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Sustainable Production of Bioelectricity from Coovum River using MFC

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ABSTRACT—*Today we are witnessing a global energy crisis due to huge energy demands and limited resources. Non renewable energy sources are depleting and renewable energy sources are not properly utilized .There is an immediate need for search of alternate way for energy generation .Microbial Fuel Cell(MFC) technology, which uses micro organisms to transform chemical energy of organic compounds into electricity is considered a promising alternative. Extensive studies have corroborated new insights into MFC, which show that a wide array of carbon sources including waste can be employed using a variety of microbes. Consequently , microbial transformation of waste using noval bio remediation strategies such as MFC for energy generations is considered as an efficient and environmentally benign approach. This paper deals with critical review of anaerobic bacterias and wastes that can be employed for bioenergy generation, microorganisms involved, power output, challenges and pit holes of MFC technology.*

Keywords— Microbial Fuel Cell, Sustainable energy source, Renewable electricity production capacity,Waste water treatment.

1. INTRODUCTION

Microbial fuel cells (MFCs) employ microbes to generate electricity from biochemical energy produced during metabolism of organic substrates. MFC consists of anode and cathode connected by an external circuit and separated by proton exchange membrane (PEM). In anode chamber, decomposition of organic substrates by microbes generates electrons (e^-) and protons (H^+) that are transferred to cathode through circuit and membrane respectively[1]. Organic substrates are utilized by microbes as their energy sources, outcome of this process is in release of high-energy electrons that are transferred to electron acceptors (molecular oxygen) but in absence of such electron acceptor in a MFC, microorganisms shuttle electron onto anode surface that results in generation of electricity[2]. Bacteria are most preferred microbes that can be used in MFCs to generate electricity while accomplishing biodegradation of organic matters or wastes[3,4]. Biodegradable organic rich waters (municipal solid waste, industrial and agriculture wastewaters) are ideal candidates of sustainable energy sources for electricity production. MFCs can also be used as biosensors and in secondary fuel production.This paper reviews recent developments in MFC technology highlighting working principle and applications of MFC technology.

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2. MFC EXPERIMENT SYSTEM

The MFC experimental system used in this study, which was built from the scratch using generic off-the-shelf components. The MFC experiment is made of the following four parts

- Anode chamber which holds bacteria and organic matter in an anaerobic environment
- Cathode chamber, which holds a conductive saltwater solution
- Proton-exchange membrane, also known as salt bridge, which separates the aode and cathode and allows protons to move between the two chambers
- External circuit, which allows electrons to enter the cathode and functions as a path for electrons to travel through when pulled out of the solution in the anode.

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 an electrode. The electrons are then conducted through the external circuit and into the cath- ode chamber by way of the cathode's electrode. The electrode is made of bare copper wire glued with nickel epoxy on carbon cloth. The protons from the solution in the anode travel through the proton-exchange membrane to meet with the electrons at the cathode.

3. STUDY OF MFC EXPERIMENT

The MFC is powered primarily by the bacteria in the anode chamber. Thus, it is expected that the electricity production is affected by a number of factors that influ- ence the metabolic process of bacteria and are particu- larly relevant in the sensor application of interest:

- The type of bacteria in the anode and the organic matter that the bacteria digest;
- The temperature at which the metabolic process takes place;
- The amount of bacteria used and the size of anode chamber.

