Supporting Information

Noble-metal high-entropy-alloy tunning the products of electrocatalytic 5-hydroxymethylfurfural oxidation

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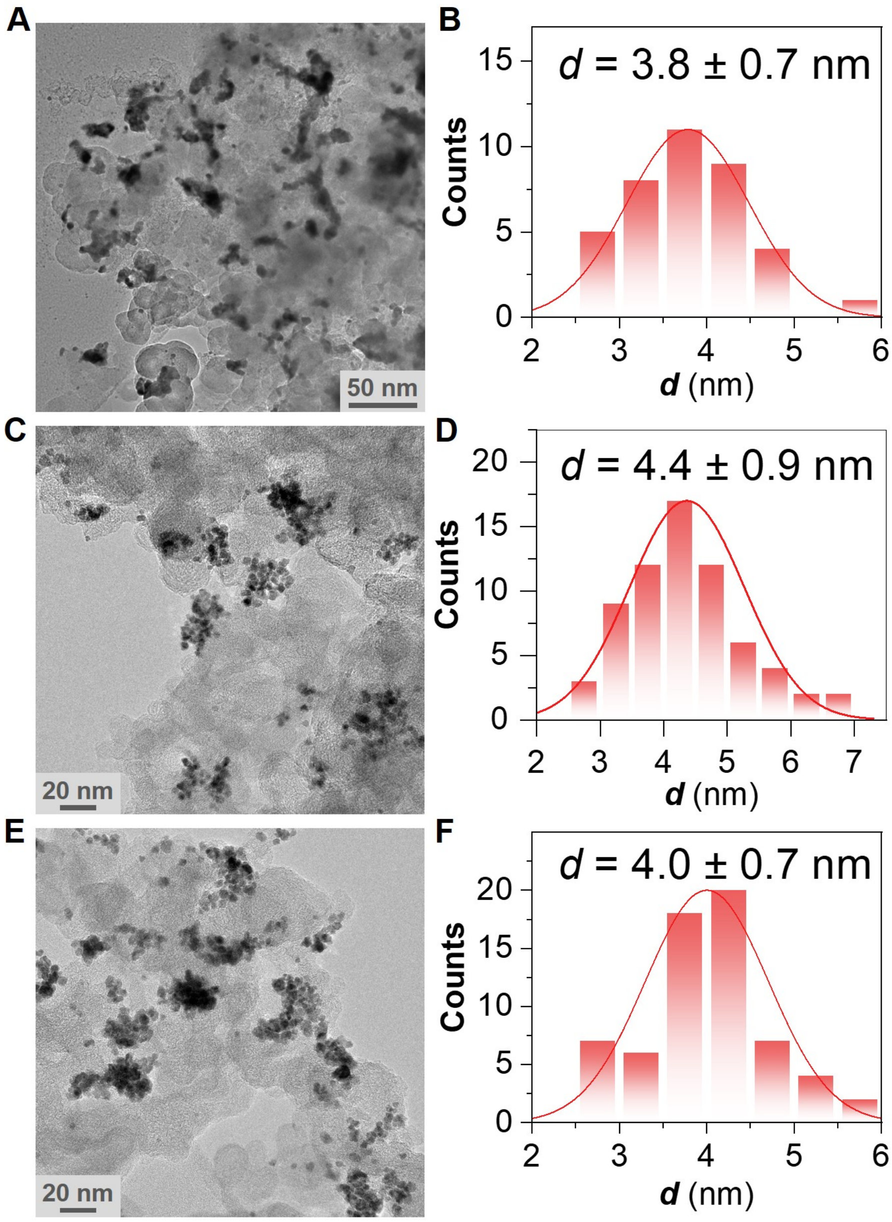

Figure S1. TEM images and corresponding histogram of size distribution for (A and B) PtRhPdIr, (C and D) PtRhPdIrRu and (E and F) PtRhPdIrAu NPs.

