

Supporting Information

Mild and fast construction of Ni-based electrodes for industrial-grade water splitting

Zikang Lu^{#a}, Rikai Liang^{#a}, Yuqi Shao^a, Weiju Hao^{a}*

^a University of Shanghai for Science and Technology, Shanghai 200093, China

*Corresponding author.

E-mail addresses: wjhao@usst.edu.cn

[#] Equal to this work

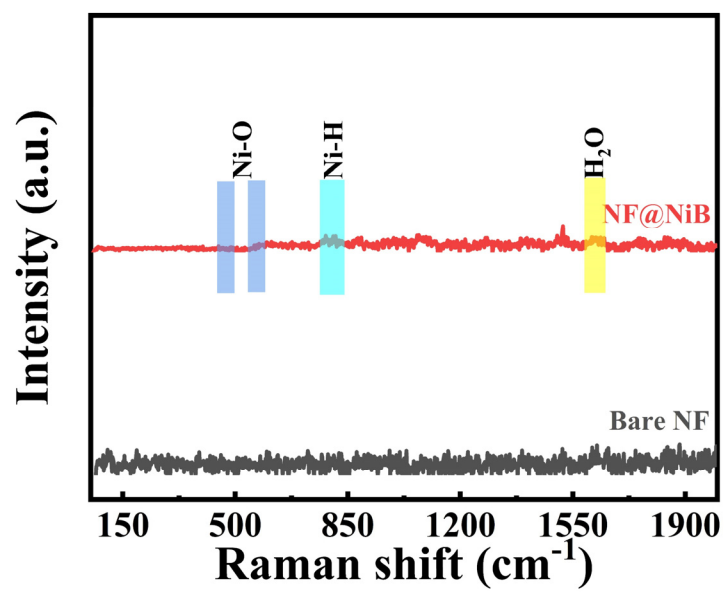


Figure S1. Raman spectrum of NF@NiB_x and Bare NF electrodes at 532 nm excitation.

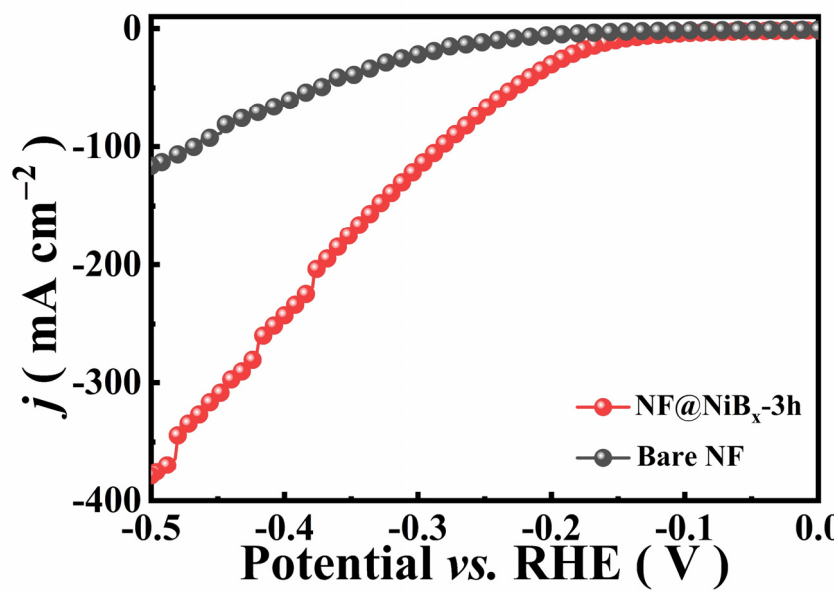


Figure S2. LSV curves of NF@NiB_x and Bare NF electrodes for HER in 1 M KOH solution.

