Supporting Information

Ammonium Removal from Domestic Wastewater Using Selective Battery Electrodes

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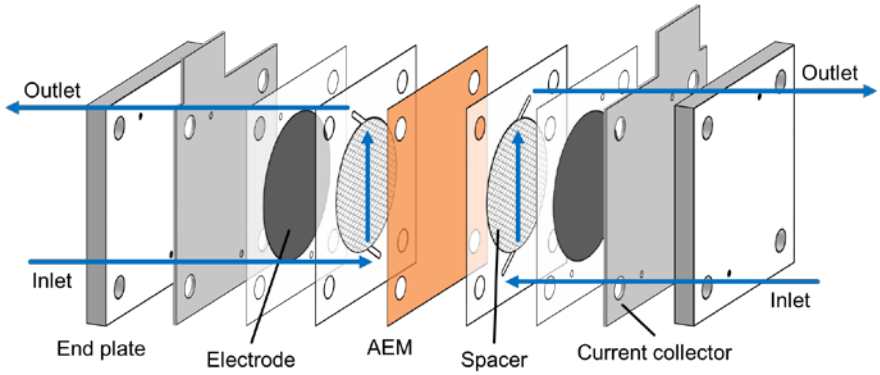

Figure S1. Schematic of the flow cell assembly, modified from our previous work for water desalination.[1]

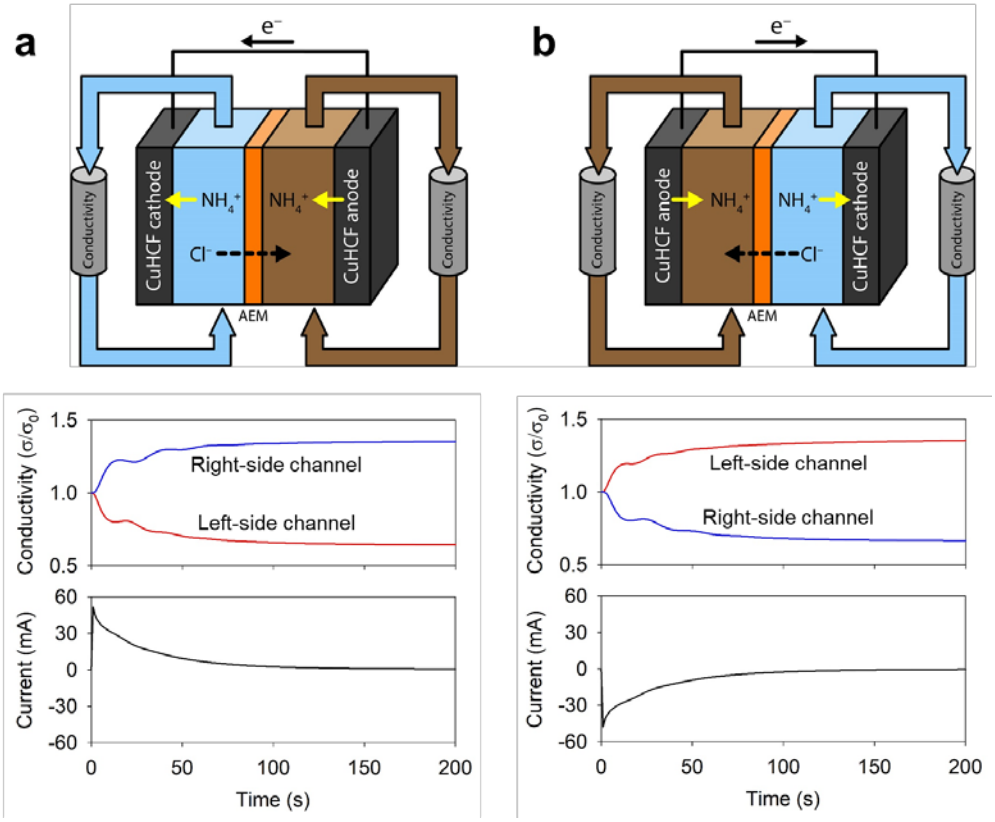

Figure S2. Schematic of the flow cell, modified from our previous work,[1] conductivity and current profiles using a synthetic wastewater containing 20 mM NaCl and 5 mM NH_4Cl at ±0.2 V. (a) In the first cycle, CuHCF cathode in the left-side channel captured Na^+ and NH_4^+ from the synthetic wastewater and therefore produced a treated solution. After completing a cycle, treated and concentrated solutions in each channel were replaced with fresh synthetic wastewaters. (b) In the subsequent cycle, the opposite voltage was applied to the flow cell, and thus, CuHCF cathode in the previous cycle served as anode and produced a concentrated solution.

