CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Dhuvarakesh Karthikeyan

Project Number

35635

Project Title

Utilizing Emerging Bio-Metallic Properties to Enhance Power Production and Cost Efficiency of a Biochemical Fuel Cell

Abstract

Objectives/Goals

To discover and harness latent properties that exist between exoelectrogenic communities in a biochemical fuel cell and their organic interactions with different types of electrode material.
New methods of increasing fuel cell efficiency are urgently needed as current labs, in looking for breakthroughs, focus solely on the mechanical aspect of engineering solutions, completely overlooking the fact that efficiency is tied inextricably to the living populations. By focusing engineering efforts around the organic facet of the system, I aim to reinvent the concept of the bio-fuel cell as a dynamic system with unique parameters dependent upon the biological agents powering it.

Methods/Materials

The electrogenetic efficacies of four cost-effective and catalytic transition metals (Co-59, Zn-65, Ni-59, and Cu-54) were tested against each other and against a graphite control which was employed to establish a baseline for results. The transition metals were ionized by splitting metal anhydrites in solution and the resulting cations were reduced at the cathode by means of an external power source therein electroplating these metals onto non-corrosive graphite rods.
These electroplated graphite rods served as the anodic electrode for the fuel cells while the standard graphite rod was used for all the cathodes. Benthic mud samples served as the source of exoelectrogenically active anaerobes and were inputted into each of the fuel cells. Results were taken every 12hrs including and after the initial setup of the fuel cells for a total of 144 hours.

Results

Both Zn and Co plated electrodes gave a significant 80%-160% increase in overall power production over the control graphite. The Cu fared far worse than even the graphite at 22% the capability of the control. The Ni-plated electrode outperformed all of the other electrodes with a 207% increase in power production.

Conclusions/Discussion

I successfully identified and tested select transition metals in the sphere of fuel cells with potential in utilizing biochemical pathways to optimize bacteria function and bring newfound emphasis on their role in these dynamic systems. Furthermore, using properties that exist between metals of varying potential in galvanic series and coupling this phenomenon with existing biochemical relations, I was able to achieve a statistically significant increase in power production while simultaneously increasing cost efficiency.

Summary Statement

By combining chemical properties unique to only metals and biological fuel cells, I identified novel interactions between exoelectrogenic populations and optimized their coulombic output in a scalable and practical fuel cell application.

Help Received

All research and experimentation was conducted autonomously; sister and mother helped with board construction