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Dairy Effluent: A Source for the Production of Bio-energy

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Abstract—*The current global warming crisis can be mitigated by using renewable bio-energy. Production of Microbial Fuel is one such example. MFC is used to convert energy stored in chemical bonds in organic compounds to electric energy through the reactions catalyzed by microorganisms. This application of MFC has generated considerable interests among researchers in recent years. MFC can also be used to treat industrial wastewater. Through our research work, we attempt to make microbial fuel cell from the mother dairy effluent sample by exploiting the reaction catalyzed by the microbial population present in the sample. The cathode and anode of MFC were prepared using activated carbon cloth surrounded in an aluminum mesh. Glucose was used as a substrate and methylene blue was used as a mediator. The production of electricity was measured using a multimeter at regular intervals. Minimum of 2.24 Voltage and maximum of 7.02 Voltage was obtained during experimental conditions in the laboratory.*

Keywords*: MFCs, Bio-energy, Effluent*

1. INTRODUCTION

Water is an utmost requirement of human beings. Without water, life is not possible. Out of the total ground water available to humankind, only 0.29-0.49% is available in the form of drinking water. This necessitates the treatment and recycling of water [6]. It is not only a universal and precious solvent but also one of the abundantly available resources in ecosystem which can be utilized by human beings for their day-to-day activities. Since past few years, due to the uncontrolled population growth and intensive agricultural activities, ground and surface water has been exploited on a large scale. These activities finally lead to the major issues related to the public health like poor water quality, its safety and conservation [6].

Microbial Fuel Cell is a Bioreactor which is capable of converting chemical energy stored in chemical compounds in a biomass to electrical energy with the aid of micro-organisms. MFCs are used to produce electricity from renewable resources without the net carbon-di-oxide emission. Fig. 1 shows a schematic diagram of MFC with its various parts. It consists of an anode chamber where fuel/substrate is being oxidized to generate electrons and protons. These electrons are absorbed by anode and transfer to cathode through an external circuit [6]. The transfer of electrons must be matched by the number of protons moving between the electrodes in order to preserve electroneutrality. As shown in Fig. 1, the two chambers are connected via Proton Exchange Membrane (PEM). This is a salt bridge through which protons enters into cathode chamber where they combine with oxygen to form water. Electric current is generated as microbes are present in anode chamber which is also an anaerobic chamber and hence no end-terminal acceptor or oxygen is present here [6]

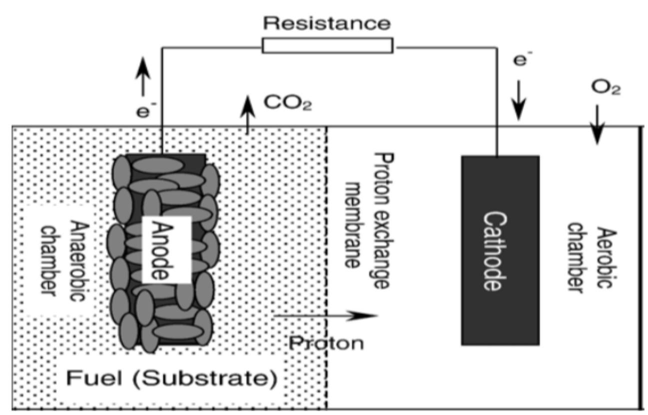

Fig. 1: Schematic diagram of a typical two chamber Microbial Fuel Cell [6]

Many microbes have been reported to be useful biocatalyst for the MFCs. Marine sediments; soil, fresh water sediments, wastewater and activated sludge are all rich sources of these types of micro-organisms [6]. During the past few years, many different types of wastewater or effluent samples have been used for the production of MFCs. In one of the study, water from the Yamuna river was used to construct MFCs [1]. MFCs have been specifically used for the treatment of Municipal wastewater effluent also [6]. However, not much work has been carried out for the construction of MFCs using dairy effluent. In 2015, Rahul et.al, construct MFC using lactobacillus species inoculated in dairy industry effluent sample [5]. But very less voltage has been generated through this MFC. Through our research work, we have constructed MFC using Mother Dairy Industrial effluent sample collected from Mother Dairy Plant located in Delhi. The two chambers MFC was made using Glucose as a substrate and Methylene blue as a mediator.

2. METHODOLOGY

2.1 Sample collection and storage

The sample was collected from Mother Dairy Plant (located at Patparganj, Delhi) and for our study we collected inlet or untreated effluent sample in order to get good microbial population for MFC production. For MFC, the effluent sample was collected in a sterile plastic container and stored at room temperature.

