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Supporting Information

Engineering the coupling interface of rhombic dodecahedral NiCoP/C@FeOOH nanocages toward advanced water oxidation

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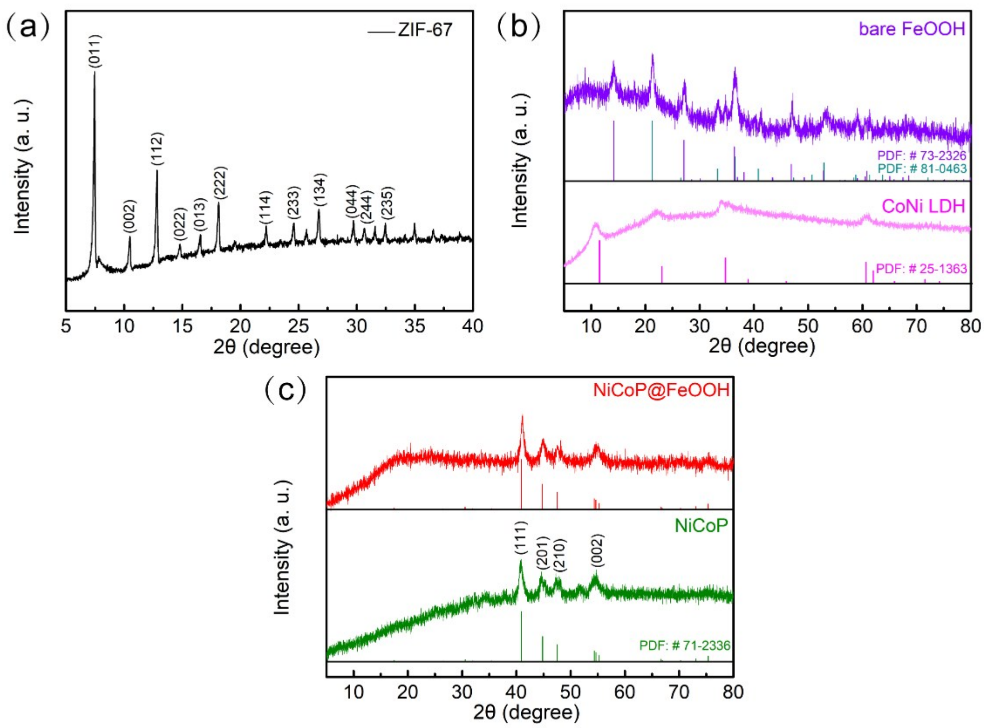


Fig. S1 XRD patterns of ZIF-67 (a), CoNi LDH/C and bare FeOOH (b), NiCoP/C and NiCoP/C@FeOOH (c).

