Production of Electricity from Domestic Wastewater Using Microbial Fuel Cells

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ABSTRACT

In recent years, research on microbial fuel cells (MFCs) has progressed from two-chambered systems requiring mediators and defined substrates to systems designed to generate electricity from domestic wastewater. The production of electricity by MFCs and simultaneous degradation of the organic matter present in wastewater may prove a cost-effective alternative to conventional wastewater treatment. Organic matter in wastewater is an abundant, essentially free source of energy that can be harvested in various forms, including methane and hydrogen gases, and electricity (Logan et al., 2004). In related research, MFCs have been developed to tap the immense source of energy supplied by the oxidation of organic carbon in marine sediments (Reimers et al., 2001, and Tender et al., 2002). The electricity generated by these simple MFC systems is capable of powering long-term monitoring equipment in the ocean. To be feasible for wastewater treatment, the design of MFCs must be economical. As pointed out by Angenent et al. (2004), technical feasibility, simplicity, economics, societal needs, and political priorities will determine whether bioprocesses such as MFCs will be used to treat wastewater in the future. Recent research has focused on developing prototype MFCs that will reduce capital costs and optimize power production and efficiency.

KEYWORDS

Microbial fuel cell, wastewater treatment, electricity, economics

INTRODUCTION

In the U.S. alone, over $25 billion dollars is spent annually to treat domestic wastewater (WIN, 2001). The economic challenges posed by annual expenses of wastewater treatment are compounded by the additional $45 billion needed for infrastructure improvements. To offset these high costs, new methods such as microbial fuel cells are needed to produce useful products from the treatment processes. Microbial fuel cells (MFCs) have been investigated as a method of generating electricity from the oxidation of organic matter in wastewater. Research on biological fuel cells has progressed over the last twenty years to recent applications including the use of the marine sediment-seawater interface to generate electricity for monitoring equipment. The foundations of current studies for wastewater treatment using MFCs are built on the concept of conventional fuel cells modified for biological systems. Initial research investigating sulfate-reducing bacteria has led to improved current yields with mediators, and later to systems utilizing iron-reducing bacteria with no mediators needed. The objectives of current research for wastewater treatment using MFCs are to improve and simplify the design so as to optimize power output and develop an economically feasible treatment option.

SCHEMATICS

The concept of a conventional fuel cell is to generate electricity by converting the chemical energy of redox reactions into electrical energy. To create an electrochemical cell, the oxidation half-reaction is isolated from the reduction half-reaction. Platinum or copper wires are introduced into both sides of the container, and are connected externally via a high-resistance voltmeter. Ensuring connection between the solutions is important so that ions formed in one can move to the other to maintain electroneutrality. The electromotive force of the cell, or potential difference between the electrodes, is used to supply the electrical energy. In microbial fuel cells (MFCs),