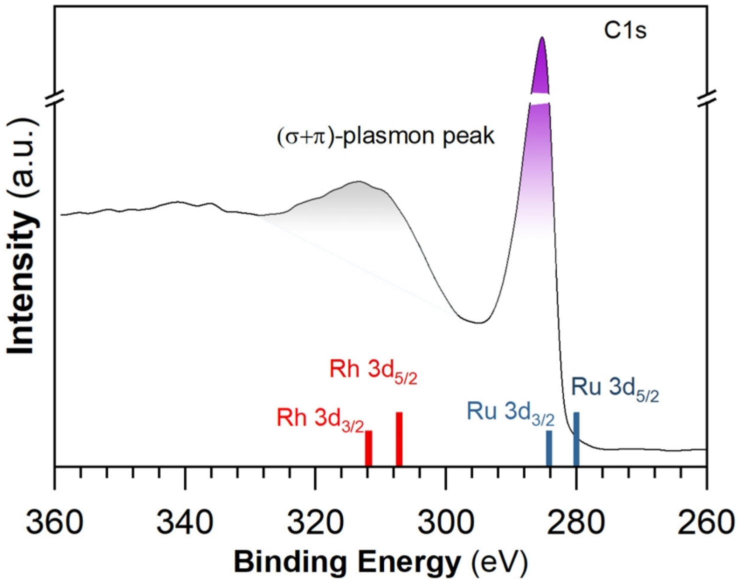

Figure S2 XPS spectrum from 260 to 360 eV for PtRhPdIrRuAu HEA NPs.

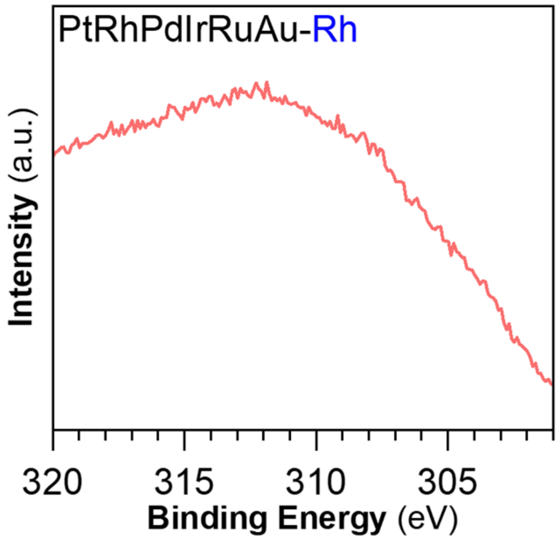

Figure S3 XPS spectrum from 301 to 320 eV (Rh 3d) for PtRhPdIrRuAu HEA NPs.

