Electronic Supplementary Information (ESI)

Hierarchically porous Mo-doped Ni-Fe oxide nanowires efficiently catalyzing oxygen/hydrogen evolution reactions

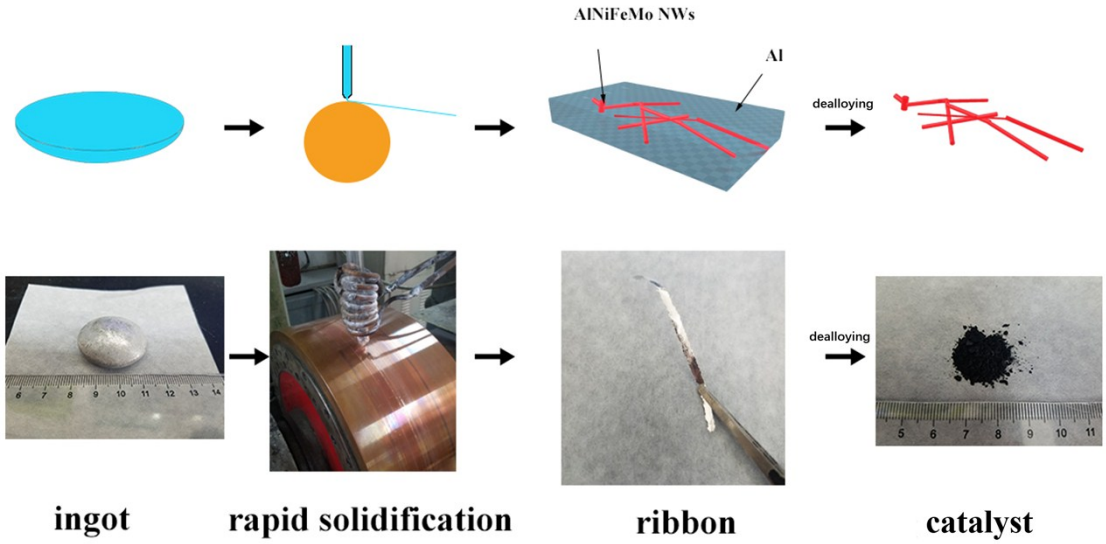
Yangjia Chen,[a,†] Chaoqun Dong,[a,†] Jie Zhang,[a] Chi Zhang,[b] Zhonghua Zhang[a,b,*]

[a]Key Laboratory for Liquid-Solid Structural Evolution and Processing of Materials (Ministry of Education), School of Materials Science and Engineering, Shandong University, Jingshi Road 17923, Jinan 250061, P.R. China

[b]School of Applied Physics and Materials, Wuyi University, 22 Dongcheng Village, Jiangmen 529020, P.R. China

† These authors equally contribute to this work.

*Corresponding author. Email: zh_zhang@sdu.edu.cn (Z. Zhang)



Scheme S1. Schematic diagrams (top) and photographs (bottom) showing the preparation process of the Ni_2Fe_1-Mo nanowire electrocatalysts.

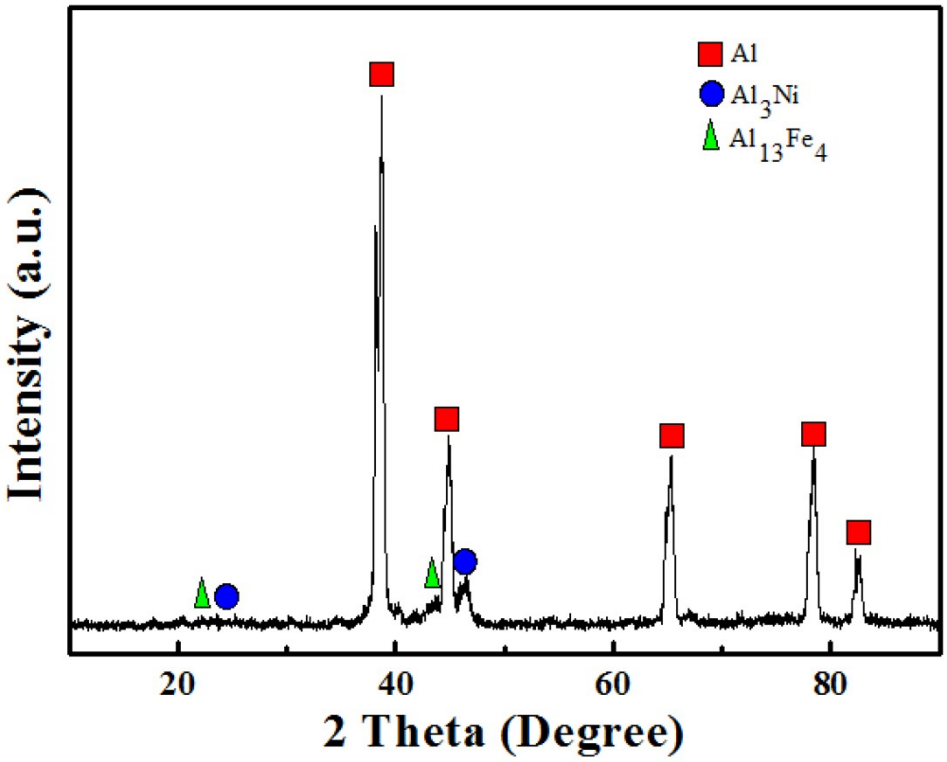


Figure S1. XRD pattern of the rapidly-solidified $Al_{96.5}Ni_2Fe_1Mo_{0.5}$ precursor ribbons.

