CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Dang Khoa Nguyen Ngoc

Project Number

S0618

Project Title

Investigating the Effects of Various Energy Sources on Electrochemical Cells' Potentials

Abstract

Objectives/Goals

As battery technology, specifically lithium-ion, reaches a physical limit, it is crucial to study the roots of electrochemistry to identify possible improvements so as to formulate a better model. In this project, the performance of a basic electrochemical cell setup is studied as different energy sources are introduced.

Methods/Materials

The "battery cell" is tested against thermal energy (temperature), chemical potential energy (electrolytic concentration and electrode mass), and for future studies: physical kinetic energy (ultrasonic waves) and even an atomic combination of chemical and physical (with 2D graphene). The cell in question is a galvanic zinc-copper setup, with either one (H_2SO_4) or two ($CuSO_4$ and $ZnSO_4$) electrolytes, depending on the objective.

Results

As per intuition, the voltage level of any kind of electrochemical cell should increase if additional energy is introduced and properly exploited. The results reflect this hypothesis but varied for different types of setting. For example, temperature, despite being negative in the Nernst equation ($E_{cell} = E_{ocell} - (RT/nF) \ln Q_r$), turned out to have a positive effect of voltage in the experiment with a double-cell setup (around +200 mV for a 90oC difference on average) because of the increase in atomic kinetic energy, but has a negative effect when studying a single-cell due to local action and polarization. Also, the concentration of the electrolyte in the single-cell has a linear negative relationship with voltage (-250 mV for a 55% difference) but a positive one in a double-cell (+150 mV for 0.9M difference), which is also inconsistent with the Nernst Equation. Finally, the introduction of a sacrificial anode proved effective in limiting mass loss in the anode electrode over 24 hours with no significant effect on the voltaic output.

Conclusions/Discussion

In the big picture, these findings can be applied to advancing our battery models to optimize performance and lifespan by thoroughly utilizing the available energy sources surrounding and within materials.

Summary Statement

I tested the effects of different energy sources on the potentials of electrochemical cells.

Help Received

I carried out and analyzed my results for initial hypotheses and explanations, which are then revised by Dr. Grant, my adviser.