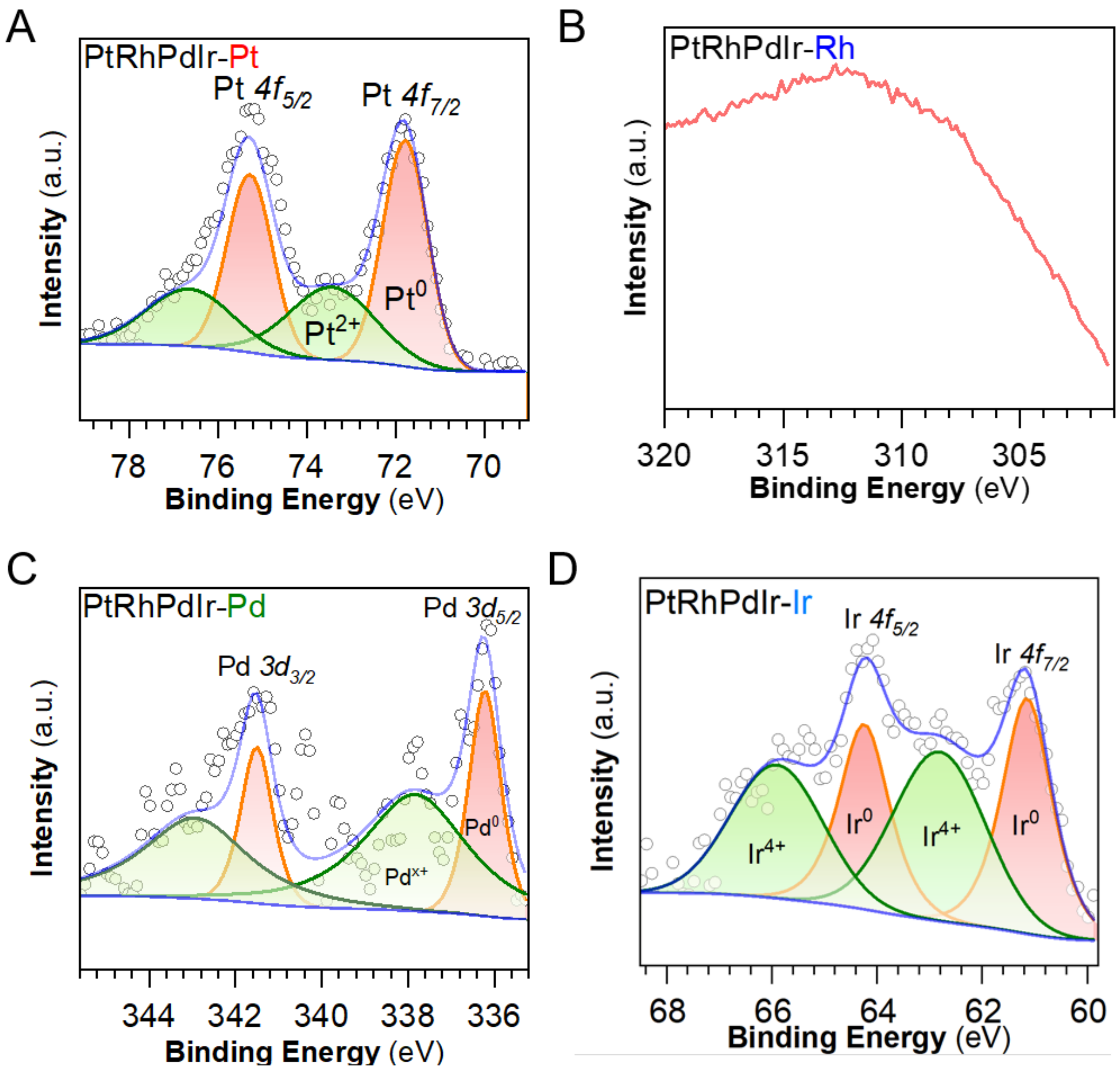

Figure S4 XPS spectra of (A) Pt 4f, (B)Rh 3d, (C)Pd 3d, and (D) Ir 4f for PtRhPdIr HEA NPs.

