Supporting Information

Transition-Metal Ions Intercalation Chemistry Enabled Manganese Oxides-Based Cathode with Enhanced Capacity and Cycle Life for High-Performance Aqueous Zinc-Ion Batteries

Hongyu Zhao[1,*], Li Wang[1], Meiling Li[1]

[1]School of Electronic Engineering, Lanzhou City University, Lanzhou 730000, Gansu, People's Republic of China

Corresponding author, E-mail address: ruofan_1007@126.com

1. The nominal valence states calculation

The nominal valence states of Mn of the different samples can be calculated based on the measured ΔE in Figure 2b, which can be determined quantitatively with the following equation.[1-2]

$$AOS = 8.956\text{-}1.126\ \Delta E$$

Where AOS denotes the calculated nominal valence states of Mn. The energy differences (ΔE) were measured with 4.63 eV, 4.98 eV, and 5.21 eV for the MnO_2, MnO_2-Na and MnO_2-Cu samples, respectively. Accordingly, the valence states of Mn in MnO_2, MnO_2-Na, and MnO_2-Cu are 3.74, 3.35, and 3.1, respectively.

2. Supplementary Figures

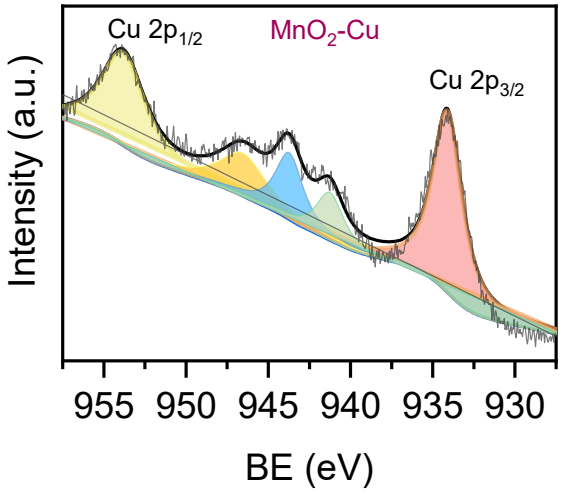

Figure S1. XPS core-level spectra of Cu 2*p* of the obtained MnO_2-Cu.

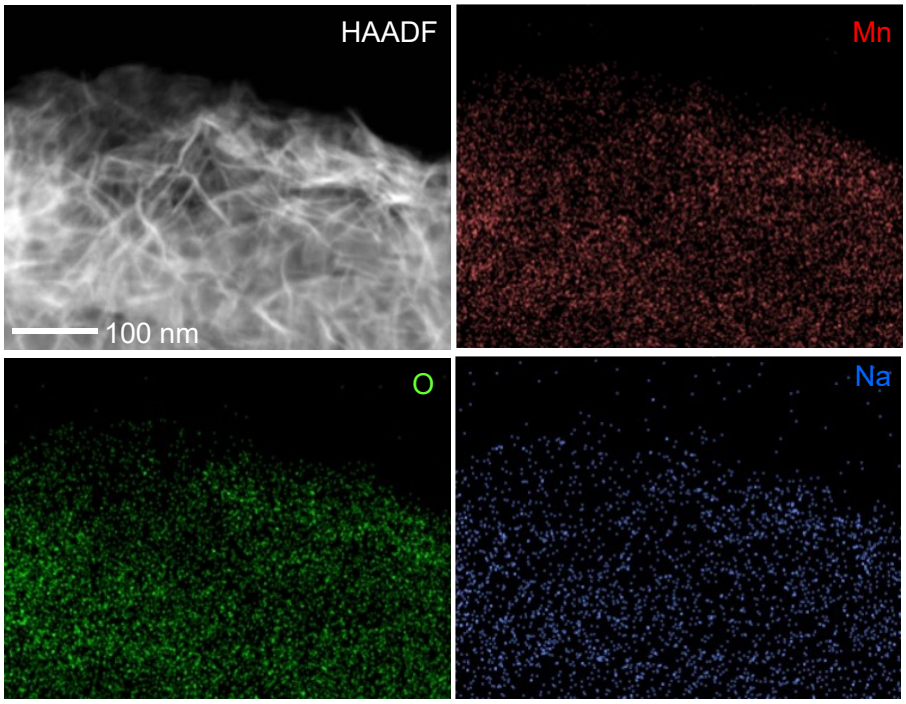

Figure S2. Elemental maps of the sample MnO_2-Na.

