Supporting information

Ultradispersed Ir_xNi clusters as Bifunctional Electrocatalysts for High-Efficiency Water Splitting in Acid Electrolytes

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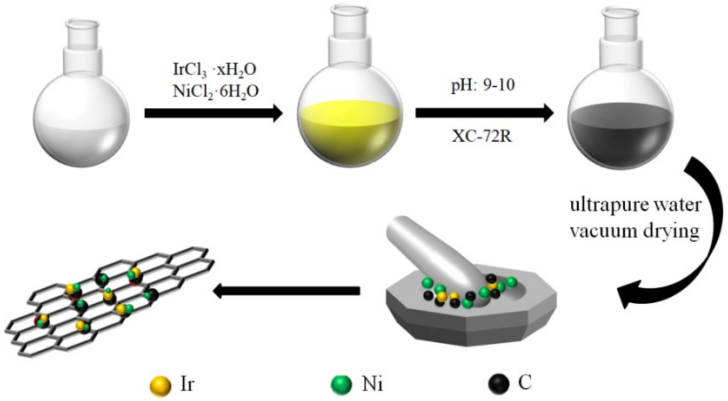

Figure S1. Synthesis diagram of Ir_xNi clusters was prepared by oil bath.

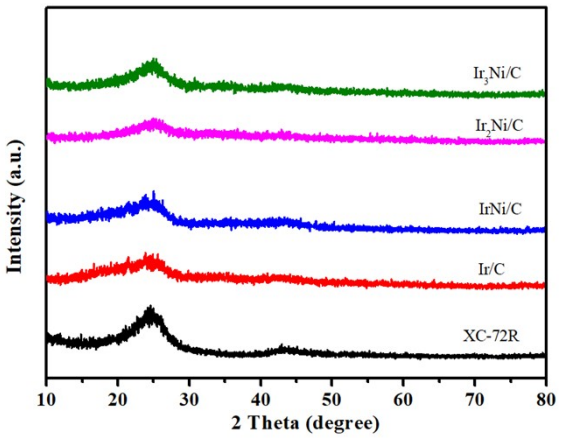

Figure S2. XRD patterns of XC-72R Vulcan carbon, Ir/C, IrNi/C, Ir_2Ni/C and Ir_3Ni/C.

