Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

An Aqueous Copper Battery Enabled by Cu^{2+}/Cu^{+} and Cu^{3+}/Cu^{2+} Redoxes Conversion Chemistry

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Experimental

Material preparation

The cathode was prepared with AC, Ketjen Black (KB), and Polytetrafluoroethylene (PTFE) binder in isopropanol with a weight ratio of 7:2:1. The mixed slurry was plated to a self-standing film and dried in an oven at 80°C for 12 hours. The loading mass of AC is controlled to ~ 5 mg cm^{-2} with a round piece in a diameter of 10 mm. The cooper anode foil was 0.03 mm in thickness and 10 mm in diameter with a mass of ~19.5 mg. Glass fiber of Pall Corporation was used as the separator. All electrolyte samples were prepared by mixing the designated molality of copper chloride ($CuCl_2$, anhydrous, ≥98%, Sigma Aldrich) and choline chloride (ChCl, TCI) with de-ionized water.

Material Characterization

The specific surface area and pore size distribution of the ac were analyzed by Brunauer-Emmett-Teller (BET) on NOVA 4000. Raman spectroscopy measurement was performed by Horiba LabRAM HR Evolution microscope. The morphology and elemental distribution of all samples were examined using the field-emission scanning electron microscopy (SEM) (HITAS-4800). X-ray diffraction (XRD) patterns of all samples were collected on a Rigaku Ultima IV Diffractometer with a Cu Kα radiation (λ = 1.5406 Å).

Electrochemical measurements

The electrochemical performance was evaluated using a Swagelok® cell (a T-cell) configuration. Galvanostatic charge/discharge tests were carried out on a LAND-CT2001A system at room temperature. Cyclic voltammetry (CV) was carried out on a Bio-logic electrochemical workstation (SP-150). The galvanostatic of Cu plating/striping was measured in Cu||Cu symmetric cells, and the coulombic efficiency (CE) of Cu plating/striping was studied in Ti||Cu cells.

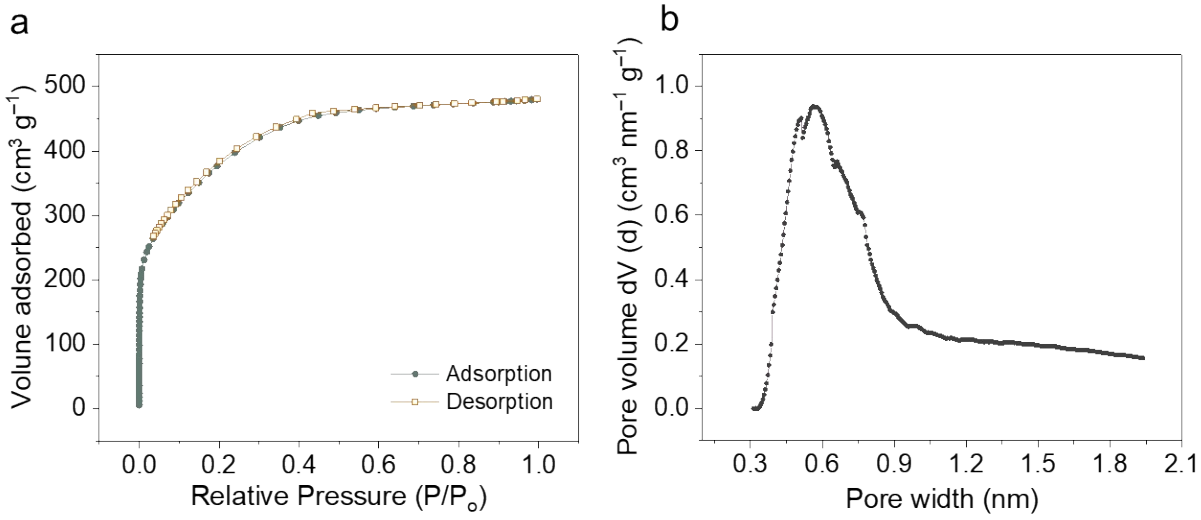

Figure S1 (a) Volume of gas adsorbed vs relative pressure and (b) BET pore size distribution of activated carbon.