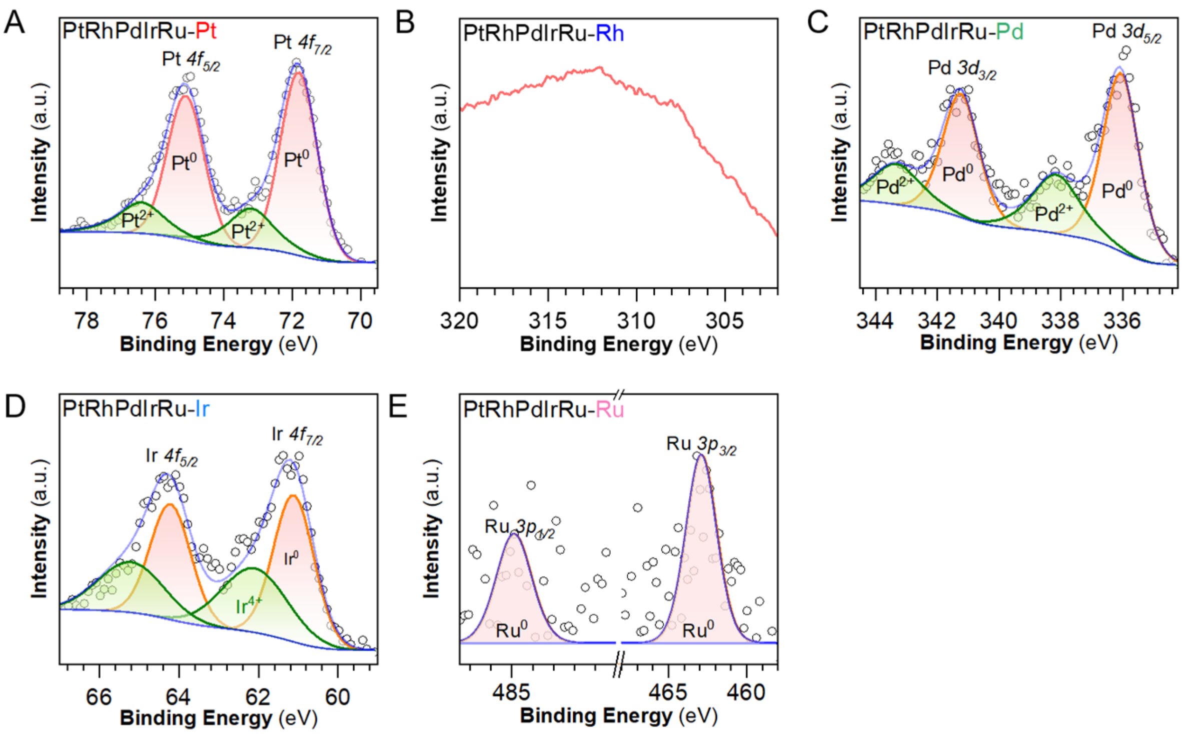

Figure S5. XPS spectra of (A) Pt 4f, (B)Rh 3d, (C)Pd 3d, (D) Ir 4f , and (E) Ru 3p for PtRhPdIrRu HEA NPs.