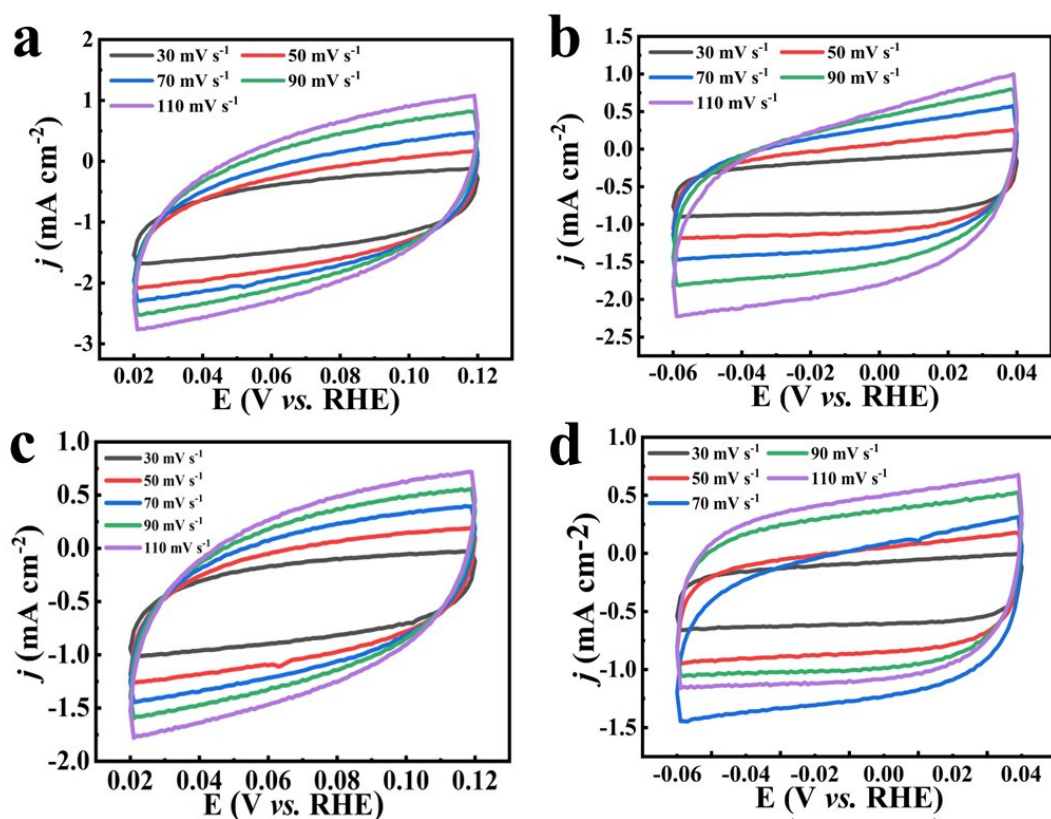


Figure S3. CV curves within a non-faradaic reaction region of 0.02 ~ 0.12 V (vs. RHE) at different scan rates toward HER for NF@NiB (a) and Bare NF (c); -0.06 ~ 0.04 V (vs. RHE) at different scan rates toward OER for NF@NiB (b) and Bare NF (d).

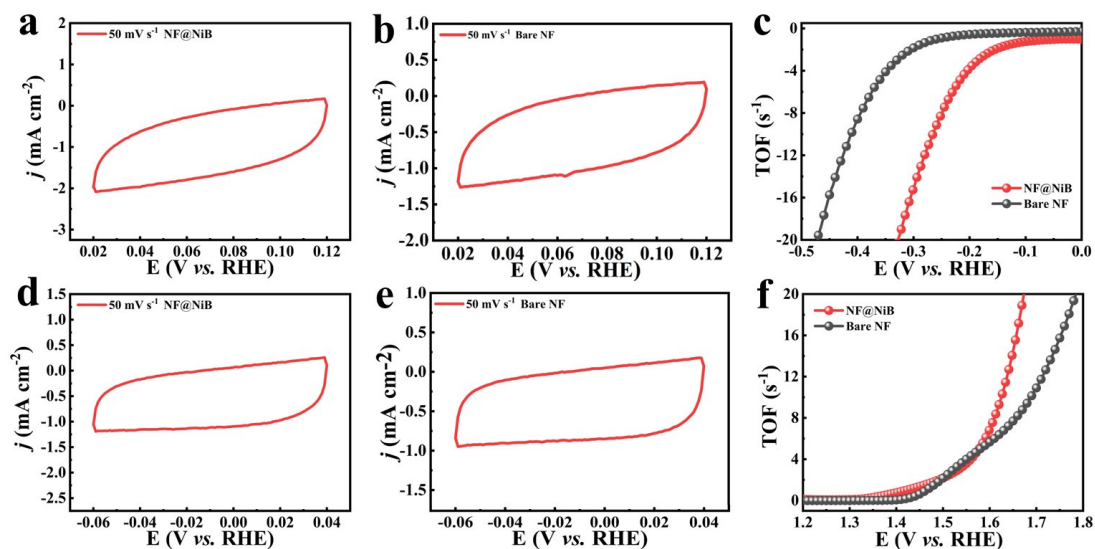


Figure S4. (a, b) CV curves of NF@NiB and Bare NF for HER in 1.0 M KOH + 0.5 M NaCl with a scan rate of 50 mV s⁻¹; (d, e) CV curves of NF@NiB and Bare NF for OER in 1.0 M KOH + 0.5 M NaCl with a scan rate of 50 mV s⁻¹; (c, f) The calculated TOFs curves for HER and OER.

