

Electronic Supplementary Information

Electronic Modulation of Cobalt Phosphide by Lanthanum Doping for Efficient Overall Water Splitting in Alkaline Media

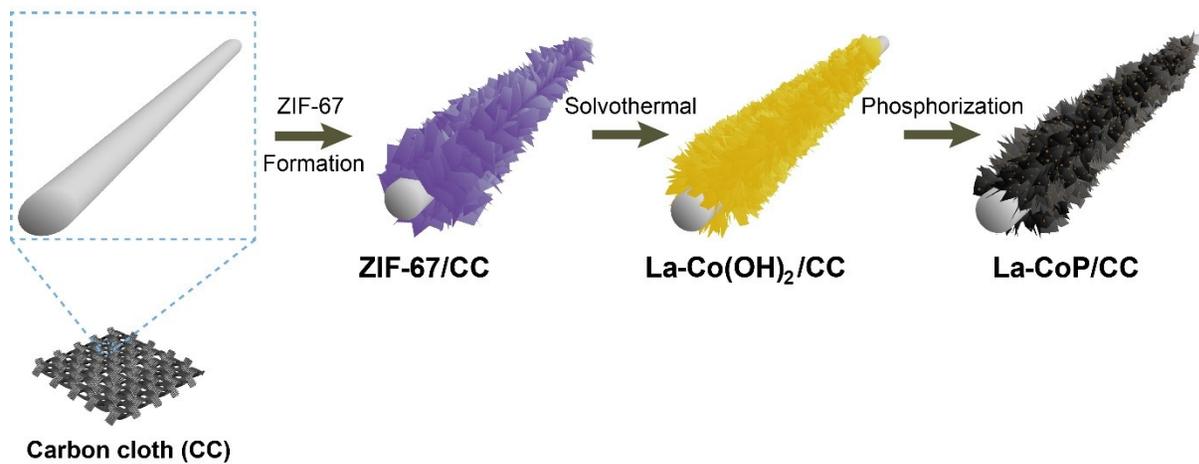
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Figures



Scheme 1. Schematic illustration of the fabrication process of La-CoP on carbon cloth (CC).

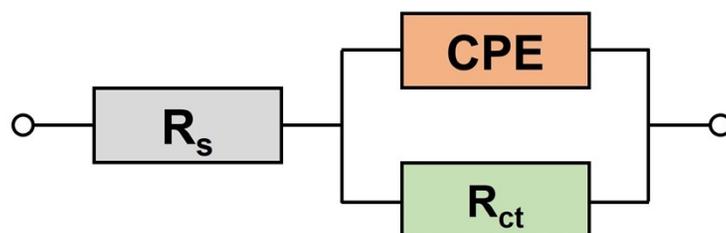


Fig. S1. Equivalent circuit used for EIS data analysis.