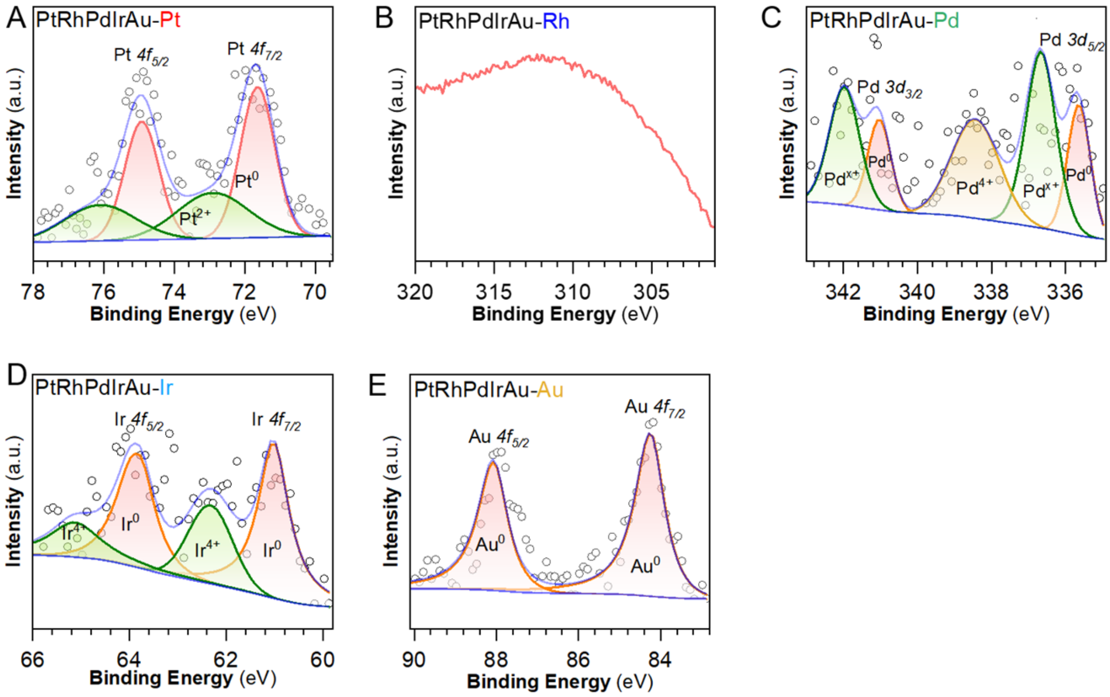

Figure S6. XPS spectra of (A) Pt 4f, (B)Rh 3d, (C)Pd 3d, (D) Ir 4f , and (E) Au 4f for PtRhPdIrAu HEA NPs.

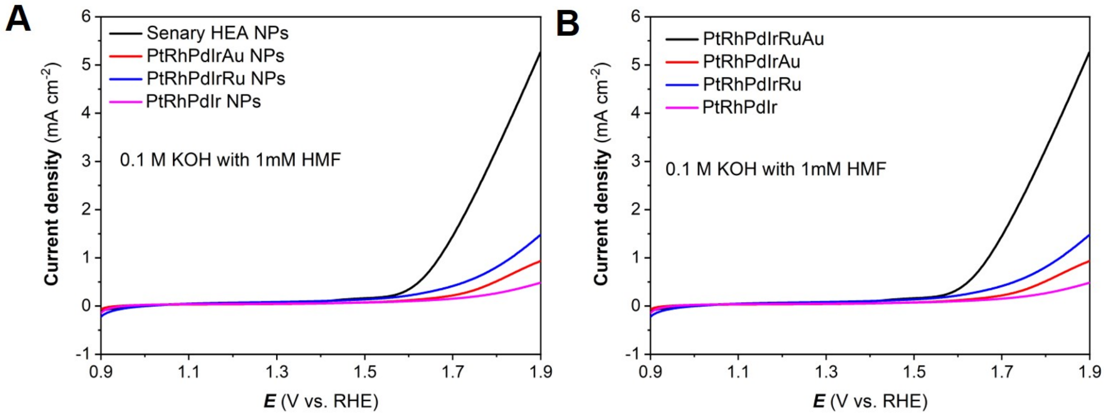

Figure S7. Comparison of LSV curves of HEA NPs in 0.1 M KOH without/with 1 mM HMF at a scan rate of 10 mV s^{-1}.