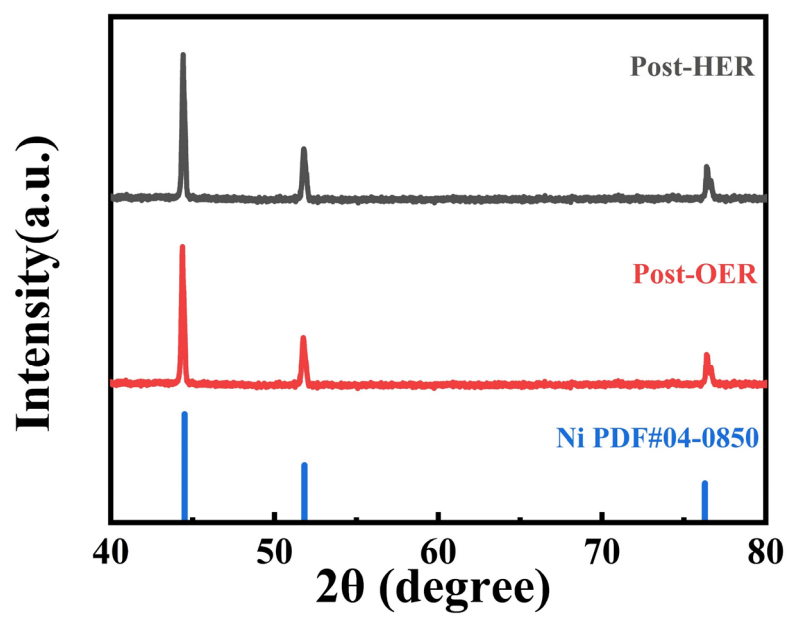


Figure S5. XRD spectra of NF@NiB_x after HER and OER stability measurements.

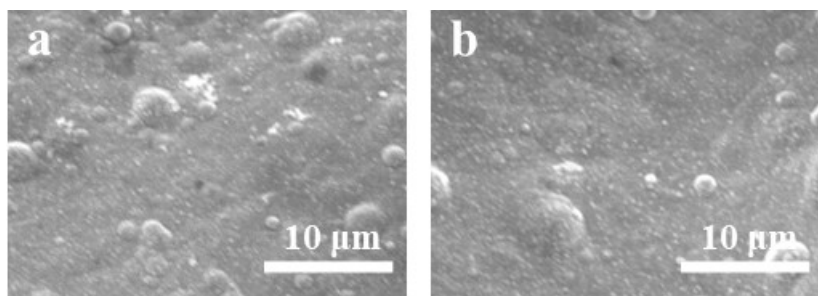


Figure S6. SEM images of NF@NiB after HER (a) and OER(b) stability tests.

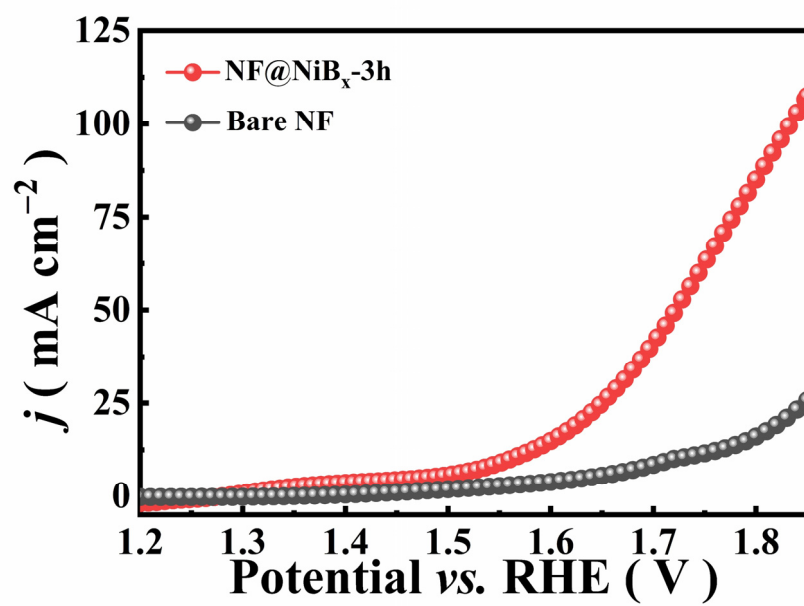


Figure S7. LSV curves of NF@NiB_x and Bare NF electrodes for OER in 1 M KOH solution.