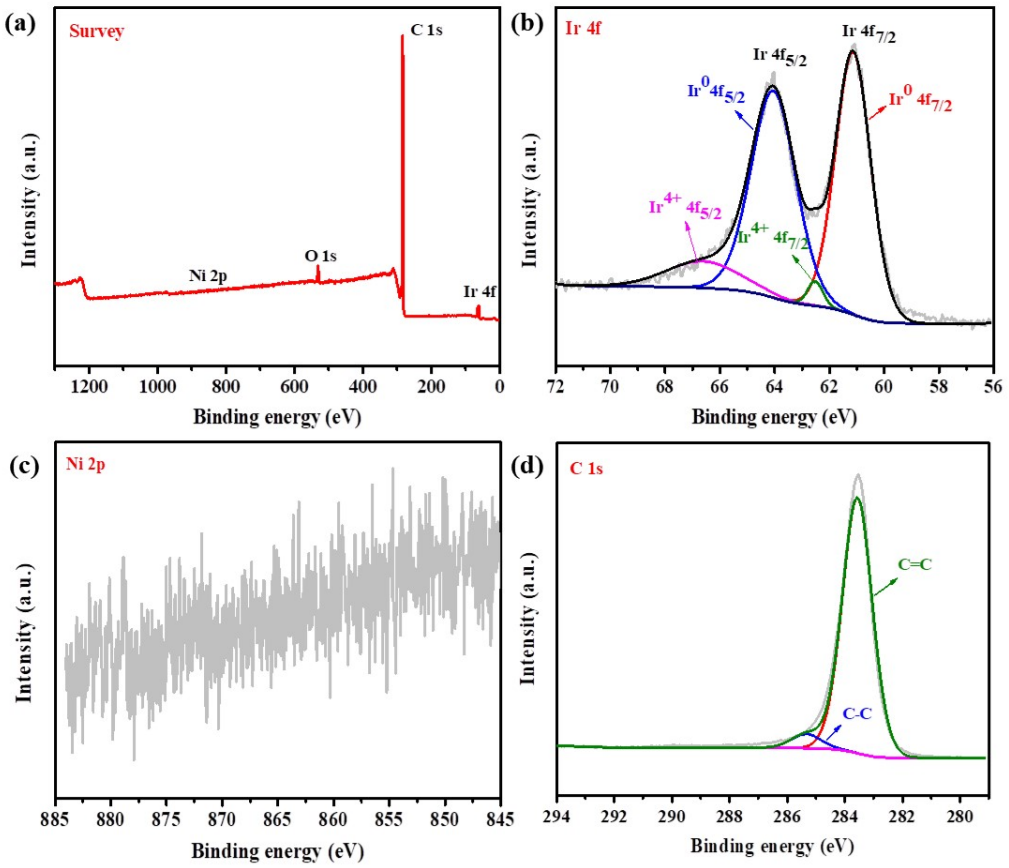

Figure S3. XPS spectra of Ir_2Ni/C: (a) survey, (b) Ir 4f, (c) Ni 2p, (d) C 1s.

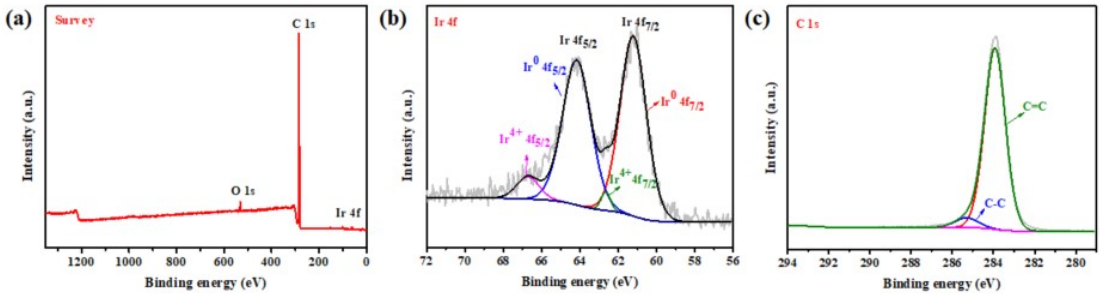

Figure S4. XPS spectra of Ir/C: (a) survey, (b) Ir 4f, (c) C 1s.

