

Supporting Information

ZnO-Fe-N/C bimetallic electrocatalysts with antibacterial activity
for durable oxygen reduction in microbial fuel cells

Dong-Ni Ou, Fan-li Xiao, Qi-Wen Zhu, Hao-Peng Ye, Nan Li*

School of Chemistry and Chemical Engineering/Guangzhou Key Laboratory for Clean
Energy and Materials, Guangzhou University, Guangzhou 510006, China.

* Corresponding author Tel.: +86 20 39366908; fax: +86 20 39366908

E-mail: nanli@gzhu.edu.cn

Figures

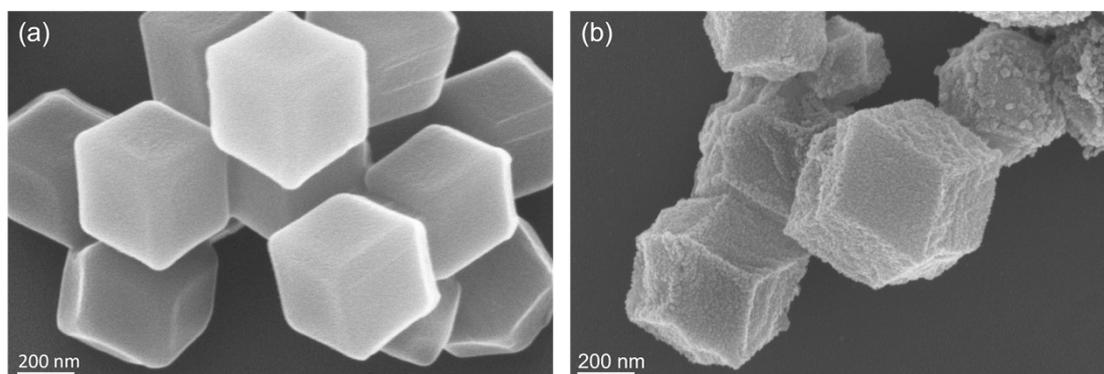


Fig. S1 SEM images of the precursor ZIF-8 and Fe-N/C catalysts.

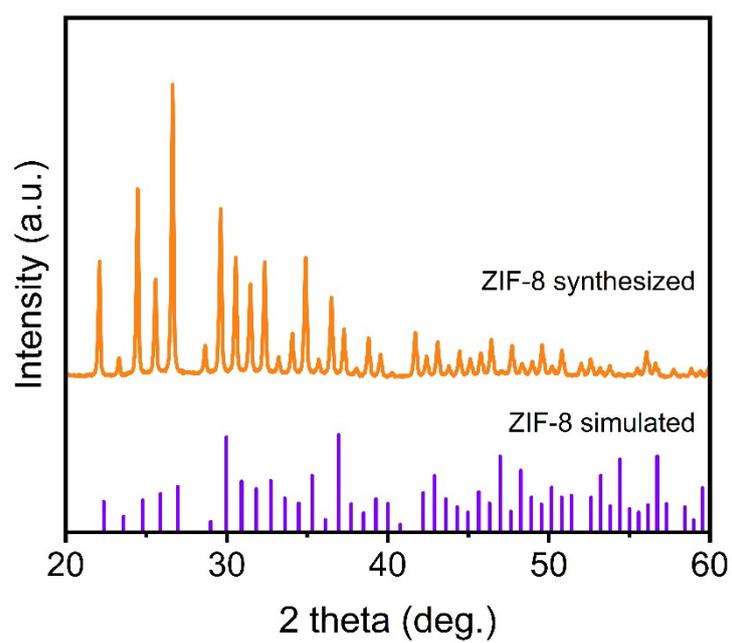


Fig. S2 XRD pattern of the precursor ZIF-8.

