

A Short Review on Microbial Fuel Cell Technology and A Proposed approach for Generation of Electricity using Waste Water Treatment

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Abstract— Microbial Fuel Cell (MFC) technology is an efficient technology which has a practical aspect of conversion of chemical energy in organic compounds directly to electrical energy through degradative activities of microorganisms. MFCs can be used in wastewater treatment plants with simultaneous generation of electricity. A lot of research has already been done and different types of MFCs have been constructed which have varied applications in addition to electricity generation. This article presents a short review on MFCs stating its working, types and applications with broader view on wastewater treatment.

Key words: MFC, PEM, Chlorella

I. INTRODUCTION

Modern age presents us with a series of graduated problems among which the global energy crisis is topping the list. In the wake of the fact that the non-renewable sources of energy like coal, petroleum etc. are short-lived, one of the most challenging issue today is production of clean yet sustainable sources of alternative and renewable energy. Major efforts are underway all over the world to develop alternative electricity production methods. Alternative source of energy are in high demand because developed as well as developing countries are facing serious energy crisis[1]. Our group has been actively engaged in green energy generation initiative as we need to do our bit for the environment and the dangling energy scenario in the world. The construction of the prototype and analyzing the efficiency of a bio-photovoltaic device which uses photosynthetic reaction of algae such as Chlorella for generation of electricity was the part of our previous project. This is our interdisciplinary green energy generation initiative. A technology using Microbial Fuel Cell has caught attention of researchers all over the world. It envisages to produce useable electrical energy from waste while it (waste) is being degraded by bacteria. Microbial Fuel Cell (MFC) is a highly practical technology that harnesses the power of bacteria to generate electricity from wastes (sewage and similar wastes). Bacteria in a MFC break down the organic matter from the food and bodily wastes present in sewage generating electricity while accomplishing the degradation of organic matter or waste.

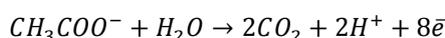
The earliest Microbial Fuel Cell Concept was demonstrated by Potter in 1910[2]. Electrical energy was produced from living cultures of Escherichia Coli & Saccharomyces by using Platinum electrodes (Potter 1912)[3]. Since then there has been no looking back. MFCs can be grouped into two general categories, those that use a mediator and those that are mediator-less. Mediator MFCs[4]: When the direct electron transfer from the microorganism (E. coli, Saccharomyces) to the anode is very inefficient as a result of selective permeability of the cell wall and cell membrane, the inclusion of redox mediators such as methylene blue, thionine, neutral red will facilitate the transfer of electrons to the anode. Most of the mediators available are expensive and toxic. Mediator free MFCs[4]: Some microorganisms (Shewanella putrefaciens, Aeromonas hydrophila) can transfer electrons directly to anode. These bacteria are bio-electrochemically active and can form a biofilm on anode surface. These are cost efficient as cost of mediator is eliminated.

Since the turn of the 21st century, MFCs have started to find a commercial use in the treatment of wastewater in addition to having other applications as well such as in the area of Bio-sensors, bio-recovery of metals, in methane production etc. [4].

II. WORKING OF A MICROBIAL FUEL CELL

Microbial fuel Cells are bio reactors involving a microbial setup in the conventional electric cell setup. The Bacterial reactions account for the anodic part of the cell. The electrolyte is waste water which consequently also serves as the source of organic contents. The Anode and Cathode are separated by a selective Proton Exchange membrane. For example, If acetate is used as the substrate [5],

Anodic Reaction:



Cathodic Reaction :



