

Supplementary material

(Co,Mn)₃O₄ Doping Carbon Nanotubes Composite as

Bifunctional Electrocatalyst for Aluminum-air Battery

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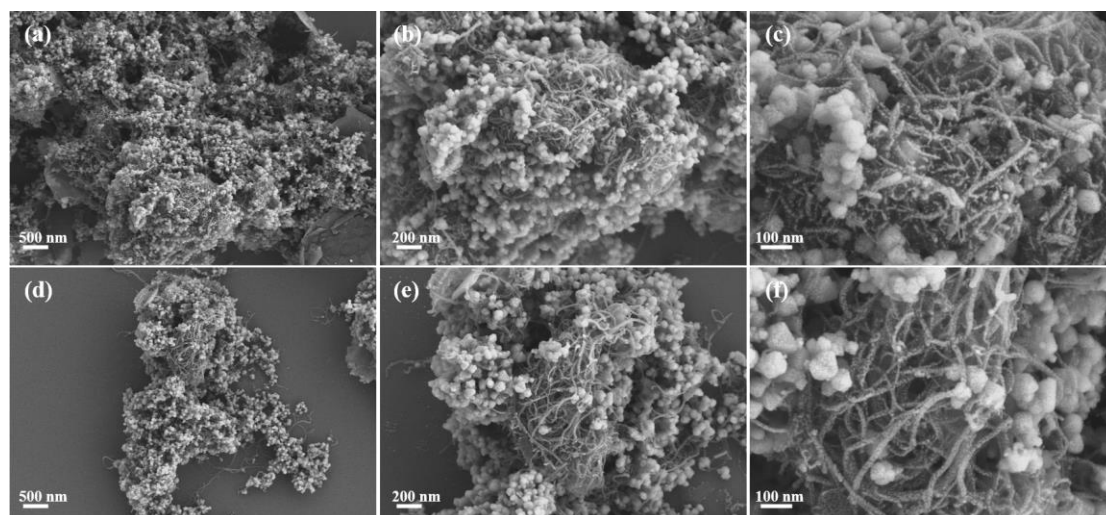


Fig. S1. SEM images of (a-c) Co₃O₄/NG, and (d-f) Mn₃O₄/NG.

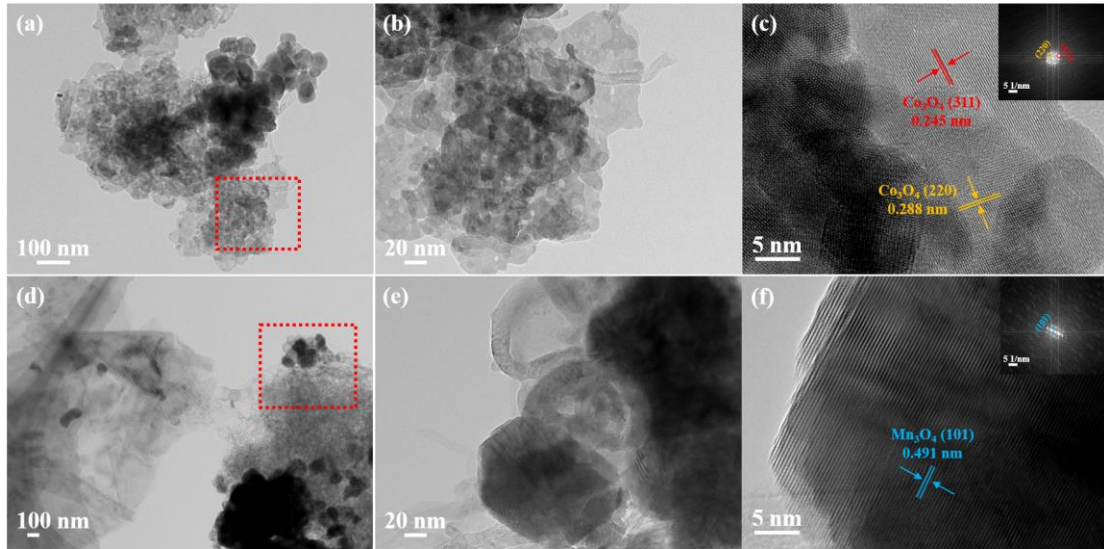


Fig. S2. TEM and HRTEM images (the inset is corresponding FFT pattern) of (a-c) $\text{Co}_3\text{O}_4/\text{NG}$ and (d-f) $\text{Mn}_3\text{O}_4/\text{NG}$ sample.

