Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Supporting Information

Hierarchical Porous NiFe-P@NC as Efficient Electrocatalyst for Alkaline Hydrogen Production and Seawater Electrolysis at Large-Current-density

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Experimental Section

1. Sample preparation

Firstly, 2-Aminoterephthalic Acid (5 mmol/L) and NaCl (50 mmol/L) were added to 30 ml of deionized water and stirred well. prepared ferric nickel foam was added to the mixture and stirred at room temperature for 12 h. The resulting ferric nickel foam was rinsed three times with deionized water and dried in a vacuum drying oven for 3 hours. Then 500 mg of sodium hypophosphite monohydrate was placed upstream of the tube furnace and the treated ferric nickel foam was placed downstream of the tube furnace. NiFe-P@NC was obtained on the nickel foam iron by holding it at 350°C for 2 h under Ar atmosphere at a heating rate of 5°C/min.

2. Physical Characterization

Morphological and dimensional analysis of the prepared catalysts was performed by field emission scanning electron microscopy (SEM, S-4800, Hitachi) and transmission electron microscopy (TEM, Tecnai G2-F20). X-ray photoelectron spectroscopy (XPS) analysis was performed on a Phi X-tool XPS spectrometer, and X-ray diffraction (XRD) patterns were obtained with an XRD, Bruker D8-Advance diffractometer. Infrared spectroscopy was carried out using a Nicolet 170SX spectrometer.

3. Electrochemical Measurements

All tests were carried out at room temperature using an electrochemical workstation CHI 760D, Gamry Reference 3000) through a typical three-electrode system. Reversible hydrogen (RHE) was used as the reference electrode, graphite carbon rods as the counter electrode and a synthetic catalyst as the working electrode. Linear scanning voltammetry (LSV) was obtained at a scan rate of 5 mV s^{-1} and 95% IR correction.

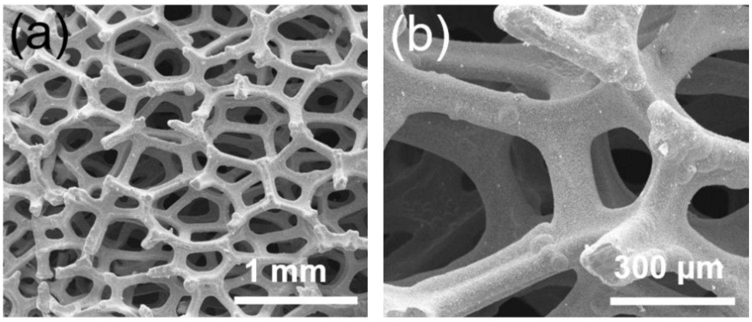

Figure S1 SEM images of NIF (a, b).

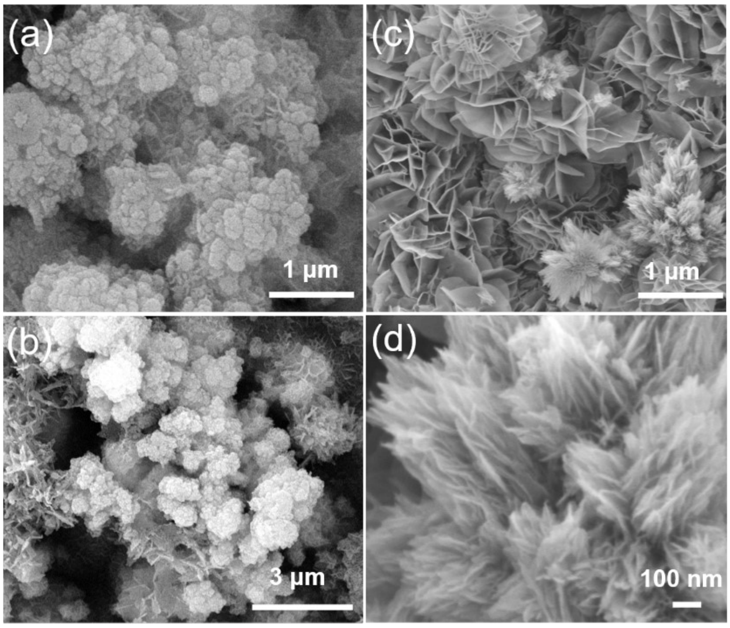

Figure S2 TEM images of (a, b) NiFe LDH, (c, d) NiFe MOF.

