Magnetic Effects on Electrochemical Systems: Batteries, Fuel Cells, Academically Interesting Probes, and CO Oxidation

Presenter: Professor Johna Leddy, Department of Chemistry, University of Iowa
Title: Magnetic Effects on Electrochemical Systems: Batteries, Fuel Cells, Academically Interesting Probes, and CO Oxidation

Abstract:

An electron has properties of spin and charge. To transfer an electron, both spin and charge must transfer. In systems of slow transport and high concentration, introduction of a magnetic field increases electron transfer rates in electrochemical systems. Increased rate is manifest as increased current, which is useful in electrochemical energy systems such as fuel cells and batteries. Academically interesting redox species provide some access to a fundamental appreciation of these effects. Specific energy systems improved by magnetic modification include:

Proton exchange membrane (PEM) fuel cells with higher efficiencies on hydrogen and increased tolerance to CO that is important in indirect and direct reformation (e.g., DMFC) fuel cells

- MnO2 alkaline battery electrodes with near doubled energy density as primaries (disposables) and attractive properties as secondaries (rechargeables)
- Nickel metal hydride battery electrodes with significantly improved charge and discharge rates
- Electrodes are readily modified with magnetic microparticles by embedding microparticles in films on electrodes and in battery electrode matrices. When compared to similarly modified electrodes that contain nonmagnetic microparticles, magnetically modified electrodes yield significantly higher currents. For example, micromagnets in Nafion as compared to nonmagnetic microparticles in Nafion yield four fold higher currents for the redox probe Ru(bpy)32+ and twenty five fold higher currents for Co(bpy)32+. A simple transition state model for the self exchange process describes electron transfer as a process where enthalpy is almost entirely driven by the electric field and charge; entropy arises from spin states. Data for the near diffusion limited oxidation of CO on Pt will be presented.

Biography:

Johna Leddy received her BA in chemistry from Rice University in 1978 and a PhD from the University of Texas in 1984. She worked with Allen J. Bard on characterization of modified electrodes. After a postdoctoral appointment in the Fuel Cell Program at Los Alamos National Laboratories, where she worked with Nick Vanderborgh, Leddy joined the faculty at Queens College, City University of New York. In 1991, she moved to the University of Iowa where she is now Associate Professor of Chemistry. Her research interests include electrochemistry, the effects of magnetic fields on electrochemical systems including fuel cells and batteries, modeling and simulation, and breath sensors. Leddy holds 18 US and 14 international patents on her work. She is currently the Secretary of the Electrochemical Society and Treasurer for the Society for Electroanalytical Chemistry.

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