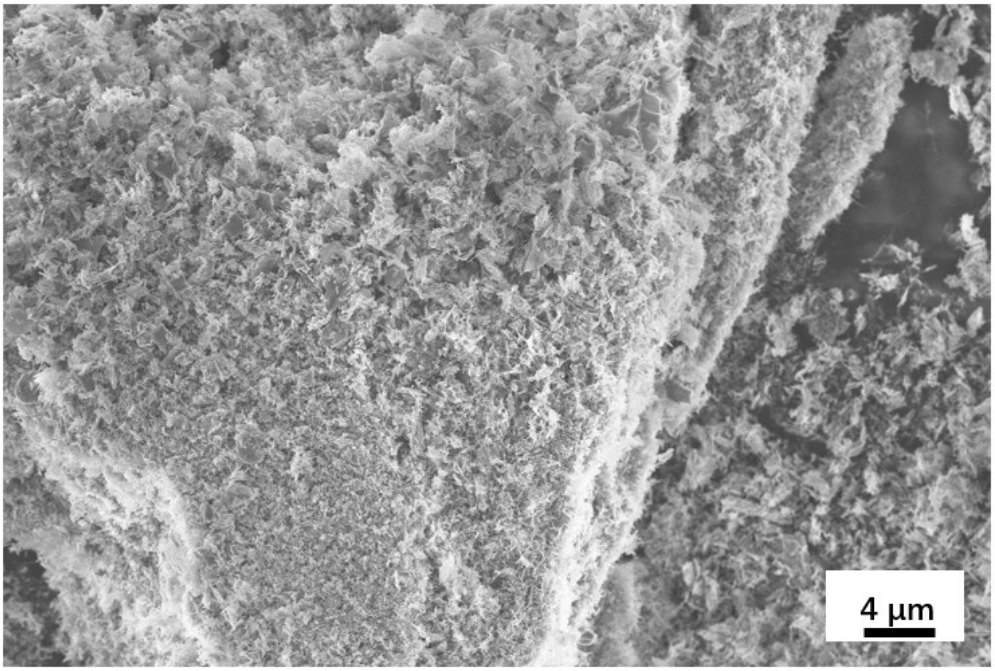


Figure S2. SEM image of the Ni_2Fe_1-Mo catalyst.

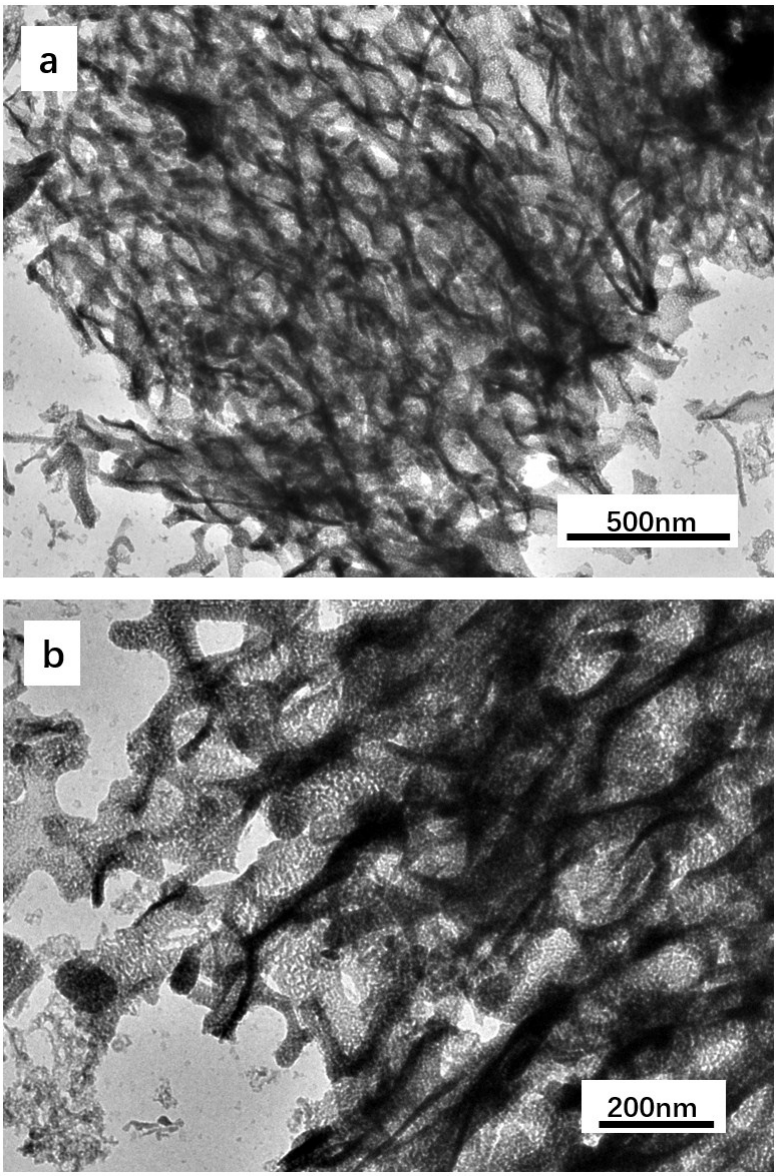


Figure S3. TEM images of the Ni_2Fe_1-Mo catalyst.