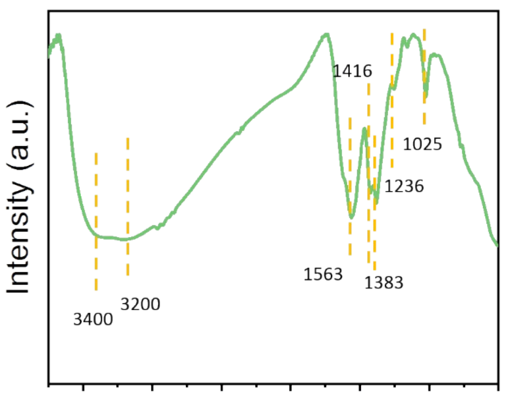

Figure S3 IR spectrum of prepared NiFe MOF.

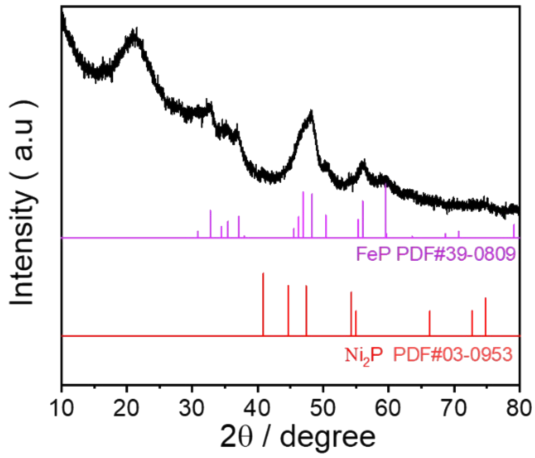

Figure S4 XRD patterns of NiFe-P@NC.

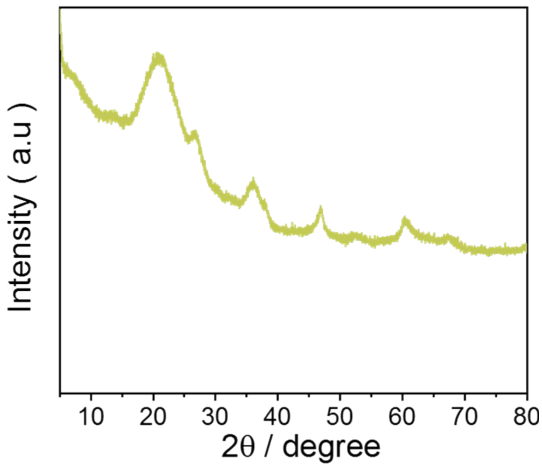

Figure S5 XRD patterns of NiFe MOF.

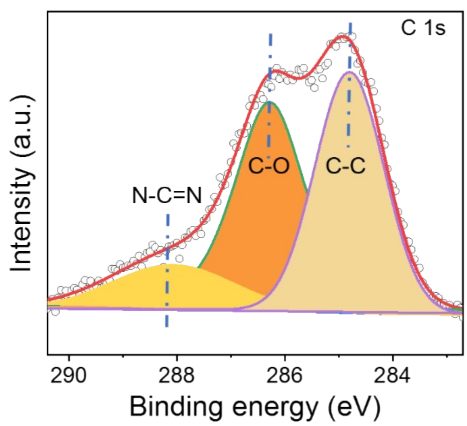

Figure S6 High-resolution XPS images of C 1s.

