

# Interfacial Electron Transfer and Synergistic Effects on NiCo(CA)@M Microbars that Boost the Alkaline Oxygen Evolution Reaction

Jiajia Liu<sup>1</sup>, Xiao Wang<sup>2</sup>, Yulin Min<sup>1,3</sup>, Qiaoxia Li<sup>1,3\*</sup>, and Qunjie Xu<sup>1,3\*</sup>

<sup>1</sup> Shanghai Key Laboratory of Materials Protection and Advanced Materials Electric Power, Shanghai University of Electric Power, Shanghai 200090, P. R. China

<sup>2</sup> School of Environmental and Chemical Engineering, Shanghai University, Shanghai 200444, China

<sup>3</sup> Shanghai Institute of Pollution Control and Ecological Security, Shanghai 200092, P. R. China

\* Corresponding authors

E-mail : [liqiaoxia@shiep.edu.cn](mailto:liqiaoxia@shiep.edu.cn); [xuqunjie@shiep.edu.cn](mailto:xuqunjie@shiep.edu.cn)

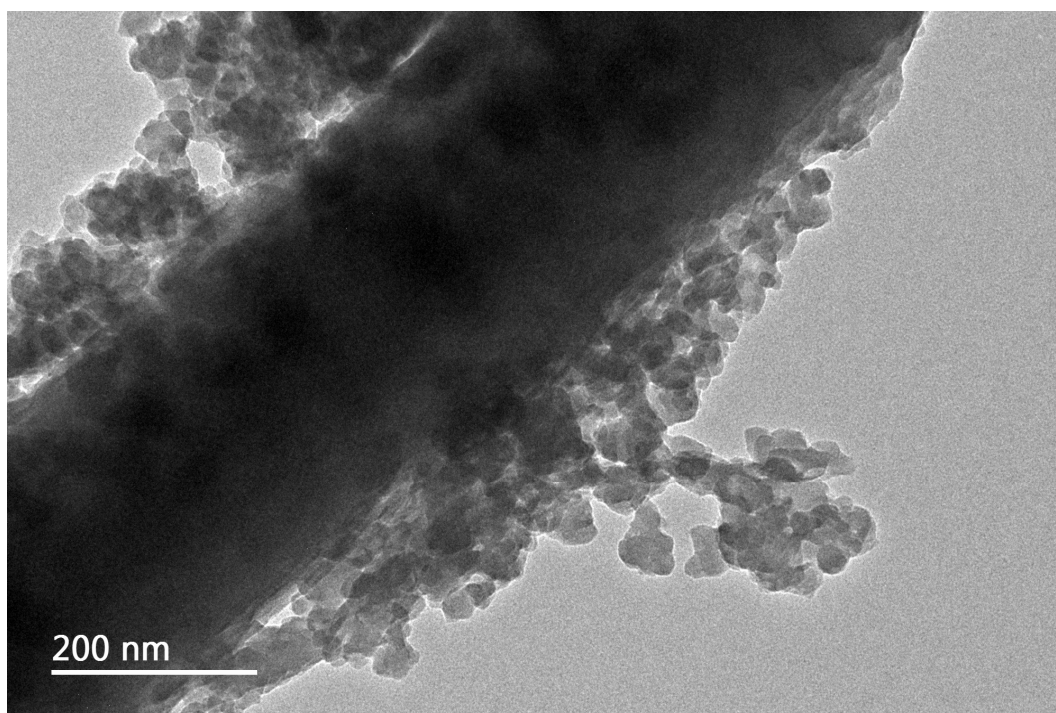


Figure S1. locally enlarged TEM images of NiCo(CA)@M.



Figure S2. EDS spectrum of NiCo(CA)@M.