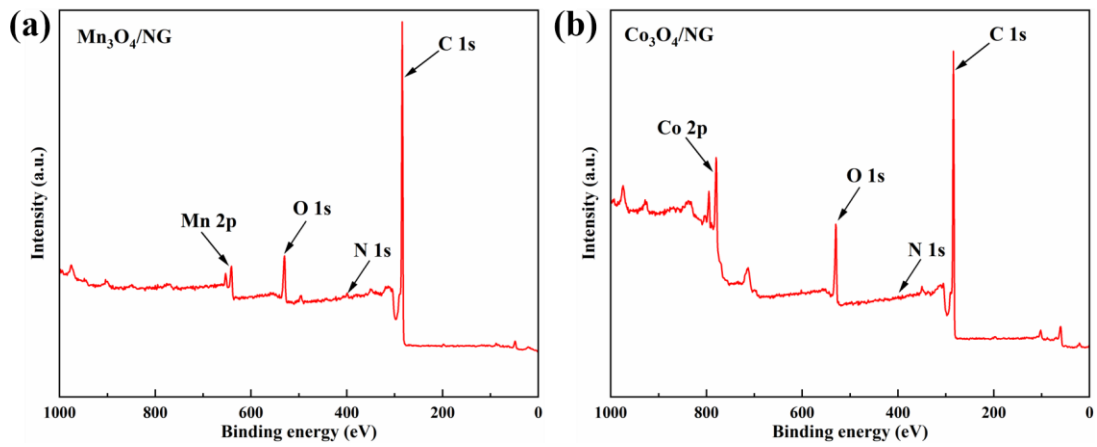


Fig. S3. XPS survey spectrums of (a) $\text{Co}_3\text{O}_4/\text{NG}$ and (b) $\text{Mn}_3\text{O}_4/\text{NG}$.

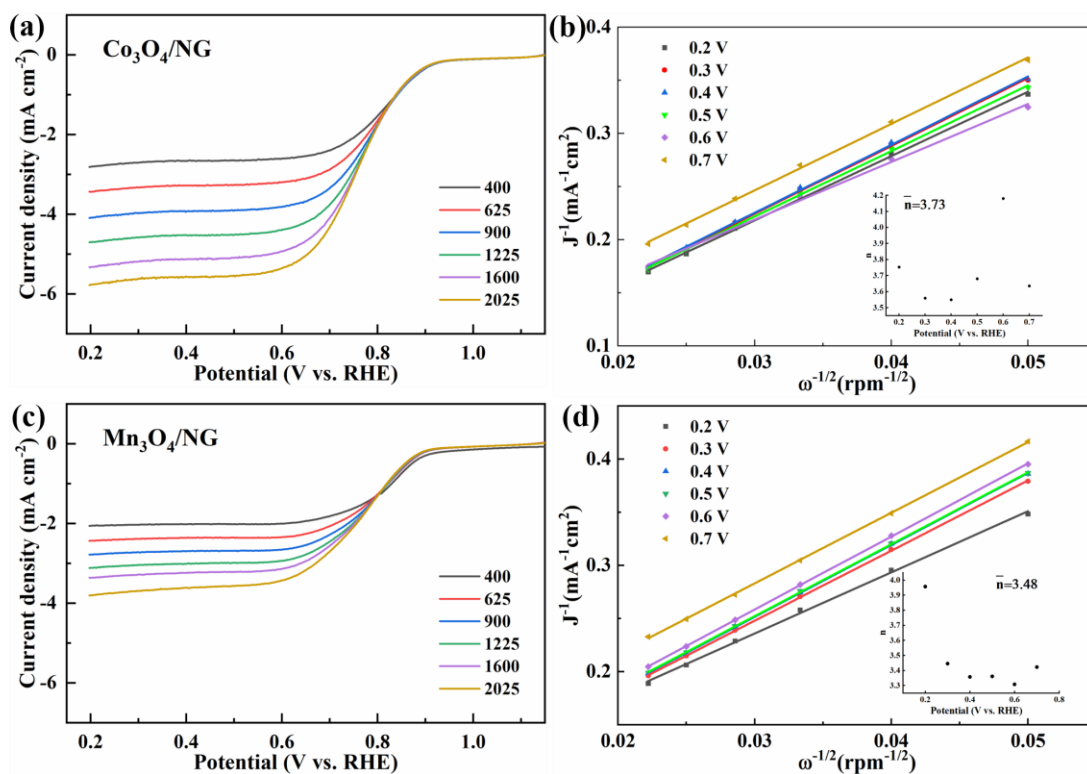


Fig. S4. (a) ORR LSV curves of $\text{Co}_3\text{O}_4/\text{NG}$ at different rotating rates and (b) corresponding K-L plots and electron transfer numbers at different potentials, (c) ORR LSV curves of $\text{Mn}_3\text{O}_4/\text{NG}$ at different rotating rates, and (d) corresponding K-L plots and electron transfer numbers at different potentials.

