Supporting information
Controllable construction of IrCo nanoclusters and the performance for water electrolysis

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S1. Experimental materials and Materials characterization

1. Experimental materials

Table S1. Main reagents in the experiment.

Name	Molecular formula
Iridium(III) chloride hydrate	$IrCl_3 \cdot xH_2O$
Cobalt(II) chloride hexahydrate	$CoCl_2 \cdot 6H_2O$
Sodium citrate	$C_6H_5Na_3O_7$

Potassium hydroxide	KOH
Ethylene glycol	C_2H_5OH
XC-72R carbon powder	C
Nafion (~5 wt%)	-
Ultrapure water	-

All the materials were purchased from reagent company, except the ultrapure water. The water was obtained by an ultrapure purification system. And none of them were processed. The specific materials are as follows:

Iridium(III) chloride hydrate ($IrCl_3\cdot xH_2O$, A.R), Cobalt(II) chloride hexahydrate ($CoCl_2\cdot 6H_2O$, A.R), Sodium citrate ($C_6H_5Na_3O_7$, A.R), potassium hydroxide (KOH, A.R), ethylene glycol (C_2H_5OH, A.R), XC-72 carbon powder, Nafion (~5 wt%) and ultrapure water.

2. Materials characterization

Table S2. Main instruments of the experiment.

Apparatus	Manufacturers
Electrochemical workstation CHI 660E	Chenhua, Shanghai, China
X-ray photoelectron spectroscopy	ESCALAB 250Xi
X-ray diffraction	Rigaku Ultima IV
High-resolution TEM	FEI Tecnai G2 F30
Transmission electron microscopy	FEI Tecnai G2 F20
Ultrasonic cleaning instrument	Ningbo Xinzhi Biotechnology Co., LTD.
Circulating water vacuum pump	Zhengzhou Great Wall Science, Industry and Trade Co., LTD.
Magnetic stirred base	Germany IKA Co., LTD.
Constant temperature blast oven	Shanghai Yiheng Science & Technology Co., LTD.

2.1 Characterizations of crystal structure

X-ray diffraction (XRD, Rigaku Ultima IV) (scan speed: 4° min^{-1}, 2θ range: 5-90°) to observe the crystal structure of the catalysts.

2.2 Characterizations of surface composition

X-ray photoelectron spectroscopy (XPS, ESCALAB 250Xi) to study the surface composition of the catalysts.

2.3 Characterizations of morphology and structure

The morphology and structure of the catalysts were characterized by Transmission electron microscopy (TEM, FEI Tecnai G2 F20) and High-resolution TEM (HRTEM, FEI Tecnai G2 F30).

S2. Preparation of working electrode

1) Nafion (5%), ultra-pure water and ethanol were used to prepare slurry at 1:9:10.
2) 5 mg catalyst was mixed with 1mL of the slurry.
3) Ultrasonic to uniform dispersion.
4) The pipette gun was used to take 16 μL of the slurry and uniformly add it to the carbon paper with an area of 0.25 cm^2.

