CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)

David M. Zimmerman

Project Number

J1043

Project Title

The Relative Impact of Anode and Cathode Composition on the Performance of a Two-Chambered Microbial Fuel Cell

Abstract

Objectives/Goals

Microbial fuel cell (MFC) performance is dependent upon many complex microbe-electrode interactions. To attain commercial viability, researchers must better understand the effect of electrode composition on MFC performance. My objective was to use a two-chamber MFC to assess the impact of electrode materials on electrical output in order to determine the relative importance of anode and cathode composition. My specific hypotheses were: 1) anode composition would have a greater effect on electrical output than cathode composition because of its contact with the microbes and 2) Pt anodes would be superior to Au or Cu.

Methods/Materials

Anode and cathode chambers were constructed from converted reagent bottles. Agar/saltpeter solution was poured into a plastic mold to serve as a salt bridge interposed between the chambers of the MFC. Anode chamber contained organic sediment from a stagnant stream; cathode chamber contained saline solution. Multimeter measurements of V(OC) and I(SC) with different anode/cathode materials (Cu, Pt, Au) were used to estimate electrical output as a figure of merit (V(OC)*I(SC)) to facilitate comparisons.

Results

Anode composition had a greater effect on electrical output than did cathode composition. Electrical output was significantly different between anode groups; Cu anodes yielded a significantly greater mean wattage than either Pt ($p = 0.03$) or Au ($p = 0.01$). In contrast, there were no statistically significant differences between the mean wattages of groups sorted by cathode type.

Conclusions/Discussion

My data support my hypothesis that anode composition has a greater effect on electrical output than cathode composition, probably due to the complexity of the microbial interactions at the anode during initial electron transfer. These data suggest that future MFC development efforts should prioritize anode material selection. Contrary to my second hypothesis, Pt anodes were not superior to either Au or Cu. The small surface area of my electrodes might have been insufficient for Pt's catalytic properties to overcome its poor electrical conductivity. Cu's superior performance might be due to its excellent conductivity, the absence of bactericidal Cu compounds, and suitability for the specific bacteria in my system. This finding underscores the value of testing anode performance under system-specific conditions, especially when mixed-cultures of bacteria are utilized.

Summary Statement

A two-chambered organic sediment microbial fuel cell was used to estimate electrical output resulting from different combinations of electrode materials in order to demonstrate the effect of anode/cathode composition on MFC performance.

Help Received

Mr. Robert Kahn guided me through the planning and logistical stages of my project; My mother advised me on statistical analysis; My father helped me to obtain my project materials; My uncle inspired my interest in the use of living organisms as a source of power.