Performance Enhancement of Microbial Fuel Cell by using Ceramic Membrane Separator as a Sustainable Solution for Power Production

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ABSTRACT

Utilization of bio-electro chemical systems for resource recovery and efficient resource use towards a sustainable and eco-friendly environment is of utmost importance in the present era. Researchers are working on finding viable and alternative ways for resource utilization and energy production. For this reason, Microbial Fuel Cell (MFC) is a bio-electrochemical device that is gaining a lot of importance for sustainable bioelectricity production and wastewater treatment. It functions by utilizing the metabolic activities of microbes to oxidize the organic matter in waste effluents at anode chamber thereby releasing protons and electrons. The electrons move through the outer circuit towards cathode while protons move through a membrane in dual chambered MFC, ultimately generating a sustainable source of power. One of the key components of dual chambered MFC is membrane, which is not only the means of proton transfer but ultimately a pathway towards green power production. Several traditional Polymer Electrolyte Membranes (PEMs) are employed in MFCs like Nafion, Ultrex, SPEEK etc. but the use of these polymeric membranes in MFCs possess several drawbacks like high cost, lack of durability, high swelling ratio, susceptibility to fuel contamination, and temperature and pH imbalances which lessens the power production in MFCs for sustainable operations. Therefore, in this study novel ceramic membranes are used to assess the chemical and thermal stability, pH and temperature tolerance, flexible pore size control, durability, resistant to fouling, and eco-friendly alternative to PEM for high power production.

Keywords: Ceramics, Microbial Fuel Cell, PEMs, Power, Wastewater.

INTRODUCTION

Microbial Fuel Cell (MFC) is a bio-electrochemical device which is gaining a lot of importance due to its multiple benefits like producing energy from waste sources, treating wastewater effluents, sensing applications, and recovering the byproducts(Chen et al., 2023; Salar-García et al., 2021). However, despite several benefits associated with MFC, it also faces several limitations such as reduced power production for long term applications, high cost of membranes, fuel crossover in single chamber MFC, oxygen diffusion, and internal resistance(Malik et al., 2023). To overcome these limitations associated with traditional membranes specifically polymer-based membranes, ceramic membranes have been introduced with their unique features as membrane separators in MFCs(Mahmoodi Nasrabadi& Moghimi, 2023). Several researchers have focused on identifying inexpensive and durable ceramic separators to enhance the performance of MFCs for sustainable operations (Bai et al., 2022; Chavan et al., 2022; Dharmalingam et al., 2019; Mashkour et al., 2021; Zhang et al., 2016) but there are gaps in literature regarding ceramic membranes and power production using MFC device. Therefore, a novel and alternate way of using polymer ceramic membrane with varying compositions, thicknesses, and concentrations of mineral cation exchangers is developed. It primarily focuses on transport of ions and improved power production. In MFCs, ceramic membrane separators may increase performance and reduce the internal resistance for sustainable power generation. Therefore, the present work may set an approach for studying MFC ceramic membrane separators and their function in sustainable power production.

OBJECTIVES

- Fabrication and characterization of polymer ceramic membrane for microbial fuel cell
- Effect of polymer ceramic membrane on power production of microbial fuel cell
- Assess the performance of polymer ceramic membrane in complex wastewater.

METHODOLOGY

The experimental design involved the fabrication of dual chambered Microbial Fuel Cell (MFC) with 200ml capacity by using acrylic sheet. Graphite rods were used as both anode and cathode. For development of membrane, polymer was mixed with clay-based cation exchangers in different ratios (1:1, 1:2, 2:1) and then membrane was made by using doctor blade coating technique. Anode chamber was filled with raw wastewater obtained from wastewater lake at NUST-H12, Islamabad, Pakistan. The experiment was performed by using batch analysis and each batch included continuous readings of electrical and physicochemical parameters in MFC device. Furthermore, ionic conductivity, membrane swelling ratio, and oxygen diffusion coefficient were determined by using various formulas.

CONCLUSION

The polymer ceramic membrane is a cost-effective and viable solution in Microbial Fuel Cell (MFC) as it offers thermochemical stability, reduced internal resistance, and increased ionic conductivity. As a result of these benefits, the performance of MFC increased. Furthermore, the results of this study may help to solve the limitations associated with conventional polymer membranes and may enhance the application of these devices for sustainable operations.

ACKNOWLEDGMENT

The authors would like to acknowledge World Technology Partners (USA)for their support forthis work.

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