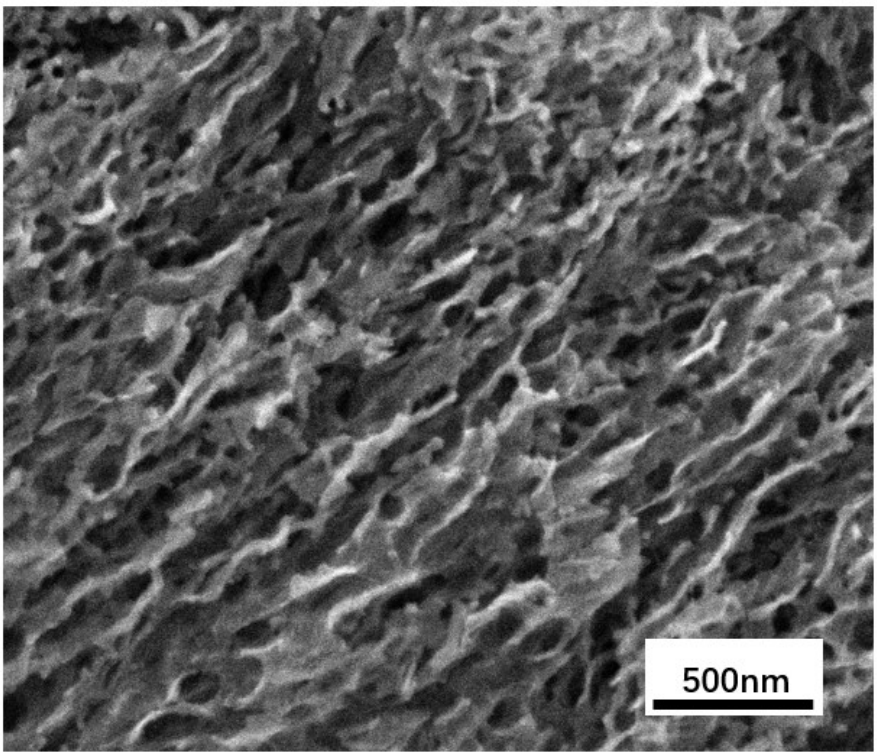


Figure S4. SEM image of the Ni_2Fe_1 catalyst.

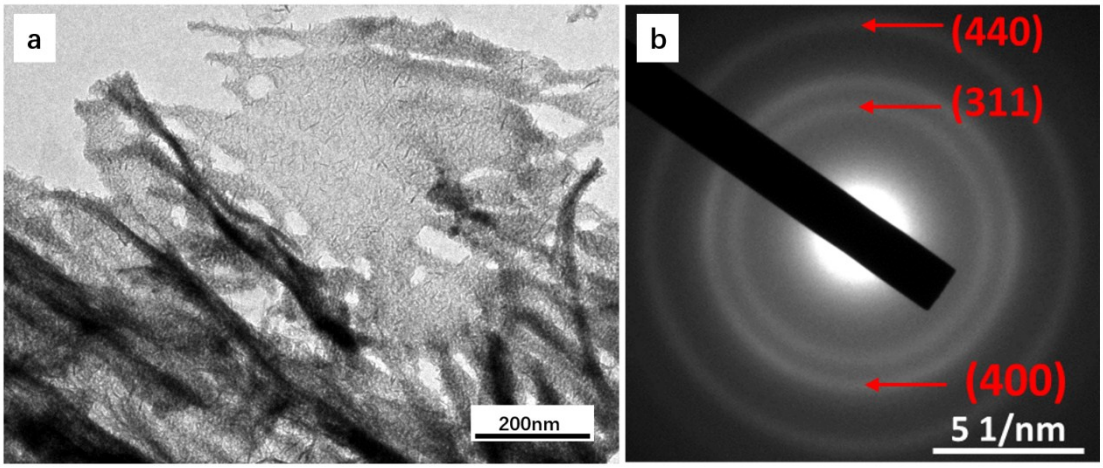


Figure S5. (a) TEM image and (b) SAED pattern of the Ni_2Fe_1 catalyst.