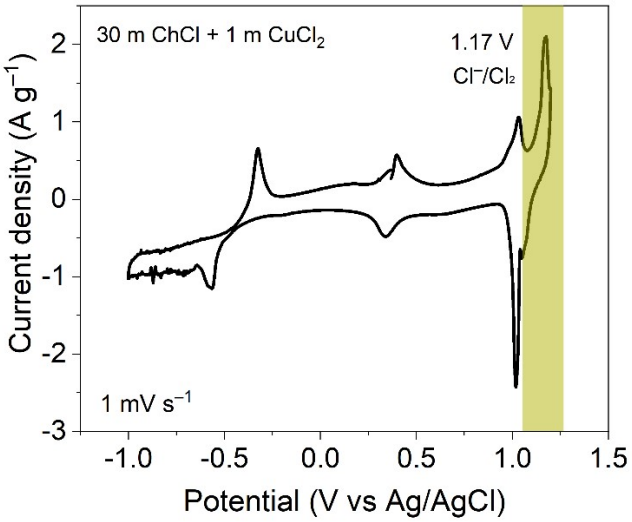

Figure S2 CV curves of the AC cathode in a three-electrode cell with AC cathode as the counter electrode at the 1st cycle in the 30 m ChCl + 1 m $CuCl_2$ electrolyte.

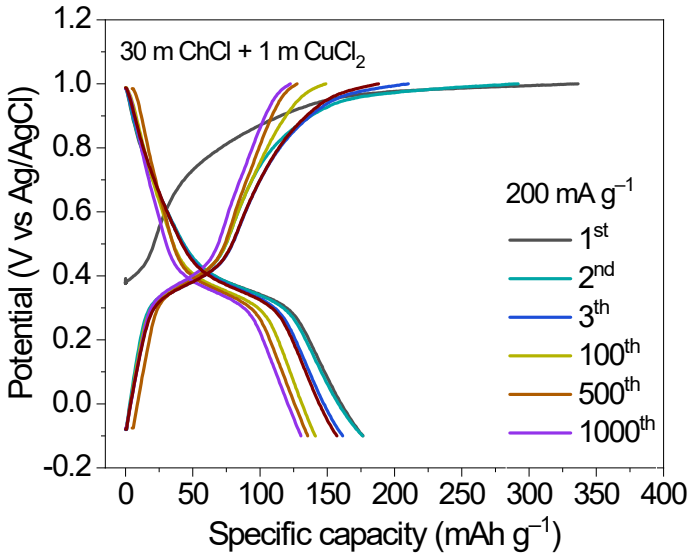

Figure S3 GCD potential profiles of AC in the 30 m ChCl + 1 m $CuCl_2$ electrolyte in a three-electrode cell with Ag/AgCl as a reference electrode with a charge capacity of 200 mAh g^{-1} within (a) -0.1–1.0 V.

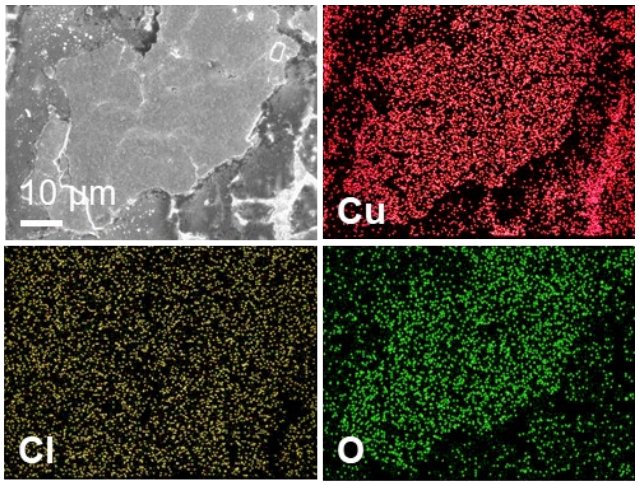

Figure S4 SEM image of the plated Cu metal.

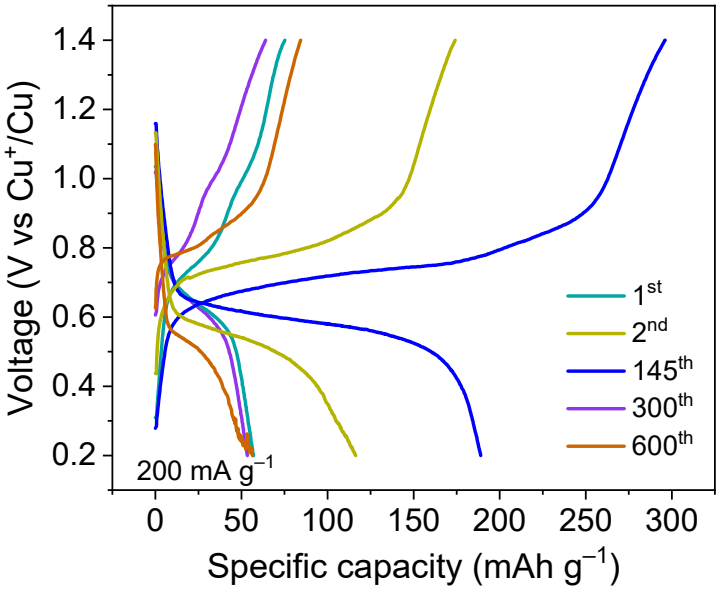

Figure S5 GCD potential curves of the AC||Cu cell in the 30 m ChCl + 1 m $CuCl_2$ electrolyte within 0.2–1.4 V, where Cu foil is used as a counter electrode.