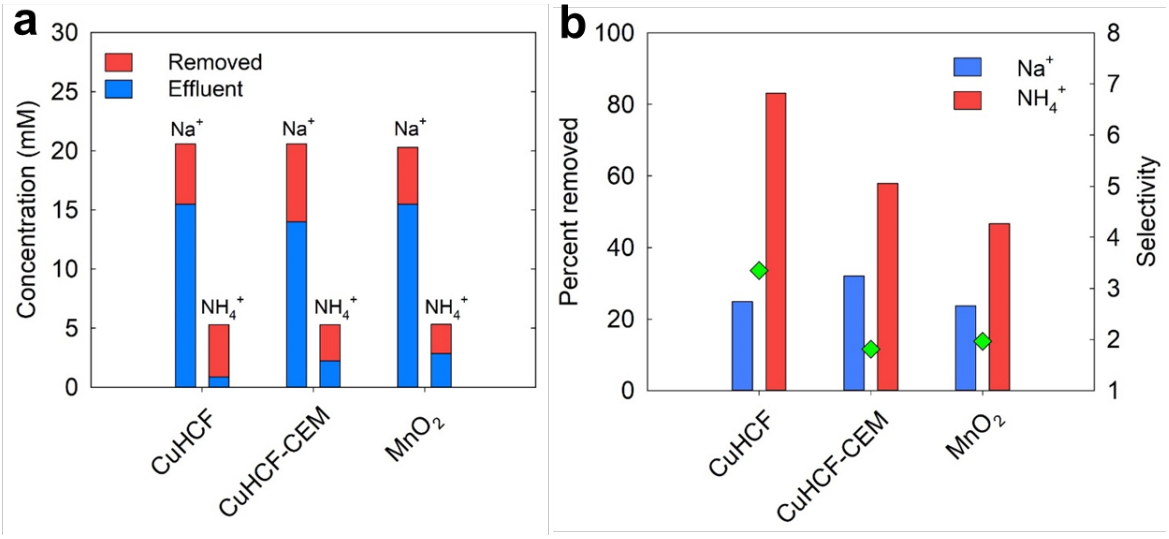

Figure S3. (a) Concentration, (b) percent removed, and selectivity of systems using CuHCF electrodes (CuHCF), cation-exchange membranes (CuHCF-CEM), and non-selective electrodes (MnO_2). Tests were conducted using synthetic wastewater containing 20 mM NaCl and 5 mM NH_4Cl. Applied voltages were 0.2 V for CuHCF and CuHCF-CEM, and 0.5 V for MnO_2.