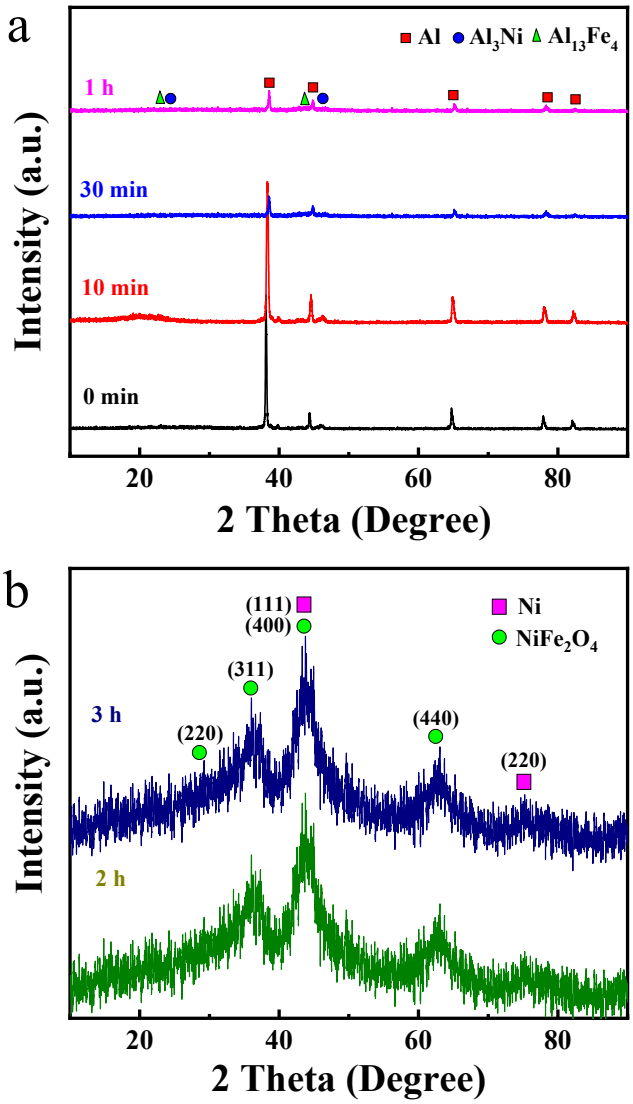


Figure S6. XRD patterns of the $Al_{96.5}Ni_2Fe_1Mo_{0.5}$ precursor alloy after different dealloying time, showing the phase transformation information occurred during the dealloying process.

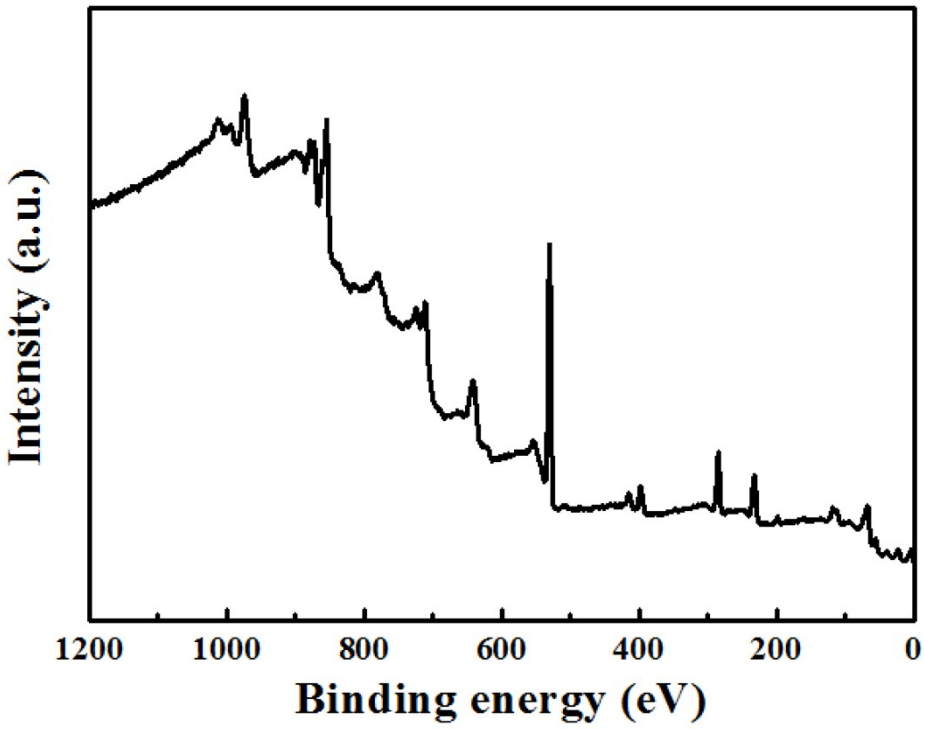


Figure S7. XPS spectrum of the Ni_2Fe_1-Mo catalyst.