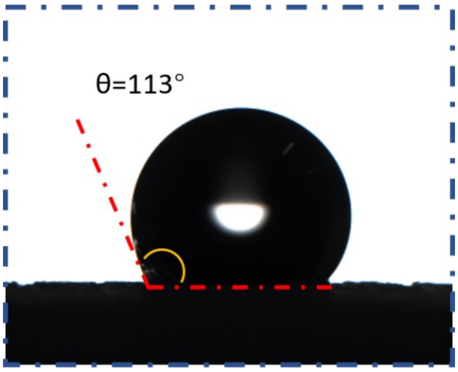

Figure S7 Contact angles of NIF.

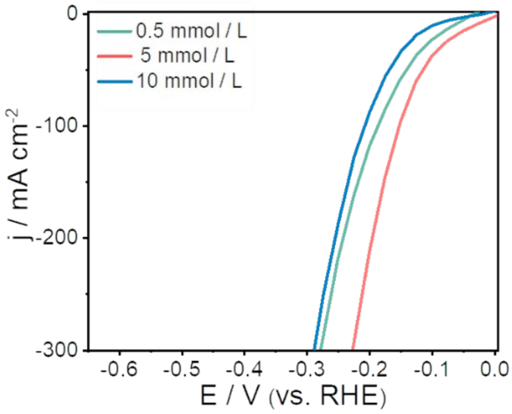

Figure S8 LSVs of NiFe-P@NC with various different contents of 2-Aminoterephthalic Acid.

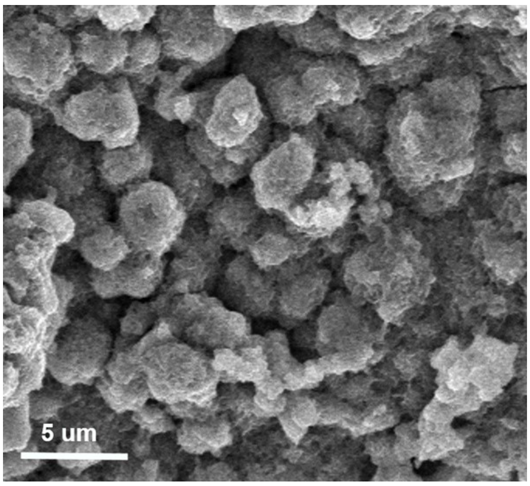

Figure S9 SEM images of NiFe-P@NC afters stability test.

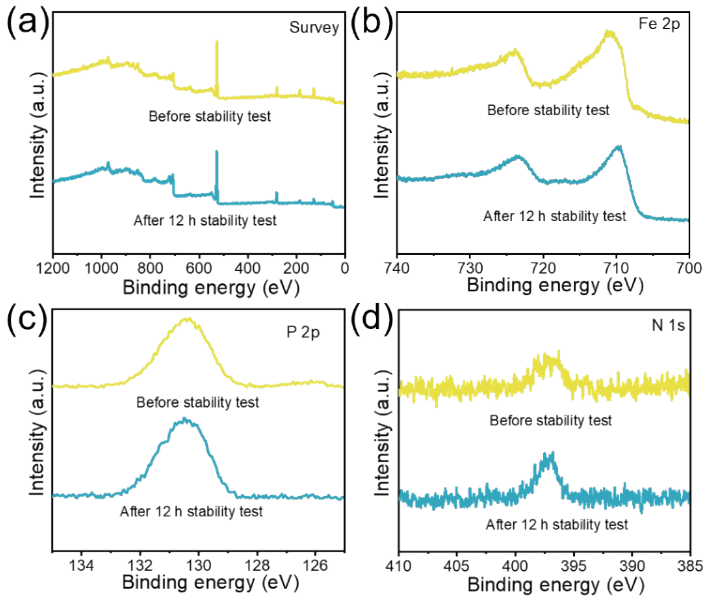

Figure S10 XPS patterns of NiFe-P@NC before and after stability testing. (a) Full range XPS pattern, High-resolution XPS images of (b) Fe 2p, (c) P 2p, (d) N 1s.