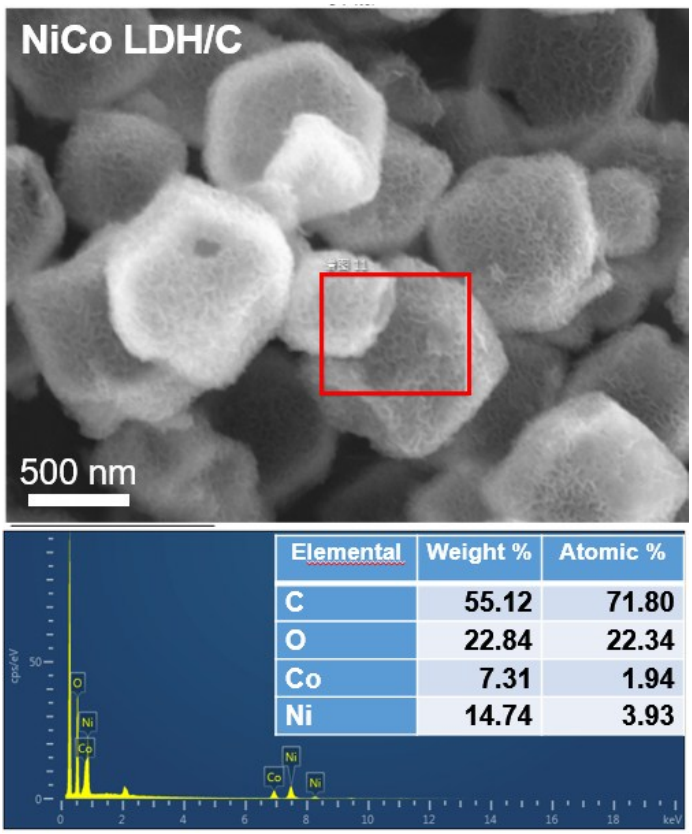
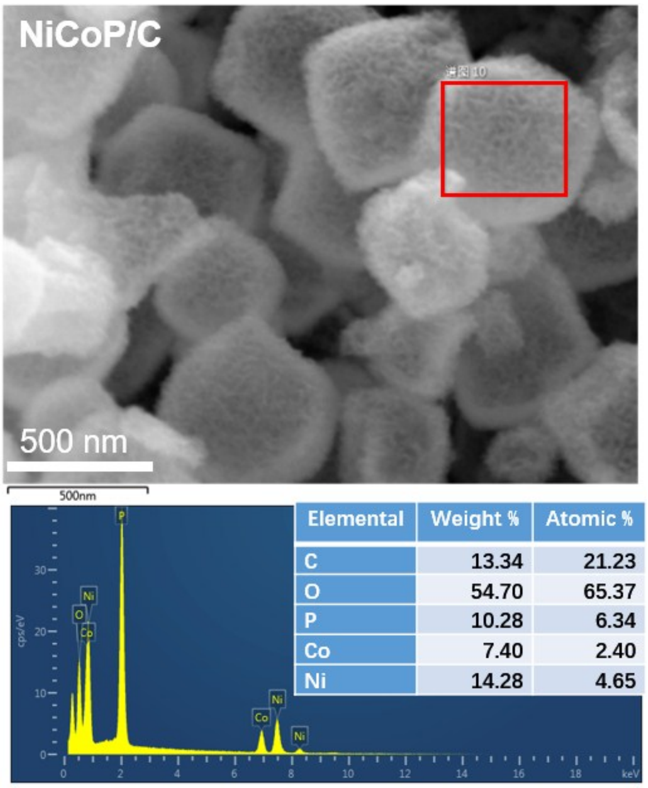


Fig. S2 SEM image of CoNi LDH/C and the corresponding EDS and elements analysis of the selected area.



Elemental	Weight %	Atomic %
C	13.34	21.23
O	54.70	65.37
P	10.28	6.34
Co	7.40	2.40
Ni	14.28	4.65

Fig. S3 SEM image of NiCoP/C and the corresponding EDS and elements analysis of the selected area.