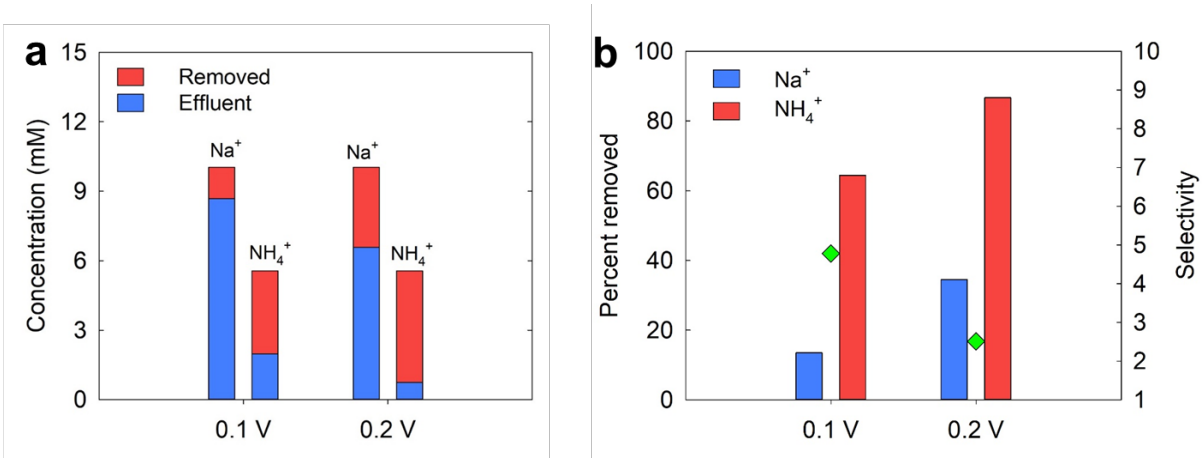

Figure S4. (a) Concentration, (b) percent removed, and selectivity at constant voltages of 0.1 and 0.2 V. Tests were conducted using synthetic wastewater containing 10 mM NaCl and 5 mM NH_4Cl.

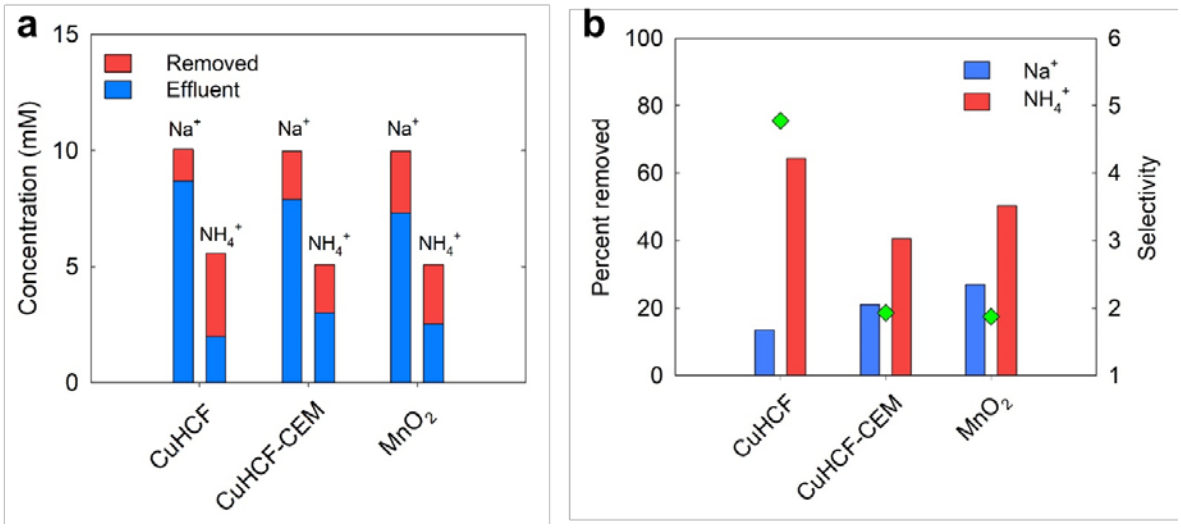

Figure S5. (a) Concentration, (b) percent removed, and selectivity of systems using CuHCF electrodes (CuHCF), cation-exchange membranes (CuHCF-CEM), and non-selective electrodes (MnO_2). Tests were conducted using synthetic wastewater containing 10 mM NaCl and 5 mM NH_4Cl. Applied voltages were 0.1 V for CuHCF and CuHCF-CEM, and 0.5 V for MnO_2.