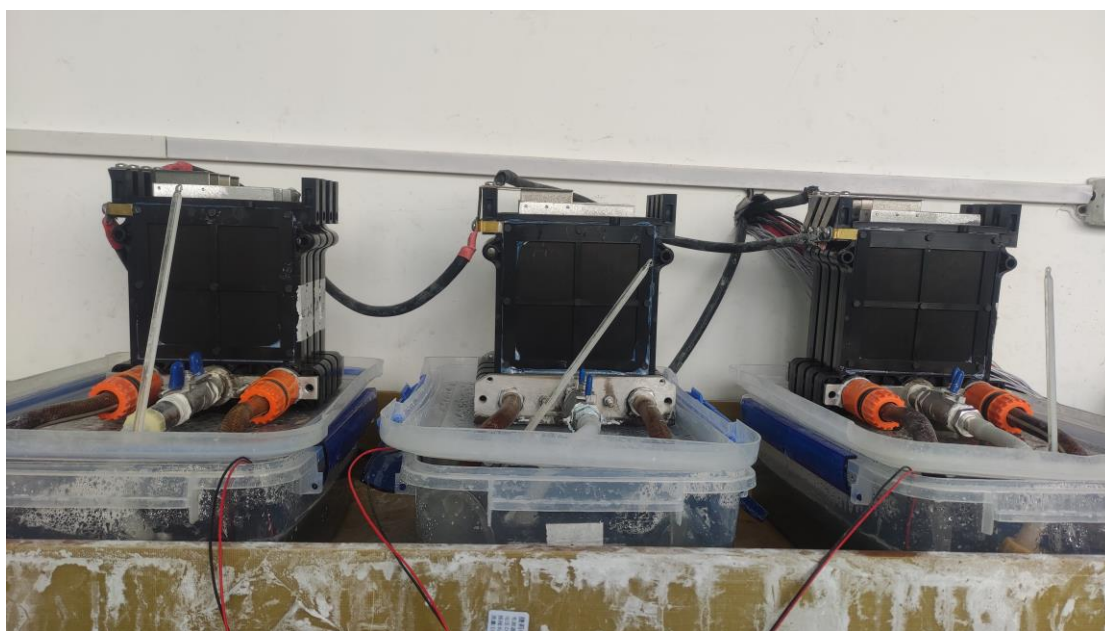


Fig. S5. Image of 200 W Al-air batteries stack in series.

Table S1. The detailed electrochemical parameters from various catalysts.

Catalyst	ORR					OER			
	Cathodic peak potential (V vs. RHE)	Anodic peak potential (V vs. RHE)	Limiting current density (mA cm ⁻²)	Half-wave potential (V vs. RHE)	Average electron transfer numbers	Tafel slope (mV dec ⁻¹)	E _j (V vs. RHE)	Tafel slope (mV dec ⁻¹)	Current retention rate (%)
Pt/C	0.78	0.99	5.529	0.839	-	87.17	1.90	291.45	70.84
NG	0.67	1.03	3.670	0.764	-	-	-	-	-
Co ₃ O ₄ /NG	0.84	1.02	5.329	0.765	3.77	92.49	1.75	120.34	81.33
Mn ₃ O ₄ /NG	0.71	-	3.364	0.776	3.48	113.09	1.84	202.03	89.58
(Co,Mn) ₃ O ₄ /NG	0.83	1.03	5.361	0.831	3.99	84.53	1.72	112.51	93.53

Table S2. Comparison of Co, Mn oxides electrocatalysts performance for ORR and OER.

Catalyst	Limiting current density (mA cm ⁻²)	Half-wave potential (V vs. RHE)	Average electron transfer numbers	E _j @10 mA cm ⁻² (V vs. RHE)	Ref.
(Co,Mn) ₃ O ₄ /NG	5.361	0.831	3.99	1.72	This work
Co ₃ O ₄ /Mn ₃ O ₄ /CNFs	6.96	0.85	3.96	1.63	S1
Co ₃ O ₄ /Mn ₃ O ₄ (2:1)/N-rGO	-	0.86	3.85	1.59	S2
Mn ₃ O ₄ /O-CNTs	3.26	0.85	3.95	1.64	S3
Co ₃ O ₄ /Co ₂ MnO ₄	5.17	1.09	3.80	1.77	S4
Mn _{0.25} -Co ₃ O ₄ /CNTs	6.17	0.75	3.84	1.76	S5
Mn _{1.8} Co _{0.2} (OH) ₃ VO ₃	5.50	0.785	-	1.74	S6
Mn/Co-N-C-0.02-800	5.30	0.80	4.00	1.66	S7
Co/Zn/Mn@NC-800	~5.50	0.86	3.65	1.59	S8
Mn/Co-450/ZIF-67	7.04	0.78	4.00	1.61	S9
MnO-Co@N-doped carbon	4.64	0.82	4.08	1.59	S10

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