Microbial fuel cells (MFCs) as model bioelectrochemical waste water treatment systems.

John Logan*

Department of Civil and Environmental Engineering, Penn State University, University Park, USA

Abstract

Organic substrate-containing wastewater from various industrial sources provides an essential foundation for generating bioenergy. The continual energy needs for aeration and sludge control make aerobic wastewater treatment techniques like the activated sludge process and trickling filters unsustainable. The Microbial Fuel Cell (MFC) technology currently available allows for synchronised wastewater treatment, bioelectricity production, and resource recovery via bioelectrochemical remediation mediated by electroactive microbes. MFC technology is an appropriate alternative for energy positive wastewater treatment. The additional benefit of adopting MFC technology for effluent treatment is the ability to conduct many bio-based processes in the same bioreactor, including the removal of heavy metals, nitrification, denitrification, and the elimination of biochemical and chemical oxygen demand. In order to efficiently remove and recover sulphate, nitrogen, and phosphate without tertiary treatment, MFCs can thus both replace and supplement the traditional energy-intensive processes. The removal of organic and refractory pollutants from a variety of industrial and home effluents while producing affordable energy is covered in the current assessment of recent developments in the use of microbial fuel cell technology. This review also highlights hybrid systems that were created in conjunction with traditional treatment methods to make the process energy neutral and open the door to scaling-up MFCs for environmentally friendly wastewater treatment.

Keywords: Microbial fuel cells, Wastewater treatment, Electroactive microbes, Bio-electrochemical remediation, Bioenergy.

Introduction

In the past 20 years, microbial fuel cells (MFCs) have seen significant technological advancement, but nothing has been done to make them commercially viable. The ability to produce power and treat wastewater simultaneously is one characteristic that significantly boosts interest in using MFCs. This type of distributed energy generation is eco-friendly and renewable and is simple to incorporate into a smart grid. High construction costs, the challenge of creating high power structures, MFC longevity, and keeping a high level of efficiency are some of the major problems with their commercialization. With the aid of an appropriate microbial substrate, microbial fuel cells (MFCs) are chemical reactor systems that produce electricity from the biodegradation of organic materials. To test the behaviour of electrode materials, membranes, and other such things, as well as the design of the reactor or microbial activity, the earliest substrates employed in the laboratory were primarily glucose, acetate, or other simple substrates. Beginning in 2004, the study used actual wastewater as a substrate. The energy savings from the wastewater aeration and sludge treatment were the biggest benefit. Additionally, MFC methods produce less sludge than aerobic activated sludge (AS) treatment systems and anaerobic digesters. These have less temperature sensitivity, fewer sludge treatment facilities and related electrical infrastructure, and no energy is used for aeration. Wastewater, in general, is the most widely used substrate for an MFC operation because it has a high percentage of organic loads and is free of charge [1-3].

Wastewater from the agro-food industry is particularly suited because of its high biodegradability. The numerous electroactive and complimentary non-electroactive microorganisms convert the chemical energy stored in the chemical components of wastewater or biomass into electrical energy. With its low thermal efficiency, the Carnot thermodynamic cycle at an ideal thermal machine is avoided by this direct conversion of chemical energy to electrical energy. Theoretically, MFCs are comparable to traditional fuel cells in that they can achieve higher efficiency (>70%). Additionally, because wastewater is used, it is a renewable energy source whose "fuel" supply can be managed somewhat more readily than wind turbines, where the wind can't be controlled at all, and photovoltaics, where the sun can't be controlled but is predictable. This is helpful whether it's used as a distributed power unit or as a component of a smart grid. Of However, because microorganisms are involved in the production of power, its performance is not

***Correspondence to:** John Logan, Department of Civil and Environmental Engineering, Penn State University, University Park, USA, E-mail: jlogan@psu.edu

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entirely under control. In contrast to biomass thermal units, the amount of energy produced by bacteria varies over time and is proportionate to their development as long as they are fed with organic materials that have a relatively constant calorific value. Although maximum power densities and chemical oxygen demand efficiencies in cross-laboratory research on MFCs using domestic wastewater in identical single-chamber MFCs have been very similar, starting times and acclimation stages have varied due to the diversity of the microbial populations [4-7].

Conclusion

In conclusion, a variety of criteria have been used to evaluate the MFCs economically, and the findings have been mixed. The MFC was not a financially feasible source of power in 2006. The same result was obtained when the typical values of the power level, efficiency (from power input to electrical output), technical lifespan, capital cost per installed nominal active power, and capacity factor for conventional fuel cells, conventional renewable energy sources, and traditional power plants were taken into account. However, because full-scale wastewater treatment plants do not yet exist and only a small number of scaling-up trials have been examined in actual plant conditions, the application of the MFC in a wastewater treatment plant will result in the economic viability of the investment if the cost of wastewater treatment is significantly reduced. Similar to this, the production of electric power using bioelectrochemical processes is extremely promising provided that pilot studies and focused future research are carried out with positive outcomes.

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