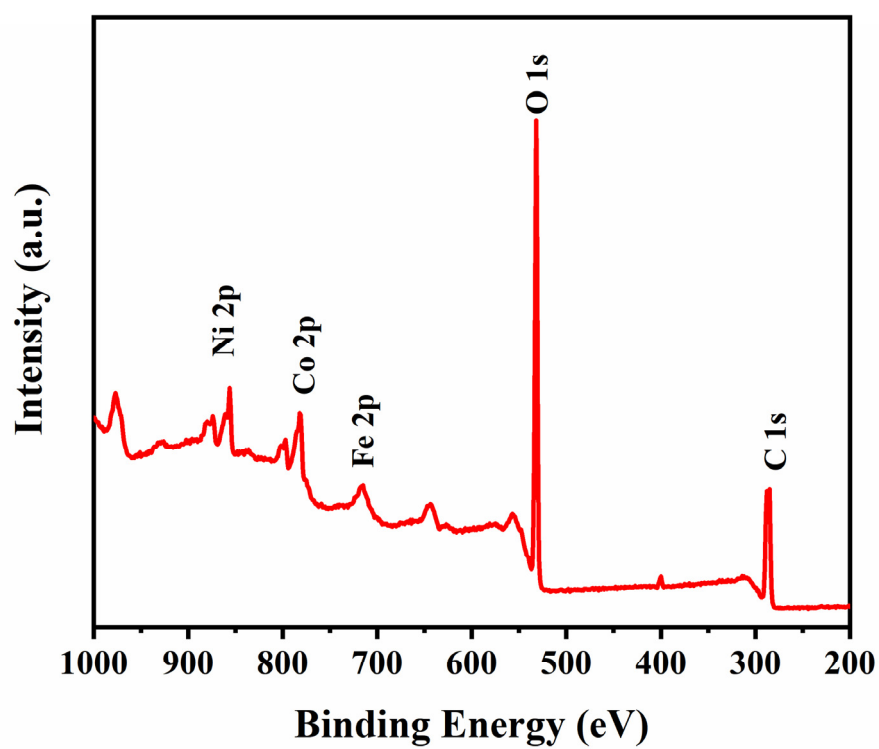


Figure S3. XPS survey spectrum for NiCo(CA)@M.

Table S1. The energy dispersion spectrum(EDS) element analysis results of NiCo(CA)@M.

Element	wt%	$\sigma$
C	51.33	0.2
O	27.42	0.1
Fe	18.81	0.1
Co	1.64	0
Ni	0.80	0

Table S2. Impedance fitting data  $R_{ct}$  for MIL-88A, Ni(CA), Ni(CA)@M, NiCo(CA)@M, Co(CA)@M, and Co(CA).

Catalyst	$R_{ct}$
MIL-88A	7.879 $\Omega$
Ni(CA)	11.970 $\Omega$
Ni(CA)@M	2.510 $\Omega$
NiCo(CA)@M	2.255 $\Omega$
Co(CA)@M	2.620 $\Omega$
Co(CA)	2.877 $\Omega$

Table S3. Comparison of the activity for the NiCo(CA)@M catalyst with recently reported electrocatalysts in alkaline media.

Catalyst	$\eta_{10}$ (vs.RHE)	References
CoMo-MI-600	316 mV	1
Co-Fe-BDC	295 mV	2
Co(OH) <sub>2</sub> /MIL-88A	278 mV	3
NiCoFe LTHs/CFC	320 mV	4
CoNi/NC-YS	292 mV	5
Ni <sub>x</sub> Co <sub>3-x</sub> O <sub>4</sub>	337 mV	6
NiFe-MOF	390 mV	7
NiCoP/NF	370 mV	8
NiFe alloy	298 mV	9
NDA/MWCNTs-a	295 mV	10
Co <sub>3</sub> O <sub>4</sub> -NiO/NF	311 mV	11
300h/Co/CC	300 mV	12
UTSA-16	408 mV	13
MIL-88A	402 mV	<b>This work</b>
NiCo(CA)@M	270 mV	<b>This work</b>