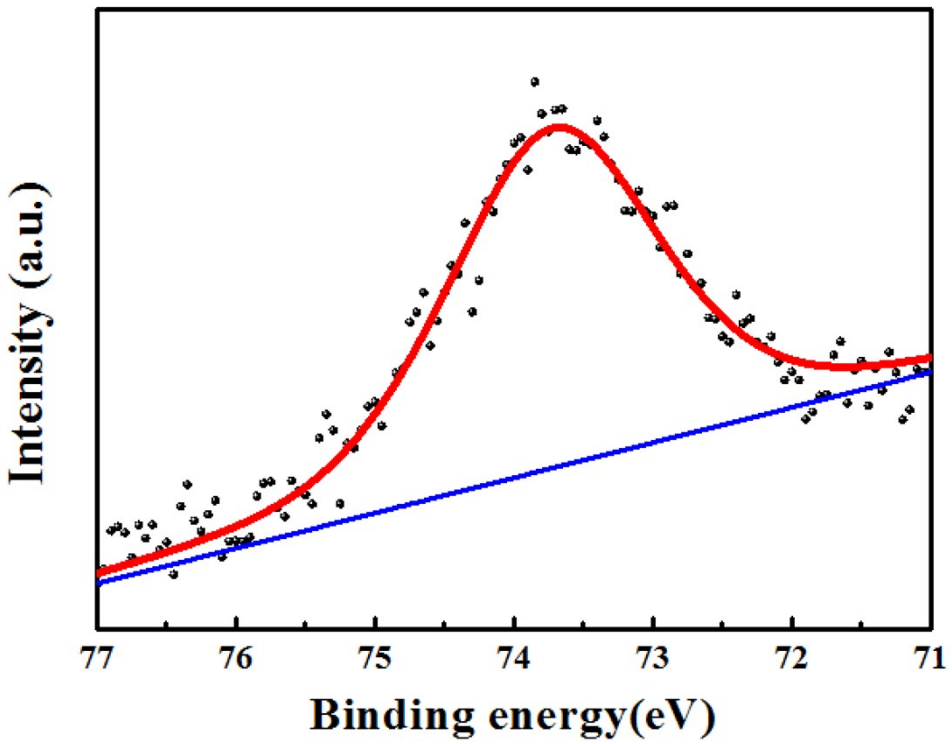


Figure S8. XPS spectrum of element Al in the Ni_2Fe_1-Mo catalyst.

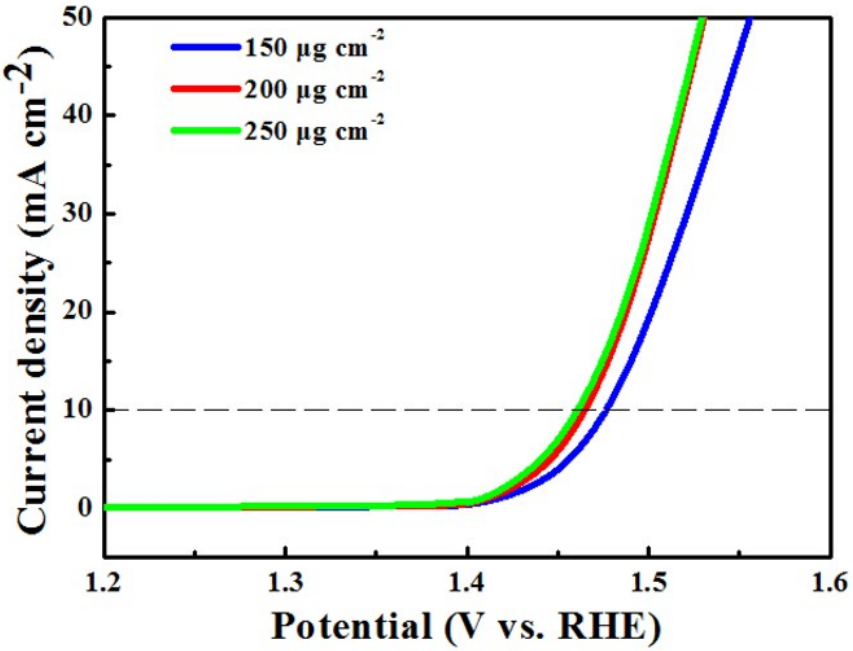


Figure S9. OER polarization curves of the Ni_2Fe_1-Mo catalyst with different loadings on GC: 150, 200 and 250 μg cm^{-2}.

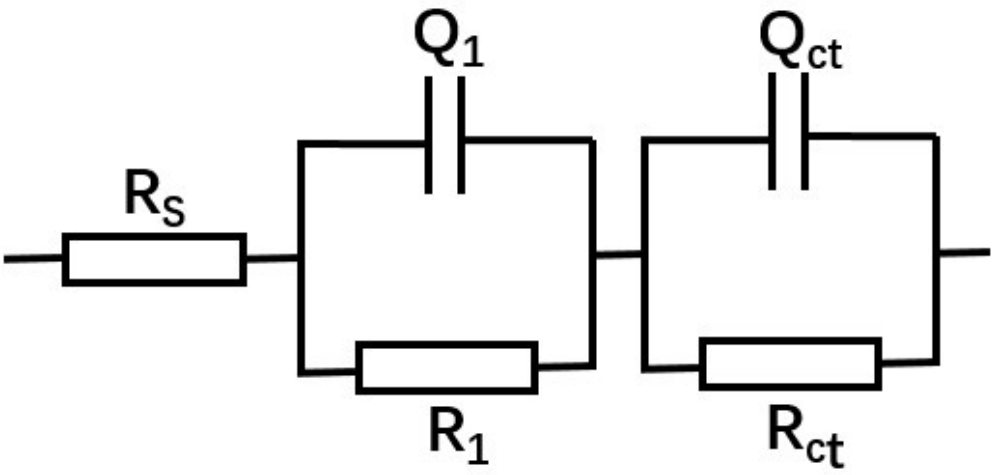


Figure S10. Equivalent circuit used for simulating the Nyquist plot in Figure 3c.

