Name(s)

Paulomi Bhattacharya

Project Number

S0904

Project Title

Optimizing the Microbial Fuel Cell-Microbial Electrolysis Cell System: A Novel Anaerobic Design for Hydrogen Generation

Abstract

Objectives/Goals

A microbial fuel cell (MFC)-microbial electrolysis cell (MEC) coupled system is a bioelectrochemical system that produces hydrogen gas as an alternative fuel. Oxygen leakage across the MFC ion exchange membrane is known to severely lower hydrogen yield. The objective of this project is to determine if an anaerobic MFC-MEC coupled system can be designed that will generate greater amounts of hydrogen gas than conventional coupled systems.

Methods/Materials

To compare voltage and hydrogen outputs, two systems were built for each trial: a conventional coupled system (the control) and the new optimized system. The new anaerobic MFC-MEC system was built by using a microbial biocathode in the MFC and an anion exchange membrane in the MEC. Double-chamber MFCs and MECs were constructed, and the source of microbes was wastewater with added organic substrates. Each half-cell was filled with dry ice that was allowed to sublimate and then with the appropriate electrolytic or wastewater solutions, eliminating O(2) gas from the system. The system was then sealed to be airtight and gastight and assembled accordingly. Voltages were measured for 15-hour periods with a multimeter. After each run, the MEC headspace was sampled with a gastight syringe. Using the known densities of H(2) and CO(2), the mass of the collected sample was compared to the mass of a pure CO(2) sample to determine the amount of H(2) produced.

Results

The conventional system produced a maximum of 0.178 V, while the optimized system produced a maximum of 0.266 V and sustained a higher voltage for a longer period of time. The conventional system produced a hydrogen yield of (0.00001 ± 1.238 # 10-4) g/ 3mL (SE at 90% confidence level, student t-dist. with n=9), while the sample from the optimized system produced a hydrogen yield of (0.00024 ± 1.238 # 10-4) g/ 3mL (SE at 90% confidence level, student t-dist. with n=9). The optimized system produced 1.5 times higher maximum voltage and 20 times higher hydrogen yield than the conventional system.

Conclusions/Discussion

In this design, while the anion exchange membrane in the MEC increased the hydrogen yield, the anaerobic biocathode-based MFC eliminated the key problem of oxygen leakage and provided a higher maximum voltage to sustain the optimized MEC. Data and consistent trends show that the anaerobic design was more efficient than the conventional system for producing hydrogen as a viable alternative fuel.

Summary Statement

This project developed a novel self-sustaining anaerobic microbial fuel cell (MFC)-microbial electrolysis cell (MEC) coupled system design that eliminates the external oxygen supply and produces a higher hydrogen yield than current systems

Help Received

Used school lab equipment under the guidance and supervision of mentor, Mr. Chris Spenner. Chemistry teachers Mr. Robbie Korin and Dr. Mala Raghavan answered questions that arose about solution chemistry