The working electrode load obtained was 0.32 mg cm^{-2}

S3. Supplementary Figures

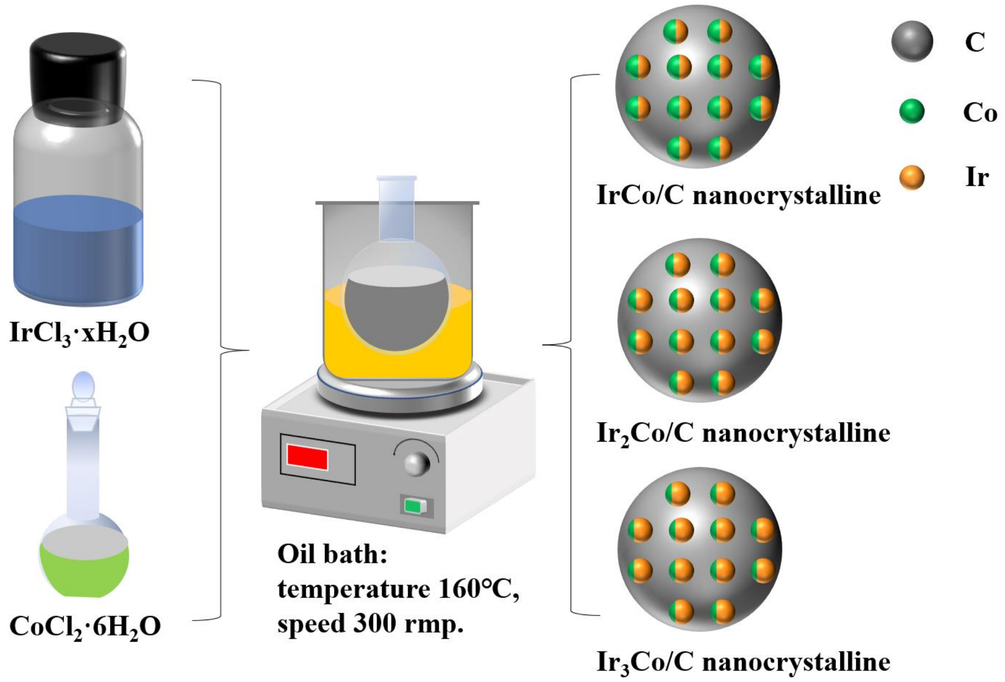

Figure S1 Synthesis diagram of Ir_xCo clusters was prepared by oil bath.

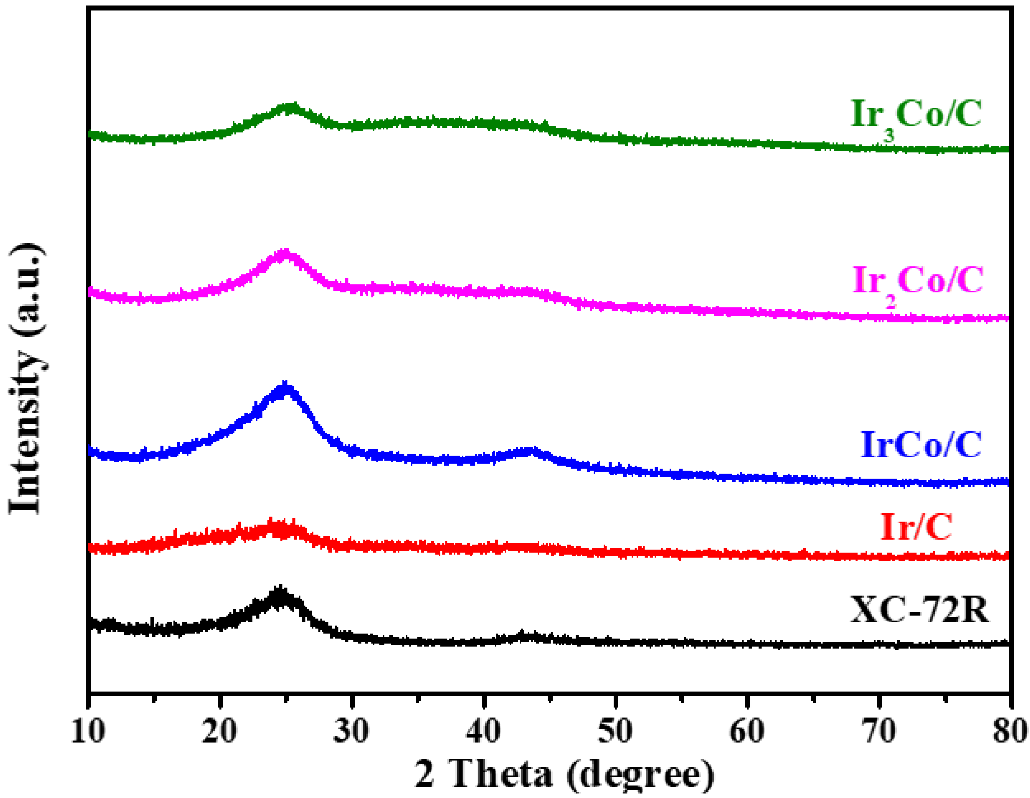

Figure S2 XRD patterns of XC-72R Vulcan carbon, Ir/C, IrCo/C , Ir_2Co/C and Ir_3Co/C.