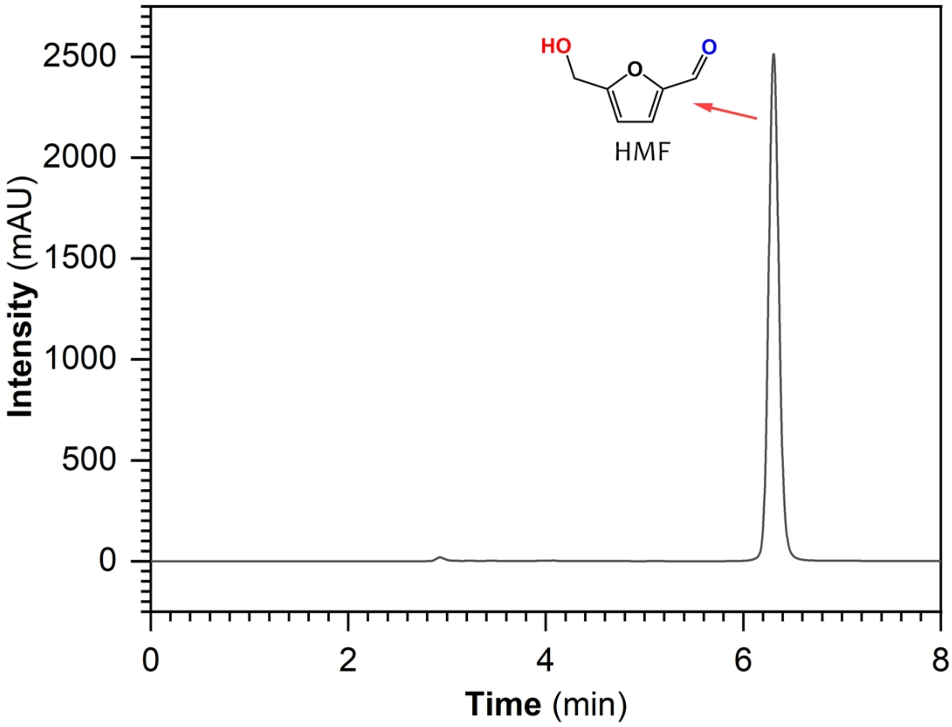

Figure S8. HPLC chromatogram of 0.1 M KOH + 1 mM HMF.

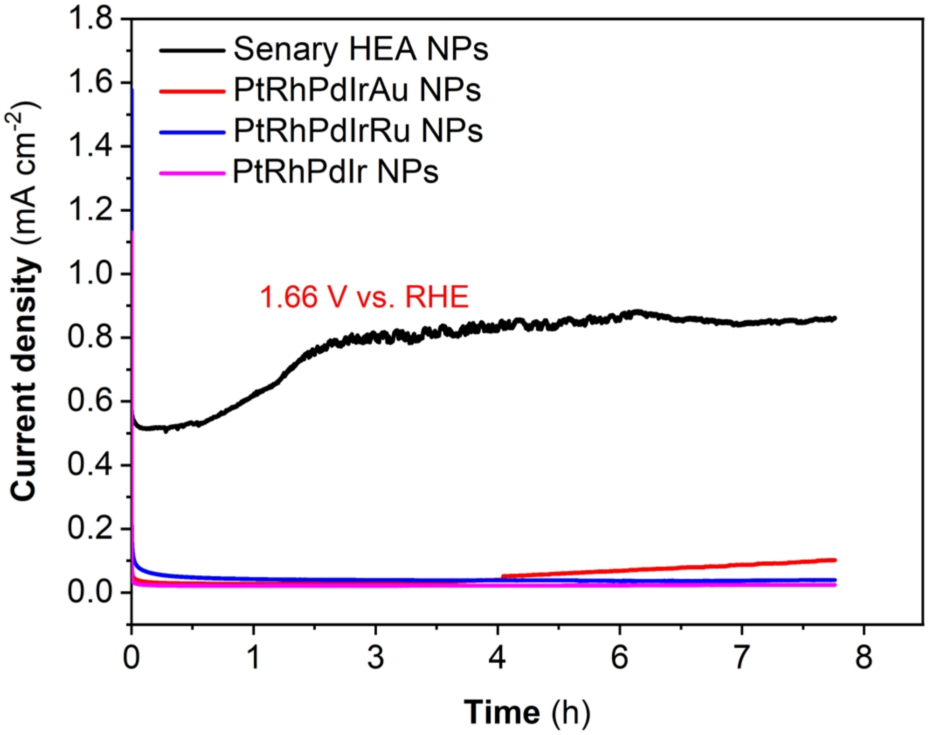

Figure S9. Chronoamperometric curves of HEA NPs in 0.1 M KOH + 1 mM HMF at 1.66 V vs. RHE.

