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Characterization of a microbial fuel cell with reticulated carbon foam electrodes

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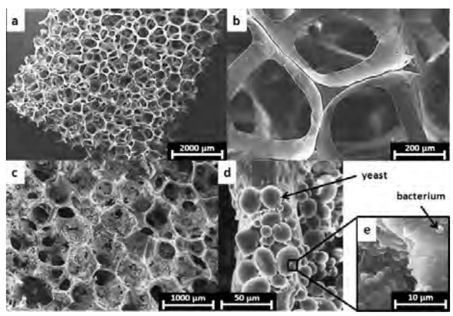
HIGHLIGHTS

- ▶ Reticulated vitreous carbon is tested as electrode material in a microbial fuel cell.
- ▶ Good stability and robustness of the biofilm to feeding risks are found.
- ▶ The power density is 40 W/m^3, limited by cathode overpotentials.
- ▶ Impedance spectrometry reveals the complex nature of the phenomena.
- ▶ Oxygen diffusion at the cathode is modeled by a Warburg element.

GRAPHICAL ABSTRACT



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ABSTRACT

A microbial fuel cell with open-pore reticulated vitreous carbon electrodes is studied to assess the suitability of this material in a batch mode, in the perspective of flow-through reactors for wastewater treatment with electricity generation. The cell shows good stability and fair robustness in regards to substrate cycles. A power density of 40 W/m^3 is reached. The cell efficiency is mainly limited by cathodic transfers, representing 85% of the global overpotential in open circuit. Through impedance spectrocopy, equivalent circuit modeling reveals the complex nature of the bioelectrochemical phenomena. The global electrical behavior of the cell seems to result in the addition of three anodic and two cathodic distinct phenomena. On the cathode side, the Warburg element in the model is related to the diffusion of oxygen. Warburg resistance and time are respectively 2.99 kΩ cm^2 and 16.4 s, similar to those published elsewhere.

1. Introduction

Microbial fuel cells (MFC) are of promising interest in the environmental and sustainable development area due to their potentiality to reduce the organic charge in wastewater and simultaneously produce electrical energy in an economical way. A great variety of micro-organisms communities can convert organic matter directly into electricity (Logan and Regan, 2006; Pham et al., 2009; Rabaey et al., 2007). For that purpose, various designs and electrode materials have been tested for a decade, in order to understand the involved phenomena and to improve efficiency of both organic charge removal in wastewater and electricity generation (Logan et al., 2006; Rabaey and Verstraete, 2005). The most common technology is based on anodic and cathodic chambers separated by an ion-exchange membrane. Usually, a bacterial film is naturally allowed to grow on an anode, enabling the oxidation reaction of an organic charge to take place and to produce electrons through an external circuit consisting of a resistive load. Protons move towards the cathodic compartment via an ion-selective membrane, commonly a Nafion™ or similar polymer sheet. Protons and electrons then combine at the carbon cathode surface through oxygen reduction into water.

Carbon is a good candidate for electrode material, thanks to its good electrical conductivity and harmlessness to living organisms, together with low prices. It can be easily manufactured to various forms and geometries, and has been adapted to a great number of cell configurations. Classical blocks, bars, rods and disks are used (Chaudhuri and Lovley, 2003; Kim et al., 2009; Liu et al., 2010; Rodrigo et al., 2007), but higher specific areas are reached with

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