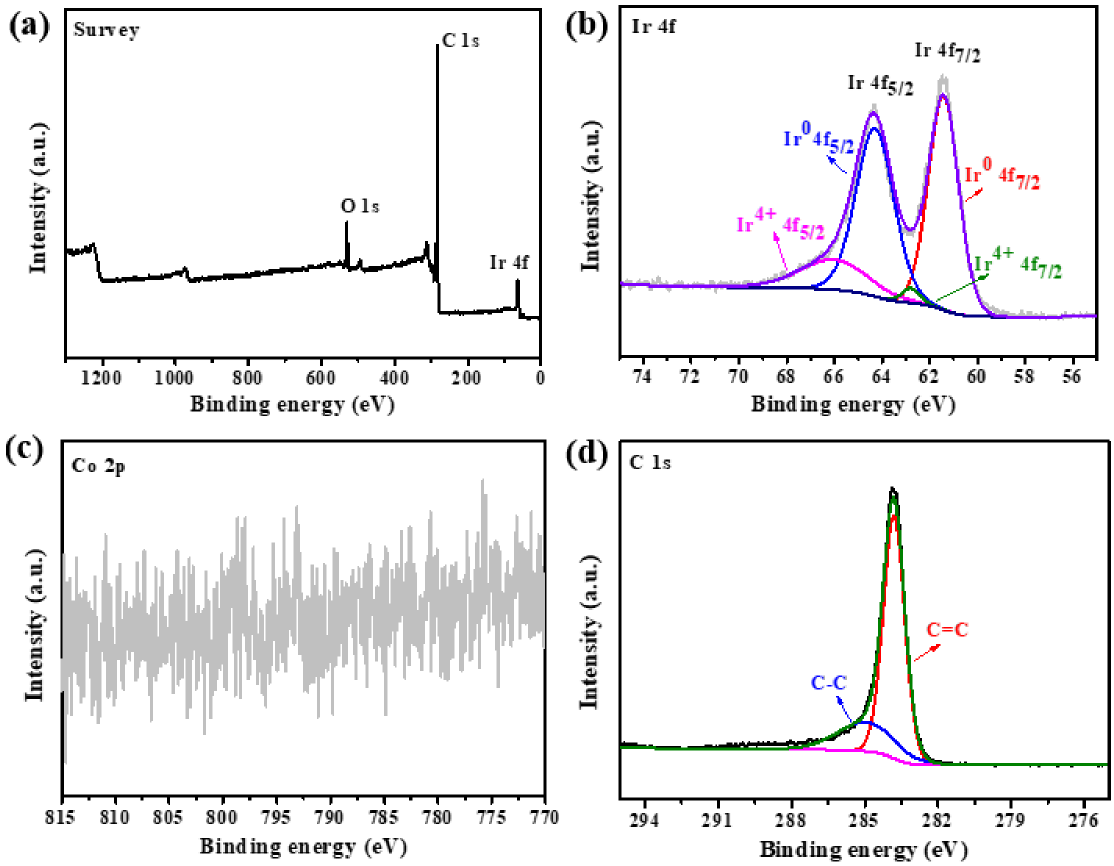

Figure S3 XPS spectra of Ir_3Co/C: (a) survey, (b) Ir 4f, (c) Co 2p, (d) C 1s.

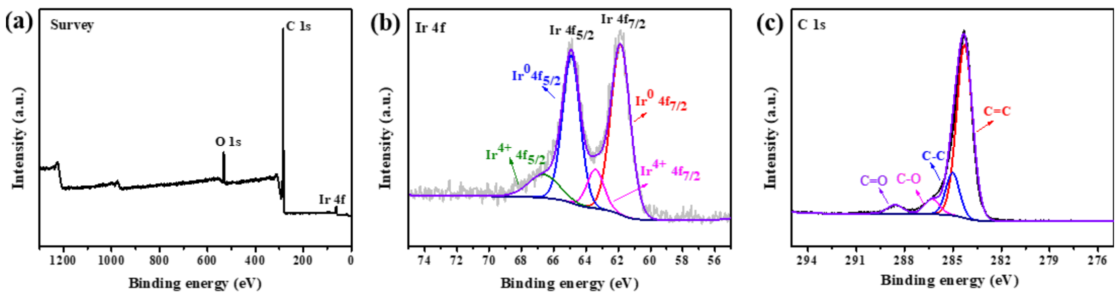

Figure S4 XPS spectra of Ir/C: (a) survey, (b) Ir 4f, (c) C 1s.