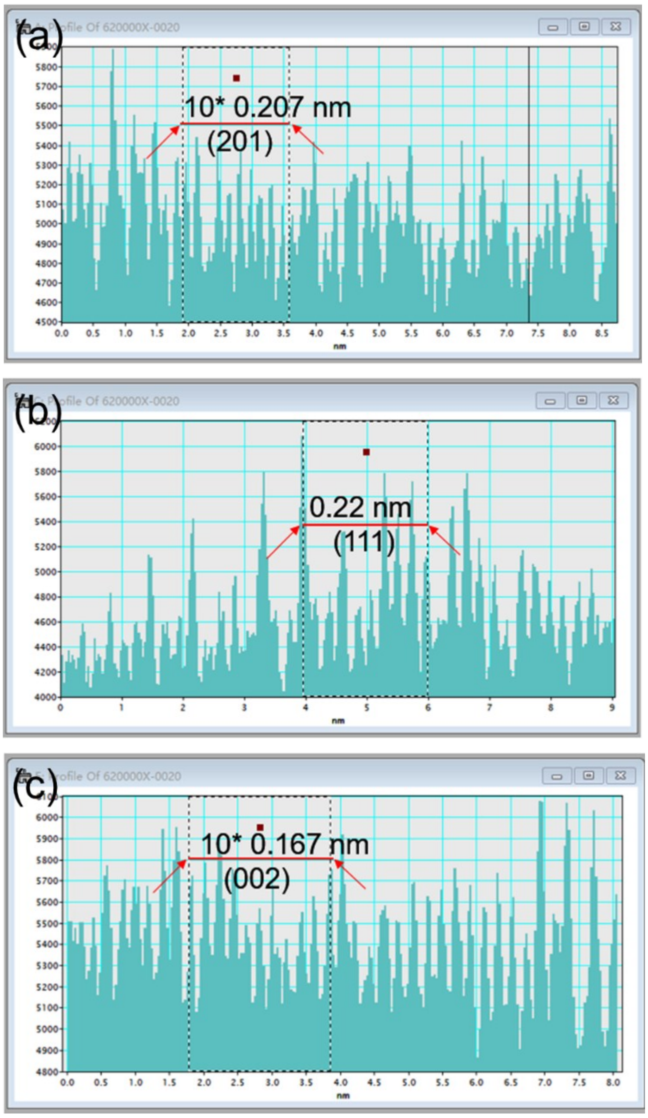
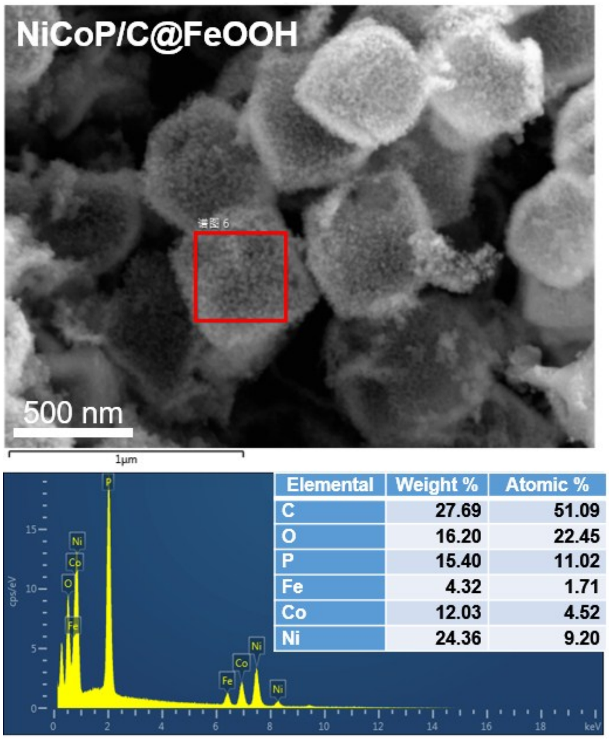


Fig. S4 Line profiles of NiCoP/C collected from the HRTEM image.



Elemental	Weight %	Atomic %
C	27.69	51.09
O	16.20	22.45
P	15.40	11.02
Fe	4.32	1.71
Co	12.03	4.52
Ni	24.36	9.20

Fig. S5 SEM image of NiCoP/C@FeOOH and the corresponding EDS and elements analysis of the selected area.

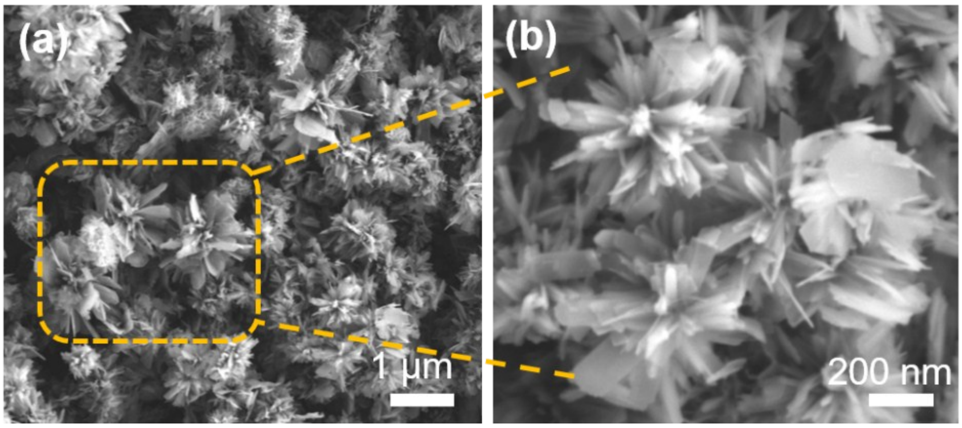


Fig. S6 SEM images of bare FeOOH with different magnifications.

