Electrochemical Reduction of CO_2 on Transition Metal Catalysts

Etosha Cave, Kendra Kuhl, David Abram, Toru Hatsukade and Thomas F. Jaramillo
Dept. of Chemical Engineering, Stanford University
381 North-South Mall, Stanford, CA 94305 USA

INTRODUCTION

The economic conversion of CO_2 into more reduced species such as alcohols or hydrocarbons would: create CO_2 neutral fuels, generate feedstocks for industrial chemicals and store electricity from renewable sources such as solar cells or wind turbines. Almost all metals have the ability to catalyze the electrochemical reduction of carbon dioxide at room temperatures, however, most do so with low current efficiencies or high overpotentials, when producing carbon-based fuels that are conventionally made from petroleum [1].

EXPERIMENTAL METHODS

We studied several polycrystalline transition metals: Au, Ag, Zn, Cu, Pt, Fe, and Ni for CO_2 electroreduction with a custom-made electrochemical cell, designed with a high surface area- to-volume ratio for enhanced sensitivity for liquid products. Constant potential experiments were conducted for an hour, with multiple repeats, across various potentials. Gas products were detected with a gas chromatograph at regular intervals during the experiment. Liquid products were detected via ^1H Nuclear Magnetic Resonance at the end of the tests.

RESULTS AND CONCLUSION

Hydrogen, carbon monoxide, formate, methane and ethylene were the major gas products formed on the surfaces, which is consistent with previous studies. The minor products included a range of alcohols, aldehydes, ketones, esters and hydrocarbons, some which have not been detected previously in literature. This presentation discusses trends in the metals selectivity and activity to CO_2 electroreduction based on proposed mechanisms [2,3]. Our data suggest that CO binding energies correlate with activity

REFERENCES

1. Azuma, M., et al., Electrochemical Reduction of Carbon Dioxide on Various Metal Electrodes in Low-Temperature Aqueous $KHCO_3$ Media. Journal of The Electrochemical Society, 1990. **137**(6): p. 1772-1778.
2. Peterson, A.A., et al., How copper catalyzes the electroreduction of carbon dioxide into hydrocarbon fuels. Energy & Environmental Science, 2010. **3**(9): p. 1311-1315.
3. Peterson, A.A. and J.K. Nørskov, Activity Descriptors for CO_2 Electroreduction to Methane on Transition-Metal Catalysts. The Journal of Physical Chemistry Letters, 2012. **3**(2): p. 251-258.