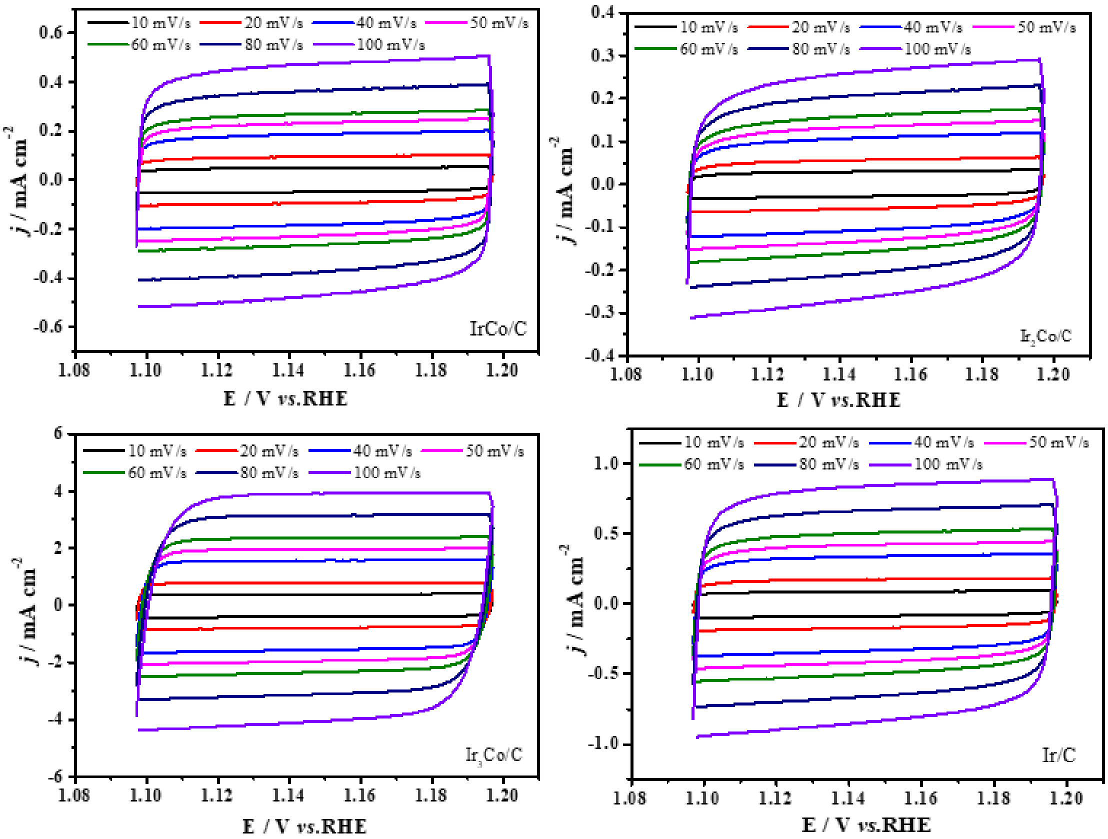

Figure S5 CV curves at different scan rates (10, 20, 40, 50, 60, 80 and 100 mV s^{-1}) for (a) IrCo/C, (b) Ir_2Co/C, (c) Ir_3Co/C, (d) Ir/C.