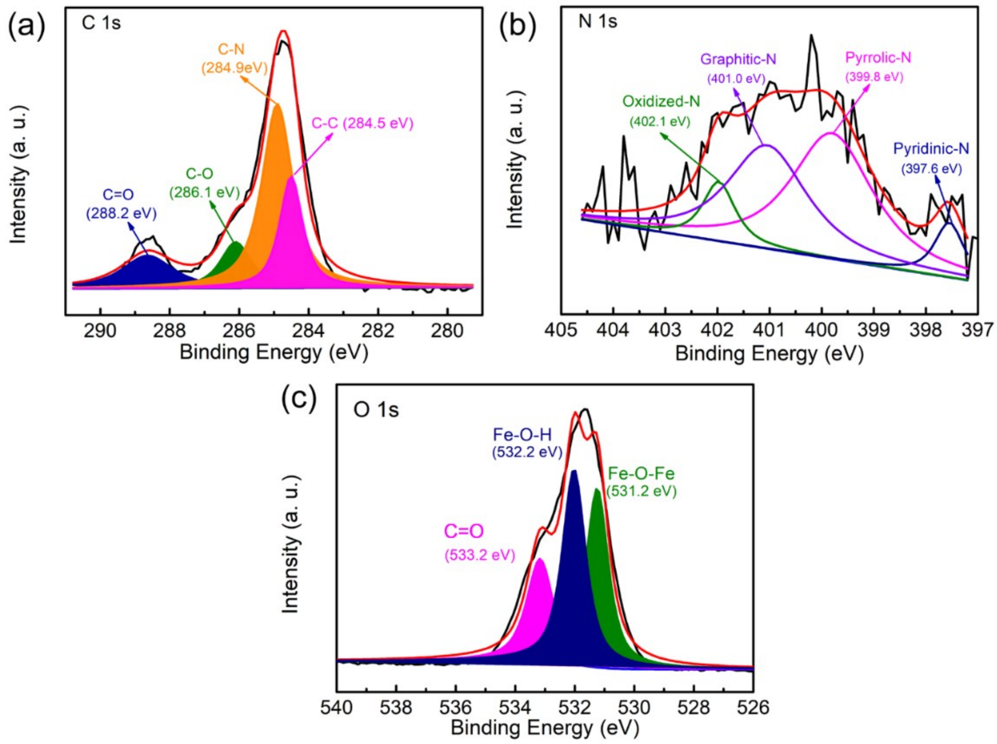


Fig. S7 XPS spectra of NiCoP/C@FeOOH: (a) C 1s, (b) N 1s and (c) O 1s.

In Fig. S7(a), after carefully deconvolution and fitting, four peaks were split, namely 284.6 (C-C/C=C), 285.6 (C=N), 286.3 (C-O/C-N) and 289.2 (O-C=O) eV, confirming that the carbon framework was in-situ nitrogen-doped.[5, 6] More evidences were provided in Fig. S7(b)—N 1s core-level spectrum, in which four peaks were split, which were located at 397.6, 398.8, 401.1 and 402.1 eV, being associated to pyridinc-N, pyrrolic-N, graphitic-N and oxidized-N, respectively. This nitrogen signals unanimously validate the nitrogen doping of carbon framework.[7] Fig. S7(c) shows the XPS spectra of O 1s of the NiCoP/C@FeOOH, in which the peaks C=O (533.2 eV), Fe-O-H (532.2 eV) and Fe-O-Fe (531.2 eV) were deconvoluted.[3, 4, 8]