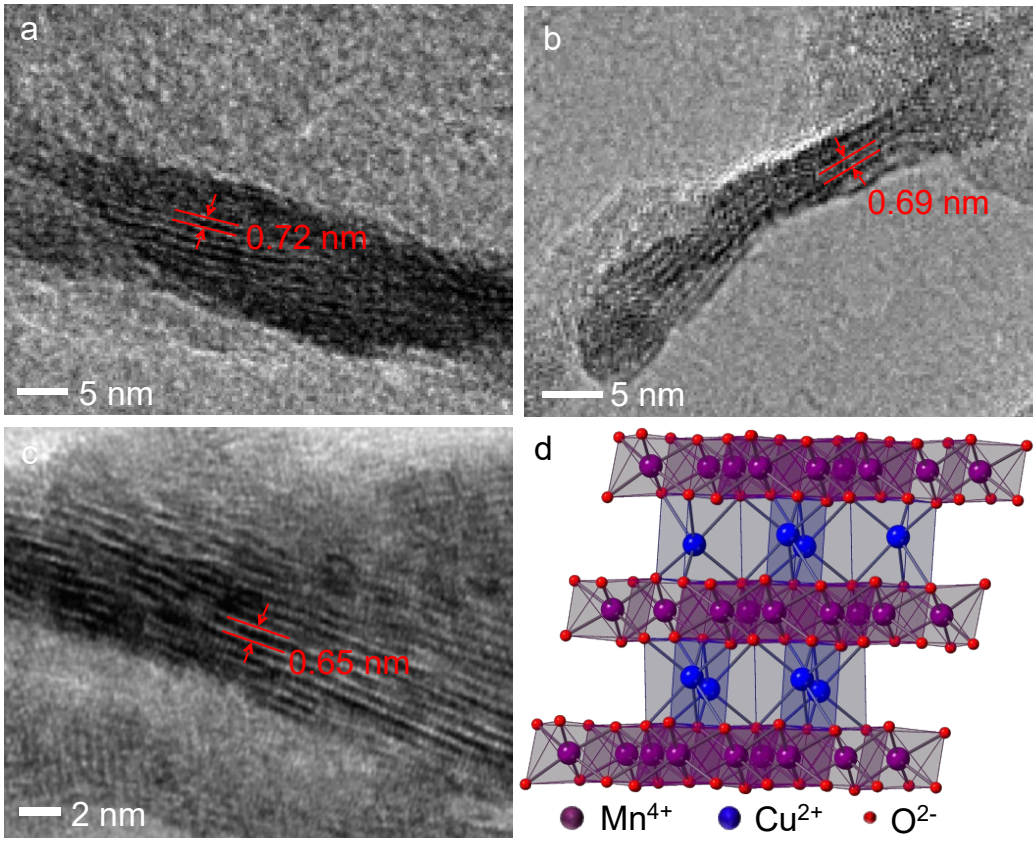

Figure S3. Representative TEM images with the lattice stripe view of the obtained MnO_2, MnO_2-Na, and MnO_2-Cu. (a) MnO_2 with the interlayer spacing of 0.72 nm; (b) MnO_2-Na with the interlayer spacing of 0.69 nm; (c) MnO_2-Cu with the interlayer spacing of 0.65 nm; (d) schematic illustrating the crystal structure of MnO_2-Cu with the interlay intercalated Cu^{2+}.

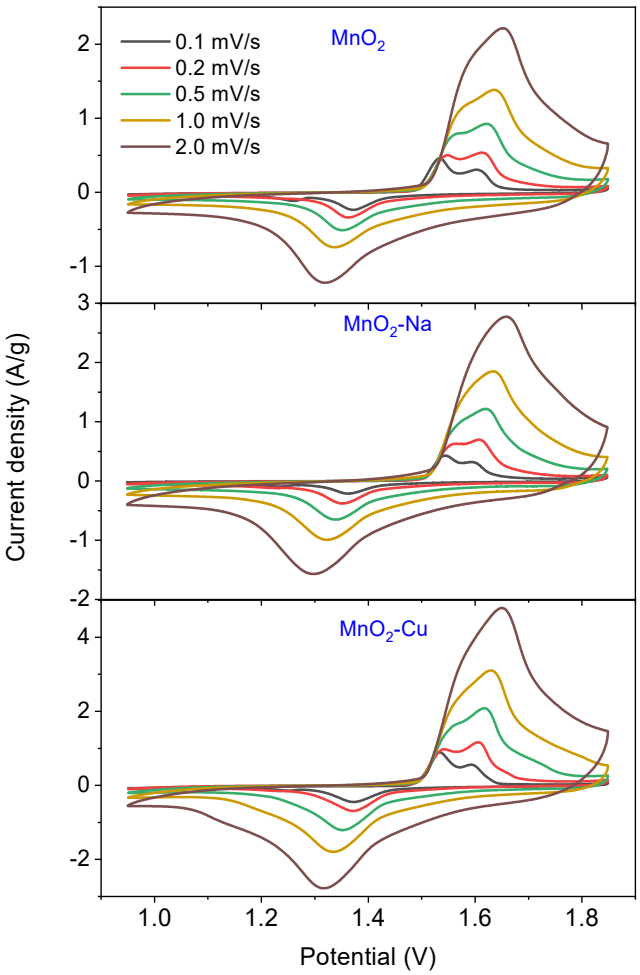

Figure S4. CV curves of the obtained MnO_2, MnO_2-Na, and MnO2-Cu electrodes were recorded at the scan rate ranging from 0.1 mV/s to 2.0 mV/s.

