Supplementary Materials

Fe-NC@NiFe-LDH Derived from Iron-Based Metal–Organic Frameworks as an Efficient Bifunctional Oxygen Electrocatalyst for Zn–Air Batteries

Pengfei Sha [1,†], Zhi Ling [1,†], Kaifa Liu [1], Di Chen [2], Beili Pang [1], Fengying Yan [1], Jing Sui [1], Qian Zhang [1], Jianhua Yu [1,*], Liyan Yu [1] and Lifeng Dong [1,3,*]

[1] College of Materials Science and Engineering, Qingdao University of Science and Technology, Qingdao 266042, China
[2] Shandong Engineering Research Center of Green and High-Value Marine Fine Chemical, Weifang University of Science and Technology, Shouguang 262700, China
[3] Department of Physics, Hamline University, Saint Paul, MN 55104, USA
* Correspondence: jianhuayu@qust.edu.cn (J.Y.); ldong03@hamline.edu (L.D.)
† These authors contributed equally to this work.

Figures

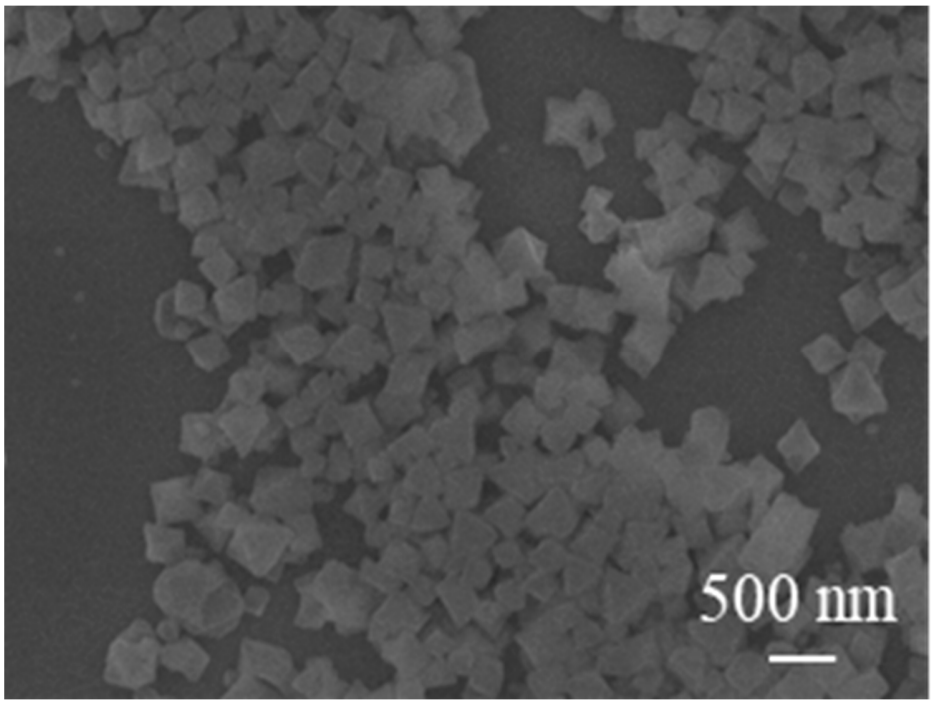


Figure S1. SEM image of NH_2-MIL-101(Fe).