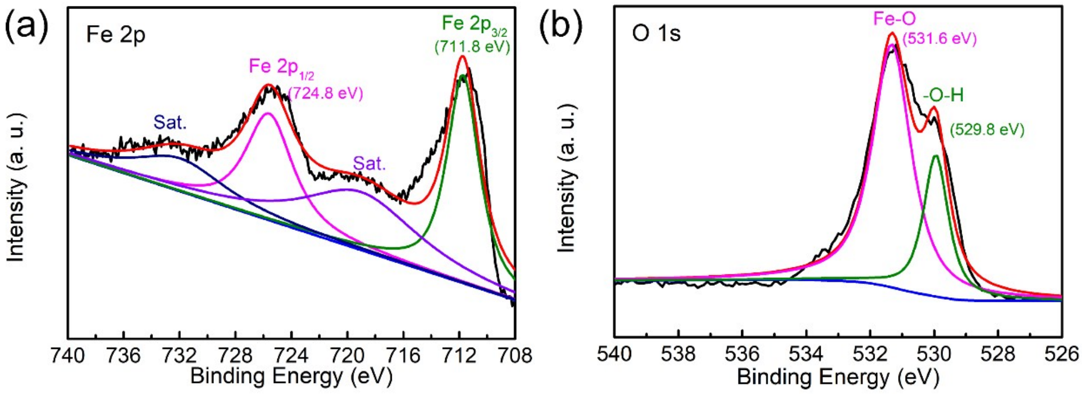


Fig. S8 XPS spectra of Fe 2p (a) and O 1s (b) of FeOOH.

The XPS spectra of Fe 2p are shown in Fig. S8(a). The peaks of Fe $2p_{1/2}$ and Fe $2p_{3/2}$ locating at 724.8 and 711.7 eV confirm that Fe element is mainly of Fe(III).[1, 2] The two satellite peaks at 733.59 and 719.39 eV further prove the +3 oxidation state of Fe.[3, 4] The XPS spectra of O 1s can be deconvoluted into two peaks at 529.8 and 531.6 eV (Fig. S8(b)), suggesting being associated to Fe-O-Fe and Fe-O-H units in this case, respectively, which are in agreement with FeOOH.[3]

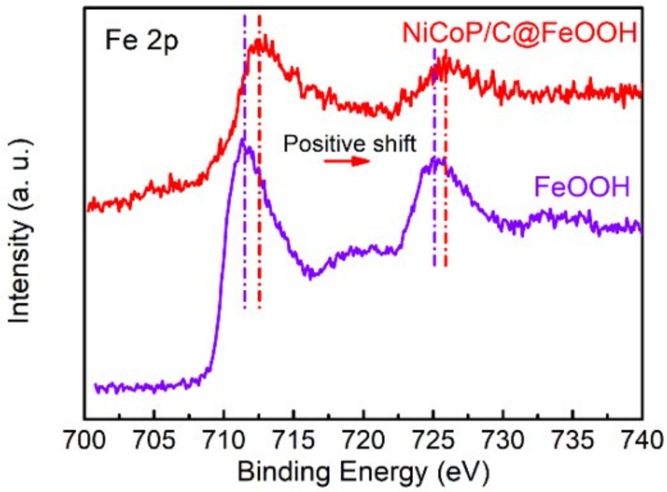


Fig. S9 The Fe 2p XPS spectra comparison of FeOOH and NiCoP/C@FeOOH.