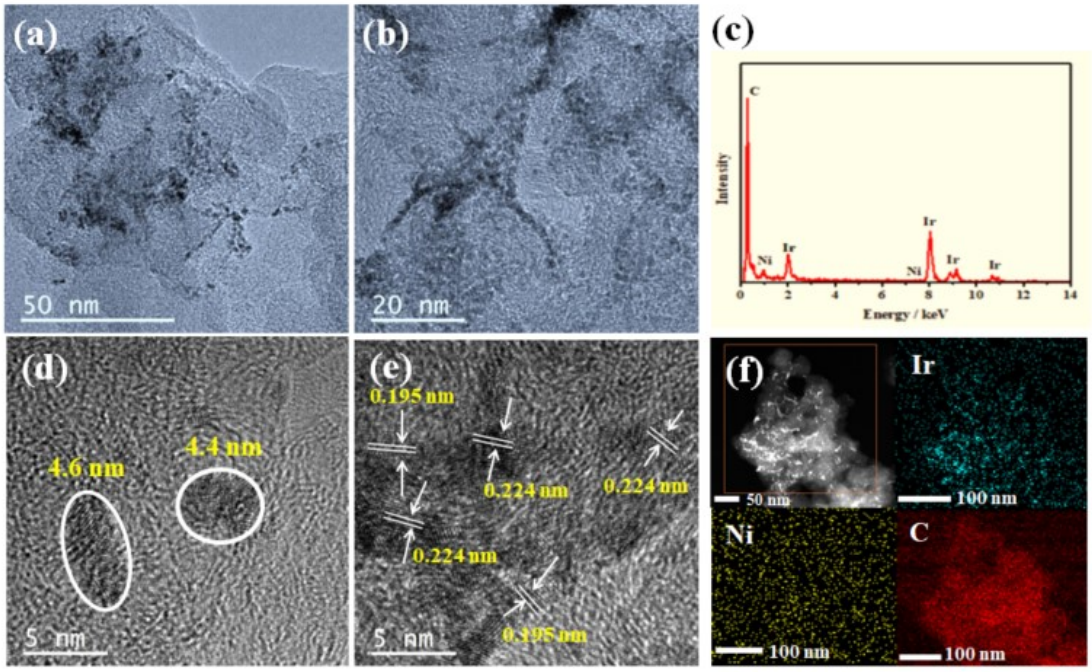

Figure S5. (a, b) TEM image and (c) EDS spectrum of IrNi/C. (d, e) HRTEM image of IrNi/C. (f) HAADF-STEM image, Ir STEM-EDS mappings, Ni STEM-EDS mappings, and C STEM-EDS mappings that were obtained for IrNi/C.

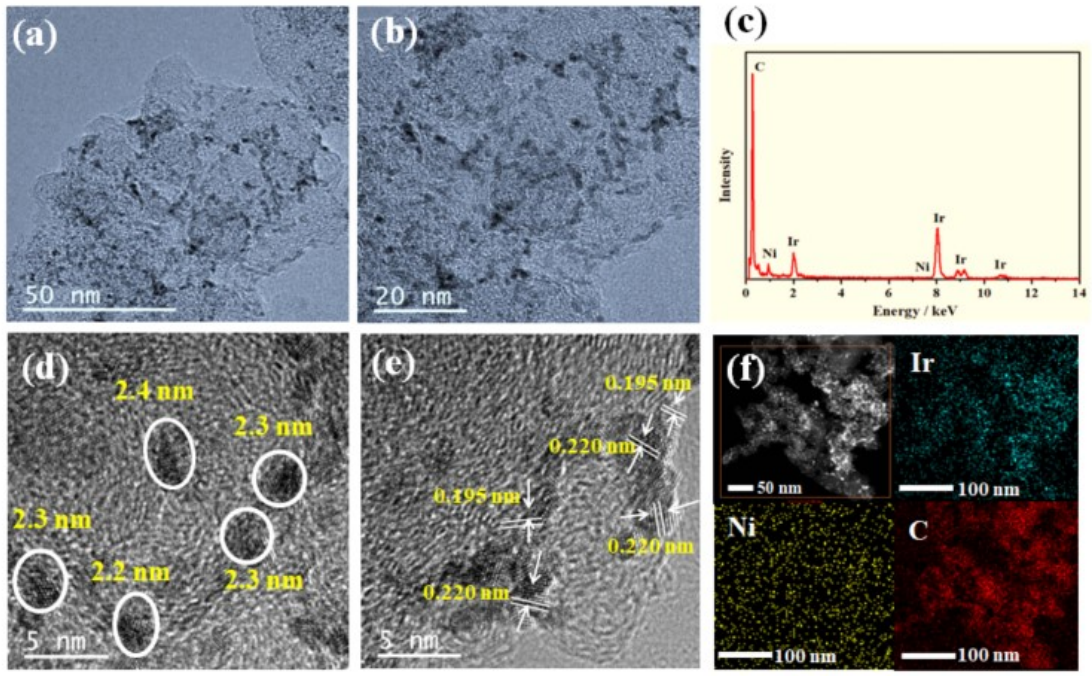

Figure S6. (a, b) TEM image and (c) EDS spectrum of Ir_3Ni/C. (d, e) HRTEM image of Ir_3Ni/C. (f) HAADF-STEM image, Ir STEM-EDS mappings, Ni STEM-EDS mappings, and C STEM-EDS mappings that were obtained for Ir_3Ni/C.