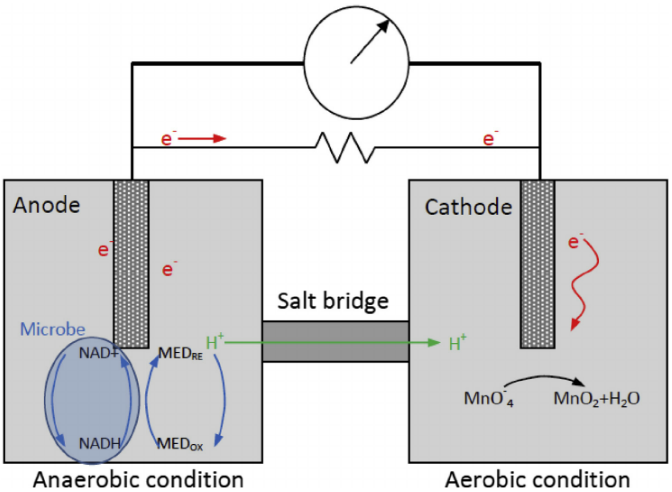
We next elaborate on how these factors are investigated in the experiment. For the sensor application, we chose to study three different types of samples, namely, benthic mud sample, top soil sample, and marsh sample, which exist in the environments where sensors are commonly placed to monitor environment ecosystems. The benthic mud sam- ple collected was first filtered so that it would only contained rich mud and a minimum amount of rocks or twigs. However, even after filtration, the benthic mud sample still contained some small rocks. The top soil and marsh samples were also filtered in the same way. Unlike the benthic mud sample, neither of these samples contained a visible amount of small rocks after filtration. The benthic mud, top soil, and marsh samples most likely held different amounts of bacteria. Since the benthic mud sample contained the most percentage of small rocks, it was expected that this sample contained the lowest percentage of organic matter. The marsh sample seemed to contain the richest, thickest mud, and was expected to have the highest percentage of organic matter such as bits of decaying leaves. However, this initial belief was solely based upon qualitative data. It was possible that a higher percentage of organic matter existed in the benthic mud and top soil samples. It is believed that a sample with higher percentage of organic matter, which presumably contains more bacteria and bacterial food sources per a unit of sample, allows for the production of more electrons and thus electricity, a hypothesis we will examine in this experiment. In addition, the type of bacteria may play a role as well. For example, the types of bacteria found in the benthic mud and top soil samples may be more effective in producing electricity. Hence, before the completion of this experiment, it was unclear which bacteria sample would produce the greatest amount of electricity. Bacteria grow and the metabolic process takes place with equal efficiency at all temperatures between the freezing point of water (0˚C) and the temperature at which protein or protoplasm coagulates (40˚C). The metabolic process of bacteria slows down and the growth of the organism ceases when bacteria are placed in an environment below the freezing temperature of water, but the bacteria present are not killed. However, when bacteria are in an environment above the temperature at which protein or protoplasm coagulates, most are killed. Based on our extensive literary search, no MFC efficiency test has been performed at a temperature below 0˚C or above 40˚C. For the sensor application of interest, it is important to test beyond these upper and lower thermal limits so that we can understand how MFCs would performance under extreme temperature conditions. Indeed, as will be discovered in this experiment, at −5˚C, surprisingly the MFC is able to produce a decent amount of electricity, thereby potentially being able to power sensors below the freezing point of water. The size of the anode chamber or more importantly the amount of sample used was expected to have an effect on the electricity production of the MFC. It would not be surprising that a larger amount of sample would contain more bacteria and produce more electricity. However, what we intended to examine in this experiment was whether the efficiency, defined as electricity production per unit sample size, was lost when a larger MFC was used. Will the electricity capacity increases linearly with the MFC size, or will some efficiency be lost as the size increases? The importance of this study is that ultimately large scale MFCs will be needed in real world applications and the efficiency will be a crucial performance metric that determines the extent to which MFCs can scale in size.

3.1 Substrate used for Electricity Generation

Substrate is a key factor for efficient production of electricity from a MFC. Substrate spectrum used for electricity generation ranges from simple to complex mixture of organic matter present in wastewater. Although substrate rich in complex organic content helps in growth of diverse active microbes but simple substrates considered to be good for immediate productive output. Acetate and glucose are most preferred substrate for basic MFC operations and electricity generation. Lignocelluloses biomass from agriculture residues as hydrolysis products (Monosaccharide's) are a good source for electricity production in MFCs. Another promising and most preferred unusual substrate used in MFCs operations for power generation is brewery wastewater as it is supplemented with growth promoting organic matter and devoid of inhibitory substances. Starch processing water can be used to develop microbial consortium in MFCs. Cellulose and chitin (from industrial and municipal wastewaters) synthetic or chemical wastewater, dye wastewater and landfill leachates are some unconventional substrates used for electricity production via MFCs.

3.2 Commonly used Microbes in Microbial Fuel Cells (MFCs)

Usually mixed culture of microbes is used for anaerobic digestion of substrate as complex mixed culture permits broad substrate utilization. But there are some regular MFCs designs which explore metabolic tendency of single microbial species to generate electricity. Organic component rich sources (marine sediment, soil, wastewater, fresh water sediment and activated sludge) are rich source of microbes that can be used in MFCs catalytic unit. Bacteria used in MFCs with mediator or without mediators have been extensively studied and reviewed. Metal reducing and anodophilic microorganisms show better opportunities for mediator less operation of a MFC.



4. FUTURE PROSPECTS

MFC is a promising technology for generation of electricity from organic substances, especially from organic waste of different origin. However, there are certain drawbacks, which has hindered to make it more applicable when practical applications are concerned. The major drawback of MFC technology is the low power density; this can be rectified by either isolation of potent microorganisms that can efficiently transfer electrons to anode or by generating engineered strains through recombinant DNA technology that show greater electron transfer rates. Many reports have confirmed that rather than pure cultures, consortium of many bacteria show improved electron transfer rates to the anode. Many bacterial strains have been shown to produce mediators which efficiently transfer electrons to the anode. Identification of new mediators can also increase the performance of MFC technology. Another drawback of MFC is the limited surface area of the electrodes where microorganisms adhere. Extensive studies have been performed to identify methods that enhance the performance of MFC reactors and have resulted in the designing of more efficient laboratory-scale MFCs. These technologies include the use of air cathodes (Liu and Logan 2004), stacked reactors (Aelterman et al. 2006) and cloth electrode assemblies (Fan et al. 2007). Among these, the use of air cathodes (Liu and Logan 2004) is very effective since it helps in efficient use of oxygen from air and avoids the need for aerating the water or using chemical catholytes such as ferricyanide that must be regenerated. Air cathodes have been optimized for the use in MFCs (Cheng et al. 2006), and the effects of shape and position on MFC performances have been evaluated using different reactor designs (Zuo et al. 2007; Fan et al.2007). These efforts have resulted in highly efficient small-volume laboratory MFCs (~20 ml in anode volume) that produced electrical outputs of over 1000 W m^3 (Fan et al. 2007). However, it is still a challenge for MFC researchers to construct large-scale MFCs that have both high power production and stable performance (Zuo et al. 2007). Liu et al. (2008) have recently reported the construction of a 500-ml MFC reactor with the maximum power density of 20 W m^3. Another drawback of this technology is in treatment of wastewaters and scaling up of MFC. Scaling up of MFCs for large-scale applications and for improving the overall performance of MFC technology will help in treatment of wastewater, which is present in large quantities

