Faculty Summer Research Award 2018

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Title: Task-Specific Ionic Liquids for Efficient and Selective Electrochemical Carbon Dioxide Reduction to Formate

Abstract:

The continued growth and implementation of grid-scale renewable energy sources requires the development of a vast portfolio of energy storage technologies to bridge the gap between peak energy production and peak energy demand. Mimicking processes observed in nature, we can use chemical bonds to store/extract energy gathered from a variety of renewable sources. The electrocatalytic conversion of CO_2 to chemicals and fuels shows great promise for energy conversion and storage in the form of a closed-loop carbon cycle. Current challenges faced by electrochemical CO_2 reduction technologies include poor efficiency due to the inherent stability of the nonpolar CO_2 molecule and poor selectivity, necessitating down-stream separations that further lower the efficiency of the process. Here we propose the development of a composite electrocatalytic architecture to produce formate/formic acid at high rates and with high selectivity. The proposed electrocatalytic electrode is composed of a nanoporous Sn electrode interfaced with an "Active Electrolyte" composed of a water doped task-specific ionic liquid (TSIL) with chemical functionalities that facilitate the chemisorption of CO_2 in a near 1:1 molar ratio. Chemisorption of CO_2 induces charge redistribution, pre-bending the molecule which is hypothesized to significantly lower the activation barrier for the first charge transfer to CO_2; known to be the rate-determining step in aqueous CO_2 electrochemical reduction. The adsorbed $*CO_2^-$ is then readily converted to $HCOO^-$/HCOOH on the Sn catalyst with high selectivity. By controlling the pKa of the TSIL anion, we can tune the balance of the interaction between CO_2, TSIL, and electrode and significantly improve the efficiency of the CO_2 reduction reaction. Demonstration of the utility of TSILs here will provide insight for application to the selective formation of other useful hydrocarbon products from CO_2.