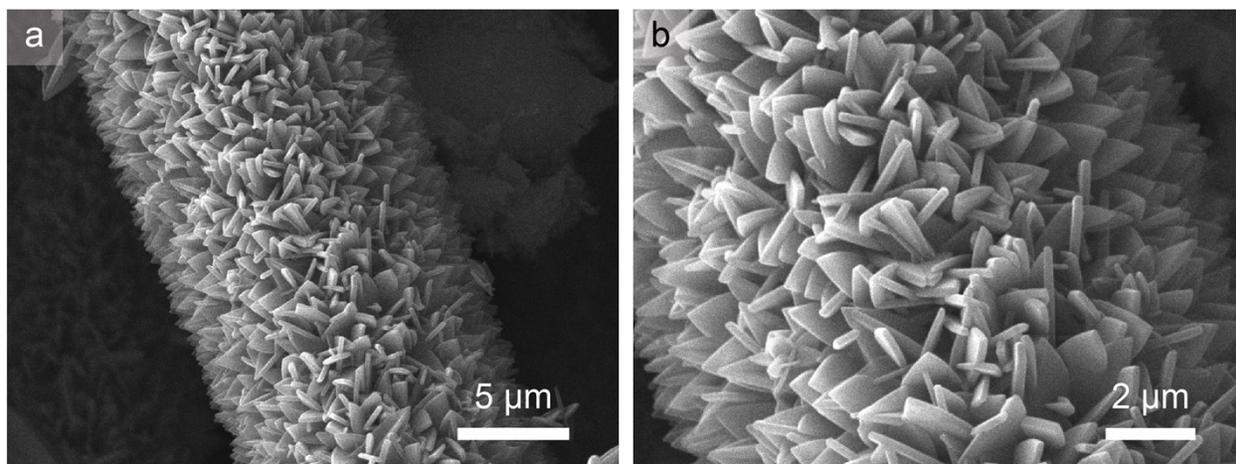


Fig. S2. (a, b) SEM of ZIF-67 on carbon cloth.

