A terracotta bio-battery
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ABSTRACT
Terracotta pots were converted into simple, single chamber, air-cathode bio-batteries. This bio-battery design used a graphite-felt anode and a conductive graphite coating without added catalyst on the exterior as a cathode. Bacteria enriched from river sediment served as the anode catalyst. These batteries gave an average OCV of 0.56 V ± 0.02, a Coulombic efficiency of 21 ± 5%, and a peak power of 1.06 mW ± 0.01(33.13 mW/m²). Stable current was also produced when the batteries were operated with hay extract in salt solution. The bacterial community on the anode of the batteries was tested for air tolerance and desiccation resistance over a period ranging from 2 days to 2 weeks. The results showed that the anode community could survive complete drying of the electrolyte for several days. These data support the further development of this technology as a potential power source for LED-based lighting in off-grid, rural communities.

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1. Introduction

An important potential application of microbial fuel cell (MFC) technologies is off-grid lighting in poor regions of the world where millions of people rely on fuel based lighting due to lack of access to electricity. Fuel-based lighting has a number of distinct drawbacks that call for a replacement technology including fire hazards, cost burden (Mills, 2005), and indoor air-pollution (Apple et al., 2010). The use of MFCs for powering a lamp has become more feasible due to the availability of cheap, energy efficient, LED (light emitting diodes) lamps (Mills, 2005). Powering these lamps with MFCs in rural communities will require the development of simple, practical, and robust cells that can be operated with readily available materials such as table salt solution as electrolyte and waste biomass as electron donor.

An MFC converts biomass to electricity using bacteria as an anodic biocatalyst. Studies have shown that some facultative and anaerobic bacteria from the environment can generate energy from biomass oxidation by using a solid electrode (anode) as a final electron acceptor in the absence of oxygen (Logan and Regan, 2006). The electrons harvested from biomass by these bacteria can be used for electrical current production if the anode is connected in a circuit with a cathode in a cell filled with an electrolyte at neutral or a near neutral pH (Bennetto, 1990; Habermann and Pommer, 1991; Kim et al., 2008; Logan, 2009; Logan et al., 2006; Rabaey and Verstraete, 2005; Stirling et al., 1983). A current is maintained when the electrons flowing through the circuit are continuously consumed by oxygen or other chemical oxidants at the cathode. Therefore, MFCs can be referred to as bacterial batteries (Scholz and Schroder, 2003) or bio-batteries since they produce direct current like other galvanic cells when connected to a load. Bio-batteries can potentially operate for years providing a cheaper and more environmentally friendly alternative to chemical batteries. We envision a system composed of multiple microbial fuel cells operating in unison together with a microprocessor controlled power management circuit and LED lamp as a potential alternative to fuel-based lighting.

In this work, we converted terracotta flowerpots into air-cathode MFCs (which are henceforth referred to as bio-batteries). Each pot was coated on the outside with conductive graphite paint (to serve as the cathode). A roll of carbon felt placed inside each pot served as the anode. We tested the batteries first with defined medium (M9) containing acetate and then with water extract of timothy hay containing common salt (NaCl) or a phosphate buffer as the electrolyte. The batteries were operated with platinum-free cathodes and zero additional energy input; i.e., no stirring or pumps for oxygenation, feeding, and pH control.

2. Methods

2.1. Bio-battery construction

Generic terracotta flowerpots were obtained from a local garden supply center in Ipswich, Massachusetts. The pots were 11.5 cm in diameter at the top, 7.5 cm diameter at the bottom, 14 cm high and enclosed a volume of approximately 800 mL. The drainage hole at the base of each pot was sealed with plastic and adhesive. The pots