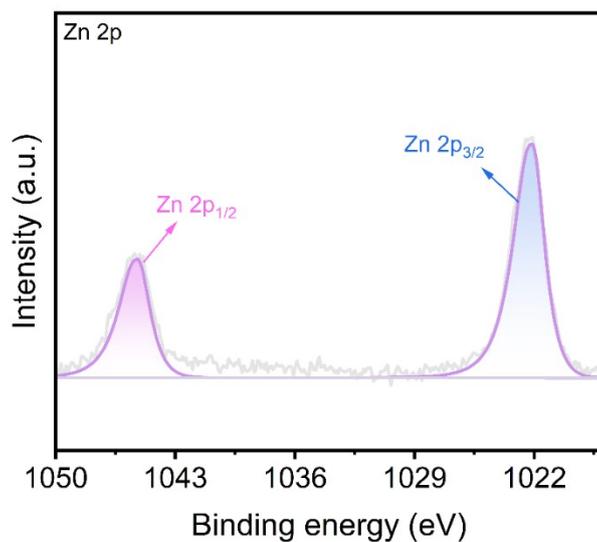


Fig. S3 High-resolution XPS spectra of Zn 2p signal in ZnO-Fe-N/C-1 catalysts.

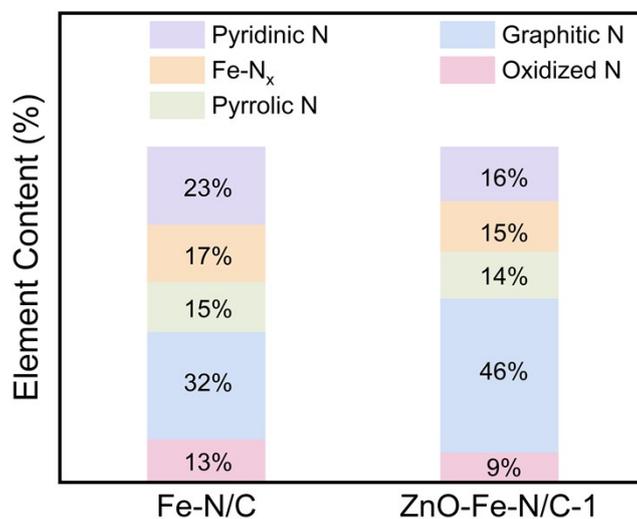


Fig. S4 Contents of catalyst active species of Fe-N/C and ZnO-Fe-N/C-1 catalysts.

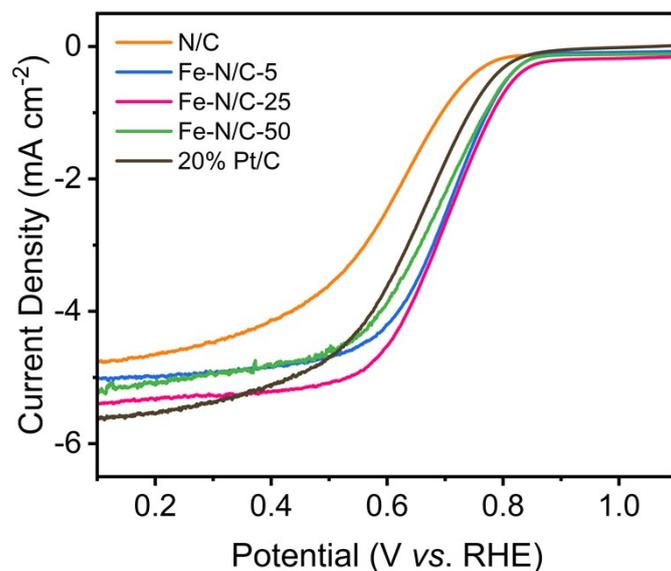


Fig. S5 LSV curves in 50 mM PBS of N/C, Fe-N/C-5, Fe-N/C-25 (Fe-N/C), Fe-N/C-50, 20% Pt/C.