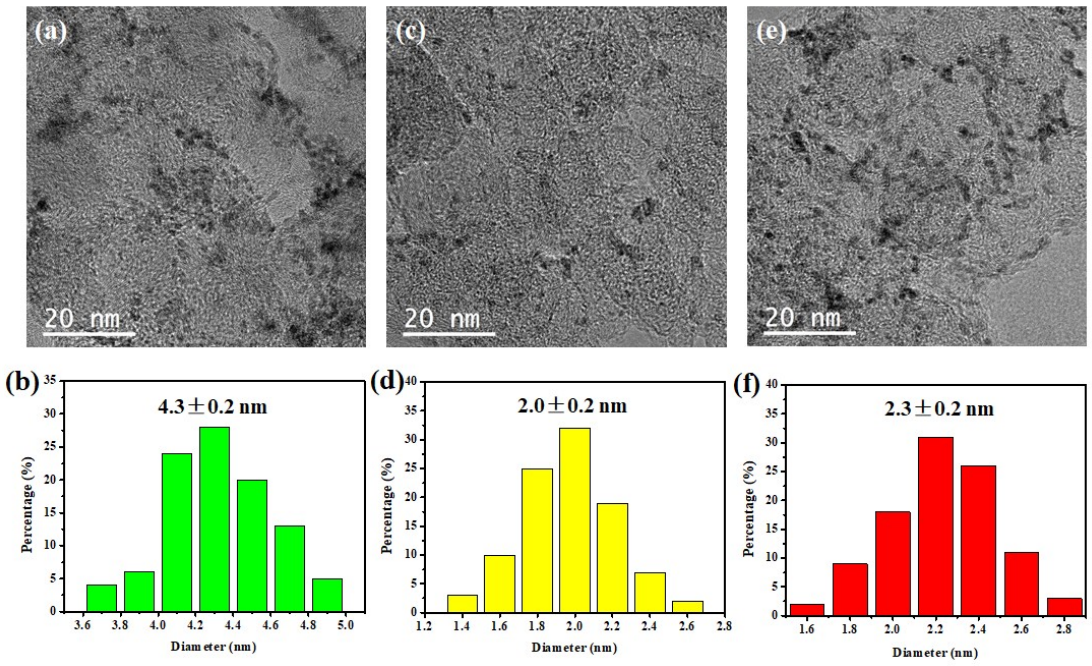

Figure S7. TEM image and particle size distribution of (a, b) IrNi/C, (c, d) Ir_2Ni/C, (e, f) Ir_3Ni/C, respectively.

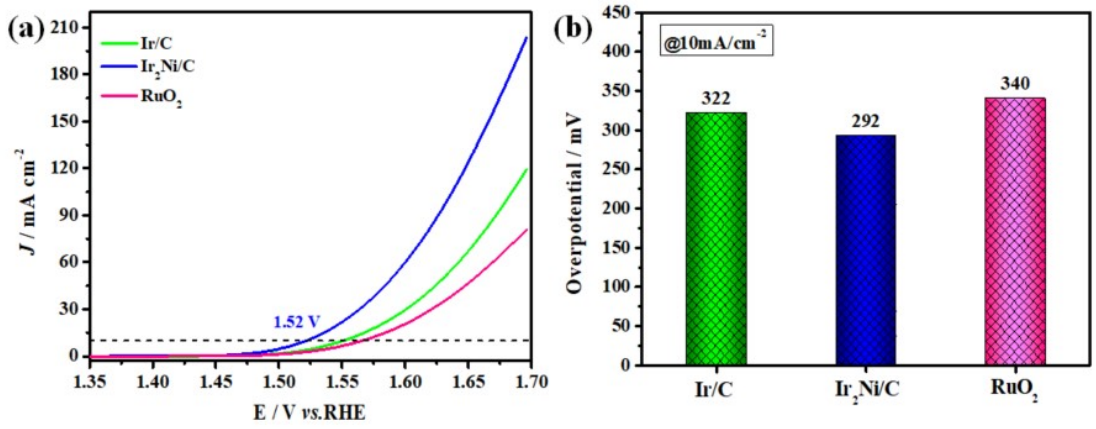

Figure S8. (a) LSV curves of the OER in 0.5 M H_2SO_4 and (b) The overpotential at 10 mA cm^{-2} of Ir/C, Ir_2Ni/C and RuO_2.