## References

1. Guo, Y.; Huang, Q.; Ding, J.; Zhong, L.; Li, T.-T.; Pan, J.; Hu, Y.; Qian, J.; Huang, S. CoMo carbide/nitride from bimetallic MOF precursors for enhanced OER performance. *Int J Hydrogen Energy*. **2021**, 46, 22268-22276.
2. Li, F.; Li, J.; Zhou, L.; Dai, S. Enhanced OER performance of composite Co-Fe-based MOF catalysts via a one-pot ultrasonic-assisted synthetic approach. *Sustain Energy Fuels*. **2021**, 5, 1095-1102.
3. Zhang, Q.; Han, P.; Zhang, H.; Yao, J.; Wang, X.; Chen, D.; Zuo, X.; Yang, Q.; Jin, S.; Li, G. Enhanced Oxygen Evolution Activity Aroused from Interfacial Electron Transfer and Synergism in Co(OH)<sub>2</sub>/MIL-88A Heterostructure. *J Electrochem Soc*. **2022**, 169, 106518.
4. Wang, A.-L.; Xu, H.; Li, G.-R. NiCoFe Layered Triple Hydroxides with Porous Structures as High-Performance Electrocatalysts for Overall Water Splitting. *ACS Energy Lett*. **2016**, 1, 445-453.
5. Hou, G.; Jia, X.; Kang, H.; Qiao, X.; Liu, Y.; Li, Y.; Wu, X.; Qin, W. CoNi nano-alloys modified yolk-shell structure carbon cage via *Saccharomyces* as carbon template for efficient oxygen evolution reaction. *Appl. Catal. B Environ*. **2022**, 315, 121551.
6. Yan, X.; Li, K.; Lyu, L.; Song, F.; He, J.; Niu, D.; Liu, L.; Hu, X.; Chen, X. From Water Oxidation to Reduction: Transformation from Ni<sub>x</sub>Co<sub>3-x</sub>O<sub>4</sub> Nanowires to NiCo/NiCoO<sub>x</sub> Heterostructures. *ACS Appl. Mater. Interfaces*. **2016**, 8, 3208-3214.
7. Zhou, J.; Han, Z.; Wang, X.; Gai, H.; Chen, Z.; Guo, T.; Hou, X.; Xu, L.; Hu, X.; Huang, M.; et al. Discovery of Quantitative Electronic Structure-OER Activity Relationship in Metal-Organic Framework Electrocatalysts Using an Integrated Theoretical-Experimental Approach. *Adv. Funct. Mater*. **2021**, 31, 2102066.
8. Wang, D.; Zhang, Y.; Fei, T.; Mao, C.; Song, Y.; Zhou, Y.; Dong, G. NiCoP/NF 1D/2D Biomimetic Architecture for Markedly Enhanced Overall Water Splitting. *Chemelectrochem*. **2021**, 8, 3064-3072.
9. Lim, D.; Oh, E.; Lim, C.; Shim, S. E.; Baeck, S.-H. Bimetallic NiFe alloys as highly efficient electrocatalysts for the oxygen evolution reaction. *Catal Today*. **2020**, 352, 27-33.
10. Kiran, S.; Yasmeen, G.; Shafiq, Z.; Abbas, A.; Manzoor, S.; Hussain, D.; Pashameah, R. A.; Alzahrani, E.; Alanazi, A. K.; Ashiq, M. N. Nickel-based

nitrodopamine MOF and its derived composites functionalized with multi-walled carbon nanotubes for efficient OER applications. *Fuel*. **2023**, 331, 125881.

11. Gaur, A.; Pundir, V.; Krishankant; Rai, R.; Kaur, B.; Maruyama, T.; Bera, C.; Bagchi, V. Interfacial interaction induced OER activity of MOF derived superhydrophilic Co<sub>3</sub>O<sub>4</sub>-NiO hybrid nanostructures. *Dalton T.* **2022**, 51, 2019-2025.
12. Kang, T.; Kim, J. Optimal cobalt-based catalyst containing high-ratio of oxygen vacancy synthesized from metal-organic-framework (MOF) for oxygen evolution reaction (OER) enhancement. *Appl. Surf. Sci.* **2021**, 560, 150035.
13. Jiang, J.; Huang, L.; Liu, X.; Ai, L. Bioinspired Cobalt-Citrate Metal-Organic Framework as an Efficient Electrocatalyst for Water Oxidation. *ACS Appl. Mater. Interfaces*. **2017**, 9, 7193-7201.