in diameter on Vulcan XC-72 carbon support.

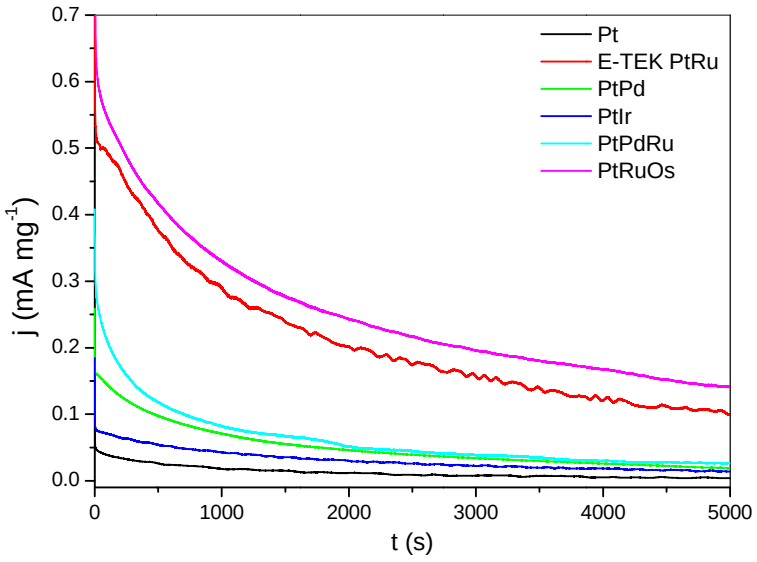

Fig. S8 Chronoamperograms of the Pt-containing NMNDs at 0.45 V vs. Ag/AgCl at room temperature in argon-purged $HClO_4$ (0.1 M) with methanol (1 M).

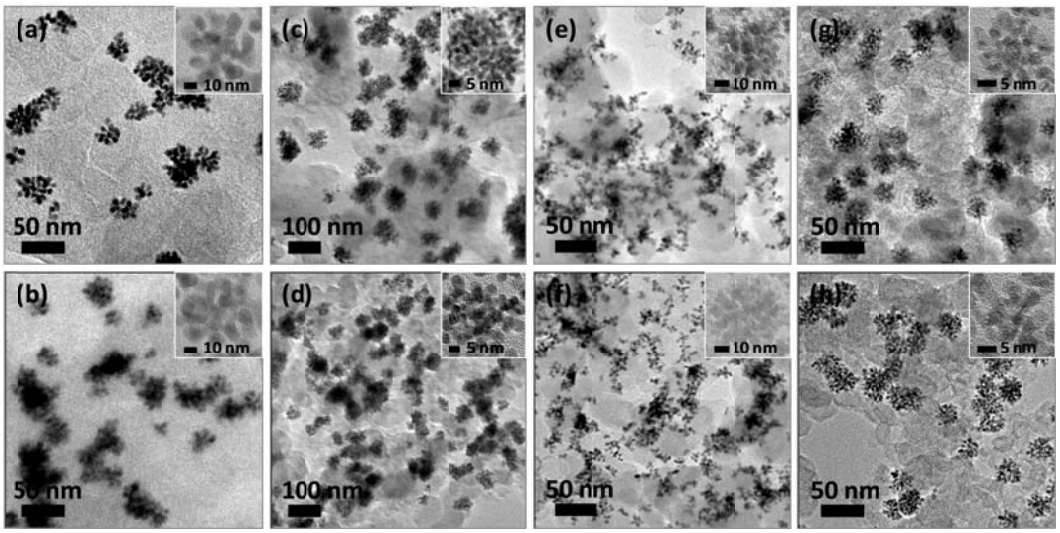

Fig. S9 TEM and HRTEM images (insert of each TEM image) images of Pt (a,b), PtPd (c,d), PtIr (e,f), and PtRuOs (g,h) nanodendrites before (a,c,e,g) and after electrochemical measurements (b,d,f,h).