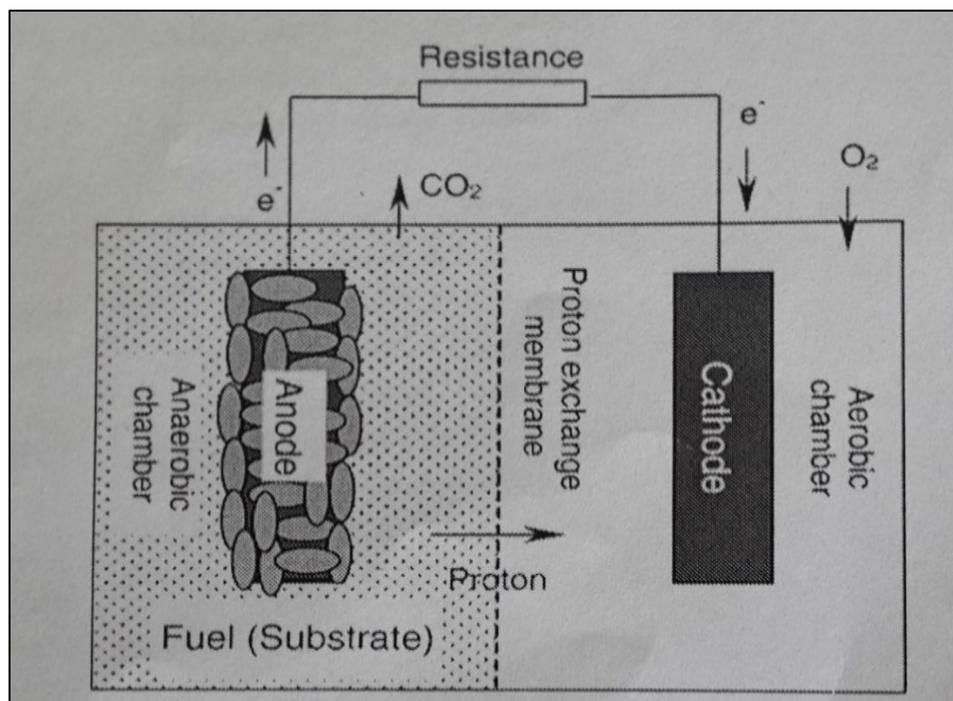


Fig. 1: Microbial Fuel Cell [4]

The MFC is made of four parts as shown in Figure 1– Anode chamber which holds the bacteria and organic matter in an anaerobic environment. – Cathode chamber which holds the conductive saltwater solution – Proton exchange membrane which separates anode and cathode and – external circuit. Bacteria in the anode chamber create protons and electrons during oxidation as part of their digestive process. The electrons are pulled out of the solution in the anode and placed onto the electrode. The electrons are then conducted through the external circuit and into the cathode chamber by the way of the cathode's electrode. The protons from the solution in the anode travel through the proton exchange membrane to meet with the electrons at the cathodes [4,6].

In a double chambered fuel cell, both the cathode and anode are housed in different compartments or chambers connected via proton exchange membrane (PEM) or sometimes salt bridge[5]. Electrode materials and their form (like graphite fiber brush anodes)[7] play an important role in the performance (e.g., power output) and cost of microbial fuel cells (MFCs). The substrate in the anode chamber is oxidized by microbial metabolism under anaerobic conditions, producing electrons(e-) and protons(p+). After being transferred to the anode by direct membrane-associated electron transfer, electron mediators or nanowires, the electrons flow to the cathode, which is linked by an external circuit. Simultaneously, protons reach the cathode through the PEM. The output power depends on the rate of substrate degradation, the rate of electron transfer from the bacteria to the anode, the circuit resistance, the proton mass transfer in the liquid, the performance of the electrode and the external operating conditions and so on.

III. APPLICATIONS AND FUTURE SCOPE

Microbial fuel cells can be used for different purposes such as electricity generation, Biohydrogen production, biosensors and waste water treatment. Low power wireless systems can also be powered with MFCs. There has been reported study of using the MFC to utilize the body glucose to power implanted medical devices. Robotics has also high usage of MFCs for sustaining self-sustainable autonomous robots. MFCs are especially suitable for powering small telemetry systems and wireless sensors that have only low power requirements to transmit signals such as temperature to receivers in remote locations. MFCs are viewed by some researchers as a perfect energy supply candidate for Gastrobots by self-feeding the biomass collected by themselves. The robot EcoBot-II solely powers itself by MFCs to perform some behaviour including motion, sensing, computing and communication[4]. MFCs have a wide scope in environmental sensors [8].

IV. PROPOSED WORK PLAN

Our DU Innovation Project is based on the use of Microbial Fuel Cell technology for harnessing electricity with simultaneous treatment of wastewater. In this project, our group has members from two unlike departments of Microbiology and Electronics who would be coming together once again on a common platform to initiate research in this area to harness clean and green energy for a brighter tomorrow. In continuation to our previous year DU innovation project (BCAS-201), we are looking forward to construct a prototype of a Microbial Fuel Cell for microbial degradation of organic matter with simultaneous generation of electricity. Our project aims to collect waste water samples from various sites and analyzing those samples. We will have the comparative study of electricity generation from a Bio-photovoltaic Cell (using photosynthetic activity of algae) and Microbial Fuel Cell (using metabolic activity of bacteria present in the waste water samples).

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