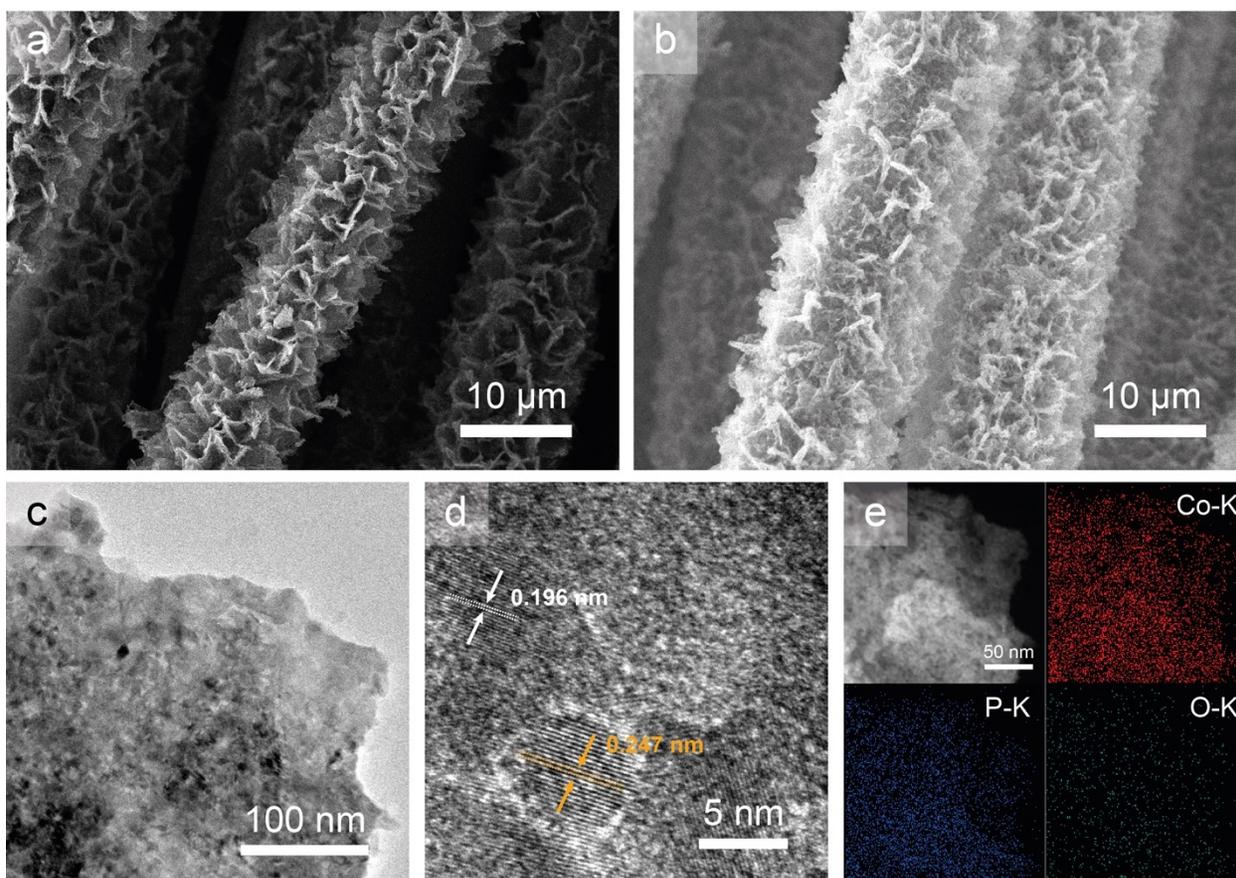


Fig. S3. SEM images of (a) Co(OH)_2 and (b) CoP on carbon cloth. (c) TEM and (d) HRTEM images of CoP . (e) The corresponding EDX mapping images of CoP showing Co, P, and O elements.

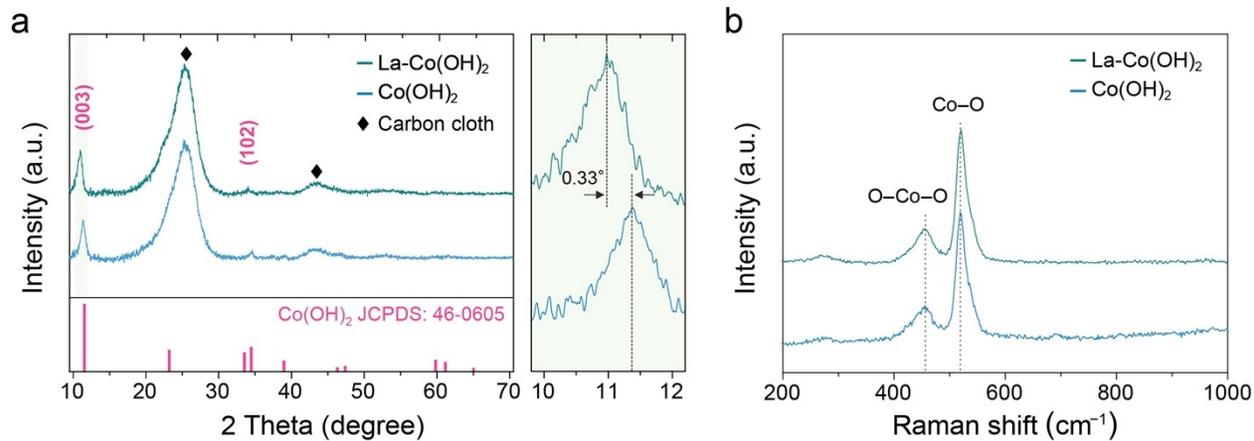


Fig. S4. (a) XRD patterns and (b) Raman spectra of Co(OH)₂ and La-Co(OH)₂ on carbon cloth. The right panel in (a) is the enlarged region between 10 and 12°.