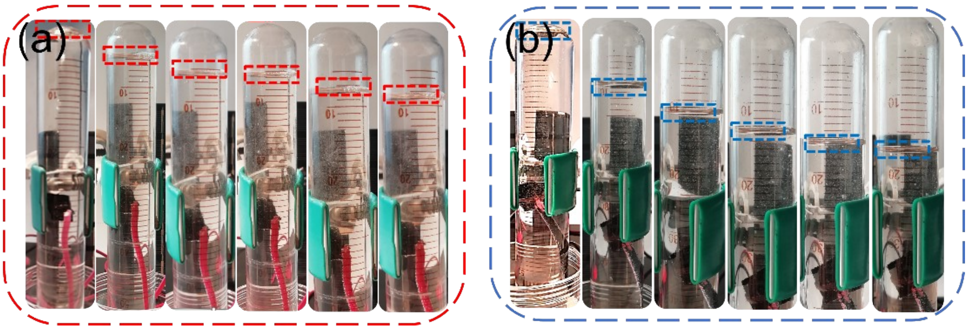

Figure S11 Photographs of (a) oxygen and (b) hydrogen collected at different times.

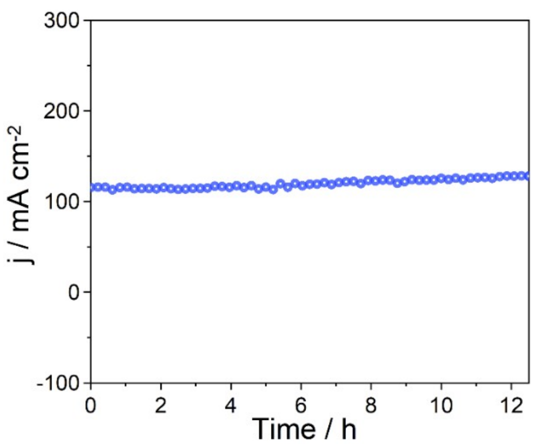

Figure S12 Stability test of NiFe-P@NC in 1 M KOH + 0.5 M NaCl.

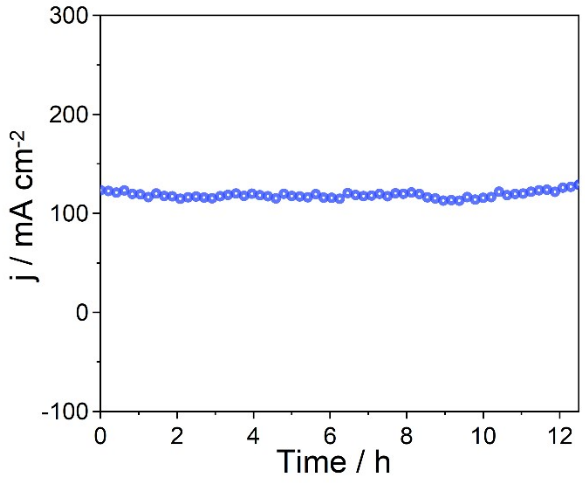

Figure S13 Stability test of NiFe-P@NC in 1 M KOH + 1 M NaCl.