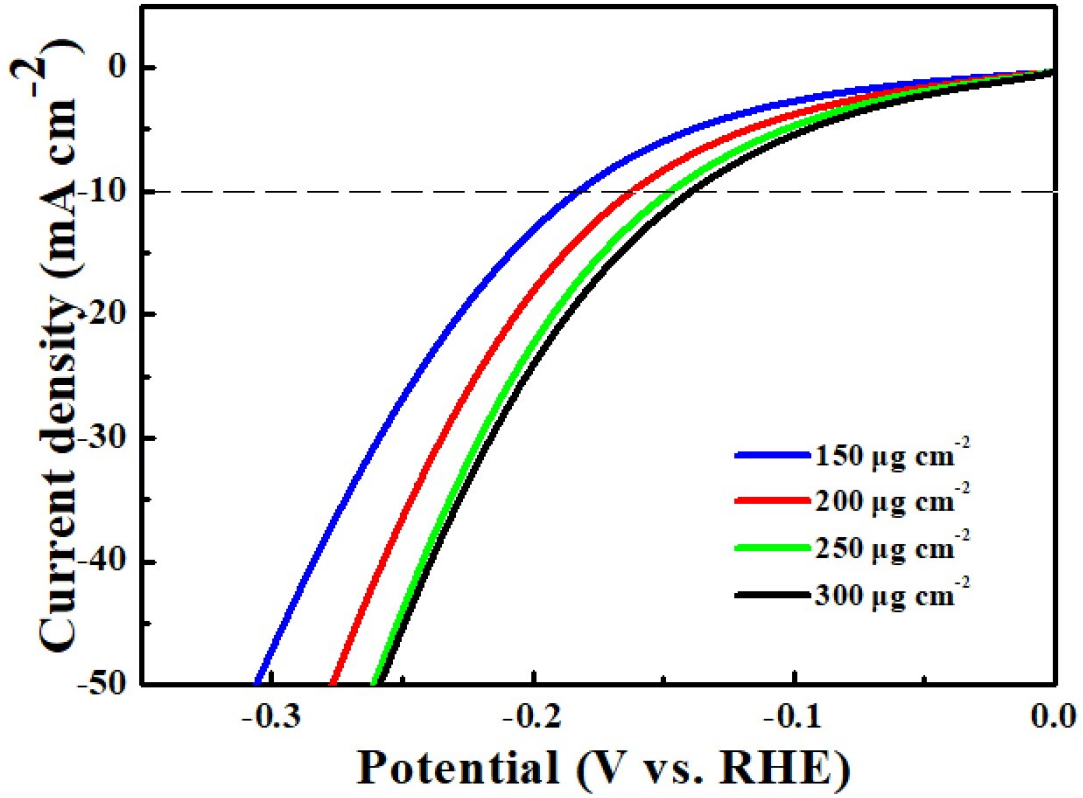


Figure S11. HER polarization curves of the Ni_2Fe_1-Mo catalyst with different loadings on GC: 150, 200, 250 and 300 μg cm^{-2}.

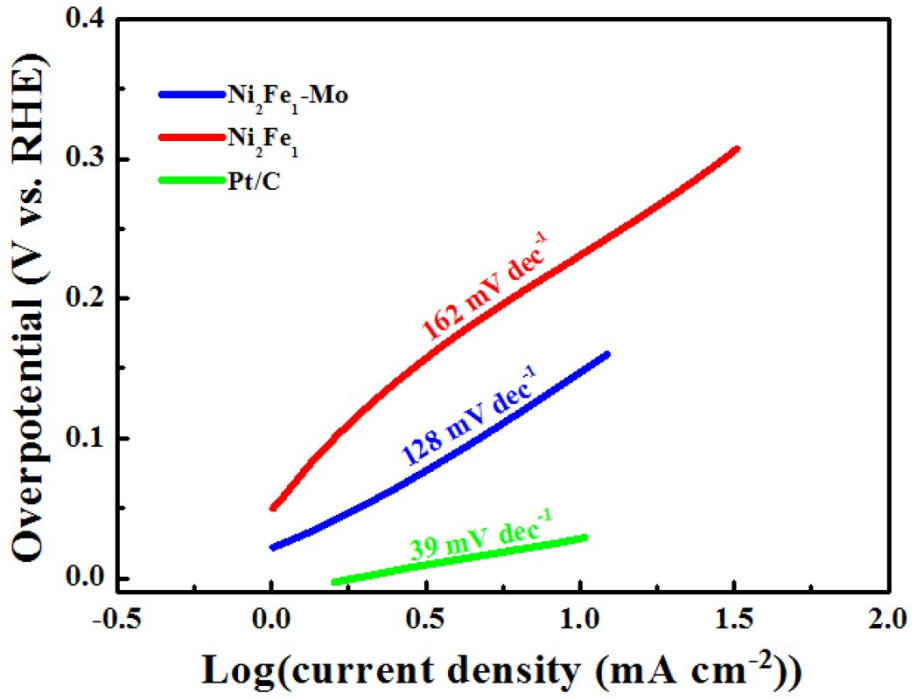


Figure S12. HER Tafel slopes of different catalysts on GC.

