Supporting Information

Electrical power production from low-grade waste heat using a thermally regenerative ethylenediamine battery

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Calculations using the Nernst Equation:

The Nernst equation for calculating the anode electrode potential of TRENB with ethylenediamine (en):

$$E = E^0 - \frac{RT}{2F} ln \frac{[\alpha(en)]^2}{\alpha\left(Cu(en)_2{}^{2+}\right)} \quad \text{(S1)}$$

where E^0 is the standard reduction potential of anodic reaction, R the gas constant (J K^{-1} mol^{-1}), T the solution temperature (K), F the Faraday constant (96485 C mol^{-1}), α (*en*) the activity of ethylenediamine, and α $\left(Cu(en)_2{}^{2+}\right)$ the activity of copper complex. The equation was used to estimate the anode potential of TRENB with different concentrations of ethylenediamine.

The acid/base reaction of ammonia:

$NH_4^+ = NH_3 + H^+$, pK_a=9.25 (S2)

Increasing the ethylenediamine concentration enhances the anolyte pH from 9.29 for 2 M to 9.74 for 4.5 M, leading to the formation of neutrally charged ammonia from the positively charged ammonium, which exists as the supporting electrolyte.

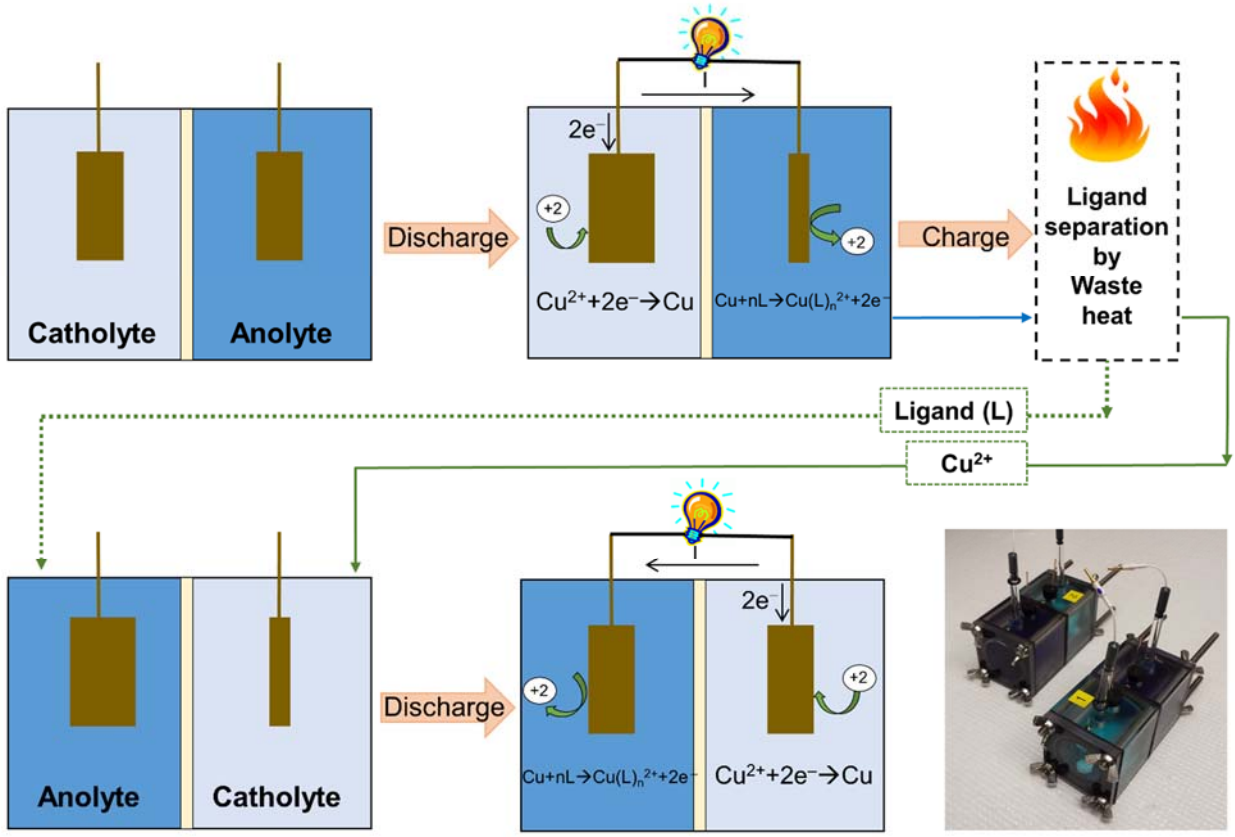

Figure S1. Scheme of the TRB to convert waste heat to electricity. A potential difference between the chambers is generated by adding the ligand (i.e. either ammonia or ethylenediamine) to the anolyte. By discharging the cell, corrosion occurs in the anode, while deposition achieves on the cathode side. After the complete discharge, the cell is charged by separating the ligand using waste heat, and adding it to the other chamber.