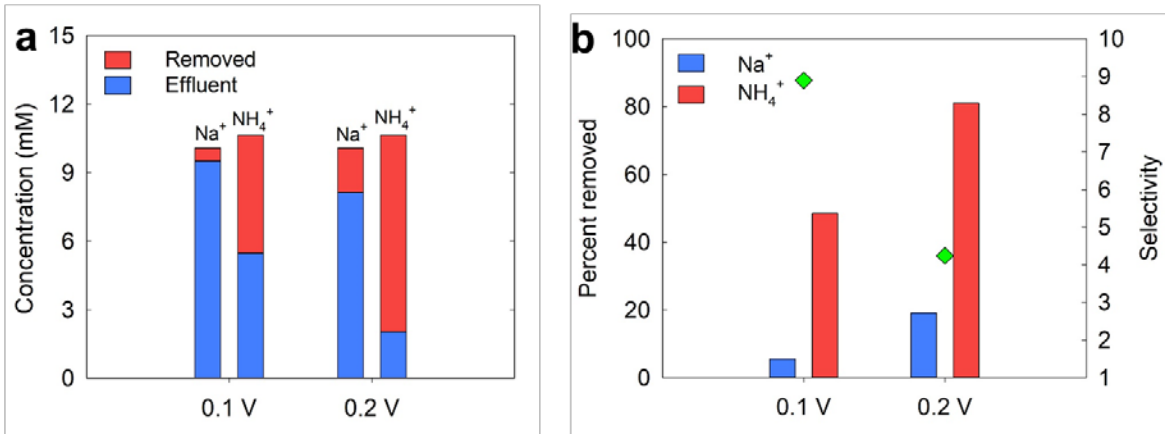

Figure S6. (a) Concentration, (b) percent removed, and selectivity at constant voltages of 0.1 and 0.2 V. Tests were conducted using synthetic wastewater containing 10 mM NaCl and 10 mM NH_4Cl.

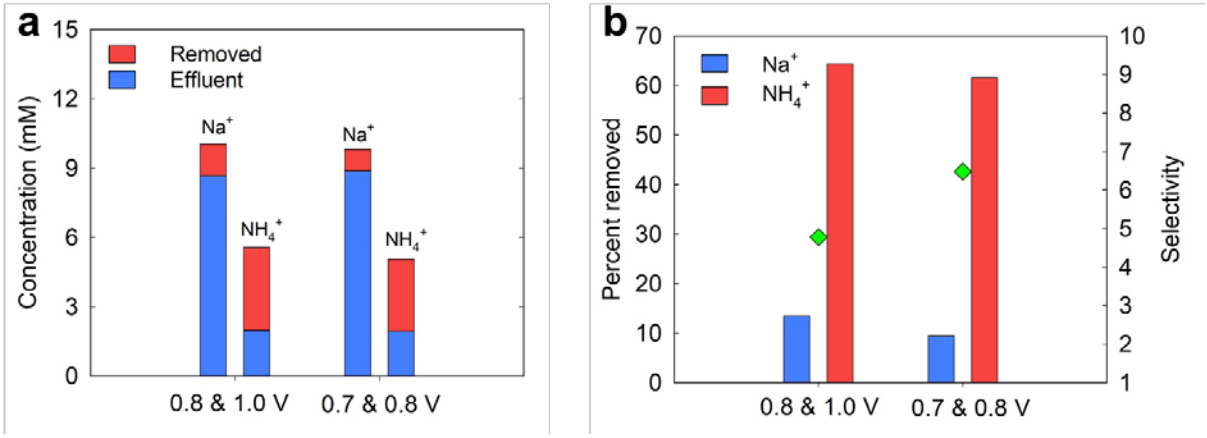

Figure S7. (a) Concentration, (b) percent removed, and selectivity of two electrode pairs with different initial potentials. Potentials of each CuHCF electrode were adjusted to 0.8 and 1.0 V (0.8 & 1.0 V) or 0.7 and 0.8 V (0.7 & 0.8 V) in a 3-electrode system using 1 M NaCl as an electrolyte and Ag/AgCl (in 3 M NaCl) as a reference electrode prior to ion removal tests.