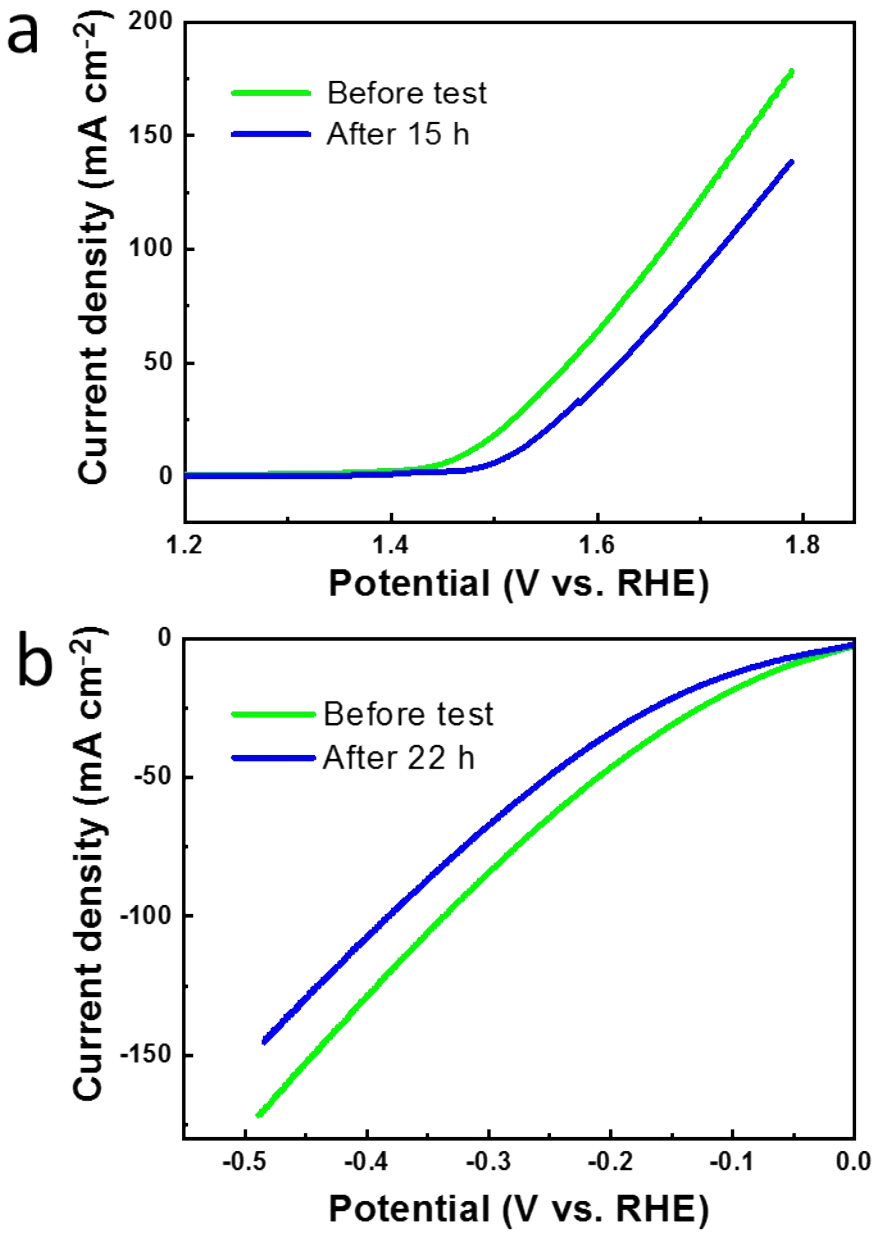


Figure S13. Comparison of polarization curves of the Ni foam-supported Ni_2Fe_1-Mo electrode before and after stability test for (a) OER and (b) HER.

Table S1. Comparison of the OER performance of the Ni_2Fe_1-Mo with other reported catalysts in 1 M KOH.

Samples	Mass Loading (mg cm^{-2})	Electrode	Overpotential at 10 mA cm^{-2} (mV)	Tafel slope (mV dec^{-1})	Reference
Ni_2Fe_1-Mo	0.2	GC	231	39	This work
Ni_2Fe_1	0.2	GC	244	39	Our previous work
NiO/Ni	--	Ni plate	294	41	[1]
Co_3O_4	2.2	Co plate	268	--	[2]
$Ni_{12}P_5$	~3	Ni foam	240	--	[3]
Fe-CoP	1.03	Ti foam	230	67	[4]
NiFe@nitrogen-doped carbon	0.2	GC	310	56	[5]
NiFe@nitrogen-doped carbon	0.288	GC	239	75	[6]
$SrNb_{0.1}Co_{0.7}Fe_{0.2}O_{3-\delta}$	0.232	GC	370	48	[7]
$NiFe_{0.52}$-LDH	0.14	GC	344	97	[8]
$Na_{0.08}Ni_{0.9}Fe_{0.1}O_2$	--	GC	260	44	[9]
NiFe hydroxide	--	GC	240	38.9	[10]
N, S-doped CNT	--	GC	360	56	[11]
MoO_2	2.9	Ni foam	260	54	[12]
$Fe_{0.4}Co_{0.6}$	1.2	CFP	283	34	[13]
$Ni_{1.5}Fe_{0.5}P$	1.38	CF	264	55	[14]

Table S2. Comparison of overall water splitting performance of the Ni_2Fe_1-Mo bifunctional catalyst with other reported catalysts in 1 M KOH.