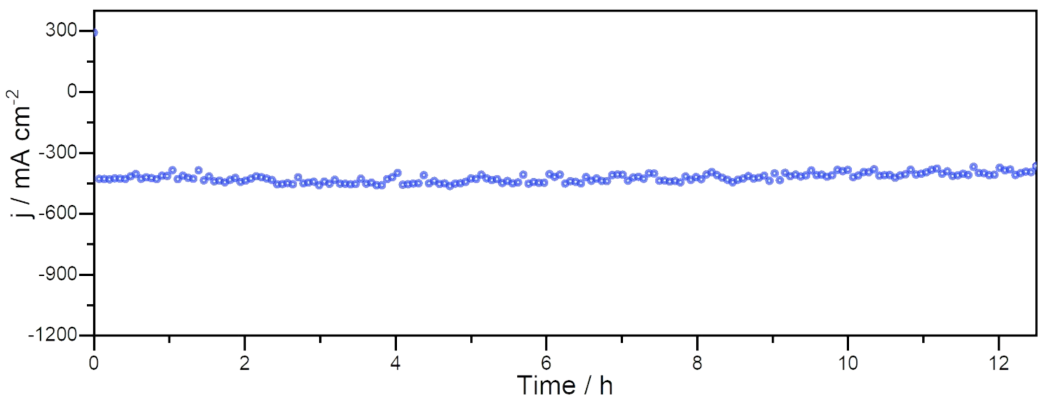

Figure S14 Stability test of NiFe-P@NC in 1 M KOH + Seawater.

Table S1. Comparison of the HER activity of the NiFe-P@NC with other previously reported electrocatalysts under 1 M KOH

Catalysts	Electrolyte	η_{10} / mV	Tafel slope / mV dec^{-1}	Ref.
$Ni_{0.85}Se$-$MoSe_2$ interfacial structure	1 M KOH	108	77	[1]
Co_9S_8@MoS_2 heterostructure	1 M KOH	177	83.6	[2]
R-MoS_2@NF	1 M KOH	71	100	[3]
CoP NS/C	1 M KOH	111	70.9	[4]
Ni, Zn dualdoped CoO NRs	1 M KOH	53	79	[5]
CoFeP	1 M KOH	78	94	[6]
$Ni(OH)_2$-Fe_2P/TM	1 M KOH	76	105	[7]
NHPBAP	1 M KOH	121	67	[8]
CoFe-PBANS@NF-24	1 M KOH	48	66	[9]
$CoSe_2$/$MoSe_2$	1 M KOH	218	76	[10]
CoP/NCNHP	1 M KOH	115	66	[11]
CoFe PBA@CoP/NF	1 M KOH	171	75.7	[12]
NiCoFeP/C	1 M KOH	149	89	[13]
CoFeP/CNT	1 M KOH	178	71	[14]
NCP/G NSs	1 M KOH	119	62.3	[15]
P-S-24	1 M KOH	61	52	[16]
Ni_2P/Ni/NF	1 M KOH	98	72	[17]
Ni/Ni_2P	1 M KOH	73	76	[18]
NiFe-P@C	**1 M KOH**	40	58	**This Work**

Table S2. Comparison of some recently reported representative electrocatalysts for overall water splitting under1 M KOH.

Catalysts	Electrolyte	η_{10} / V	Ref.
CoP-InNC@CNT/CC ||CoP-InNC@CNT/CC	1 M KOH	1.57	[19]
$FeOOH/Ni_3N$|| $FeOOH/Ni_3N$	1 M KOH	1.58	[20]
NCS/NSrGO|| NCS/NS-rGO	1 M KOH	1.58	[21]
NiCoP/SCW|| NiCoP/SCW	1 M KOH	1.59	[22]
NiCoP/NF|| NiCoP/NF	1 M KOH	1.58	[23]
NiCo-PBA/NF|| NiCo-PBA/NF	1 M KOH	1.49	[24]
S:CoP@NF || S:CoP@NF	1 M KOH	1.61	[25]
$NiCo_2S_4$/NF|| $NiCo_2S_4$/NF	1 M KOH	1.61	[26]
CoP/NCNHP || CoP/NCNHP	1 M KOH	1.64	[11]
Co_2P/Co-Foil || Co_2P/Co-Foil	1 M KOH	1.71	[27]
CP/CTs/Co-S || CP/CTs/Co-S	1 M KOH	1.743	[28]
NiFe-P@C || NiFe LDH	**1 M KOH**	**1.57**	**This work**

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