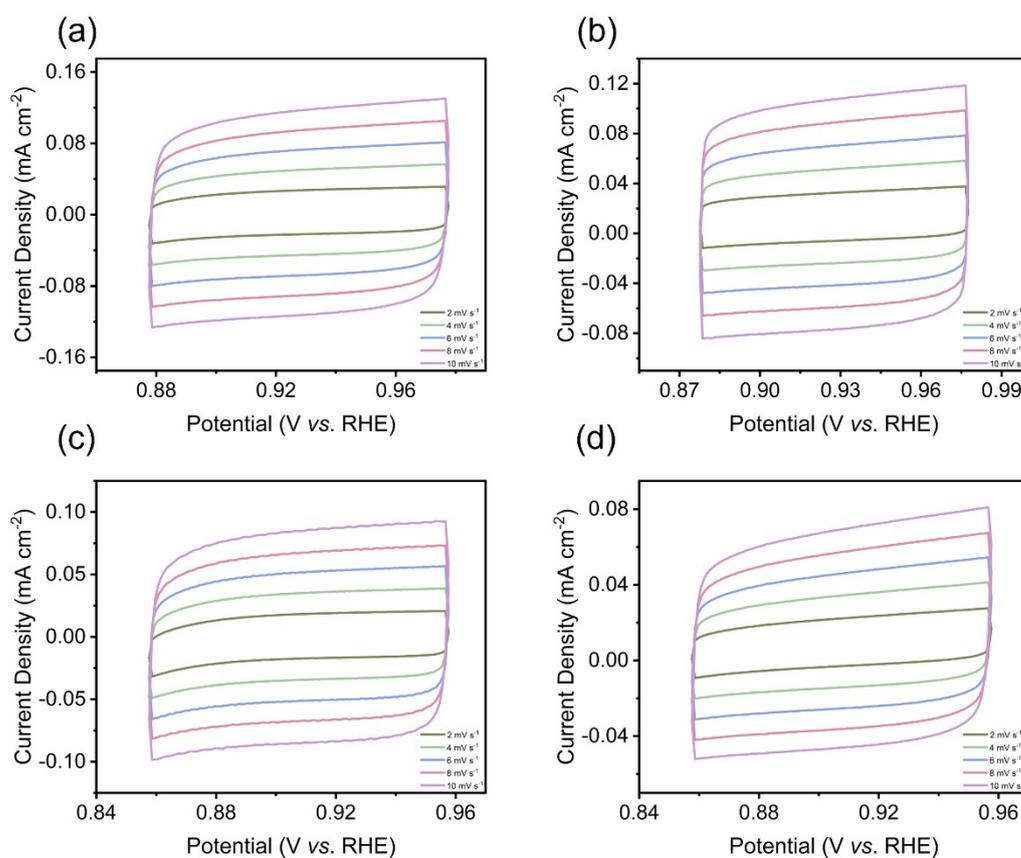


Fig. S6 CV curves in 50 mM PBS of (a) Fe-N-C, (b) ZnO-Fe-N/C-1, (c) ZnO-Fe-N/C-2, and (d) ZnO-Fe-N/C-3 with the scan rate of 2, 4, 6, 8, and 10 mV s^{-1} .

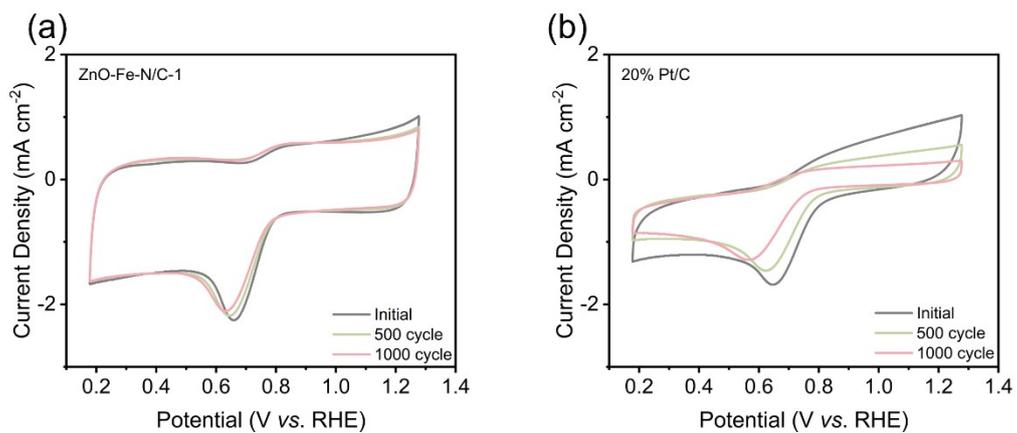


Fig. S7 CVs of (a) ZnO-Fe-N/C-1, (b) 20% Pt/C for 500 cycles and 1000 cycles in 50 mM PBS with scan rate of 50 mV s⁻¹.