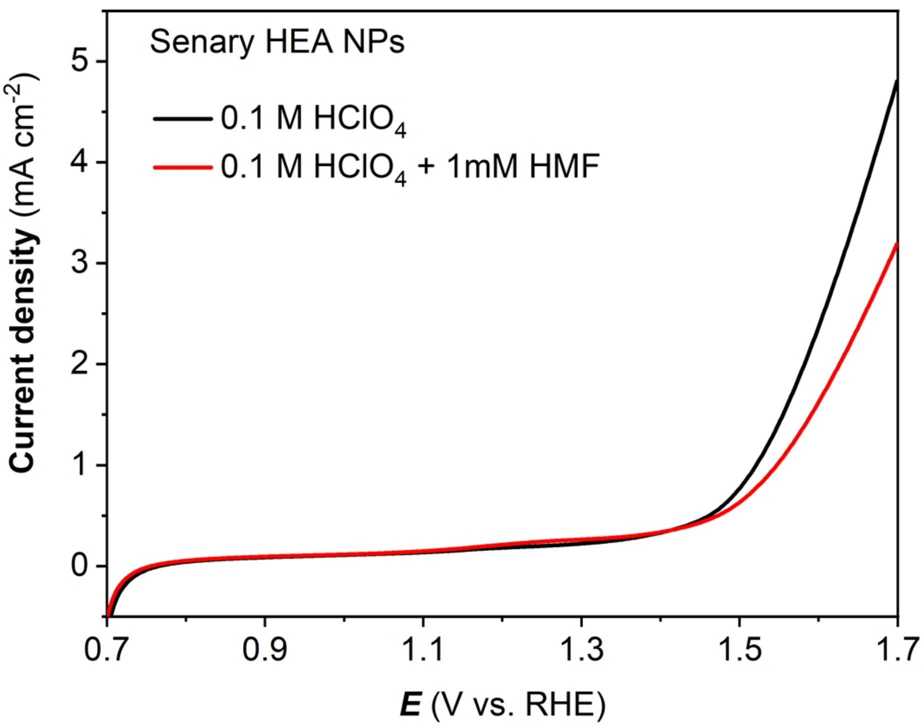

Figure S10. Comparison of LSV curves of Senary HEA NPs in 0.1 M $HClO_4$ without/with 1 mM HMF at a scan rate of 10 mV s^{-1}.

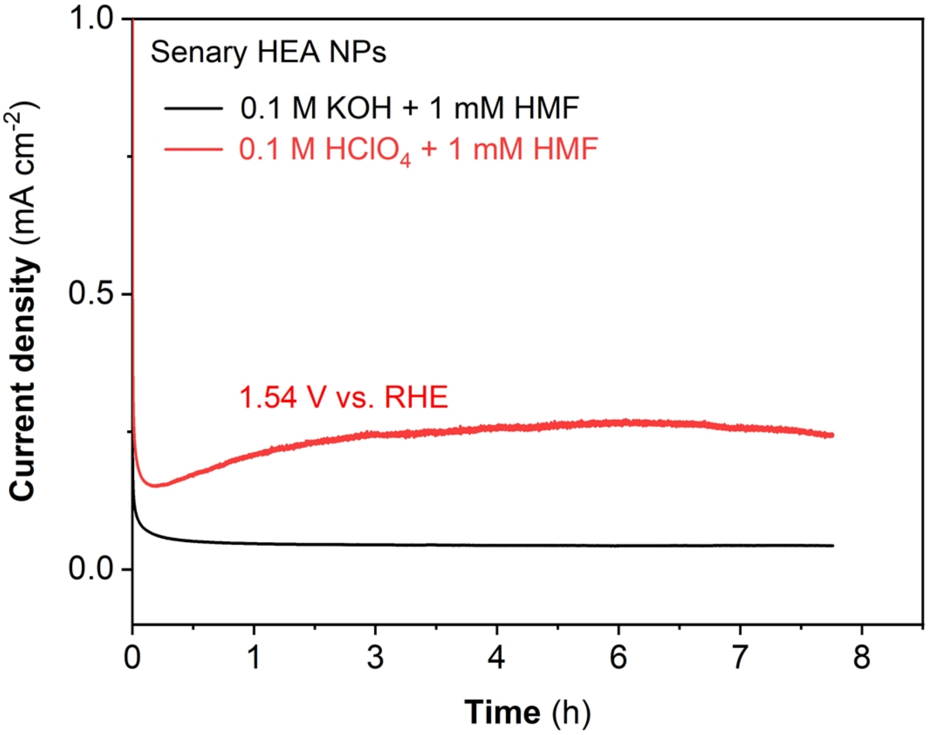

Figure S11. Chronoamperometric curves of Senary HEA NPs in alkaline/acidic electrolytes at 1.54 V vs. RHE.