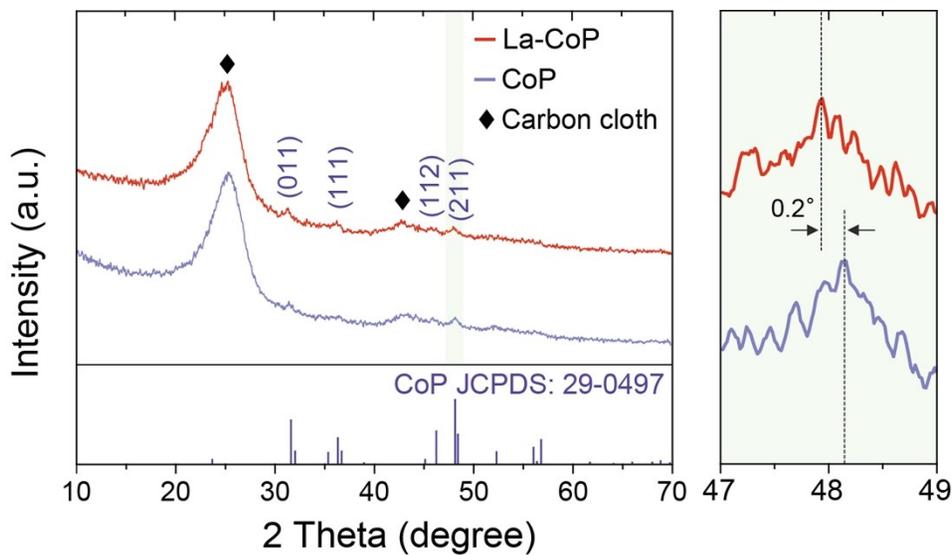


Fig. S5. XRD patterns of CoP and La-CoP on carbon cloth. The right panel is the enlarged region between 47 and 49°.

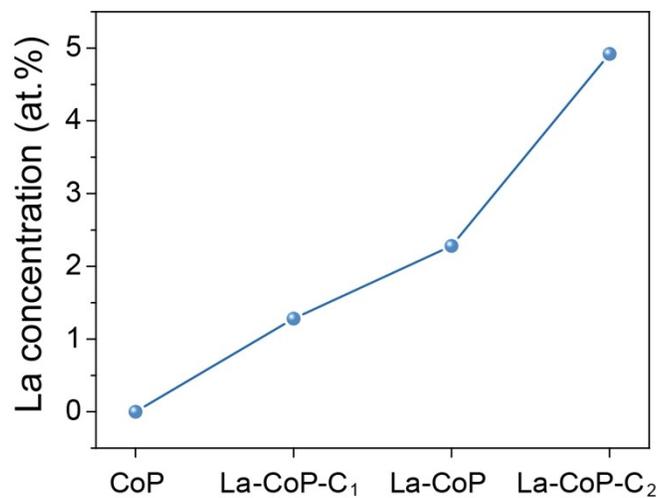


Fig S6. La-doping levels in a series of La-doped CoP.

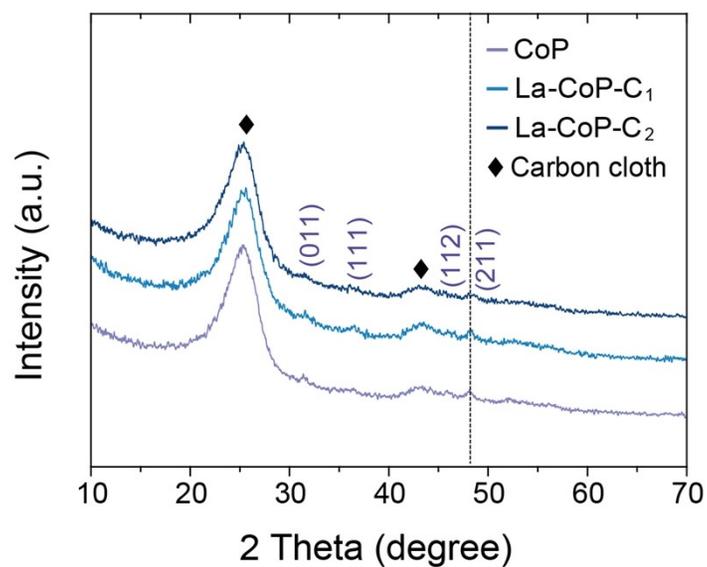


Fig. S7. XRD patterns of CoP, La-CoP-C₁, and La-CoP-C₂ on carbon cloth.

