Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

One-step synthesis of amorphous transition metal sulfides as bifunctional electrocatalysts for hydrogen evolution reaction and oxygen evolution reaction

Wenjun He, [a] *Fangqing Wang,* [a] *Yaohui Gao,* [a] *Qiuyan Hao* *, [a] *and Caichi Liu* *, [Δ]

[a] Key Laboratory of Special Functional Materials for Ecological Environment and Information (Hebei University of Technology), Ministry of Education, Tianjin 300130, People's Republic of China.

E-mail: hqy1218@163.com; ccliu@hebut.edu.cn

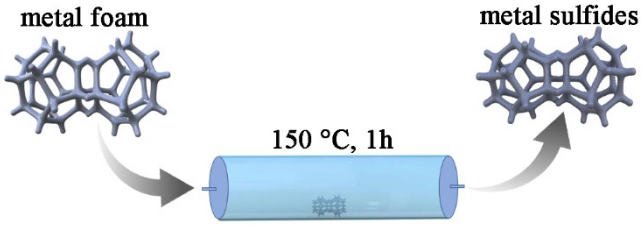

Fig. S1. Schematic illustration of the synthesis process.

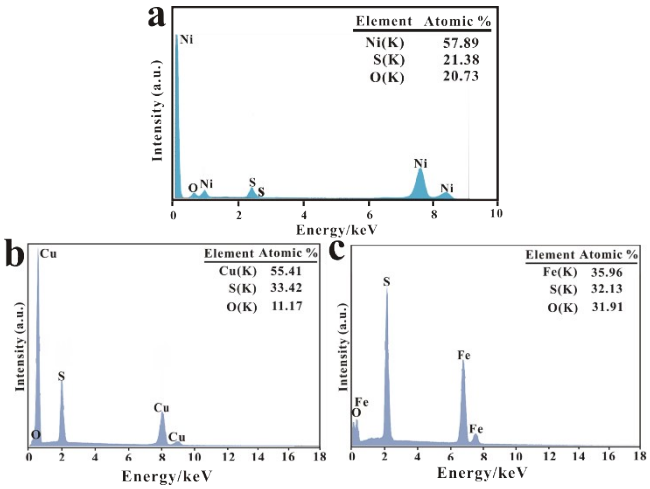

Fig. S2. EDS spectra of (a) NiSx/NF, (b) CuSx/CF and (c) FeSx/IF.

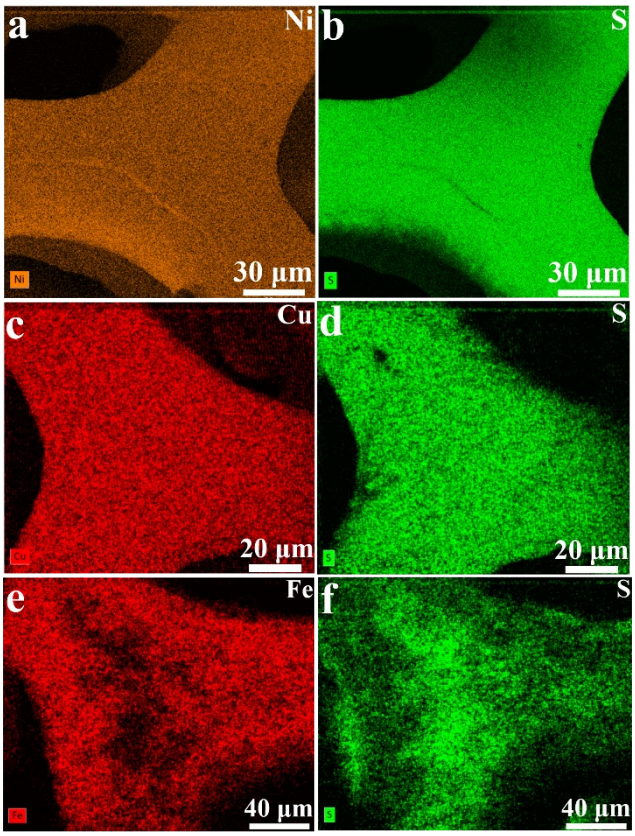

Fig. S3. Elemental mapping of (a) Ni, (b) S for NiSx/NF, (c) Cu, (d) S for CuSx/CF and (e) Fe, (f) S for FeSx/IF.

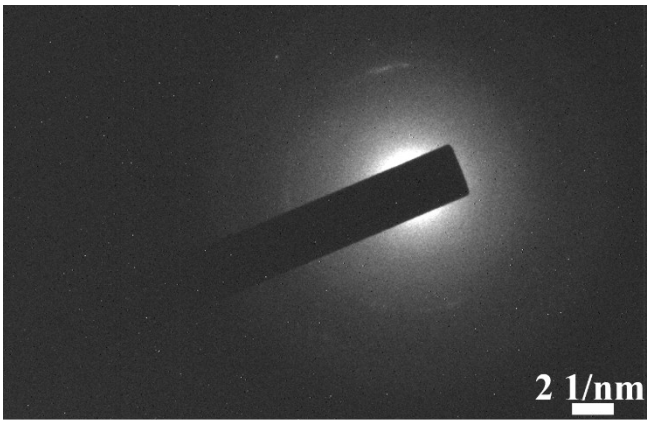

Fig. S4. SAED pattern of NiSx/NF.