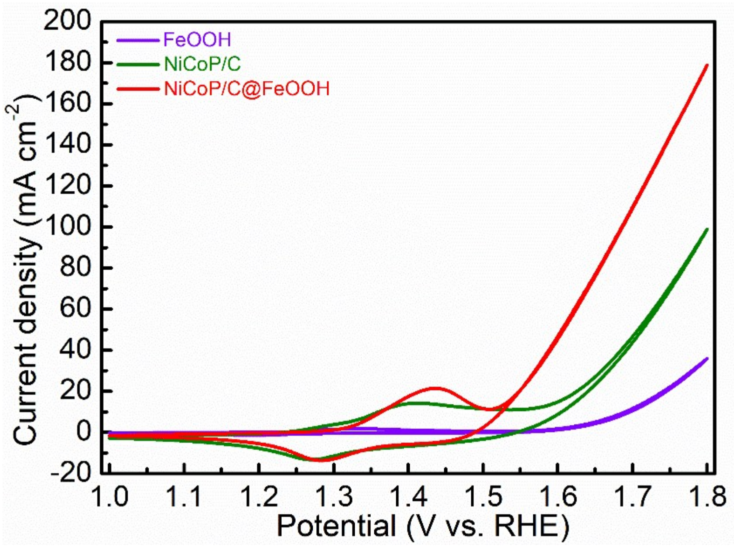


Fig. S10 CV curves of FeOOH, NiCoP/C and NiCoP/C@FeOOH.

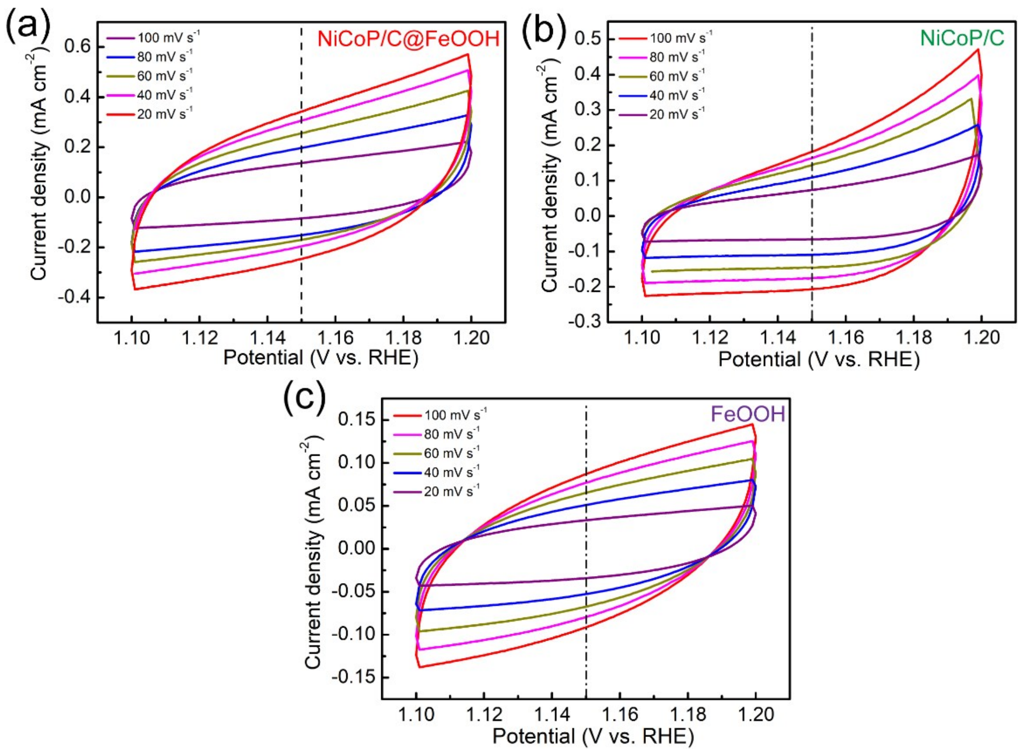


Fig. S11 CV curves of (a) NiCoP/C@FeOOH, (b) NiCoP/C and (c) FeOOH with different scan rate.