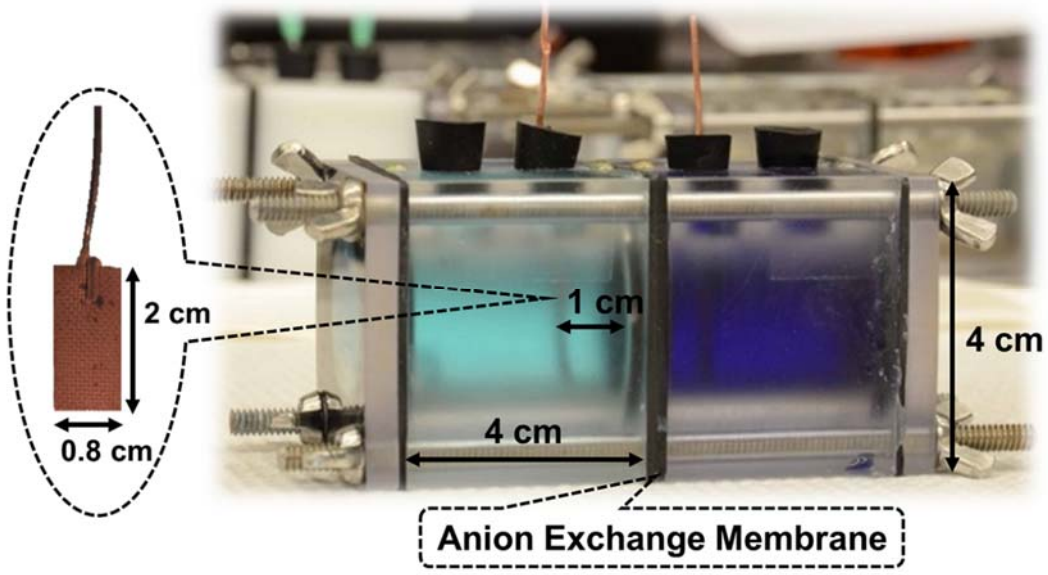

Figure S2. Image of a thermally regenerative battery with copper mesh electrodes. The electrodes were faced toward the membrane.

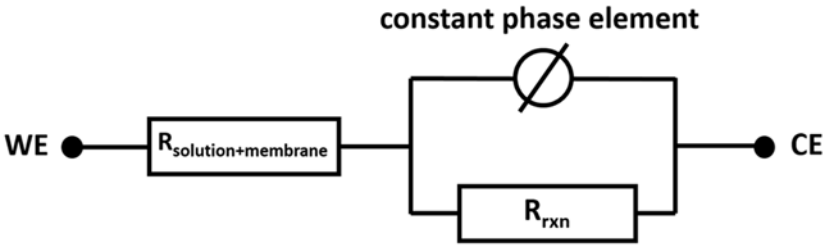

Figure S3. Equivalent circuit for the cell impedance analysis to measure the components of cell impedance.

