

Supplementary Information for

Nickel-doped δ -MnO₂ abundant in oxygen vacancies as cathode for aqueous Zn-ion batteries with superior performance

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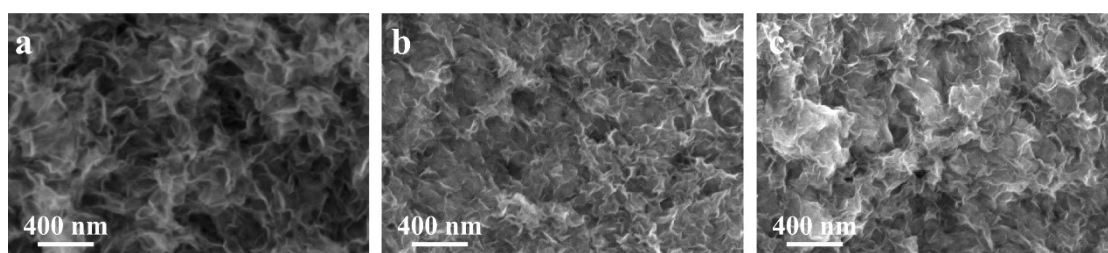


Fig. S1. SEM images of (a) 3%Ni- δ -MnO₂, (b) 4%Ni- δ -MnO₂ and (c) 6%Ni- δ -MnO₂.

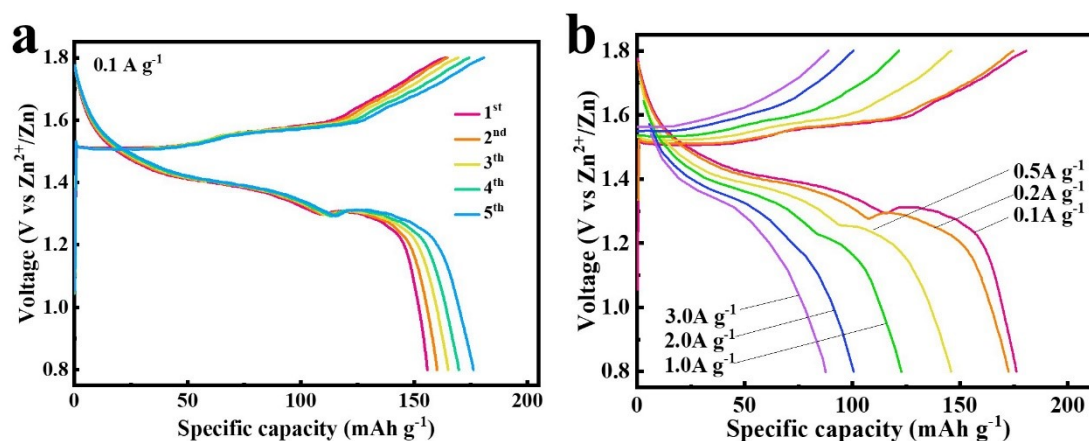


Fig. S2. (a) GCD profiles at 0.1 A g⁻¹ in the initial five cycles, and (b) GCD profiles of the δ -MnO₂ cathode across different current densities.