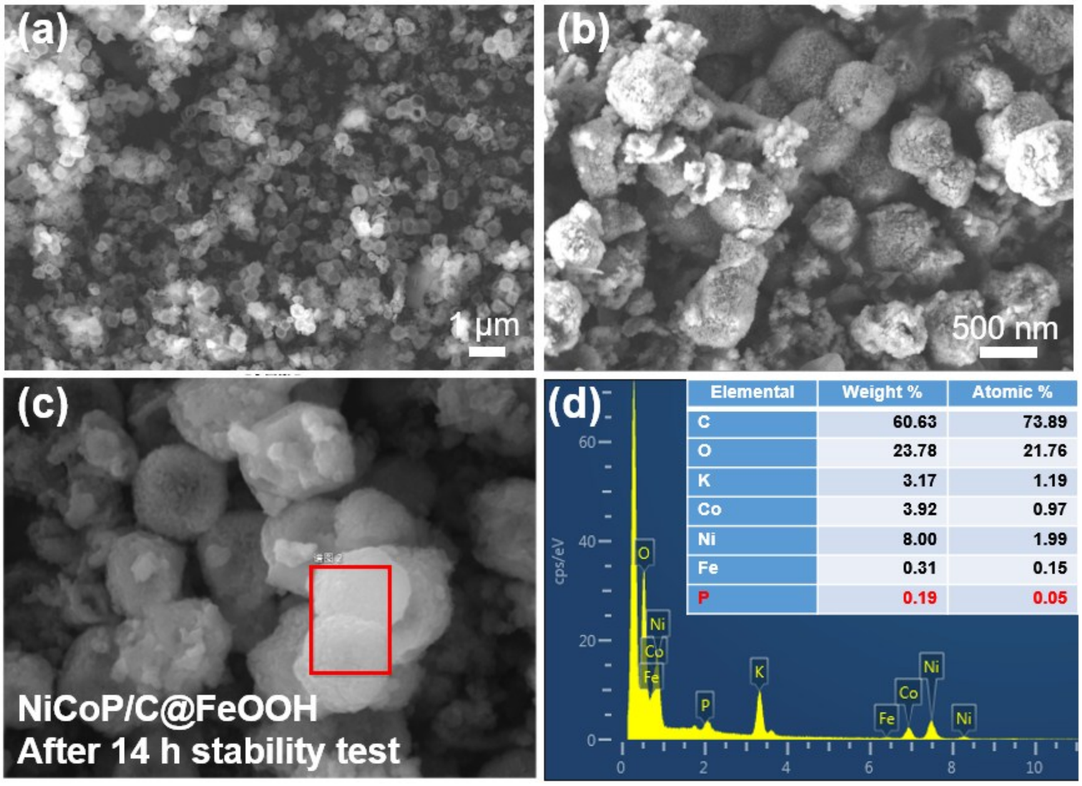


Fig. S12 SEM images of NiCoP/C@FeOOH with different magnifications which after 14 h stability test (a, b, c) and the corresponding EDS and elements analysis of the selected area (d).

Table S1. OER performance for some very recent reported 3d transition-metal based catalysts

Catalysts (substrate)	Overpotential (mV)	Current density (mAm cm^{-2})	electrolyte	Ref.
NiCoP@FeOOH Nanocages (GC)	271 321	10 50	1.0 M KOH	This work
Nest-like NiCoP (CC)	290	10	1.0 M KOH	9
NiCoP nanocone (NF)	370	10	1.0 M KOH	10
NiCoP nanoparticles (ITO)	320	10	1.0 M KOH	11
NiCoP nanosheets Array (NF)	300	50	1.0 M KOH	12
FeOOH/Co/FeOOH Nanotubes (NF)	265	50	1.0 M NaOH	4
Crystalized α-FeOOH (FTO)	500	10	1.0 M KOH	13
CNTs@FeOOH Nanoflake (CC)	250	10	1.0 M KOH	14
NiCo/NiCoOx with FeOOH (NF)	278	10	1.0 M KOH	15
$FeOOH/CeO_2$ Nanotubes (NF)	250	20	1.0 M KOH	3
Porous Ni-Fe selenide Nanosheets (CC)	255	35	1.0 M KOH	16
NiCoP/C nanoboxes (CC)	330	10	1.0 M KOH	17
$(Co_{0.54}Fe_{0.46})_2P$ (CC)	370	10	0.1 M KOH	18
Janus $Ni_{0.1}Co_{0.9}P$ (CC)	570	5	1.0 M PBS	19

Notes: Substrates NF: nickel foam; GC: glassy carbon electrode; CC: carbon cloth.

FTO: conducting glass (F: SnO_2, FTO).

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