5. CONCLUSION

MFC is a state-of-the-art technology for production of electricity from metabolism of microorganisms. In this review, we have dealt with major wastes and xenobiotics, such as hexavalent chromium, agrowastes, nitrates and azo dyes. Some of them such as hexavalent chromium and azo dyes are very toxic to the ecosystem and cause death of organisms. In MFC, they are used for electricity production and also they are transformed into less toxic metabolites, which demonstrates its another potential use in waste management and pollution control. Till now, a large number of microbes and a waste variety of substrates (including waste and xenobiotics) have been used to produce electricity. However, a major drawback of this technology is that the power output is very low and scaling up leads to a decrease in power output. This is the main reason why this technology has yet not been commercialized. So, a lot more work is required so that this technology becomes efficient, applicable and widely accepted

7. REFERENCE

1. Logan B E, Hamelers B, Rozendal R, Schroder U, Keller J, Freguia S, Aelterman P, Verstraete W & Rabaey K, Microbial fuel cells: methodology and technology, *Environ Sci Technol*, 40 (2006) 5181-5192.
2. Wrighton K C & Coates J D, Microbial fuel cells: plug-in and power-on microbiology, *Microbes*, 4 (2009) 281-287.

3. Park D H & Zeikus J G, Electricity generation in microbial fuel cells using neutral red as an electronophore, *Appl Environ Microb*, 66 (2000) 1292-1297.
4. Oh S E & Logan B E, Hydrogen and electricity production from a food processing wastewater using fermentation and microbial fuel cell technologies, *Water Res*, 39 (2005) 4673-4682.
5. Du Z, Li H & Gu T, A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy, *Biotech Advances*, 25 (2007) 464-482.
6. Watanabe K, Recent developments in microbial fuel cell technologies for sustainable bioenergy, *J Biosci Bioeng*, 106 (2008) 528-536.
7. Ahmed Ebrahim Abu El-Maaty Behiry (2012), Evaluation of steel slag and crushed limestone mixtures, as subbase material in flexible pavement, *Ain Shams Engineering Journal* , Issue 12, volume 3, pp. 887-889..
8. Montgomery D.G and Wang.G (1992), Instant-chilled steel slag aggregate, *cement and concrete research*. Vol. 22, pp. 755-760.
9. Mahmoud Ameri, Ali Behnood (2012), Laboratory studies to investigate the properties of CIR mixes containing steel slag as a substitute for virgin aggregates, *Construction and Building Materials*, Issue 26 ,pp. 475–480.
10. Perviz Ahmedzade, Burak Sengoz (2009), Evaluation of steel slag coarse aggregate in hot mix asphalt concrete, *Journal of Hazardous Materials*, Volume 165, Issues 1–3, 15 June 2009, pp. 300-305.
11. Aelterman P, Rabaey K, Pham HT, Boon N, Verstraete W (2006) Continuous electricity generation at high voltages and currents using stacked microbial fuel cells. Environ Sci Technol 40:3388–3394
12. Aldrovandi A, Marsili E, Paganin P, Tabacchioni S, Giordano A (2009) Sustainable power production in a membrane-less and mediator-less synthetic wastewater microbial fuel cell. Biores Technol 100:3252–3260
13. Allen RM, Bennetto HP (1993) Microbial fuel-cells: electricity production from carbohydrates. Appl Biochem Biotech 39:27–40
14. K. Tweed, "Fuel Cell Treats Wastewater and Harvest Energy," *Scientific American*, 2012.
15. Y. Ahn and B. E. Logan, "Domestic Wastewater Treatment Using Multi-Electrode Continuous Flow MFCs with a Separator Electrode Assembly Design," *Applied Micro- biology and Biotechnology*, Vol. 97, No. 1, 2013, pp.409-416. doi:10.1007/s00253-012-4455-8
16. Z. Du, H. Li and T. Gu, "A State of the Art Review on Microbial Fuel Cells: A Promising Technology for Wastewater Treatment and Bioenergy," *Biotechnology Advances*, Vol. 25, No. 5, 2007, pp. 464-482. doi:10.1016/j.biotechadv.2007.05.004

7. BIOGRAPHY

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