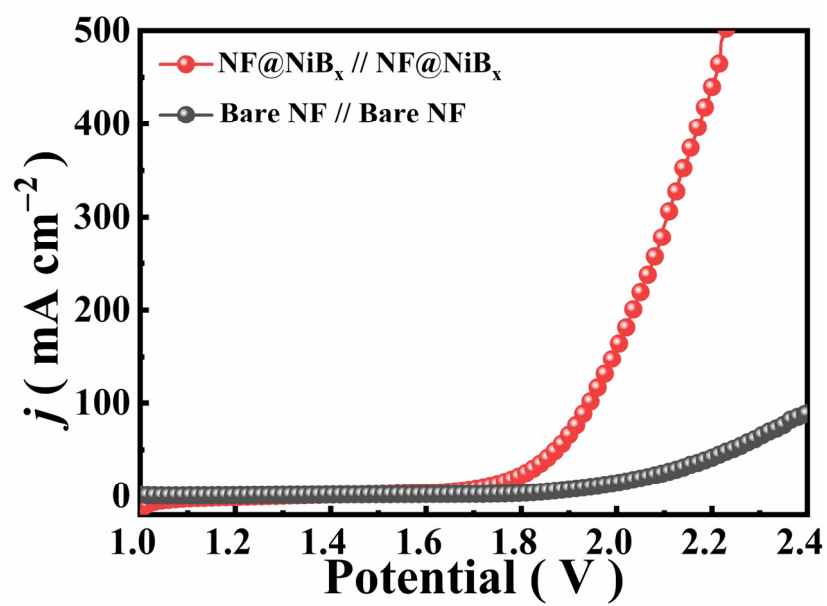


Figure S8. LSV curves of NF@NiB_x and Bare NF electrodes for OWS in 1 M KOH solution.

Table S1. Comparison of overall water splitting performance of NF@NiB electrode with state-of-the-art nickel and boron series catalysts under alkaline conditions.

Catalyst	System	Voltage ₁₀ (V)	References
NF@NiB	1.0 M KOH+ 0.5 M NaCl	1.637	This work
FeCoNiP@P-rGO	1.0 M KOH	1.77	[1]
Co/NBC	1.0 M KOH	1.68	[2]
V ₀ B-Co ₃ O ₄ /NF	1.0 M KOH	1.67	[3]
NiCo-LDH/NF	1.0 M KOH	1.66	[4]
CoFe10%-P/NF	1.0 M KOH	1.61	[5]
NiCoP/NF	1.0 M KOH	1.60	[6]
Co ₂ P-1/Ni ₂ P-1@NF	1.0 M KOH	1.63	[7]
Cu _{1-x} Ni _x S/NF	1.0 M KOH	1.64	[8]
Ni-Fe ₂ B@NF	1.0 M KOH	1.64	[9]
CoFe-LDH/NCO/NF-1	1.0 M KOH	1.65	[10]
Fe ₂ P/Ni _{1.5} Co _{1.5} N/Ni ₂ P	1.0 M KOH	V ₁₀₀ =1.624	[11]
Ni ₂ P-Fe ₂ P	1.0 M KOH	V ₁₀₀ =1.682	[12]
Co-Fe ₂ P	1.0 M KOH	V ₁₀₀ =1.69	[13]
NiMo films	1.0 M KOH+ 0.5 M NaCl	1.579	[14]
SSFF@NiFe LDH	1.0 M KOH+ 0.5 M NaCl	1.76	[15]
FeNiP/MoO _x /NiMoO ₄ /NF(-) NiFe LDH(+)	1.0 M KOH+ 0.5 M NaCl	1.47	[16]
NiFeB@OCC	1.0 M KOH+ 0.5 M NaCl	1.72	[17]