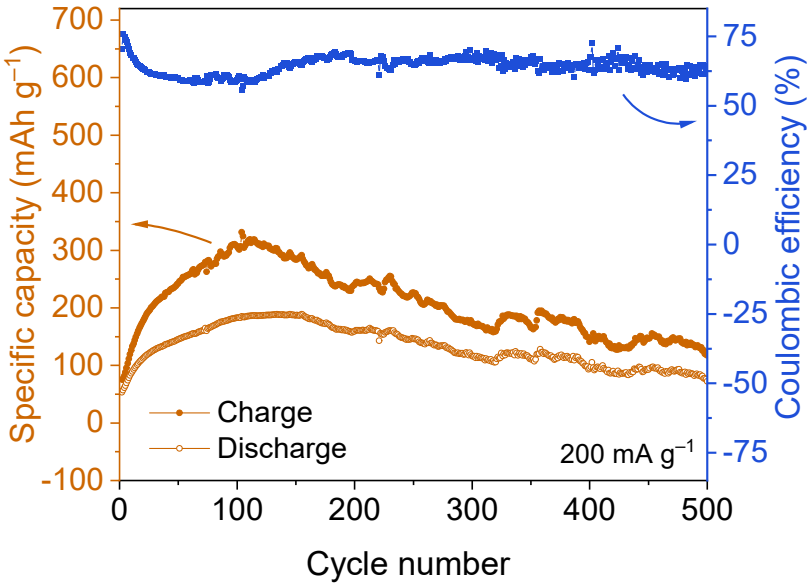

Figure S6 Cycling performance of the AC||Cu cell in 30 m ChCl + 1 m $CuCl_2$ electrolyte within 0.2–1.4 V at 200 mA g^{-1}.

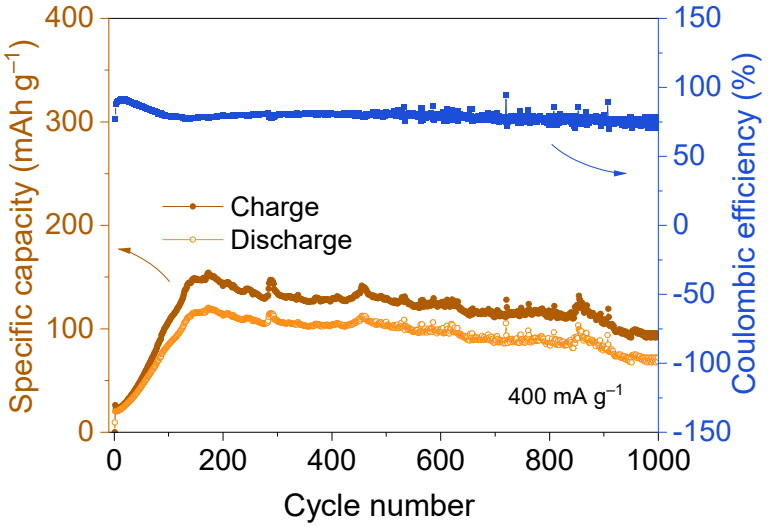

Figure S7 Cycling performance of the AC||Cu cell in 30 m ChCl + 1 m $CuCl_2$ electrolyte within 0.2–1.4 V at 400 mA g^{-1}.