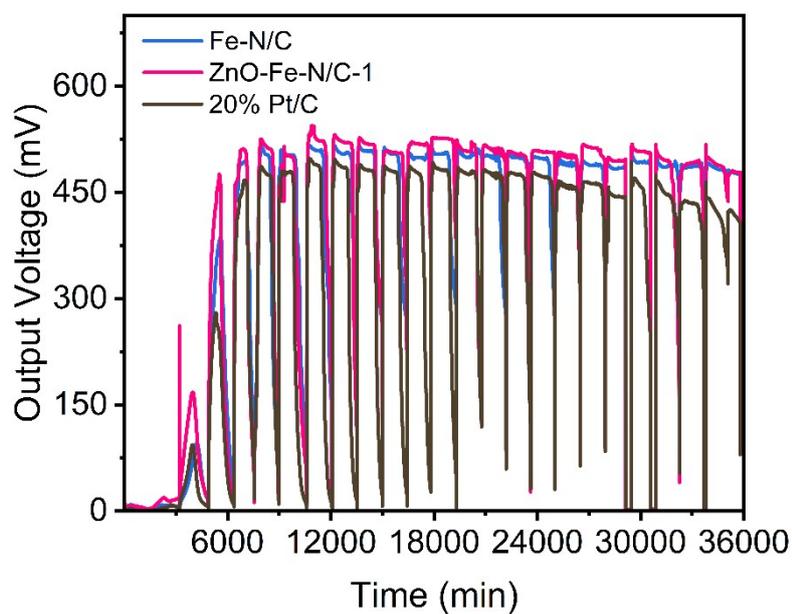


Fig. S8 Cell voltage-time curves of MFCs with ZnO-Fe-N/C-1, Fe-N/C, and 20% Pt/C catalysts.

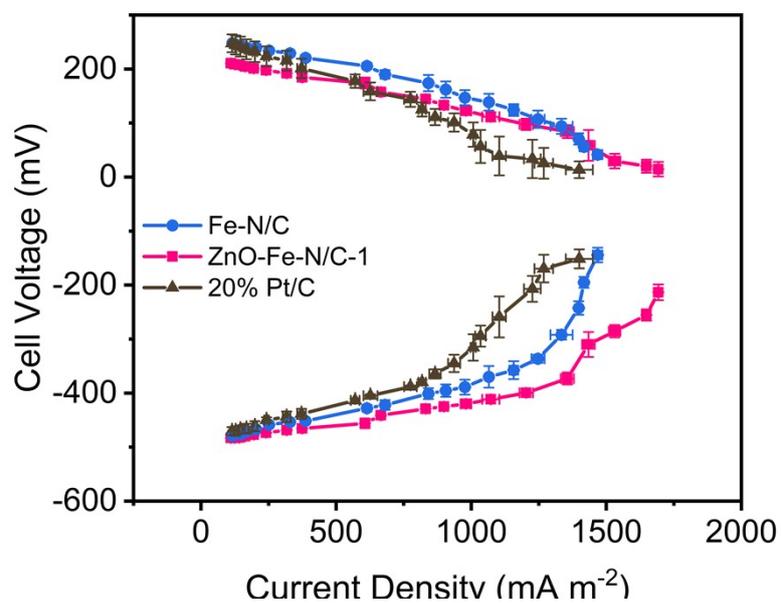


Fig. S9 The anode and cathode potentials as function of current densities of MFCs using Fe-N/C, ZnO-Fe-N/C-1 and 20% Pt/C as cathode catalysts.

Tables

Table S1 Comparison of BET specific surface area and MFCs performance of ZnO-Fe-N/C-1 with other catalysts.

Cathode catalyst	BET surface area (m ² g ⁻¹)	Output voltage (mV)	Maximum power density (mW m ⁻²)	Reference
ZnO-Fe-N/C-1	1427.1	543.2 ± 1.9	643.5 ± 23.0	This work
FNC-15	807.7	489	471.89	[1]
Cu-N/C@Cu-2	1160.51	503	581	[2]
MSAC-750	1670.3	425	378.68	[3]
MPC-800	1168	470	240	[4]
CuCo@Zn-NC-75	491.74	440	403.68	[5]
PANI@Fe/NC	312.518	609	637.53	[6]
Ag-Fe-N/C-2	805.79	568	523	[7]
Ag/Fe-N-C-2:1	311.7	425	275	[8]
ZIF-67@MoS ₂	1627.3554	420	302.5	[9]

Table S2 Cost of ZnO-Fe-N/C-1-based MFCs versus 20% Pt/C-based MFCs.