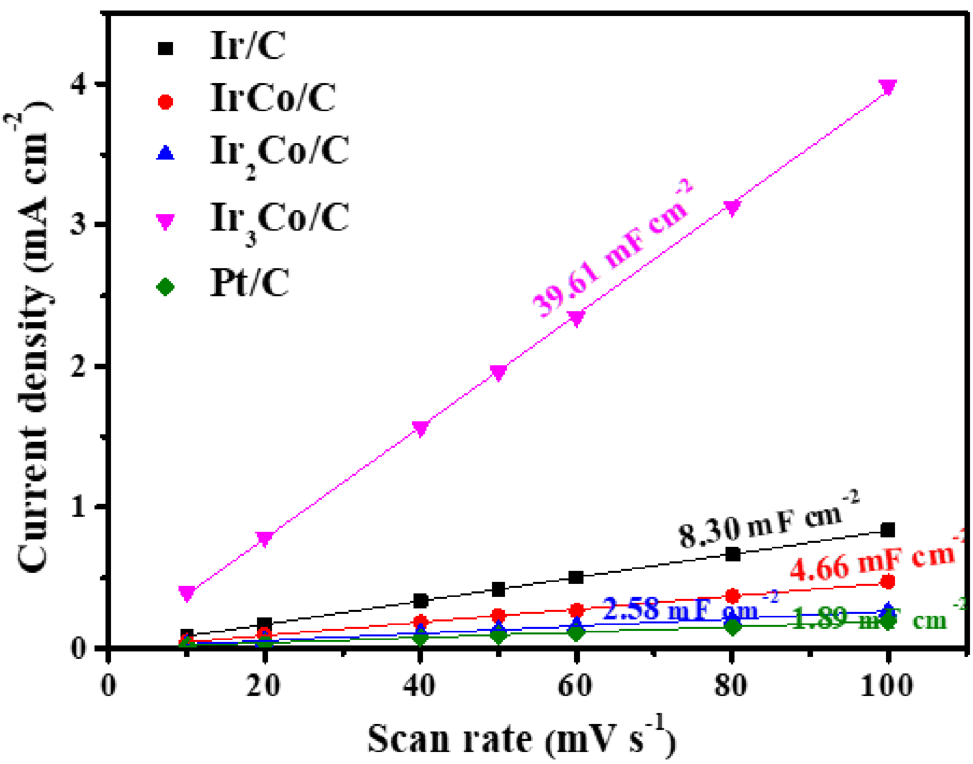

Figure S6 Electrical double layer capacitor (C_{dl}) of the OER in 0.5 M H_2SO_4.

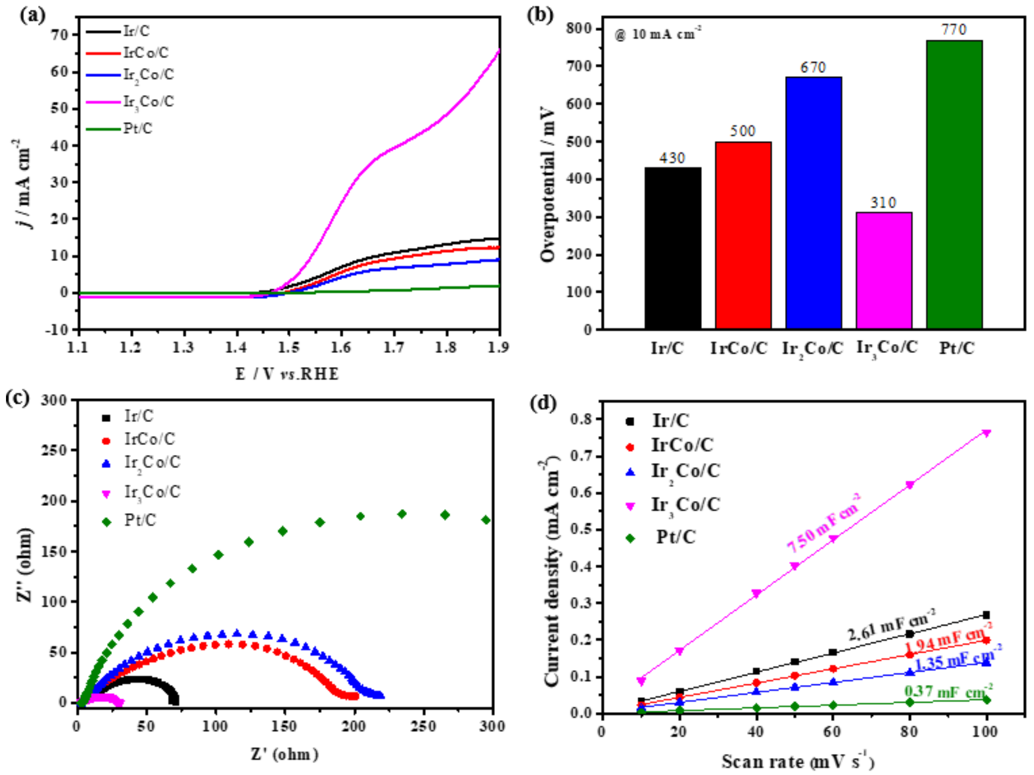

Figure S7 (a) LSV curves of the OER in 1 M KOH. (b) The overpotential at 10 mA cm^{-2}. (c) EIS results of the catalysts. (d) Electrical double layer capacitor (C_{dl}).