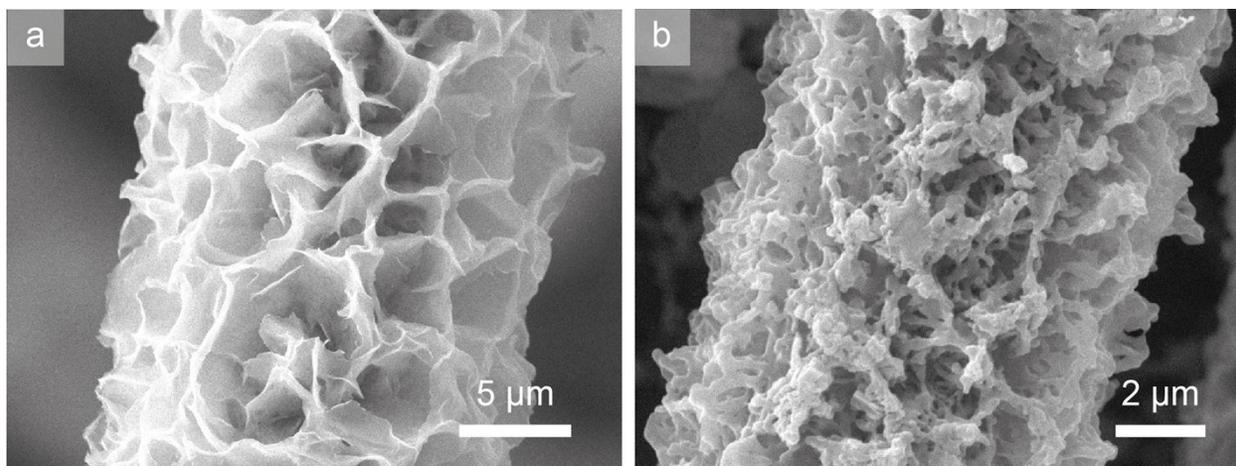


Fig. S8. SEM images of (a) La-CoP-C₁ and (b) La-CoP-C₂.