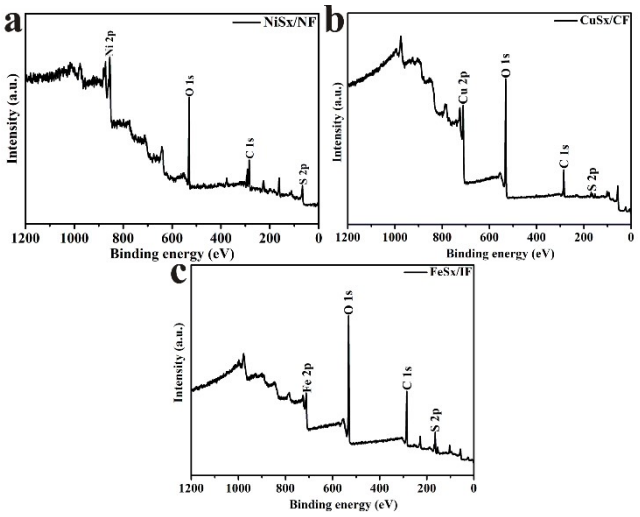

Fig. **S5.** The full spectra of amorphous (a) NiSx/NF, (b) CuSx/CF and (c) FeSx/IF.

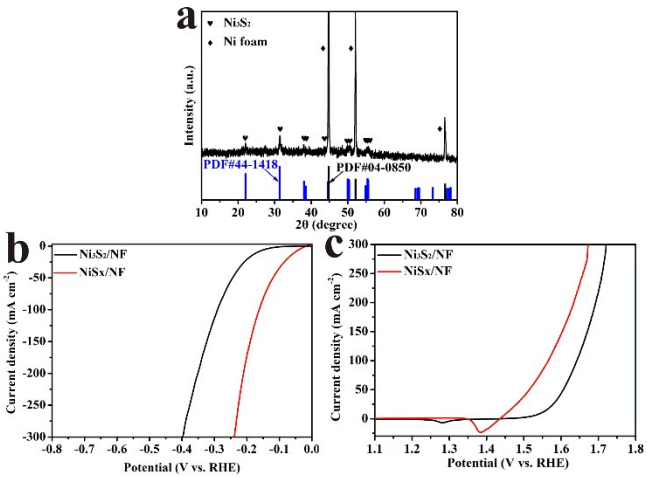

Fig. S6. (a) XRD pattern of Ni_3S_2/NF. LSV curves of Ni_3S_2/NF and NiSx/NF for (b) HER and (c) OER.

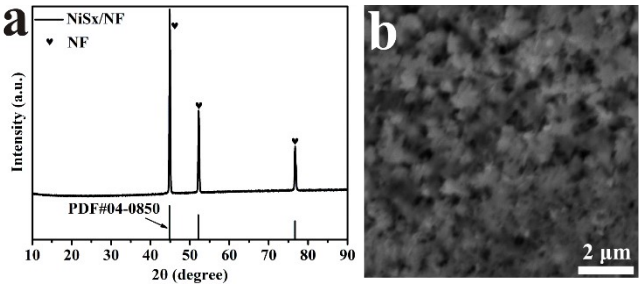

Fig. S7. (a) XRD pattern and (b) SEM image of NiSx/NF after HER stability test for 100 h.

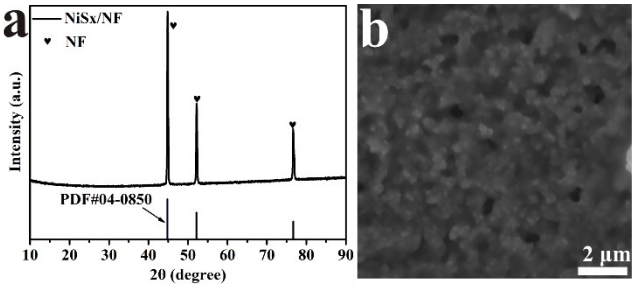

Fig. S8. (a) XRD pattern and (b) SEM image of NiSx/NF after OER stability test for 100 h.

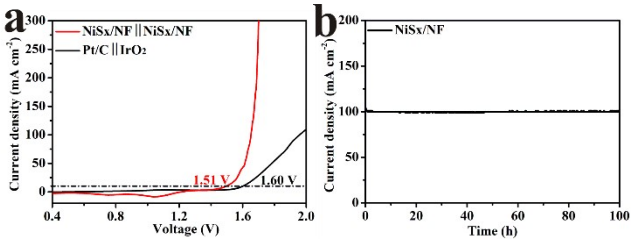

Fig. S9. (a) Overall water splitting performance of NiSx/NF||NiSx/NF and Pt/C||IrO_2 electrode pairs in 1 M KOH. (b) Chronoamperometry curve of NiSx/NF||NiSx/NF electrode pairs at 100 mA cm^{-2} for 100 h.