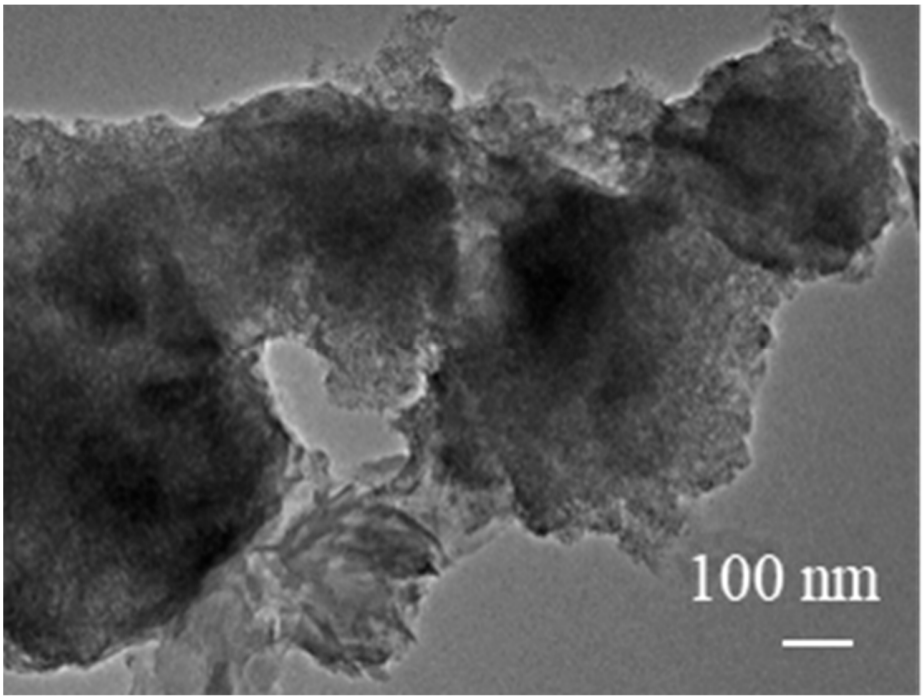


Figure S2. TEM image of Fe-NC@NiFe-LDH.

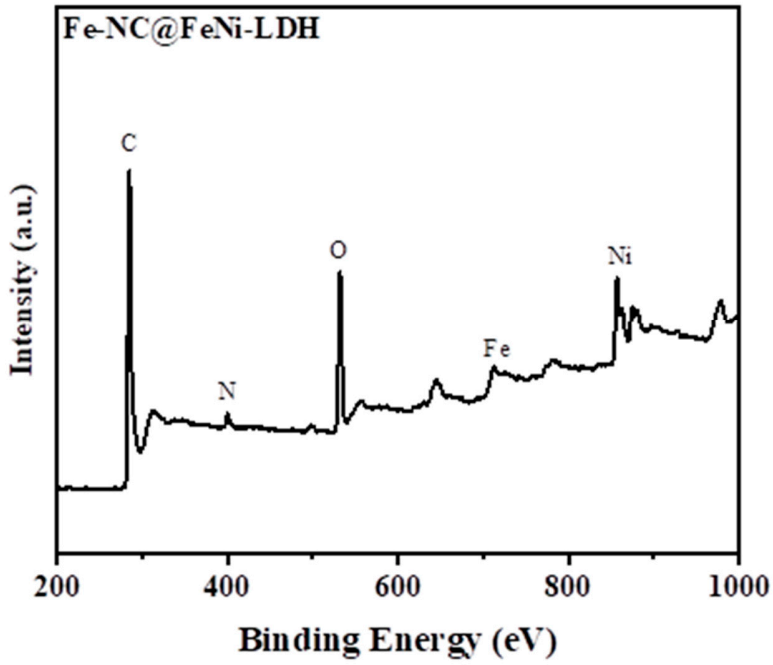


Figure S3. XPS survey spectrum of Fe-NC@NiFe-LDH.

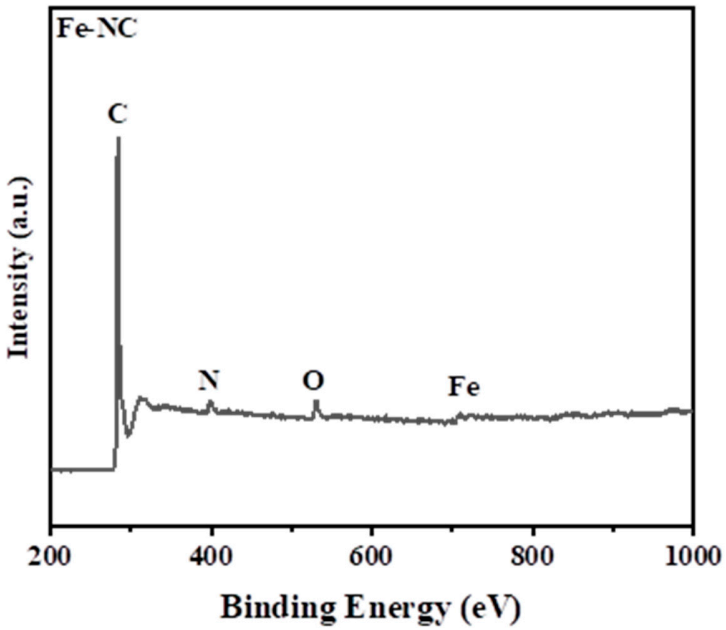


Figure S4. XPS survey spectrum of Fe-NC.

