Title

Electrochemical hydrogen looping for carbon dioxide capture from ocean water

Abstract

Efficient capture of carbon dioxide is extremely important, yet current methods are cost and energy intensive. In this work, we focus on carbon dioxide capture from ocean water because the ocean serves as a sink for atmospheric carbon dioxide, containing over 100 times the amount of carbon per unit volume than air. We utilize a simple scheme for capture of carbon from the ocean water: (1) add acid to a volume of ocean water, decreasing the pH and shifting the bicarbonate buffer equilibrium toward gaseous carbon dioxide, which can be extracted and stored; and (2) add base to neutralize the acid before returning the water back to the ocean. We demonstrate an electrochemical cell that can produce acid via hydrogen oxidation reaction at the anode and can simultaneously produce base via hydrogen evolution reaction at the cathode, achieving currents of up to 500 mA/cm^2. In net, no hydrogen is consumed or produced; it is looped from the cathode to the anode, minimizing the theoretical minimum voltage required. To keep the acid and base streams from mixing, we rely on the larger concentration of sodium ions (0.5 M) compared to protons for carrying the ionic current between the anolyte and catholyte. We also use COMSOL modelling to explore the tradeoffs in current, cell geometry, and flow rates on efficiency. Overall, we show how a hydrogen-looping device can be constructed without expensive and failure-prone ion exchange membranes, resulting in an efficient, cheap, and potentially long-lasting system that can be leveraged for carbon dioxide capture from ocean water.