# Supplementary Information

## Hierarchical mesoporous $CuMn_2O_4/ZnMn_2O_4$ hollow microspheres as cathode for aqueous zinc ion batteries

Song Liu[1,2]*, Zhengfei Zhang[1], Zhenhai Yu[1], Changguo Xue[1,3]

[1]School of Materials Science and Engineering, Anhui University of Science and Technology, Huainan 232001, China

[2]Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), Nankai University, Tianjin 300071, China

[3]CAS Key Laboratory of Mechanical Behavior and Design of Materials, University of Science and Technology of China, Hefei 230026, China

E-mail address: songliu@aust.edu.cn

### 1. Materials characterization

The surface morphology of the synthesized materials was characterized using a field-emission scanning electron microscope (Zeiss Gemini 500). High-resolution transmission electron microscopy (HRTEM) analysis was performed on an FEI-Themis Z instrument operated at 300 kV to resolve crystallographic features. X-ray diffraction (XRD) patterns were recorded with a Bruker D8 ADVANCE diffractometer using Cu Kα radiation (λ=1.5406 Å) in the 2θ range of 10°–80°. Raman spectroscopy measurements were conducted on a LabRAM HR800 spectrometer equipped with a 632.8 nm He-Ne laser, collecting spectra from 100 to 1000 $cm^{-1}$. Surface chemical states and elemental compositions were analyzed via X-ray photoelectron spectroscopy (XPS) using an ESCALAB 250XI spectrometer with monochromatic Al Kα excitation source.

### 2. Electrochemical measurement

CR2032 coin-type cells were assembled for electrochemical evaluation. The cathode slurry was prepared by uniformly mixing active material, conductive carbon (acetylene black), and poly(vinylidene fluoride) (PVDF) binder in an N-methyl-2-pyrrolidone (NMP) solvent at a mass ratio of 7:2:1. After mechanical grinding for 30 min followed by magnetic stirring for 12 h, the homogeneous slurry was coated onto carbon cloth substrates and dried at 80 °C for 12 h. The resulting electrodes exhibited an area loading

of approximately 2 mg $cm^{-2}$. Cell assembly involved zinc foil anodes, glass fiber separators, and an aqueous electrolyte comprising 2 M $ZnSO_4$ supplemented with 0.2 M $MnSO_4$ additive.

Galvanostatic charge-discharge (GCD) profiles and rate capability tests were collected on a Neware BTS-4008 battery tester within a voltage window of 0.8–1.8 V. Cyclic voltammetry (CV) measurements were carried out on a CHI660E electrochemical workstation (Shanghai Chenhua Instrument Co., Ltd.) at scan rates ranging from 0.2 to 1.0 mV $s^{-1}$. Electrochemical impedance spectroscopy (EIS) data were acquired over the frequency range of $10^{-2}$–$10^{5}$ Hz with a perturbation amplitude of 5 mV.