Table S1. Selectivity of HMF oxidation products over HEA NPs in alkaline/acidic electrolytes with 1 mM HMF at different potential for 8 h.

Catalyst	E(V vs RHE)	Electrolyte	Conversion (%)	Selectivity (%)			
				FDCA	HMFCA	FFCA	DFF
PtRhPdIr	1.66	0.1 M KOH	8.12	0	39.3	16.0	44.6
PtRhPdIrAu	1.66	0.1 M KOH	9.68	20.9	4.2	25.9	48.8
PtRhPdIrRu	1.66	0.1 M KOH	17.04	24.2	7.5	27.7	40.4
PtRhPdIrRuAu	1.66	0.1 M KOH	48.41	18.0	63.4	0.5	17.9
PtRhPdIrRuAu	1.54	0.1 M KOH	21.61	11.5	16.3	29.4	42.5
PtRhPdIrRuAu	1.54	0.1M $HClO_4$	34.92	0	8.4	17.2	74.2

Table S2. The selectivity in different products on reported noble metal based catalysts for the electrochemical oxidation of HMF.

Catalysts	Electrolyte/HMF concentration	Reaction time [h]	*E* (V vs RHE)	selectivity [%]			Ref
				DFF	HMFCA	FDCA	
Pd/C	0.02 M	1	0.6	<1	25	11	1
Pd_2Au_1/C	0.02M	1	0.6	<1	30	8	
Pd_1Au_2/C	0.02M	1	0.6	—	59	25	
Au/C	0.02M	1	0.6	—	98	1	
Pd/C	0.02M	1	0.9	—	70	29	
Pd_2Au_1/C	0.02M	1	0.9	—	35	64	
Pd_1Au_2/C	0.02M	1	0.9	—	16	83	
Au/C	0.02M	1	0.9	—	98	1	
Pd/C	0.02M	1	1.2	—	71	3	
Pd_2Au_1/C	0.02M	1	1.2	—	61	22	
Pd_1Au_2/C	0.02M	1	1.2	—	60	36	
Au/C	0.02M	1	1.2	—	81	14	
Pd_{14}	0.005M	2	0.82	—	—	12	2
Au_{14}	0.005M	2	0.82	—	—	7.7	
Au_7/Pd_7	0.005M	2	0.82	—	—	20.6	
Pd_7/Au_7	0.005M	2	0.82	—	—	23.8	
$(AuPd)_7$	0.005M	2	0.82	—	—	22.5	
Ru_1/NiO	1.0M KOH	10C	1.3	9	73	1	3
Ru_1/NiO	1.0M KOH	10C	1.5	14	40	29	
Ru_1/NiO	1.0M KOH	10C	1.7	10	41	30	
Pt	0.02M	25C	2	10.5	0	0	4
Pt	0.02M	50C	2	24.8	0	0	
Pt	0.02M	100C	2	14.8	0	0	
Pt	0.02M	150C	2	16.3	0	0	
Pt	0.02M	200C	2	9.6	0	0	
Pt	0.02M	250C	2	5.3	0	<1	
Pt/C	0.1M	17h	—	72	2	2	5
PtRu(1:1)/C	0.1M	17h	—	89	0	0	
Ru/C	0.1M	17h	—	32	20	14	
$Pt/Fe_3O_4/rGO$	0.1M KOH	20h	0.85	—	35.8	—	6
$Pt/Fe_3O_4/rGO$	0.1M K_2SO_4	20h	0.85	94.4	—	—	

References

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