Electrochemical Mass Spectrometry for Carbon Dioxide Reduction

F. Sloan Roberts, Kendra P. Kuhl, Anders R. Nilsson

Introduction

Fuels and industrial chemicals could be produced in a renewable, sustainable manner by electrochemically converting carbon dioxide into important carbon-based products. One of the key challenges of studying electrochemical carbon dioxide reduction is determining what products are formed as a result of the applied voltage. Using a mass spectrometer coupled to an electrochemical cell via a hydrophobic membrane inlet allows for the direct measurement of products. Our experimental setup, copper nanocube synthesis, and electrochemical carbon dioxide reduction results are presented here.

Instrument Design

Benefits:
- Online electrochemical mass spectrometry (OLEMS) design adapted from the Koper group with the added improvement of a vertical working electrode.
- Obtain real-time product information as a function of voltage.
- Quickly test factors such as the effect of electrolyte pH, working electrodes (including single crystals), etc.

Copper Cube Synthesis

- Electropolished copper nanocube synthesis
- Electropolished copper electrolytically oxidized and doped with chloride to form CuCube surface
- Electropolished copper electrolytically oxidized and doped with chloride to form CuCube surface

OLEMS Results

- Copper Cube surface (red) pulls much more oxidative current and has subsequent reductive peak. It also pulls more current at most negative potential.
- CuCube clearly favors ethylene formation (solid curve) over methane (dashed curve) with a relative ratio several orders of magnitude higher than for polycrystalline copper, as well as an earlier onset (compare vertical dashed lines).

References


Future Work

- Investigate copper cube formation.
- CO reduction, especially on the cubic surface – compare to single crystals.
- Study the effect of pH for the CO reduction reaction.