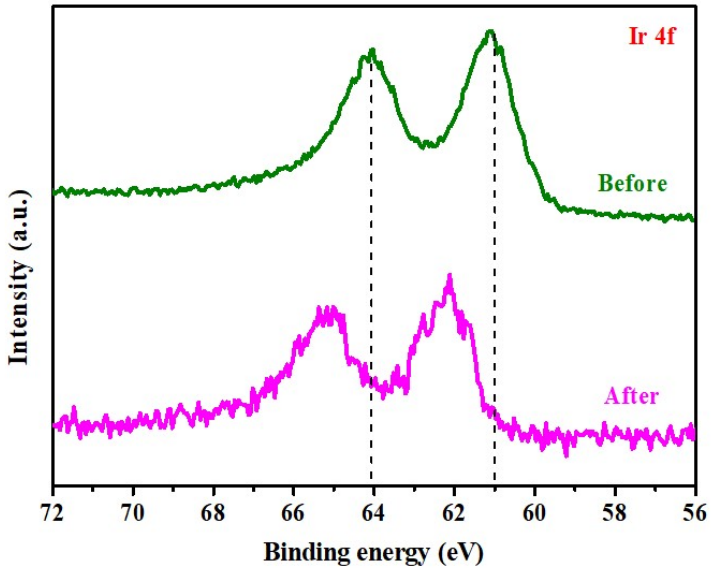

Figure S9. XPS spectra of Ir 4f for Ir_2Ni/C before and after OER in 0.5 M H_2SO_4.

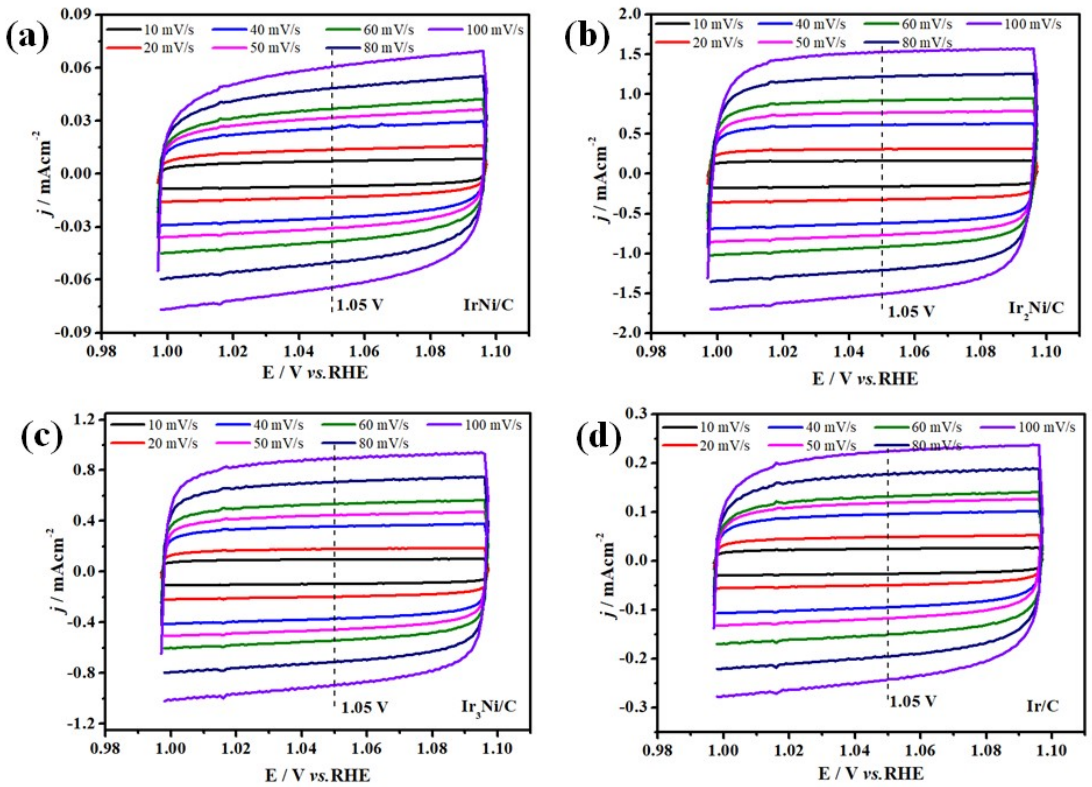

Figure S10. CV curves at different scan rates (10, 20, 40, 50, 60, 80, 100 mV s^{-1}) for (a) IrNi/C, (b) Ir_2Ni/C, (c) Ir_3Ni/C, (d) Ir/C.