Reference

1. X. Ren, Y. Tian, F. Shaik, J. Yang, R. Liu, K. Guo and B. Jiang, An efficient electrocatalyst based on vertically aligned heteroatom(B/N/P/O/S)-doped graphene array integrated with FeCoNiP nanoparticles for overall water splitting, *Adv. Sust. Syst.*, 2022, 6, 2100436.
2. M.-R. Liu, Q.-L. Hong, Q.-H. Li, Y. Du, H.-X. Zhang, S. Chen, T. Zhou and J. Zhang, Cobalt boron imidazolate framework derived cobalt nanoparticles encapsulated in B/N codoped nanocarbon as efficient bifunctional electrocatalysts for overall water splitting, *Adv. Funct. Mater.*, 2018, 28, 1801136.
3. H. Yuan, S. Wang, Z. Ma, M. Kundu, B. Tang, J. Li and X. Wang, Oxygen vacancies engineered self-supported B doped Co₃O₄ nanowires as an efficient multifunctional catalyst for electrochemical water splitting and hydrolysis of sodium borohydride, *Chem. Eng. J.*, 2021, 404, 126474.
4. W. Liu, J. Bao, M. Guan, Y. Zhao, J. Lian, J. Qiu, L. Xu, Y. Huang, J. Qian and H. Li, Nickel–cobalt-layered double hydroxide nanosheet arrays on Ni foam as a bifunctional electrocatalyst for overall water splitting, *Dalton Trans.*, 2017, 46, 8372-8376.
5. B. Liu, S. Li, T. Wang, Y. Yang, L. Wang, X. Zhang, Z. Liu and L. Niu, Construction of CoFe bimetallic phosphide microflowers electrocatalyst for highly efficient overall water splitting, *Catal. Commun.*, 2023, 175, 106607.
6. D. Wang, Y. Zhang, T. Fei, C. Mao, Y. Song, Y. Zhou and G. Dong, NiCoP/NF 1D/2D biomimetic architecture for markedly enhanced overall water splitting, *Chem. Electro. Chem.*, 2021, 8, 3064-3072.
7. H. Zhao, J. Liang and Y. Zhao, Construction of hierarchical Co₂P/Ni₂P heterostructures on Ni foam as efficient bifunctional electrocatalyst for overall water splitting, *J. Alloys Compd.*, 2022, 907, 164479.
8. Y. Li, H. Su, J. Fu and X. Du, The 3D ultra-thin Cu_{1-x}Ni_xS/NF nanosheet as a highly efficient and stable electrocatalyst for overall water splitting, *Int. J. Hydrogen Energy*, 2019, 44, 11744-11753.

9. R. Yao, Y. Wu, Q. Zhao, J. Li and G. Liu, Autogenous growth of highly active bifunctional Ni–Fe₂B nanosheet arrays toward efficient overall water splitting, *Int. J. Hydrogen Energy*, 2022, 47, 8303-8313.
10. H. Yao, S. Wang, Y. Cao, R. Chen, Z. Lu, J. Hu, J. Xie and A. Hao, High-performance bifunctional electrocatalysts of CoFe-LDH/NiCo₂O₄ heterostructure supported on nickel foam for effective overall water splitting, *J. Alloys Compd.*, 2022, 926, 166846.
11. F. Zhang, Y. Liu, F. Yu, H. Pang, X. Zhou, D. Li, W. Ma, Q. Zhou, Y. Mo and H. Zhou, Engineering Multilevel Collaborative Catalytic Interfaces with Multifunctional Iron Sites Enabling High-Performance Real Seawater Splitting, *ACS Nano*, 2023, 17, 1681-1692.
12. L. Wu, L. Yu, F. Zhang, B. McElhenny, D. Luo, A. Karim, S. Chen and Z. Ren, Heterogeneous Bimetallic Phosphide Ni₂P-Fe₂P as an Efficient Bifunctional Catalyst for Water/Seawater Splitting, *Adv. Funct. Mater.*, 2021, 31, 2006484.
13. S. Wang, P. Yang, X. Sun, H. Xing, J. Hu, P. Chen, Z. Cui, W. Zhu and Z. Ma, Synthesis of 3D heterostructure Co-doped Fe₂P electrocatalyst for overall seawater electrolysis, *Appl. Catal. B-Environ.*, 2021, 297, 120386.
14. W. Yuan, Z. Cui, S. Zhu, Z. Li, S. Wu and Y. Liang, Structure engineering of electrodeposited NiMo films for highly efficient and durable seawater splitting, *Electrochimica Acta*, 2021, 365, 137366.
15. Y. Liu, Z. Song, Z. Li, M. Han, Y. Cheng and Z. Zheng, Standing NiFe LDH nanosheets on stainless steel fibers felt: A synergistic impact on the oxygen evolution reaction (OER) for the water splitting, *Catal. Commun.*, 2022, 164, 106425.
16. Z. Xiao, M. Yang, J. Wang, Z. Xu, S. Zhang, A. Tang, R. Gao and H. Yang, FeNiP/MoO_x integrated electrode grown on monocrystalline NiMoO₄ nanorods with multi-interface for accelerating alkaline hydrogen evolution reaction, *Appl. Catal. B-Environ.*, 2022, 303, 120913.
17. A. Kafle, D. Gupta and T. C. Nagaiah, Facile fabrication of NiFeB deposited flexible carbon cloth electrode towards overall water splitting in alkaline and

saline solutions, *Electrochimica Acta*, 2023, 441, 141779.