Cathode catalyst	Maximum power density (mW m ⁻²)	Catalyst cost (dollar)	Power density cost (dollar / W m ⁻²)
ZnO-Fe-N/C-1	643.5	≈ 1.02	≈ 1.59
20% Pt/C	430.21	≈ 2.34	≈ 5.44

Table S3 Bacterial community alpha diversity analysis.

Sample	OTUs	Chao1	ACE
ZnO-Fe-N/C-1	816	816.60	819.24
Fe-N/C	952	954.34	958.85
20% Pt/C	1215	1253.79	1268.62

Table S4 The relative abundance (%) of dominant colonies in phylum level.

Phylum	ZnO-Fe-N/C-1	Fe-N/C	20% Pt/C
Proteobacteria	68.94	61.88	43.42
Bacteroidota	7.91	10.84	16.27
Firmicutes	9.93	14.09	15.51
Actinobacteriota	5.05	4.74	7.49
Patescibacteria	0.09	0.02	14.29
Chloroflexi	1.28	2.00	0.31
Gemmatimonadota	1.30	0.56	0.31
Verrucomicrobiota	0.74	0.57	0.32
Acidobacteriota	0.52	0.75	0.19
Planctomycetota	0.90	0.74	0.63
Myxococcota	0.68	0.39	0.51
Desulfobacterota	0.25	0.86	0.06
Candidatus_Saccharibacteria	0.72	0.04	0.37
Nitrospirota	0.24	0.40	0.06
Deinococcota	0.86	0.17	0.04
Campylobacterota	0.07	1.24	0.02
Bdellovibrionota	0.15	0.04	0.03
Cyanobacteria	0.07	0.10	0.02
MBNT15	0.04	0.11	0.01
Spirochaetota	0.01	0.08	0.00
Fusobacteriota	0.07	0.09	0.03
Methylomirabilota	0.04	0.09	0.01
unclassified	0.03	0.03	0.05
Armatimonadota	0.09	0.01	0.03
Synergistota	0.01	0.05	0.00
Latescibacterota	0.00	0.04	0.00
Deferribacterota	0.01	0.02	0.00
Nitrospinota	0.00	0.00	0.00
Calditrichota	0.00	0.00	0.00
Chlamydiae	0.00	0.00	0.00
Deinococcus-Thermus	0.00	0.00	0.00
Cloacimonadota	0.00	0.00	0.00
Others	0.02	0.03	0.00

References

- 1 K. Q. Zhong, H. H. You, L. Huang, H. Li, L. Z. Huang, X. J. Liu and H. G. Zhang, *J. Power Sources*, 2023, **579**, 233232.
- 2 B. L. Lai, H. X. Wei, Z. N. Luo, T. Zheng, Y. H. Lin, Z. Q. Liu and N. Li, *Sci. Total Environ.*, 2023, **856**, 159083.
- 3 H. M. Ning, Z. Zhang, C. H. Shi, X. L. Ma, J. Li, H. Y. Zhu and J. W. Hu, *RSC Adv.*, 2022, **12**, 30145-30156.
- 4 Z. T. Zha, Z. Zhang, P. Xiang, H. Y. Zhu, X. P. Shi and S. H. Chen, *Sci. Total Environ.*, 2021, **764**, 142918.
- 5 X. Yang, C. Li, C. Li, J. R. Lu, C. X. Wang and H. Liu, *J. Environ. Chem. Eng.*, 2026, **14**, 121707.
- 6 S. K. Dhillon and P. P. Kundu, *Chem. Eng. J.*, 2022, **431**, 133341.
- 7 B. L. Lai, Z. H. Xiao, P. Y. Jiang, Y. Xie, N. Li and Z. Q. Liu, *ChemElectroChem*, 2022, **9**, 1-9.
- 8 K. Q. Zhong, L. Z. Huang, H. Li, Y. Dai, H. G. Zhang, R. Y. Yang, S. R. Babu Arulmani, X. J. Liu, L. Huang and J. Yan, *Carbon*, 2021, **183**, 62-75.