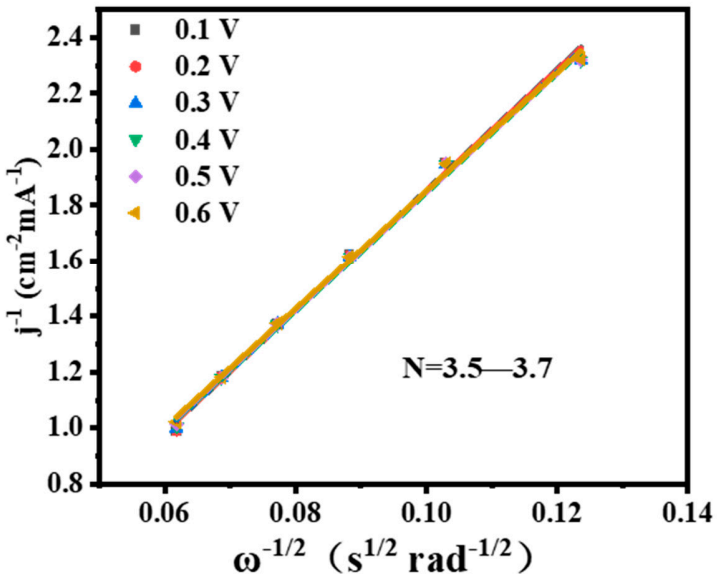


Figure S5. K–L fitting lines at various potentials of Fe-NC@NiFe-LDH.

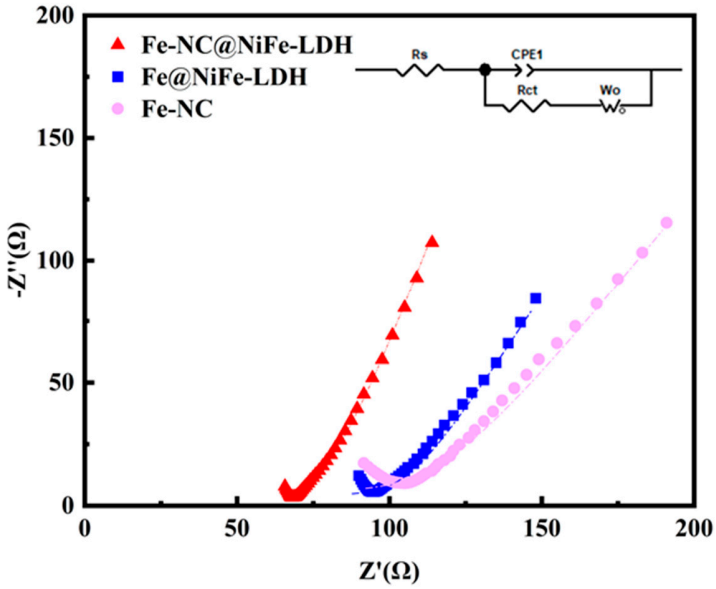


Figure S6. Nyquist plots of Fe-NC@NiFe-LDH, Fe @NiFe-LDH and Fe-NC.

Tables

Table S1. Nitrogen configuration composition in Fe-NC@NiFe-LDH and Fe-NC catalysts.

	pyridinic-N	M-N	pyrrolic-N	graphitic-N
Fe-NC@NiFe-LDH	11.36%	27.36%	46.08%	15.19%
Fe-NC	33.06%	12.00%	41.66%	13.28%

Table S2. Iron configuration composition in Fe-NC@NiFe-LDH and Fe-NC catalysts.

	Fe^{3+}	Fe^{2+}	Fe^{0}
Fe-NC@NiFe-LDH	27.92%	63.49%	8.60%
Fe-NC	22.83%	48.78%	28.39%

Table S3. Comparison of half-wave potentials for recently reported catalysts.

Catalysts	Half-Wave Potential	References
HEA/AF-5	0.94 V	Adv. Mater. 2025, e13348
D-Fe-N/C	0.918 V	Adv. Mater. 2025, 37, 2417711
Fe-N@CBs	0.91 V	Applied Catalysis b Environment-and-Energy, 2025, 370, 125189
NCHEA	0.86 V	Energy Storage Materials, 2025, 81, 104507
M-N-C	0.81 V	Electrochimica Acta, 2025, 540, 147203
$MgCoMnO_4$@CNT	0.8 V	Journal of Alloys and Compounds, 2025, 1044, 184497
$Co_{5.47}N$ PCNFs	0.79 V	Journal of Colloid and Interface Science, 2025, 680, 469-478
TON@NC	0.78 V	Advanced Composites and Hybrid Materials, 2025, 8, 335
FeCoNiCrCu/CNF	0.78 V	Journal of Materials Chemistry A, 2025, 45
70 %-γ-MnO_2/KC	0.77 V	Materials Today Energy, 2025, 53, 101975
Fe-NC@NiFe-LDH	0.83 V	This work

Table S4. The R_s and R_{ct} values of Fe-NC@NiFe-LDH, Fe @NiFe-LDH and Fe-NC.

Catalysts	R_s (Ω)	R_{ct} (Ω)
Fe-NC@NiFe-LDH	62.01	60.33
Fe@NiFe-LDH	69.93	82.99
Fe-NC	55.69	104