NDnano
Center for Nano Science and Technology

ND*nano* Summer Undergraduate Research 2018 Project Summary

1. Student name & home university:
Rebecca Radomsky
University of Notre Dame

2. ND faculty name & department:
David Go
Aerospace and Mechanical Engineering

3. Summer project title:
Determining the Faradaic Efficiency of Plasma-Liquid Systems

4. Briefly describe new skills you acquired during your summer research:
I acquired many technical skills, such as using and calibrating an ion selective electrode, setting up an electrochemical cell, using high-voltage electrical equipment, and measuring UV-visible absorbance. I also acquired the skill of analyzing data in programs such as Excel and Origin. Finally, I acquired the skill of presenting my own research in a clear way, through having a presentation to my faculty mentor, Dr. Go, every week.

5. Briefly share a practical application/end use of your research:
Plasma-liquid systems have many uses, such as nanoparticle synthesis, therapeutics, food and agriculture management, and wastewater treatment. As a specific example, after completing this NURF, I intend to continue working with Dr. Go and specifically study how to use these systems to synthesize useful chemicals from carbon dioxide. But, in order for plasma-liquid systems to be effective in these fields, more must be understood about how these plasmas and liquids interact.

6. 50- to 75-word abstract of your project:
Using a plasma cathode, our specific focus has been on understanding the inherent limitations to the Faradaic efficiency in a plasma electrolytic cell using two model systems: the classic ferri/ferrocyanide redox couple as well as the dissociative electron attachment to chloroacetate. Using optical absorption spectroscopy and an ion selective electrode, the respective concentrations of ferricyanide and chloride were measured, and calculated Faradaic efficiencies were compared to theoretical predictions.

7. References for papers, posters, or presentations of your research:

Radomsky, R. C. (2018, July). *Determining the Faradaic efficiency of plasma-liquid systems*. Poster Presented at: Notre Dame Summer Undergraduate Research Symposium. Notre Dame, IN.

One-page project summary that describes problem, project goal and your activities / results:

Plasma electrolysis is an electrochemical process where one of the metal electrodes in an electrolytic cell is replaced by a plasma (or gas discharge). In this configuration, the chemistry is driven by highly reactive dissolved species, such as the solvated electron (e^{-}_{aq}) and the hydroxyl (OH) radical. Plasma electrolysis has significant promise for materials synthesis, water purification, and chemical processing. Prior measurements of Faradaic efficiencies, or the efficiency with which charge is transferred into the electrochemical system, of these plasma electrolytic systems has shown that they are inherently low.

Using a plasma cathode, our specific focus has been on understanding the inherent limitations to the Faradaic efficiency in a plasma electrolytic cell using two model systems: the classic ferri/ferrocyanide redox couple as well as the dissociative electron attachment to chloroacetate. Using optical absorption spectroscopy and an ion selective electrode, the respective concentrations of ferricyanide and chloride can be measured and used to calculate the Faradaic efficiency of the process.

The main focus of this research has been to measure the Faradaic efficiency of the reduction of ferricyanide under various plasma electrolysis conditions to understand how plasma-generated species affect the Faradaic efficiency at the plasma-liquid interface. The Faradaic efficiency was measured as a function of ferricyanide concentration. Then, various OH radical scavengers such as glycerol and methanol, as well as active stirring, were introduced to the system to further change the Faradaic efficiency. The introduction of OH radical scavengers increased the Faradaic efficiency of the ferricyanide system because it eliminates competition with the backward oxidation reaction of ferrocyanide. The introduction of stirring did not change the Faradaic efficiency of the ferricyanide system to do boundary layer effects.

Due to complexities in the chemistry of ferri/ferrocyanide, such as the backward oxidation reaction, an alternative experiment based on the dissociative electron attachment to chloroacetate has been developed. A stable chloride ion is produced in the reaction of chloroacetate and solvated electrons, which can be measured using an ion selective electrode. This system may help prove that e^{-}_{aq} is the main species responsible for the reduction at the plasma cathode.