Title: Modeling and Design for Electrochemical Carbon Dioxide Capture Systems

As long as fossil fuels remain humanity's primary source of energy, carbon dioxide capture and storage will be needed to mitigate the effects of global climate change. Existing carbon dioxide separation technology is energetically intensive and expensive to employ in brownfield applications.

A novel CO_2 capture technology, Electrochemically-Mediated Amine Recovery (EMAR), is described herein. EMAR modifies incumbent thermal amine scrubbing through an electrochemical desorption process that manipulates the concentration of a cupric competitive complexing agent. Oxidation of copper at the anode results in the formation of a cupric-amine complex, that releases bound CO_2. Reduction of this complex at the cathode regenerates the amines for capture. This approach is more energy efficient than traditional thermal amine processes and is expected to be less capital intensive to implement.

A proof-of-concept EMAR system coupled with initial system optimization was demonstrated previously. This work is a significant expansion of the earlier advances, specifically in the areas of thermodynamics, mass and heat transport, and system design.

Three thermodynamic paths are described for the EMAR process that establish the total electrochemical work of separation for this and other similar molecular architectures. This evaluation of the electrochemical work, in concert with work of compression and pump work, allows for development of an ideal process flow scheme and optimized operating conditions for the EMAR process.

The design of the EMAR cell design has been improved significantly with transitions from a single unit cell to a modular, stacked system. The performance of two stack geometries, series and parallel, is modelled and analyzed. It is demonstrated that the series stack, which is more industrially applicable, shows less severe internal temperature gradients than that of the parallel geometry.