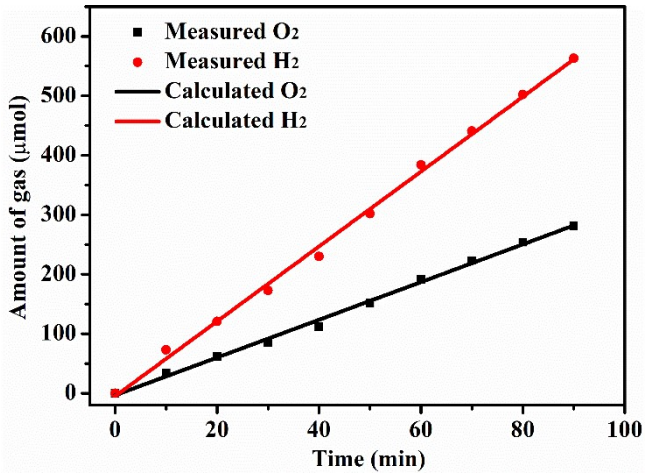

Fig. S10. Amount of O_2 and H_2 collected for NiSx/NF||NiSx/NF during water splitting.

Table S1. Comparison of the HER performance of NiSx/NF with other reported catalysts in 1 M KOH.

Catalysts	Overpotential at 10 mA cm^{-2} (mV)	References
NiSx/NF	**53**	**This work**
Cl-Ni_3S_2/NF	67	[1]

Fe9S10-Vs/IF	149	[2]
Al-Ni_3S_2/NF	86	[3]
CoSx@Cu_2MoS_4-MoS_2/NSG	118.1	[4]
CuS@MoS_2	135	[5]
Au/Ni_3S_2/NF	97	[6]
Vs-Ni_3S_2/NF	88	[7]
MoS_2/Co_9S_8/Ni_3S_2/Ni	113	[8]

Table S2. Comparison of the OER performance of NiSx/NF with other reported catalysts in 1 M KOH.

Catalysts	Overpotential at 10 mA cm^{-2} (mV)	References
NiSx/NF	**225**	**This work**
$Fe_{0.8}Ni_{0.15}S_{1.05}$	228	[9]
Al-Ni_3S_2/NF	223	[3]
CoSx@Cu_2MoS_4-MoS_2/NSG	351.4	[4]
Ni_3S_2/Ni-Fe-OH/NF	268	[10]
Au/Ni_3S_2/NF	230	[6]
CuCoS/N-rGO	288	[11]
NiS_2/$NiSe_2$	290	[12]
Co/Ce-Ni_3S_2/NF	286	[13]

References

1 W. He, H. Liu, J. Cheng, Y. Li, C. Liu, C. Chen, J. Zhao, H. L. Xin, *ACS Appl. Mater. Interfaces*, 2022, **14**, 6869-6875.

2 W. He, J. Cheng, Y. Gao, C. Liu, J. Zhao, Y. Li, Q. Hao, *Nanoscale*, 2021, **13**, 12951-12955.

3 W. He, F. Wang, D. Jia, Y. Li, L. Liang, J. Zhang, Q. Hao, C. Liu, H. Liu, J. Zhao, *Nanoscale*, 2020, **12**, 24244-24250.

4 D. C. Nguyen, D. T. Tran, T. Doan, D. H. Kim, N. H. Kim, J. H. Lee, *Adv. Energy*

Mater., 2020, **10**, 1903289.

5 L. Liu, X. Liu, S. Jiao, *J. Colloid Interface Sci.*, 2020, **564**, 77-87.

6 L. Hui, J. Cheng, W. He, Y. Li, J. Mao, X. Zheng, C. Chen, C. Cui, Q. Hao, *Appl. Catal. B,* 2022, **304**, 120935.

7 D. Jia, L. Han, Y. Li, W. He, C. Liu, J. Zhang, C. Chen, H. Liu, H. L. Xin, *J. Mater. Chem. A*, 2020, **8**, 18207-18214.

8 Y. Yang, H. Yao, Z. Yu, S. M. Islam, H. He, M. Yuan, Y. Yue, K. Xu, W. Hao, G. Sun, H. Li, S. Ma, P. Zapol, M. G. *J. Am. Chem. Soc.*, 2019, **141**, 10417-10430.

9 Z. Jing, Q. Zhao, D. Zheng, L. Sun, J. Geng, Q. Zhou, J. Lin, *J. Mater. Chem. A*, 2020, **8**, 20323-20330.

10 W. He, G. Ren, Y. Li, D. Jia, S. Li, J. Cheng, C. Liu, Q. Hao, J. Zhang, H. Liu, *Catal. Sci. Technology*, 2020, **10**, 1708-1713.

11 H. Zhang, X. Wang, Z. Yang, S. Yan, C. Zhang, S. Liu, *ACS Sustainable Chem. Eng.*, 2020, **8**, 1004-1014.

12 Y. Yang, Y. Kang, H. Zhao, X. Dai, Song, *Small*, 2020, **16**, 1905083.

13 X. Wu, T. Zhang, J. Wei, P. Feng, X. Yan, Y. Tang, *Nano Res.*, 2020, **13**, 2130-2135.