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FeCoNiW medium entropy alloys loaded on N-doped carbon skeletons as efficient electrocatalysts for oxygen evolution reactions

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Figure S1. SEM images of (a) NC, (b-c) FeCoNi-350-NC and (d-f) FeCoNiW-350-NC.

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Figure S2. (a) EDS of FeCoNiW-350-NC. (b) EDS line scan of FeCoNiW-350-NC.

Figure S3. Pore size of four samples of FeCoNi-350-NC, FeCoNiW-300-NC, FeCoNiW-350-NC, and FeCoNiW-400-NC.

Figure S4. (a) Spectra of FeCoNiW-350-NC W 4f. (b) Spectra of FeCoNiW-350-NC and FeCoNi-350-NC N 1s.

Figure S5. CV curves of FeCoNiW-350-NC and its comparison samples. (a) FeCoNi-350-NC. (b) FeCoNiW-300-NC. (c) FeCoNiW-350-NC. (d) FeCoNiW-400-NC. (Scanning rate at 1 M KOH solution: 20, 40, 60, 80, 100, 120 mV s^{-1}).

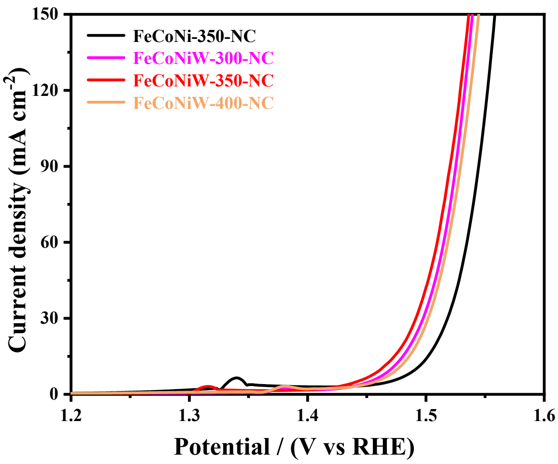

Figure S6. Specific current densities calculated from ECSAs and LSV results.

The normalized current density curves obtained according to the geometric current density (Fig.4a) and ECSA are shown in Fig.S6 The highest specific current density is achieved over FeCoNiW-350-NC, indicating its superior intrinsic activity (e.g., average activity per reactive site) for OER.

Figure S7. TEM images of (a) FeCoNiW-350-NC and (b) FeCoNi-350-NC. The corresponding particle size distribution of (c) FeCoNiW-350-NC and (d) FeCoNi-350-NC.

Figure S8. XPS after OER stability test. After the OER stability test, the XPS of the FeCoNiW-

350-NC sample was tested. The Fe, Co, Ni and W elements are transformed into stable oxidation states.

Figure S9. (a) Testing device for Faraday efficiency of O_2 evolution by drainage method. (b) Faraday efficiency (1M KOH) calculated from the amount of O_2 measured experimentally and theoretically on the FeCoNiW-350-NC catalyst.

In order to study the oxygen evolution Faraday efficiency of FeCoNiW-350-NC, the catalyst was tested at a constant current density of 100 mA cm^{-2}, and the amount of O_2 was collected by the drainage method (Figure S9a). The data points of FeCoNiW-350-NC calculated according to

Faraday electrolysis law and ideal gas law are shown in Figure S9b. The results show that FeCoNiW-350-NC has a Faraday efficiency of nearly 100 %.

Table S1. Comparison with already reported catalysts for the oxygen precipitation reaction in 1 M KOH solution.

Catalyst	Tafel slope (mV dec^{-1})	Overpotential (mV) @10mA cm^{-2}	Reference
FeCoNiW-350-NC	54	225	This work
MnFeCoNiCu	43	263	[1]
(CrMnFeCoNi)S	68	295	[2]
FeCoNiCuPd	96	390	[3]
AlNiCoRuMo	55	270	[4]
NiMnFeMo	65	310	[5]
FeCoNiMn@HEO	84	302	[6]
$La(CrMn_2FeCoNi)O_3$	66	353	[7]
Co-Fe-Ga-Ni-Zn	71	370	[8]
np-NCMCF	81	283	[9]
HEF/Al alloy	88	293	[10]

Reference

1. K. Huang, B. Zhang, J. Wu, T. Zhang, D. Peng, X. Cao, Z. Zhang, Z. Li and Y. Huang, *Journal of Materials Chemistry A*, 2020, **8**, 11938-11947.
2. M. Cui, C. Yang, B. Li, Q. Dong, M. Wu, S. Hwang, H. Xie, X. Wang, G. Wang and L. Hu, *Advanced Energy Materials*, 2020, **11**,2002887.

3. H. Li, H. Zhu, Q. Shen, S. Huang, S. Lu, P. Ma, W. Dong and M. Du, *Chem Commun (Camb)*, 2021, **57**, 2637-2640.
4. Z. Jin, J. Lyu, Y.-L. Zhao, H. Li, X. Lin, G. Xie, X. Liu, J.-J. Kai and H.-J. Qiu, *ACS Materials Letters*, 2020, **2**, 1698-1706.
5. H. Liu, C. Xi, J. Xin, G. Zhang, S. Zhang, Z. Zhang, Q. Huang, J. Li, H. Liu and J. Kang, *Chemical Engineering Journal*, 2021, **404**,126530.
6. W. Dai, T. Lu and Y. Pan, *Journal of Power Sources*, 2019, **430**, 104-111.
7. T. X. Nguyen, Y. C. Liao, C. C. Lin, Y. H. Su and J. M. Ting, *Advanced Functional Materials*, 2021, **31**,2101632.
8. L. Sharma, N. K. Katiyar, A. Parui, R. Das, R. Kumar, C. S. Tiwary, A. K. Singh, A. Halder and K. Biswas, *Nano Research*, 2021, **15**, 4799-4806.
9. Z.-J. Zhang, J.-P. Guo, S.-H. Sun, Q. Sun, Y.-W. Zhao, Y.-F. Zhang, Z.-Y. Yu, C.-S. Li, Y. Sun, M.-M. Zhang and Y. Jiang, *Rare Metals*, 2023, **42**, 3607-3613.
10. P. Yang, Y. An, C. Feng, Y. Liu, S. Liu, L. Gao, Y. Zhou, X. Li, P. Li and F. Zeng, *International Journal of Hydrogen Energy*, 2024, **51**, 1218-1228.