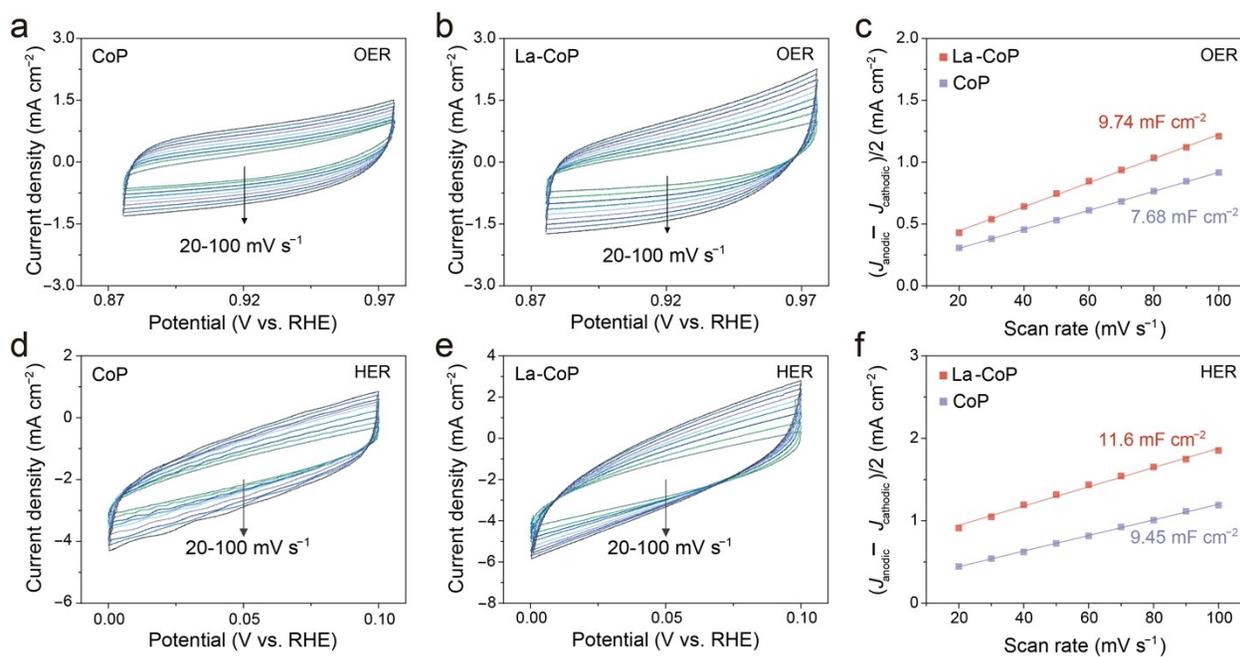


Fig. S9. CV curves of (a, d) CoP and (b, e) La-CoP obtained at various scan rates. C_{dl} measurements of CoP and La-CoP under (c) OER and (f) HER conditions.

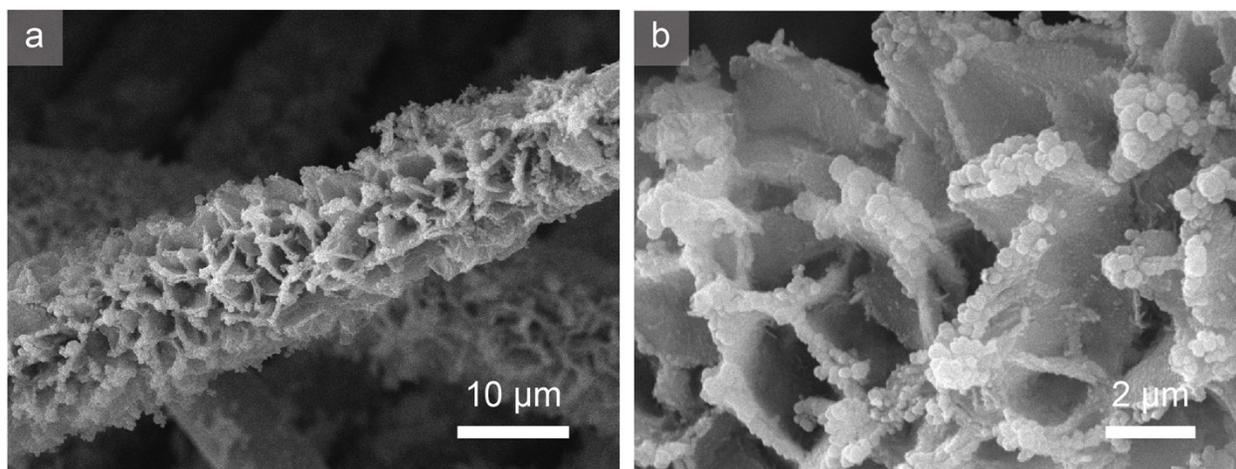


Fig. S10. (a, b) SEM images of La-CoP on carbon cloth after OER test.