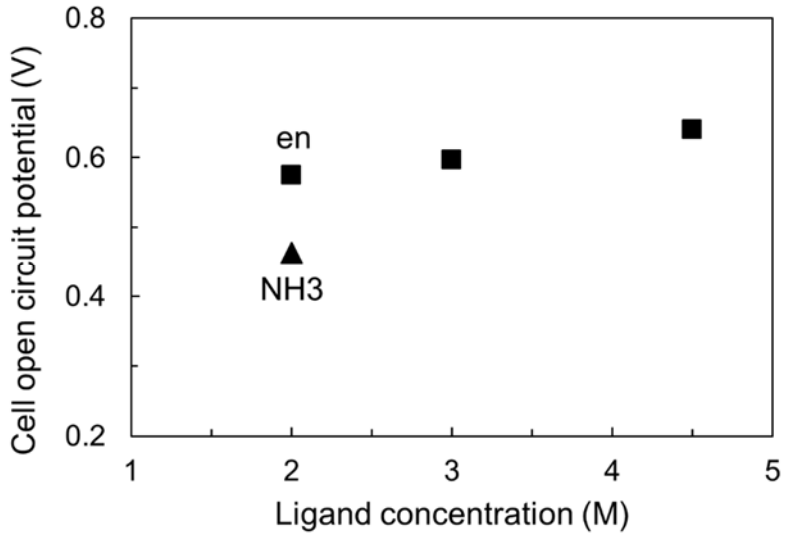

Figure S4. Cell open circuit potentials of TRAB (▲) with ammonia concentration of 2 M, and TRENBs (■) with various concentrations of ethylenediamine.

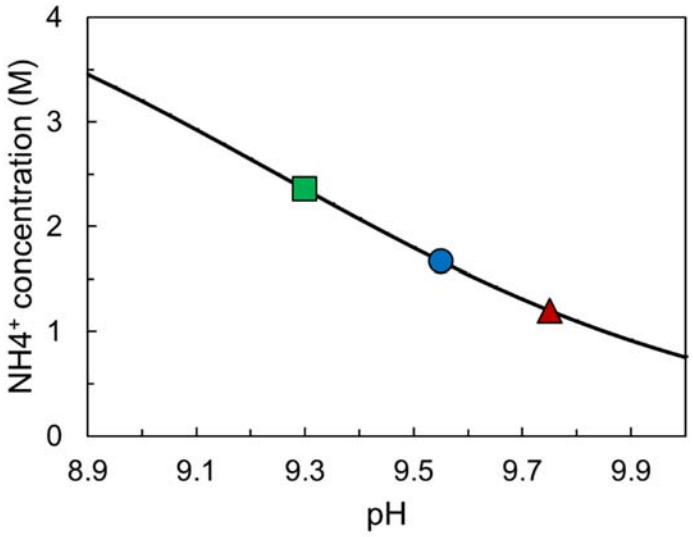

Figure S5. The concentration of ammonium ion in the anolyte as a function of pH. The colored points represent the initial pH of the anolyte with an initial ethylenediamine concentration of 2 M (green), 3 M (blue), and 4.5 M (red).

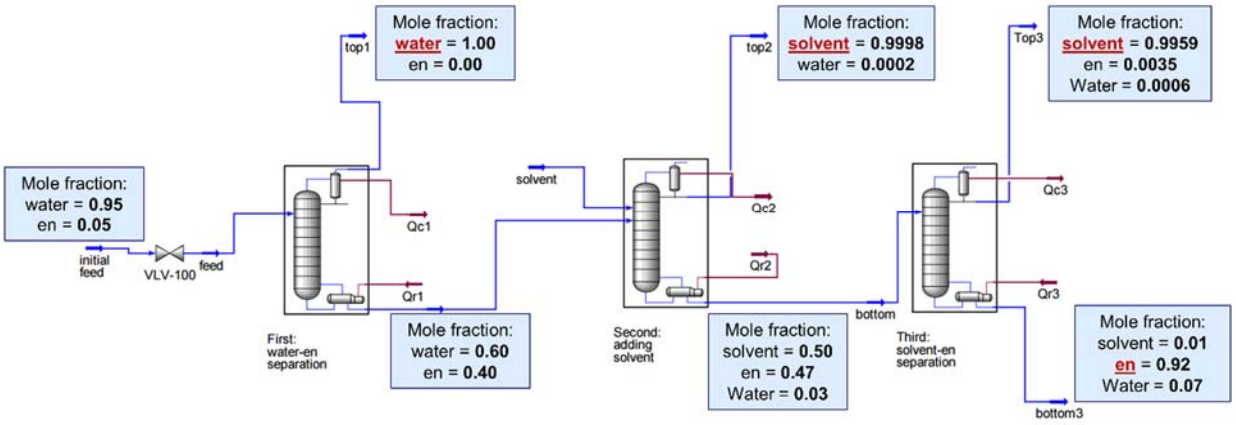

Figure S6. Charge the TRENB by separating ethylenediamine (en) from the anolyte. Due to an azeotropic point for the binary mixture of water-en, acetone is used as the solvent in the azeotropic distillation process. The initial column is used to increase the molar fraction of en in the mixture to that limited by the azeotropic point. The solvent is added in the second column, and en is separated from the bottom of the third column.