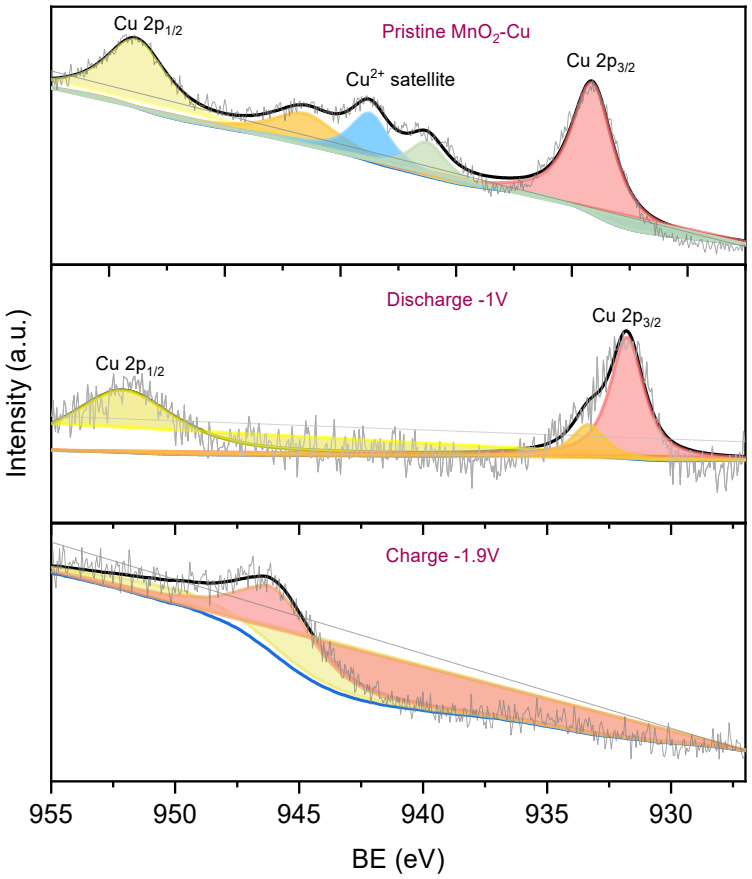

Figure S5. Valence states evolution of Mn in the MnO_2-Cu electrode during different charge-discharge stages.

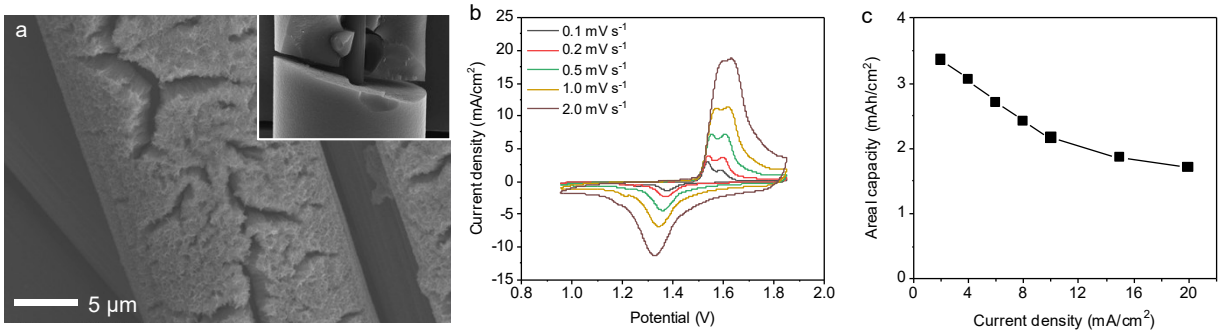

Figure S6. Electrochemical performance of MnO_2-Cu electrodes with high mass loading up to 9.6 mg/cm^2. (a) Typical SEM image of the MnO_2-Cu electrodes revealing the significantly thicker MnO_2-Cu materials electrodeposited on the current collector carbon cloth; (b) CV curves recorded at different scan rates ranging from 0.1 mV/s to 2.0 mV/s; (c) Rate capability at different charge-discharge current densities.

Reference

1 X. Tan, R. Liu, C. Xie and Q. Shen, *J. Power Sources*, 2018, **374**, 134-141.

2 A. Manceau, M. A. Marcus and S. Grangeon, *Am. Mineral.*, 2012, **97**, 816-827.