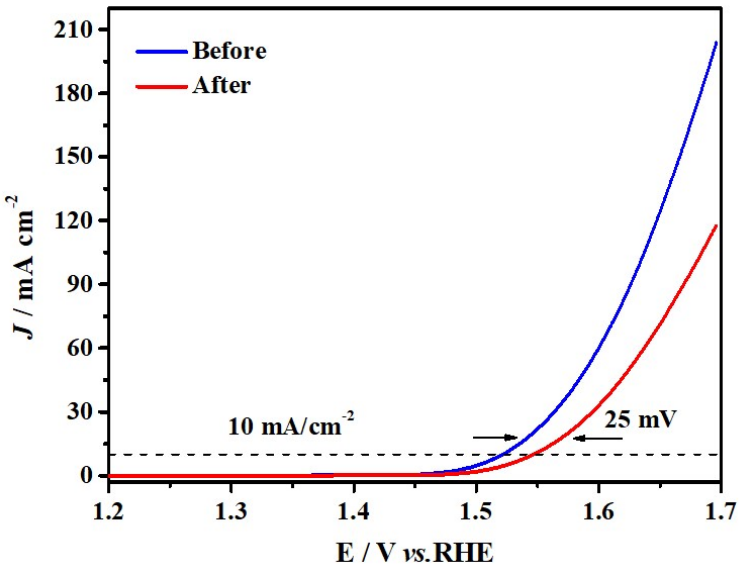

Figure S11. LSV curves for Ir_2Ni/C in 0.5 M H_2SO_4, the blue line is before chronopotentiometry test and red line is after chronopotentiometry test.

