

Polyoxometalate-Decorated MWCNTs as High-Performance Electrocatalysts for Oxygen Reactions

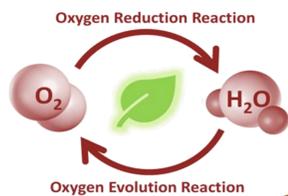
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INTRODUCTION & AIM

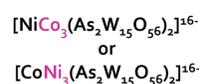
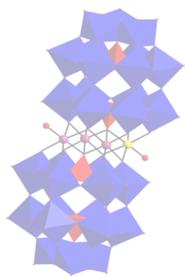
- To meet global energy demands, it's vital to develop affordable, high-quality electrocatalysts (ECs) materials.
- Current reliance on noble metal-based electrocatalysts in fuel cells and water-splitting devices is limited by their high cost, scarcity, and operational instability.
- Polyoxometalates (POMs) are presented as a promising alternative, offering a cost-effective and efficient solution for electrocatalysis.
- Synthesis of two new composites based on doped multi-walled carbon nanotubes (MWCNT_N8) and two Wells-Dawson sandwich POMs.



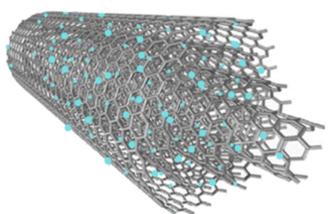
METHOD

Wells-Dawson sandwich Polyoxometalates

- ✓ Nanoscale Metal-Oxo anionic clusters;
- ✓ Unique structures and compositions;
- ✓ Tunable redox and (electro)catalytic properties;
- ✓ Capability to mediate multi-electron transfer reactions;
- ✓ Tunable redox properties via metal substitution.



Doped multi-walled carbon nanotubes

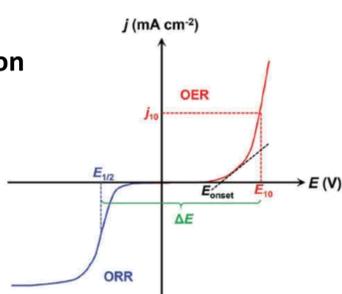


MWCNT_N8

- ✓ Pyrolysis-based synthesis;
- ✓ Mechanical treatment in ball milling using melamine as nitrogen precursor;
- ✓ Thermal/chemical stability;
- ✓ Electric conductivity;
- ✓ Porous texture.

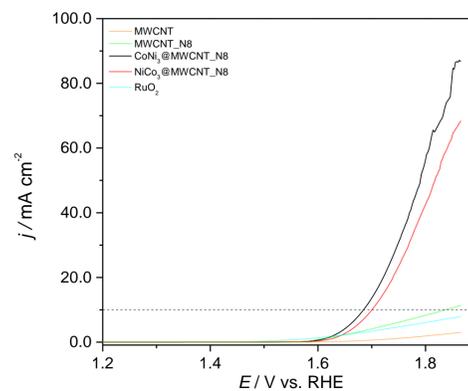
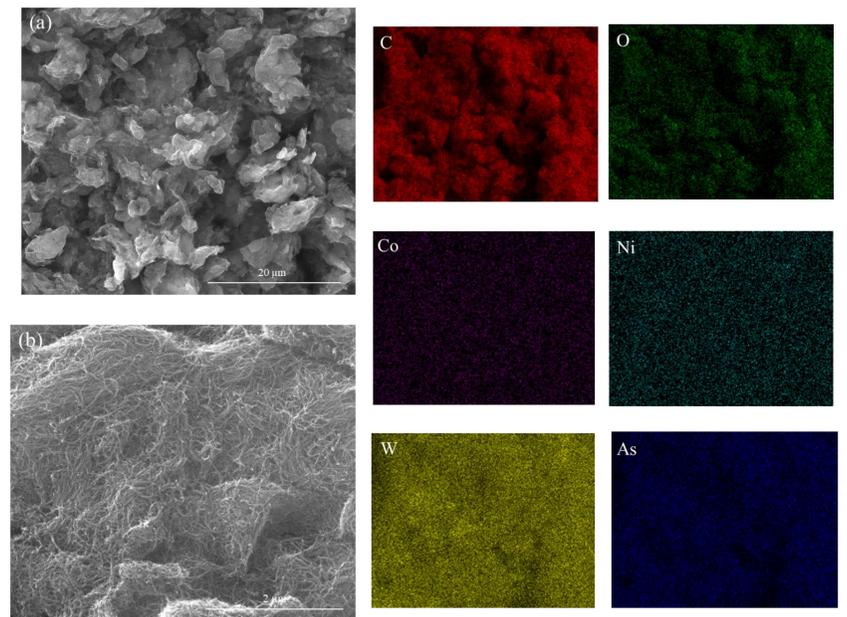
The oxygen reduction (ORR) and oxygen evolution (OER) reactions are two crucial energy-related processes in fuel cell and electrolyser system.

- ✓ 3-electrode cell setup;
- ✓ Electrolyte: 0.1 M KOH;
- ✓ WE: RDE with GC disk;
- ✓ RE: Ag/AgCl;
- ✓ CE: Pt wire for OER and C rod for ORR;
- ✓ Tests (scan rate = 5 mV/s): LSV plots at 1600 rpm.

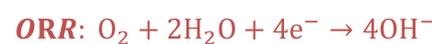


RESULTS & DISCUSSION

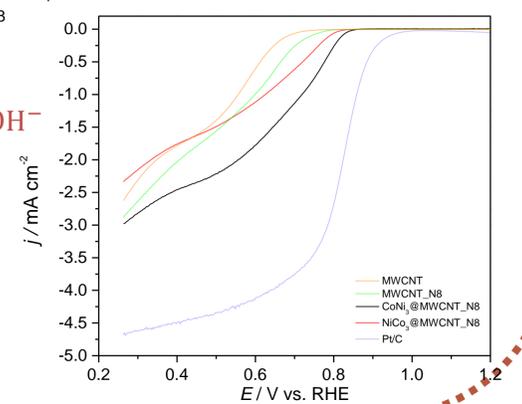
SEM/EDX Elemental mapping



Catalyst	E_{10} (V vs. RHE)	η_{10} ($j=0.1 \text{ mA cm}^{-2}$)	j_{max} (mA cm^{-2})
MWCNT	-	-	2.98
MWCNT_N8	1.84	0.61	11.28
CoNi ₃ @MWCNT_N8	1.68	0.45	86.70
NiCo ₃ @MWCNT_N8	1.70	0.47	68.32
RuO ₂	-	-	7.88



Catalyst	E_{onset} (5% Total)	j_L (mA cm^{-2})	n_{O_2}
MWCNT	0.67	-2.62	2.3
MWCNT_N8	0.73	-2.88	2.4
CoNi ₃ @MWCNT_N8	0.82	-2.98	2.1
NiCo ₃ @MWCNT_N8	0.79	-2.33	2.0
Pt/C	0.91	-4.68	3.9



CONCLUSION

- ✓ Elemental mapping confirmed uniform immobilization of POMs on MWCNT_N8.
- ✓ The CoNi₃@MWCNT_N8 composite exhibited superior bifunctional performance in both OER and ORR.
- ✓ These findings highlight its potential as a cost-effective and efficient electrocatalyst for energy conversion applications.

REFERENCES

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- Marques, I.S. et al. Synergetic Effects of Mixed-Metal Polyoxometalates@Carbon-Based Composites for ORR and OER. *Catalysts*, 2022, 12, 440