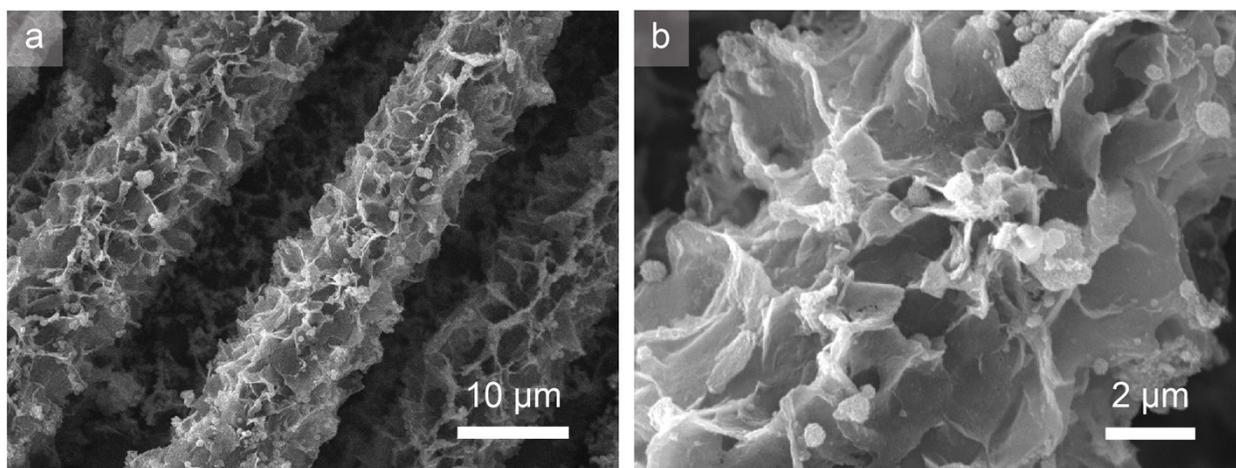


Fig. S11. (a, b) SEM images of La-CoP on carbon cloth after HER test.

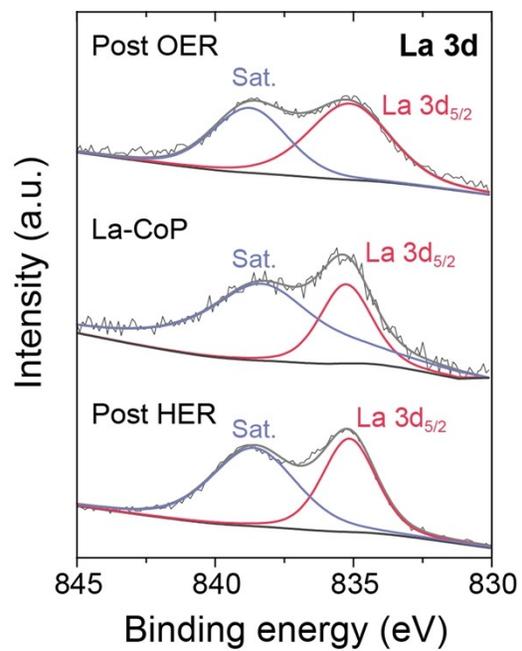


Fig. S12. High-resolution XPS spectra of La-CoP in La 3d region after OER (top) and HER (bottom).

Table S1. ICP-OES analysis results of CoP and La-doped CoP samples.

Samples	Atomic ratio		
	Co	P	La
CoP	1	1.26	-
La-CoP	1	1.44	0.06
La-CoP-C ₁	1	1.43	0.03
La-CoP-C ₂	1	1.48	0.13

Table S2. Summary of loading masses of the as-prepared catalysts on carbon cloth.

Sample	Loading mass (mg cm⁻²)
CoP	4.21
La-CoP-C ₁	4.48
La-CoP	4.88
La-CoP-C ₂	5.27

Table S3. Comparison of OER performances of La-CoP with recently reported electrocatalysts in alkaline solution.

Catalyst	Support	Overpotential (mV) at 10 mA cm ⁻²	Tafel slope (mV dec ⁻¹)	Ref.
P@pCoPc-1/Co ₃ O ₄	CC ^a	320	57.4	1
Co-LDH@ZIF-67	CC	187	59	2
Co-P@IC/(Co-Fe)P	CC	174	18	3
Cr-CoP	CP ^b	251	47	4
20% Rh-doped CoFe-ZLDH	NF ^c	245 ^e	42.8	5
CoP-InNC@CNT	CC	270	84	6
Er-doped CoP	CC	256	70	7
Co@N-CS/N-HCP	CC	248	68	8
NDCHN	GCE ^d	270	63.9	9
Ni-Co-P HNBS	NF	270	76	10
CoP/NCNHP	GCE	310	70	11
CoPO	GCE	280	59	12
Mo-CoOOH	CC	305	56	13
NiCoP@Cu ₃ P	CF	309	42	14
Co/CoP	GCE	340	79.5	15
NiCoP/C	GCE	330	96	16
CoTe ₂ @NCNTFs	NF	330	83	17
Co/β-Mo ₂ C@N-CNTs	GCE	356	67	18
CoV-UAH	NF	250	44	19
P/MoCo ₃ O ₄	CC	265	59.4	20
La-CoP	CC	270	67.4	This work

^a CC: carbon cloth, ^b CP: carbon paper, ^c NF: nickel foam, ^d GCE: glassy carbon electrode, and ^e Measured at 100 mA cm⁻².