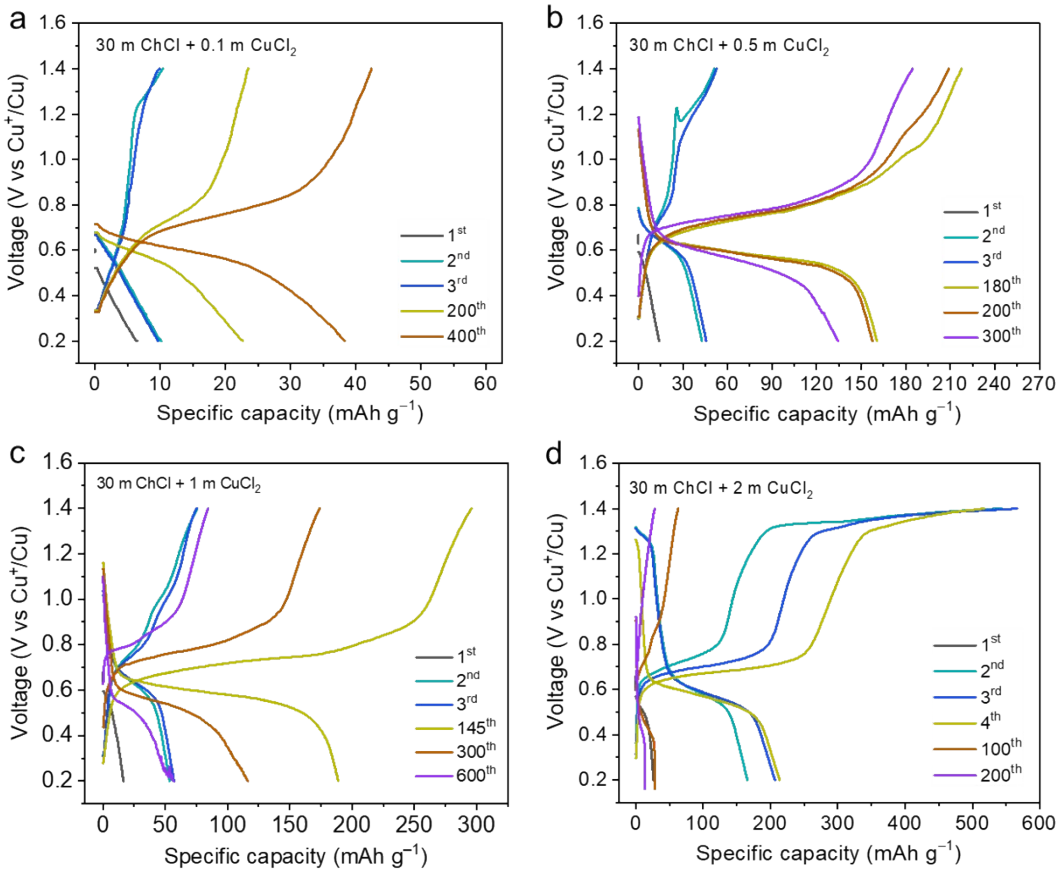

Figure S8 GCD profiles of the AC||Cu cells in the electrolytes of (a) 30 m ChCl + 0.1 m $CuCl_2$, (b) 30 m ChCl + 0.5 m $CuCl_2$, (c) 30 m ChCl + 1 m $CuCl_2$ and (d) 30 m ChCl + 2 m $CuCl_2$ at a current density of 200 mA g^{-1}.

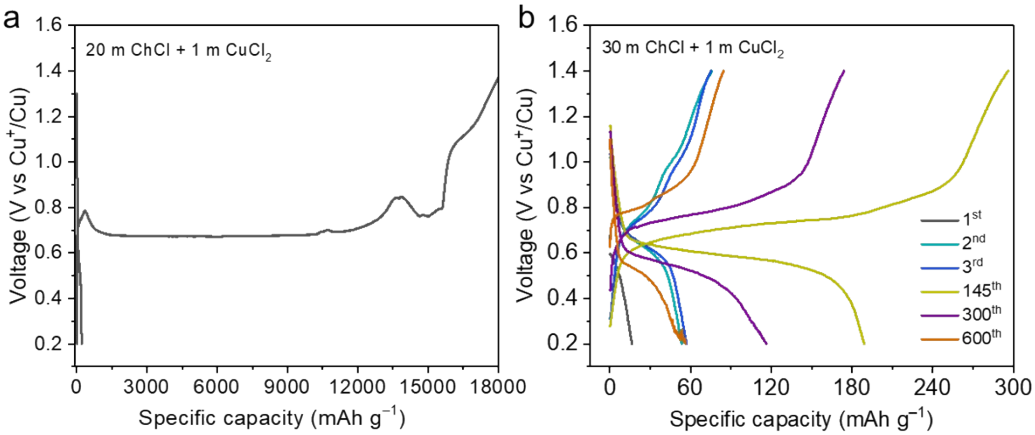

Figure S9 GCD profiles of the AC||Cu in the electrolytes of (a) 20 m ChCl + 1 m $CuCl_2$ and (b) 40 m ChCl + 1 m $CuCl_2$ at a current density of 200 mA g^{-1}.