Samples	Mass Loading (mg cm^{-2})	Overpotential at 10 mA cm^{-2} (V)	Stability (h)	Reference
Ni_2Fe_1-Mo@Ni foam	1.26	1.62	63.5	This work
$Fe_{0.4}Co_{0.6}$@carbon fier paper	1.6	1.68	10	[13]
NiO/Ni@Ni plate	--	1.7	25	[1]
$SrNb_{0.1}Co_{0.7}Fe_{0.2}O_{3-\delta}$@Al foil	~3	>1.68	30	[7]
NiFe@nitrogen-doped carbon	--	1.81	15	[5]
Ni/Mo_2C@porous carbon	~2	1.66	10	[15]
$Ni_xCo_{3-x}O_4$@glassy carbon	--	1.77	--	[16]
CoFe-LDH@Cu foam	1.8	1.681	48	[17]
Co_5Mo_1 Composite @Ni foam	--	1.68	30	[18]
3D $Co(OH)_2$@N-doped CNTs@Ni foam	--	1.72	600	[19]
S-$NiFe_2O_4$@Ni foam	--	1.65	24	[20]
Co_2P@Co foil	1.42	>1.71	14	[21]
Nitrogen & Fluorine @porous graphene nanosheets	--	1.91	12	[22]
Defect-rich porous carbon	--	1.74	12	[23]
NiZn-MOFs@Ni foam	1	1.65	24	[24]

References

1 G. Ou, P. Fan, H. Zhang, K. Huang, C. Yang, W. Yu, H. Wei, M. Zhong, H. Wu, Y. Li, *Nano Energy*, 2017, **35**, 207-214.

2 G. Cheng, T. Kou, J. Zhang, C. Si, H. Gao, Z. Zhang, *Nano Energy*, 2017, **38**, 155-166.

3 P.W. Menezes, A. Indra, C. Das, C. Walter, C. Göbel, V. Gutkin, D. Schmeiβer, M. Driess, *ACS Catal.*, 2017, **7**, 103-109.

4 C. Tang, R. Zhang, W. Lu, L. He, X. Jiang, A.M. Asiri, X. Sun, *Adv. Mater.*, 2017, **29**, 1602441-1602446.

5 Z. Zhang, Y. Qin, M. Dou, J. Ji, F. Wang, *Nano Energy*, 2016, **30**, 426-433.

6 L. Du, L. Luo, Z. Feng, M. Engelhard, X. Xie, B. Han, J. Sun, J. Zhang, G. Yin, C. Wang, Y. Wang, Y. Shao, *Nano Energy*, 2017, **39**, 245-252.

7 Y. Zhu, W. Zhou, Y. Zhong, Y. Bu, X. Chen, Q. Zhong, M. Liu, Z. Shao, *Adv. Energy Mater.*, 2017, **7**, 1602122-1602130.

8 L. J. Zhou, X. Huang, H. Chen, P. Jin, G.D. Li, X. Zou, *Dalton Trans.*, 2015, **44**, 11592-11600.

9 B. Weng, F. Xu, C. Wang, W. Meng, C.R. Grice, Y. Yan, *Energy Environ. Sci.*, 2017, **10**, 121- 128.

10 W. Zhang, Y. Wu, J. Qi, M. Chen, R. Cao, *Adv. Energy Mater.*, 2017, **7**, 1602547-1602552.

11 K. Qu, Y. Zheng, Y. Jiao, X. Zhang, S. Dai, S.-Z. Qiao, *Adv. Energy Mater.*, 2017, **7**, 1602068-1602075.

12 Y. Jin, H. Wang, J. Li, X. Yue, Y. Han, P.K. Shen, Y. Cui, *Adv. Mater.*, 2016, **28**, 3785-3790.

13 W. Liu, K. Du, L. Liu, J. Zhang, Z. Zhu, Y. Shao, M. Li, *Nano Energy*, 2017, **38**, 576-584.

14 H. Huang, C. Yu, C. Zhao, X. Han, J. Yang, Z. Liu, S. Li, M. Zhang, J. Qiu, *Nano Energy*, 2017, **34**, 472-480.

15 Z.Y. Yu, Y. Duan, M.R. Gao, C.C. Lang, Y.R. Zheng, S.H. Yu, *Chem. Sci.*, 2017, **8**, 968-973.

16 J.A. Vigil, T.N. Lambert, B.T. Christensen, *J. Mater. Chem. A*, 2016, **4**, 7549-7554.

17 L. Yu, H. Zhou, J. Sun, F. Qin, D. Luo, L. Xie, F. Yu, J. Bao, Y. Li, Y. Yu, S. Chen, Z. Ren, *Nano Energy*, 2017, **41**, 327-336.

18 Y. Zhang, Q. Shao, S. Long, X. Huang, *Nano Energy*, 2018, **45**, 448-455.

19 P. Guo, J. Wu, X.-B. Li, J. Luo, W.-M. Lau, H. Liu, X.-L. Sun, L.-M. Liu, *Nano Energy*, 2018, In Press, https://doi.org/10.1016/j.nanoen.2018.02.032.

20 J. Liu, D. Zhu, T. Ling, A. Vasileff, S.-Z. Qiao, *Nano Energy*, 2017, **40**, 264-273.

21 C.-Z. Yuan, S.-L. Zhong, Y.-F. Jiang, Z.K. Yang, Z.-W. Zhao, S.-J. Zhao, N. Jiang, A.-W. Xu, *J. Mater. Chem. A*, 2017, **5**, 10561-10566.

22 X. Yue, S. Huang, J. Cai, Y. Jin, P.K. Shen, *J. Mater. Chem. A*, 2017, **5**, 7784-7790.

23 Z. Zhang, Z. Yi, J. Wang, X. Tian, P. Xu, G. Shi, S. Wang, *J. Mater. Chem. A*, 2017, **5**, 17064-17072.

24 Y. Wang, W. Wu, Y. Rao, Z. Li, N. Tsubaki, M. Wu, *J. Mater. Chem. A*, 2017, **5**, 6170-6177.