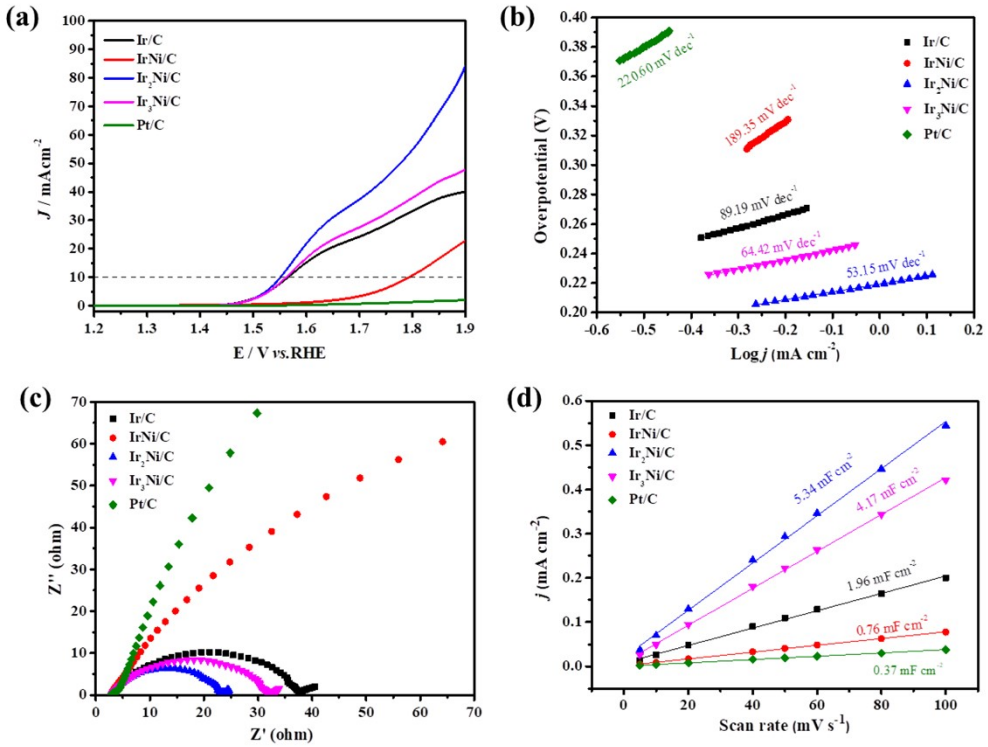

Figure S12. (a) LSV curves of the OER in 1 M KOH. (b) Tafel slopes. (c) EIS results of the catalysts. (d) Electrical double layer capacitor (C_{dl}).

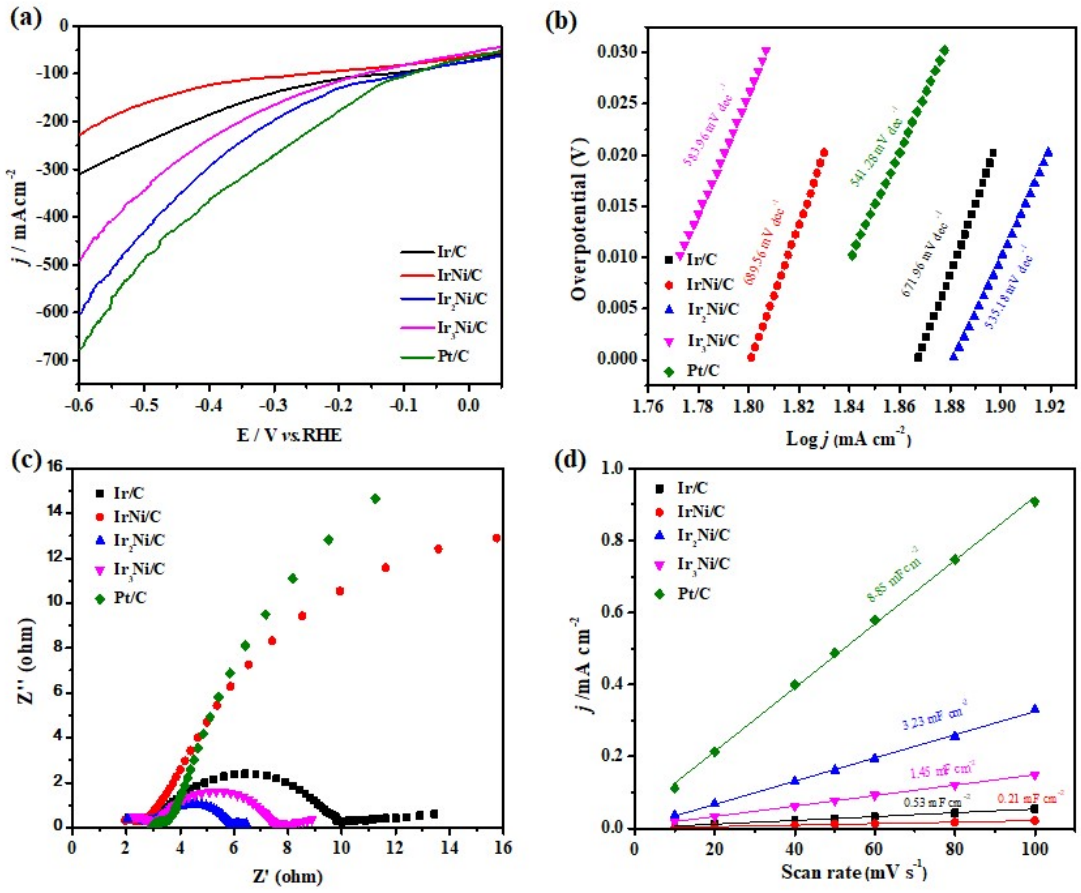

Figure S13. (a) LSV curves of the HER in 1 M KOH. (b) Tafel slopes. (c) EIS results of the catalysts. (d) Electrical double layer capacitor (C_{dl}).

