

Research review paper

A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy

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Abstract

A microbial fuel cell (MFC) is a bioreactor that converts chemical energy in the chemical bonds in organic compounds to electrical energy through catalytic reactions of microorganisms under anaerobic conditions. It has been known for many years that it is possible to generate electricity directly by using bacteria to break down organic substrates. The recent energy crisis has reinvigorated interests in MFCs among academic researchers as a way to generate electric power or hydrogen from biomass without a net carbon emission into the ecosystem. MFCs can also be used in wastewater treatment facilities to break down organic matters. They have also been studied for applications as biosensors such as sensors for biological oxygen demand monitoring. Power output and Coulombic efficiency are significantly affected by the types of microbe in the anodic chamber of an MFC, configuration of the MFC and operating conditions. Currently, real-world applications of MFCs are limited because of their low power density level of several thousand mW/m^2 . Efforts are being made to improve the performance and reduce the construction and operating costs of MFCs. This article presents a critical review on the recent advances in MFC research with emphases on MFC configurations and performances.

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Keywords: Microbial fuel cells; Wastewater treatment; Electricity generation; Biohydrogen; Biosensor

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1. Introduction

The use of fossil fuels, especially oil and gas, in recent years has accelerated and this triggers a global energy crisis. Renewable bioenergy is viewed as one of the ways to alleviate the current global warming crisis. Major efforts are devoted to developing alternative electricity production methods. New electricity production from renewable resources without a net carbon dioxide emission is much desired (Lovley, 2006, Davis and Higson, 2007). A technology using microbial fuel cells (MFCs) that convert the energy stored in chemical bonds in organic compounds to electrical energy achieved through the catalytic reactions by microorganisms has generated considerable interests among academic researchers in recent years (Allen and Bennetto, 1993; Gil et al., 2003; Moon et al., 2006; Choi et al., 2003). Bacteria can be used in MFCs to generate electricity while accomplishing the biodegradation of organic matters or wastes (Park and Zeikus, 2000; Oh and Logan., 2005). Fig. 1 shows a schematic diagram of a typical MFC for producing electricity. It consists of anodic and cathodic chambers partitioned by a proton exchange membrane (PEM) (Wilkinson, 2000; Gil et al., 2003).

Microbes in the anodic chamber of an MFC oxidize added substrates and generate electrons and protons in the process. Carbon dioxide is produced as an oxidation product. However, there is no net carbon emission because the carbon dioxide in the renewable biomass originally comes from the atmosphere in the

photosynthesis process. Unlike in a direct combustion process, the electrons are absorbed by the anode and are transported to the cathode through an external circuit. After crossing a PEM or a salt bridge, the protons enter the cathodic chamber where they combine with oxygen to form water. Microbes in the anodic chamber extract electrons and protons in the dissimilative process of oxidizing organic substrates (Rabaey and Verstraete, 2005). Electric current generation is made possible by keeping microbes separated from oxygen or any other end terminal acceptor other than the anode and this requires an anaerobic anodic chamber.

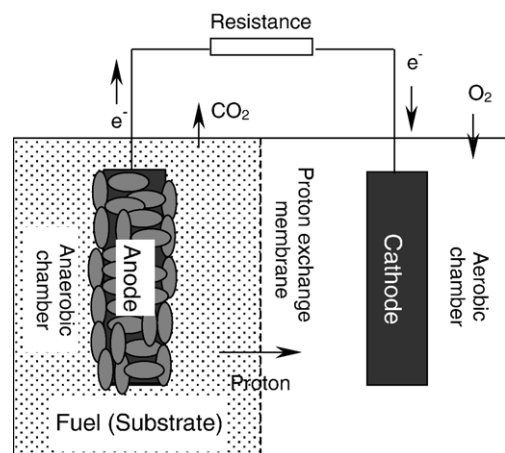


Fig. 1. Schematic diagram of a typical two-chamber microbial fuel cell.

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