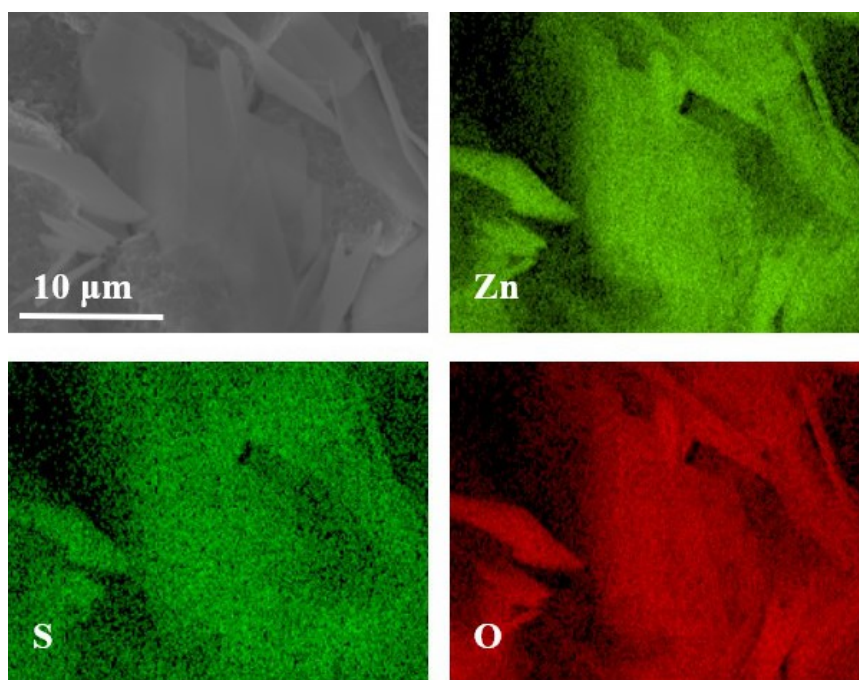


Fig. S3. EDS mapping of the 5%Ni- δ -MnO₂ cathode when discharged to 0.8 V.

Table S1. SSA, TPV and APD of δ -MnO₂ and 5%Ni- δ -MnO₂.

Samples	SSA (m ² g ⁻¹)	TPV (cm ³ g ⁻¹)	APD (nm)
δ -MnO ₂	24.02	0.053428	3.5135
5%Ni- δ -MnO ₂	84.28	0.143309	3.7450

Table S2 Summary of the electrochemical performance of various heteroatom-doped manganese-based cathodes in ZIBs.

Cathode	Electrolyte	Voltage window	Specific capacity	Cycling stability	Ref.
5%Ni- δ -MnO ₂	2 M ZnSO ₄ + 0.25 M MnSO ₄	0.8-1.8 V	401.6 mAh g ⁻¹ at 0.1 A g ⁻¹	75.5% retention after 1000 cycles at 1 A g ⁻¹	This work
Ce-MnO ₂ @CC	PAM/ZnSO ₄ - MnSO ₄	0.8-1.8 V	311 mAh g ⁻¹ at 0.1 A g ⁻¹	65.0% retention after 450 cycles at 0.1 A g ⁻¹	1
K- δ -MnO ₂	2 M ZnSO ₄ + 0.1 M MnSO ₄	1-1.9 V	270.5 mAh g ⁻¹ at 0.1 A g ⁻¹	~50% retention after 1000 cycles at 2 A g ⁻¹	2

V-doped MnO ₂	1 M ZnSO ₄	1-1.8 V	266 mAh g ⁻¹ at 0.1 A g ⁻¹	49.2% retention after 100 cycles at 0.1 A g ⁻¹	3
Zn-doped MnO ₂	2 M ZnSO ₄ + 0.2 M MnSO ₄	1-1.8 V	~320 mAh g ⁻¹ at 0.1 A g ⁻¹	66% retention after 100 cycles at 0.2 A g ⁻¹	4
La–Ca co- doped ε-MnO ₂	2 M ZnSO ₄ + 0.4 M MnSO ₄	0.8-1.9 V	297 mAh g ⁻¹ at 0.2 A g ⁻¹	76% retention after 100 cycles at 0.2 A g ⁻¹	5
Co-Mn ₃ O ₄	2 M ZnSO ₄ + 0.2 M MnSO ₄	0.2-2.2 V	220 mAh g ⁻¹ at 0.1 A g ⁻¹	72.5% retention after 1100 cycles at 2 A g ⁻¹	6
Mo-MnO ₂	2 M ZnSO ₄ + 0.1 M MnSO ₄	0.9-1.8 V	327 mAh g ⁻¹ at 0.2 A g ⁻¹	76.8% retention after 1000 cycles at 1 A g ⁻¹	7

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