Table S4. Summary of EIS parameters of the catalysts obtained during the OER process.

Sample	R_s (Ω)	CPE	R_{ct} (Ω)
CoP	4.754	0.0909	12.9
La-CoP-C ₁	3.928	0.0730	8.74
La-CoP	3.253	0.227	3.95
La-CoP-C ₂	3.399	0.144	5.02
RuO ₂	4.097	0.0033	12.8

Table S5. Comparison of HER performances of La-CoP with recently reported electrocatalysts in alkaline solution.

Catalyst	Support	Overpotential (mV) at 10 mA cm ⁻²	Tafel slope (mV dec ⁻¹)	Ref.
P@pCoPc-1/Co ₃ O ₄	CC ^a	120	98.4	1
Co-P@IC/(Co-Fe)P	CC	53	88	3
Cr-CoP	CP ^b	67	31	4
20% Rh-doped CoFe-ZLDH	NF ^c	28	42.8	5
CoP-InNC@CNT	CC	159	56	6
Er-doped CoP	CC	66	61	7
Co@N-CS/N-HCP	CC	66	65	8
NDCHN	GP ^d	201	133.2	9
Ni-Co-P HNBS	NF	107	46	10
CoP/NCNHP	GCE ^e	115	66	11
CoPO	GCE	158	101	12
Mo-CoP	CC	40	65	13
NiCoP@Cu ₃ P	CF	54	72	14
Co/CoP	GCE	253	73.8	15
CoTe ₂ @NCNTFs	NF	208	58	17
Co/β-Mo ₂ C@N-CNTs	GCE	170	92	18
Cr-doped FeNi-P/NCN	NF	190	68.51	21
CoNiP-0.25	GCE	145.8	52	22
FeCo	GCE	149	77	23
La-CoP	CC	109	64.3	This work

^a CC: carbon cloth, ^b CP: carbon paper, ^c NF: nickel foam, ^d GP: graphite paper, ^e GCE: glassy carbon electrode.

Table S6. Summary of EIS parameters of the catalysts obtained during the HER process.

Sample	R_s (Ω)	CPE	R_{ct} (Ω)
CoP	3.96	0.0048	22.3
La-CoP-C ₁	3.231	0.0068	11.8
La-CoP	4.002	0.0079	4.04
La-CoP-C ₂	3.276	0.0089	6.04
Pt/C	3.678	0.0005	2.28

Table S7. Comparison of cell potentials at 10 mA cm⁻² of La-CoP and recently reported analogous catalysts for overall water splitting catalysis.

Catalyst	Support	Overpotential (V)	Ref.
P@pCoPc-1/Co ₃ O ₄	CC ^a	1.672	1
Co-P@IC/(Co-Fe)P	CC	1.46	3
Cr-CoP	CP ^b	1.59	4
20% Rh-doped CoFe-ZLDH	NF ^c	1.46	5
CoP-InNC@CNT	CC	1.58	6
Er-doped CoP	CC	1.58	7
Co@N-CS/N-HCP	CC	1.545	8
NDCHN	GP ^d	1.701	9
Ni-Co-P HNBS	NF	1.62	10
CoP/NCNHP	GCE ^e	1.64	11
CoPO	GCE	1.67	12
CoTe ₂ @NCNTFs	NF	1.67	17
Co/β-Mo ₂ C@N-CNTs	GCE	1.64	18
La-CoP	CC	1.068	This work

^a CC: carbon cloth, ^b CP: carbon paper, ^c NF: nickel foam, ^d GP: graphite paper, ^e GCE: glassy carbon electrode. All electrochemical tests were conducted in 1.0 M KOH

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