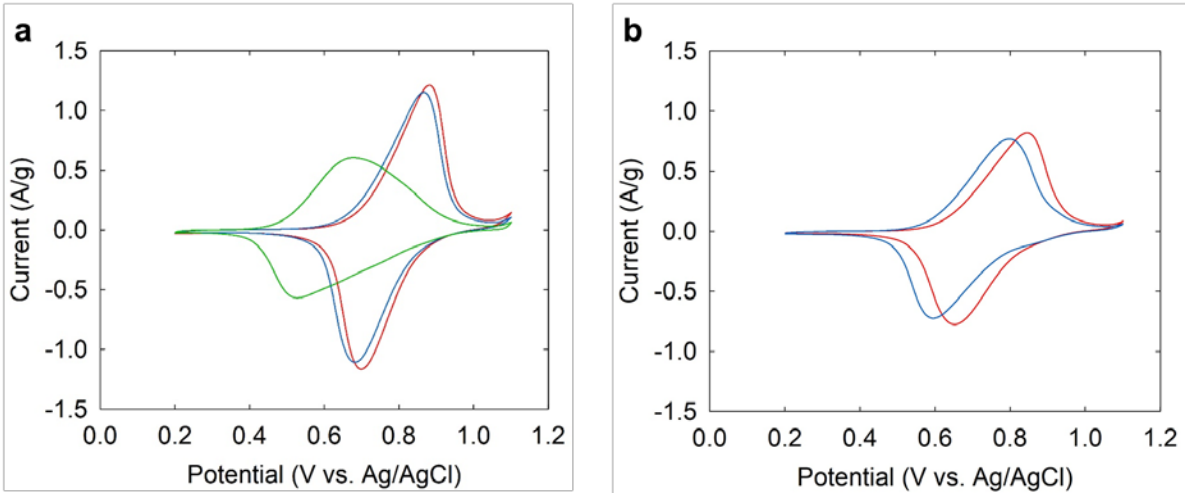

Figure S8. (a) Cyclic voltammetry profiles obtained using 1 M NaCl (green), 1 M NH_4Cl (red), and both 1 M NaCl and 1M NH_4Cl (blue). (b) Peak potentials of electrolytes containing several ions with NH_4^+ (0.2 M NH_4Cl, 0.2 M NaCl, 0.2 M KCl, 0.1 M $CaCl_2$, and 0.1 M $MgCl_2$; red) and without NH_4^+ (0.2 M NaCl, 0.2 M KCl, 0.1 M $CaCl_2$, and 0.1 M $MgCl_2$; blue).

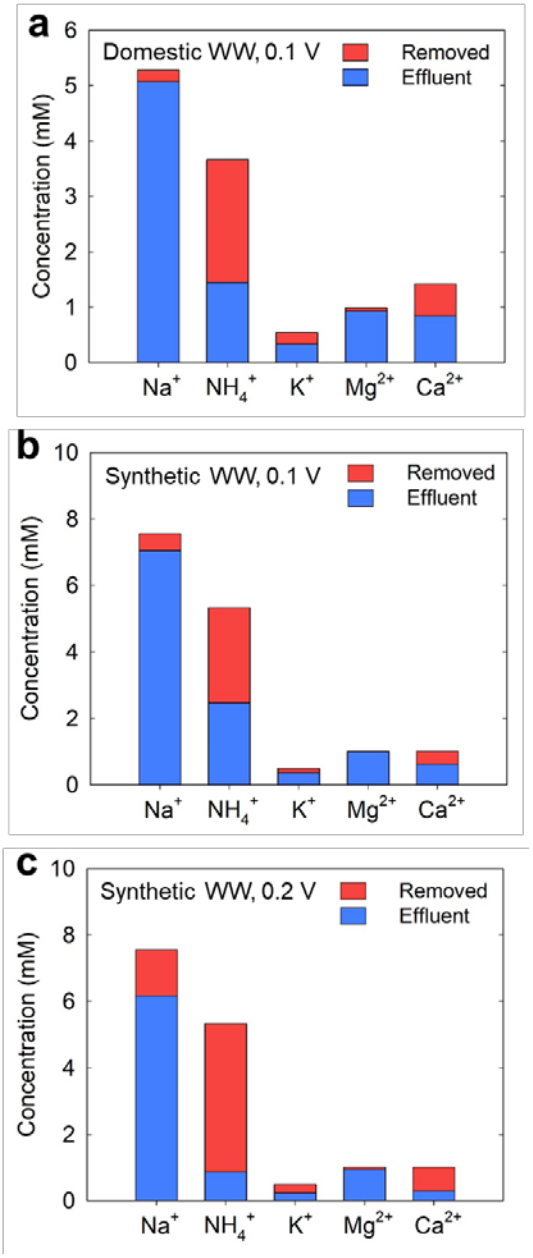

Figure S9. Concentrations of removed and effluent cations using (a) domestic wastewater at 0.1 V, (b) synthetic wastewater at 0.1 V, and (c) synthetic wastewater at 0.2 V.

Reference

(1) Kim, T.; Gorski, C. A.; Logan, B. E., Low energy desalination using battery electrode deionization. *Environ. Sci. Technol. Lett.* **2017,** *4*, 444-449.