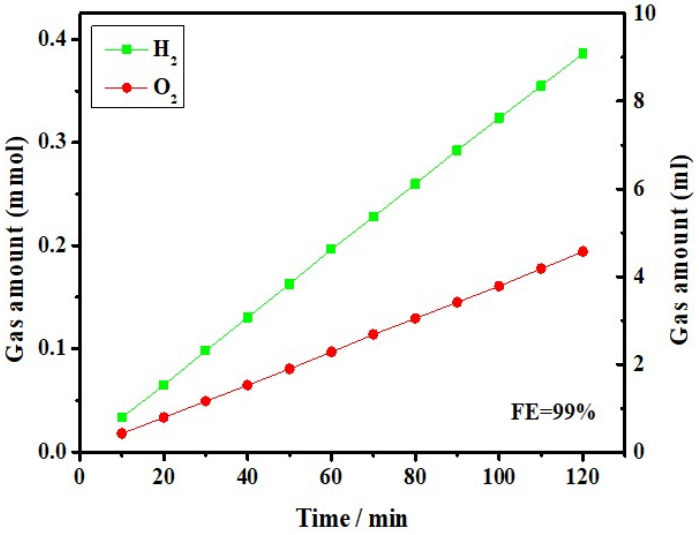

Figure S14. The Faradaic efficiency (FE) and amount of gas for HER and OER of $Ir_2Ni/C||Ir_2Ni/C$.

Table S1. Comparison of different catalysts.

Sample	Onset potential (V vs. RHE)	η @ 10 mA cm^{-2} (mV) in 0.5 M H_2SO_4	Tafel slope (mV dec^{-1})	Ir (wt%)	Ni (wt%)
IrNi/C	1.55	438	80.70	4.230	0.050
Ir_2Ni/C	1.44	292	47.83	5.140	0.047
Ir_3Ni/C	1.45	309	48.54	6.860	0.032
Ir/C	1.47	322	49.05	-	-
Pt/C	1.60	466	187.84	-	-

Table S2. OER electrocatalysts reported recently. Some of the information was not specified in the literature and was estimated according to data graphs.

Catalyst	Electrode	Loading amount (mg cm^{-2})	Electrolyte	η/mV	Reference
Ir_2Ni/C	GCE	0.32 (mg cm^{-2})	0.5 M H_2SO_4	292	This work
			1 M KOH	321	
Ir/C	GCE	20 μg_{Ir} cm^{-2}	0.5 M H_2SO_4	322	This work
			1 M KOH	335	
IrCoNi	GCE	10 μg_{Ir} cm^{-2}	0.5 M H_2SO_4	309	1
Ir-NSG	GCE	0.3 mg cm^{-2}	1 M PBS	307	2
			0.1 M $HClO_4$	275	
			1 M KOH	265	
NiV-LDH	GCE	2.6 mg cm^{-2}	1 M KOH	200	3
NiVIr-LDH		1.2 mg cm^{-2}	1 M KOH	180	
NiVRu-LDH		0.7 mg cm^{-2}	1 M KOH	190	

Table S3. HER electrocatalysts reported recently. Some of the information was not specified in the literature and was estimated according to data graphs.

Catalyst	Electrode	Loading amount (mg cm^{-2})	Electrolyte	η/mV	Reference
Ir_2Ni/C	GCE	0.32 (mg cm^{-2})	0.5 M H_2SO	30	This work
			1 M KOH	34	
Ir/C	GCE	20 μg_{Ir} cm^{-2}	0.5 M H_2SO_4	54	This work
			1 M KOH	56	
IrCoNi	GCE	10 μg_{Ir} cm^{-2}	0.5 M H_2SO_4	68	1
Ir-NSG	GCE	0.3 (mg cm^{-2})	1 M PBS	22	2
			0.1 M $HClO_4$	17	
			1 M KOH	18.5	
IrCo@NC-500	GCE	0.285 (mg cm^{-2})	0.5 M H_2SO_4	24	4
			1 M KOH	45	

DSIrNi@CNTs	GCE	19.2 μg_{Ir} cm^{-2}	1 M KOH	17	5
Ir_3V-1000	GCE	19 μg_{Ir} cm^{-2}	1 M KOH	9	6

Reference

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