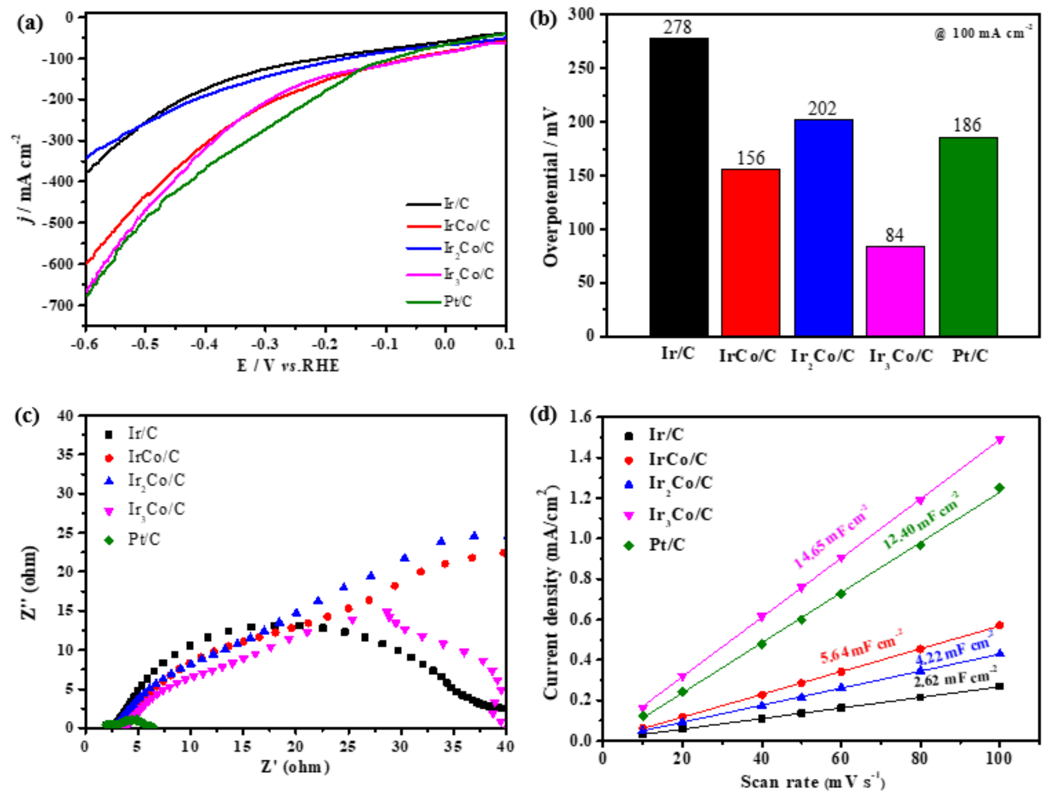

Figure S8 (a) LSV curves of the HER in 1 M KOH. (b) The overpotential at 100 mA cm^{-2}. (c) EIS results of the catalysts. (d) Electrical double layer capacitor (C_{dl}).

S4. Supplementary Tables

Table S3. 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})
IrCo/C	1.57	338	65.40
Ir_2Co/C	1.59	360	65.21
Ir_3Co/C	1.52	290	50.27
Ir/C	1.56	328	51.67
Pt/C	1.60	466	187.84

Table S4. Comparison of the OER performance of IrO_2 and RuO_2 with Ir_3Co/C.

Sample	Electrolytes	η @ 10 mA cm^{-2} (mV)	Reference
Ir_3Co/C	0.5 M H_2SO_4	290	This work
RuO_2	0.5 M H_2SO_4	340	1
IrO_2	0.5 M H_2SO_4	520	2

Table S5. OER electrocatalysts reported recently.

Catalyst	Electrolyte	η/mV	Reference
Ir_3Co/C	0.5 M H_2SO_4	290	This work
Ir/C	0.5 M H_2SO_4	328	This work
$Pt_{50}Ir_{50}$	0.5 M H_2SO_4	299	3
RuIr@Co NC	0.5 M H_2SO_4	300	4
Zn-Ir-MOF	0.5 M H_2SO_4	359	5
CFGNZ- NP	0.5 M H_2SO_4	370	6
$Sr_2Fe_{1.3}Ni_{0.2}Mo_{0.5}O_{6-\delta}$	0.5 M H_2SO_4	360	7

Table S6. HER electrocatalysts reported recently.

Catalyst	Electrolyte	η/mV	Reference
Ir_3Co/C	0.5 M H_2SO_4	91	This work
Ir/C	0.5 M H_2SO_4	222	This work
NbS_2	0.5 M H_2SO_4	100	8
$CuWO_4$ @rGO	0.5 M H_2SO_4	135	9
Mo_2C/W_2C	0.5 M H_2SO_4	140	10
Zn-Co-P	0.5 M H_2SO_4	167	11
$CoSe_2$/SDGC	0.5 M H_2SO_4	203	12

S5. References

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