Abstract

Microbial Fuel Cells (MFCs) are very interesting in the field of renewable energy because bacteria in wastewater can produce enough electricity to power small devices. Although the power generation by MFCs has improved by over 100% in the last decade, the practice is not cost efficient and can rarely power practical devices. Through this study, a one gallon fuel cell was designed while three 50 mL MFCs were tested in various conditions. If advancements continue to be made in this field, these fuel cells could possibly help provide power for devices in remote locations.

Introduction

Why Microbial Fuel Cells?
- Microbial Fuel Cells (MFCs) are devices that harness electricity from chemical reactions that occur when bacteria decomposes substrates
- Systems that can directly harvest energy from the environment can be useful in remote locations like villages or deep in the ocean
- Systems that use renewable, green energy devices have no emissions and use fuel that is otherwise considered waste
- Improvement has been vast over the last decade

Improving MFC Generation
- Goal is to increase power density and decrease creation costs
- Various materials for anode determine power output - most current designs use silver or platinum but this one uses carbon nanotubes to help cost efficiency
- In MFC design, a maximum surface area against the anode material is desirable because it offers a higher power density
- An external circuit is necessary to amplify power up to usable levels
- Various types of wastewater affect the amount of power produced

Electrochemically Active Microbes as Energy Harvesters

Biology of MFC
- As certain types bacteria respire, they release electrons
- With a semi-permeable membrane between the chambers of the MFC, the electrons can travel from the anode to the cathode
- This transfer of electrons creates a current and can be used to power devices

Carbon Nanotube Anode
- Typically, platinum and silver are used as electrode for the anodes of MFCs
- Carbon nanotubes (CNTs) are a cheaper, organic alternative for the current MFC electrodes
- Stainless steel mesh was a backbone for the CNT’s growth and provided structure to the MFC

One Gallon MFC Development

Design
- The goal was to keep MFC simple and user-friendly
- Air cathode was preferred over a two chamber system (most common) because of work constraints
- Maximized surface area by dimensioning a small width which aided in creating a continuous flow chamber
- Materials included transparent acrylic, carbon cloth, and titanium mesh
- Easy access to the electrode because of the removable top plate

Machining
- Parts were dimensioned with a high tolerance
- Machinery used included band saws, laser cutters, a milling machine, and a CNC machine

Power Management
- Because MFCs do not produce power and voltage sufficient enough to power desirable devices, such as wireless transmitters, a circuit design is necessary to boost the output power
- Simulations were used to find the effectiveness of the circuit (shown below)

Testing Results

50 mL MFC
- Voltage from the MFC device to Excel file via Keithley 2700
- Find power density by dividing by the cross surface area in the MFC
- Find current density by using 1/A

Testing Results
- Polarity curve shows the highest amount of power that the MFC produces by varying the load values and recording the voltage

Conclusions and Future Works
- One gallon MFC was successfully planned and created
- Tests on 50 mL MFCs showed that activated sludge is a better inoculum than regular wastewater
- Currently, power output from 50 mL MFC and circuit is not high enough to run useful devices
- Future experiments will be run directly on the one gallon MFC to determine its power output and polarization data

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References