CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)
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Project Number
J0206

Project Title
Microbes + Wastewater = Free Electricity

Abstract

Objectives/Goals
The objective is to determine if a polycarbonate proton exchange membrane (PEM) can produce more power and cost less than a Nafion PEM that is usually used in university research on microbial fuel cells (MFCs).

Methods/Materials
I developed a unique MFC design that allows proton exchange devices to be easily compared while controlling for changes in the microbe community. I spent a very long time searching for MFC designs, and as far as I know mine is the only MFC to control for the microbes. I was recognized by Penn State University and my MFC is on their website.

The PEMs and the salt bridge separate the anode and cathode chambers, and allow only hydrogen to pass through. The PEM or salt bridge to be tested is selected by opening and closing the correct valves. To determine the power output, the electrodes are connected to various resistances and the voltage is measured. The power is calculated at each resistance by using the formula V^2/R to find the maximum power. The maximum power is divided by the cost of the membrane, which gives watts per dollar. This is repeated for the various proton exchange devices.

Results
The Millipore polycarbonate membrane clearly performed the best out of all of the membranes and delivered 13.1 - 15.8 microwatts per dollar compared to 6.9 microwatts per dollar for the Nafion membrane. The tests showed good repeatability, even though the second test had nearly twice the power output. The tests are repeatable because the results scaled very well. The relative performance ranks of the proton exchange devices (PED) stayed the same for both tests. The significant changes in power show the importance of controlling for the microbes.

Conclusions/Discussion
The hypothesis that the Millipore polycarbonate membrane will provide more power output at a lower cost than the Nafion membrane is partially true. The Millipore membranes performed about the same as the Nafion membrane in terms of peak power but provided over twice as much power per dollar.

The real world application of MFCs is to generate electricity from wastewater treatment plants. The potential energy in U.S. wastewater today is equivalent to 15-20 nuclear power plants. Besides wastewater treatment, MFCs are also good for applications where batteries are hard to replace such as underwater sensors, space rovers and heart pacemakers.

Summary Statement
This project investigates the effect of different proton exchange membranes on microbial fuel cell performance while controlling for the microbe community.

Help Received
My father mentored me, and my mother taught me how to use a bread board for last year's science fair project.