CHAPTER

7

MICROBIAL FUEL CELL FOR POME TREATMENT

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7.1 INTRODUCTION

Global climate change, fossil fuel depletion, and diverse industrial pollution all have multifaceted negative impacts on the environment. In the palm oil industry, palm oil mill effluent (POME) stands as a significant contributor to environmental pollution, necessitating a substantial amount of water for the production of crude palm oil (CPO) (Chan & Chong, 2018).

The POME substrate is recognized for containing amino acids, as well as inorganic nutrients like sodium, potassium, calcium, magnesium, and short fibres, organelles, nitrogenous components, free organic acids, and a diverse range of carbohydrate compounds such as hemicelluloses, simple sugars, oligosaccharides, and various other molecules (Foo & Hameed, 2010). It is further concerning to note that over 2.5 tons of POME are generated during the process of producing one ton of CPO in this organic form leading to elevated levels of chemical oxygen demand (COD) and biochemical oxygen demand (BOD) which poses considerable environmental hazards. It's manufactured in an acidic environment, typical pH in ranges of 3.4 to 5.2 contribute to the generation of acidic wastewater, makes certain pollutants more soluble in water (Saputera et al., 2021).

A growing awareness of this issue has led to the exploration of potential solutions, including the use of microbial fuel cells (MFCs). MFCs are recognized as a green energy source, primarily because of their dual capability to generate electricity and concurrently purify the environment from contaminants (Suresh et al., 2022). Essentially, MFCs function as anaerobic bioreactors that utilize microorganisms to break down pollutants through anaerobic oxidation, thereby producing electrons. These generated electrons travel through an external circuit, resulting in electricity generation. The capacity of MFCs to harness microorganisms as biocatalysts for recycling organic materials found in environmental waste makes them a particularly intriguing form of sustainable technology (Pant et al., 2010)

Despite this, MFCs have yet to achieve optimal performance. These challenges encompass a range of issues, including a relatively short lifespan, a sluggish production rate, problems related to membrane fouling, high production costs, and limitations in overall efficiency. The effectiveness of MFCs is influenced by numerous factors, such as the choice of electrode materials, temperature, pH levels, the presence of biofilms, substrate loading rates, external resistance, as well as the type of membrane materials utilized (Das et al., 2021). To achieve the highest possible bioelectricity output, it is imperative to fine-tune and optimize these variables. Additionally, the design of the reactor plays a crucial role in determining the performance of MFCs, with various designs tailored to their mode of operation and the number of chambers they incorporate.

7.2 FUNDAMENTALS OF MICROBIAL FUEL CELL

In a typical MFCs, electric energy is captured from organic pollutants stored in wastewater in the form of carboneous compounds, which are converted to electricity through a biochemical process (Tatinclaux et al., 2018). Basically, MFCs system is composed of two compartments known as the anode chamber and the cathode chamber, and usually separated by a proton-exchange membrane (PEM).

In the anode chamber, electrochemically active microbes present in water serve as biocatalysts to facilitate the oxidation (degrade) of both organic and inorganic substances from the wastewater used for their cellular mechanism. These microorganisms metabolize organic matter to generate energy, promoting their growth and concurrently producing electrons, protons, and carbon dioxide as metabolic byproducts (Gul et al., 2021). This growth and electron production process results in microbial reduction, leading to the generation of electrons that are drawn towards the anode. These electrons attach to anodic surfaces, typically utilizing cytochromes or redox-active proteins.

At the same time, an external circuit transports the electrons from the anode chamber to the cathode chamber. These generated protons by the microbial activity migrate through a PEM, which is typically employed of Nafion, to reach the cathode chamber. Within the cathode chamber, these protons lead to the production of hydrogen gas (H_2) and hydroxyl ions (OH^-), while the electrons react with an oxidizing agent like oxygen. This reaction results in the reduction of electrons to produce pure and clean water (H_2O). Figure 7.1 provides a visual representation of a standard MFC setup.

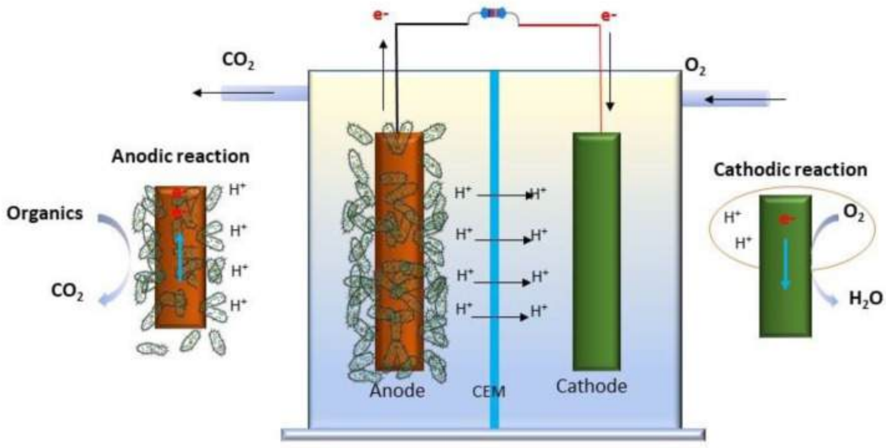

Figure 7.1 Schematic representation of a typical microbial fuel cell (Source: Sonawane et al., 2022)