2.2 Microbial Fuel Cell construction and Operation

The cathode and anode chambers of MFC were constructed using the cost effective plastic boxes of 2Liter capacity each available in local market. They were sealed with the sealing clay after the addition of required effluent sample in the anode chamber and distilled water in cathode chamber. In the anode, the anaerobic conditions are maintained by purging with nitrogen.Nafio^{R}117 membrane (sigma) was used as a proton exchanger for the transfer of hydrogen ions. The cathode and anode were made of carbon cloth which was surrounded in an aluminium mesh. The effluent sample was put in anode chamber which was stirred continuously using the magnetic stir bar and operated at room temperature. Glucose at a concentration of 3gram/liter was used as a substrate and methylene blue was used as amediator (300µM). The amount of electricity generated was measured in the form of voltage using a multimeter (Sanwa CD 770) at regular intervals. Fig. 2 shows the experimental set of MFC.

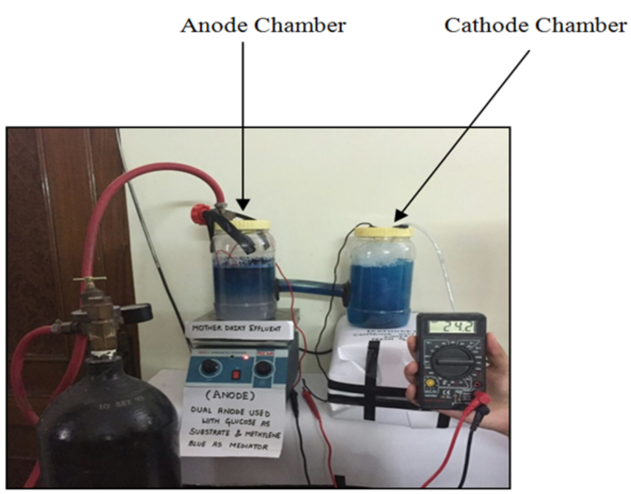

Fig. 2: Experimental setup of MFC

3. RESULT AND DISCUSSION

The working of MFC and hence the generation of electricity depends on the reactions carried out between microbes and organic substrates present in anode chamber [4]. The voltage output was recorded and plottedagainst time at regular intervals. Fig. 3 shows the graph of Voltage (V) versus Time (hrs).

The graph between voltage and time shows that the initial voltage generated in MFC was 2.24 Volt. The voltage was recorded for 4 days after every 2 hrs. The peak was observed at the end of the third day with the voltage of 7.02 volt. After that there is slight but continuous decline in voltage.

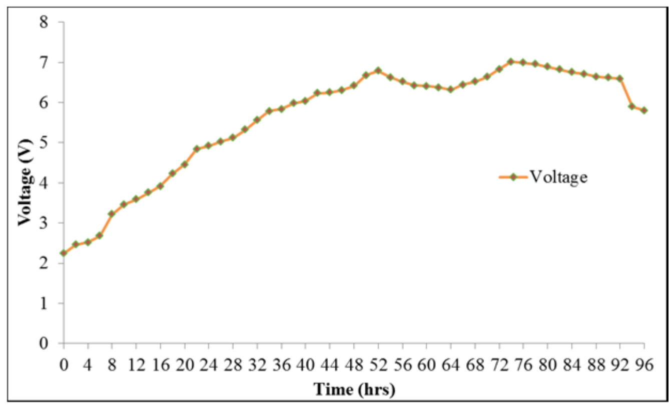

Fig. 3: Graph of Voltage versus Time

The voltage generated by MFC constructed in the present work using dairy effluent is very high. One of the reasons for this is the presence of sufficient substrate in the anode chamber and the addition of methylene blue as a mediator. The mediators function as an oxidizing agent for respiratory proteins in the outer membrane of the micro-organisms and subsequently transfer the electrons obtained at anode [2]. Therefore, these mediators shuttle between the bacteria and anode transferring the electrons and hence increase the output. It has been reported previously that methylene blue at a concentration of 300µM act as very efficient mediator for MFC [2]. We have also used methylene blue at a concentration of 300µM as a mediator and added it in the anode chamber. This result in high voltage output of MFC prepared in our study with the dairy wastewater effluent sample. Though, there are many reports where mediator-less MFCs have been constructed [1,3,4] from wastewater samples, but in our sample we have not observed the presence of various metal ions and other components which can serve as a mediator (result not shown). Therefore, we decided to construct MFC in the presence of mediator for the efficient voltage output.

4. CONCLUSION

Through our preliminary research work, we have shown that wastewater from dairy industry can be used for the generation of sustainable energy using MFC. The power generation through MFC is affected by many factors including the type of bacteria or population of microbes present in an innoculum, the type of substrate and its concentration, ionic strength, pH, temperature, materials used for electrodes & PEM and other reactor configuration [6]. We have used conventional method for the construction of MFC. Future optimizing studies can be attempted to improvise the power generation through MFC. Though Microbial Fuel Technology is still in its early stage of development but shows great promise as a new method for the sustainable electricity generation and wastewater treatment. Major issues to be solved for its practical application include its cost and power output.

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