GENERATION OF ELECTRICITY FROM SEWAGE WATER USING MFCS

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ABSTRACT

Microbial fuel cells (MFCs) are emerging as promising technology for the treatment of wastewaters. The potential energy conversion efficiencies are examined. Microbial fuel cells (MFC) can be used to directly generate electricity from organic matter, but the voltage produced by a single reactor is only 0.5-1.0V. Voltage can be increased by stacking cells, i.e. by linking individual reactors in series, to provide a higher voltage output. Sustainable electricity was generated from sewage wastewater in microbial fuel cells (MFCs) with carbon cathode and zinc anode, anode chamber with mixed inoculums of microorganisms is used as biological reactor for the fermentation of the substrates to fuel products without the use of any mediator. Development of the large scale MFCs namely, wastewater, sewage and garbage fuel cells are currently underway. This is one of the most exciting and novel methodology that will overcome the problems of energy management which is the global issue today.

Keywords: MFCs, sewage water, mixed inoculums, electricity.

INTRODUCTION

In recent days, a number of methods and sources are currently in use for production of electrical energy which includes hydro-power, solar power ,wind power, wave power, batteries, fossil fuels and chemical fuel cells. All these technologies play a significant role in the global issue of energy management. In addition to these technologies an attractive and novel alternative for the conversion of chemical energy into electrical energy is the development of microbial fuel cells (MFCs) (Katz *et al*. 2003; Lovely 2006). A microbial fuel cell is a device that converts chemical energy to electrical energy by the catalytic reaction of microorganisms (Allen and Bennetto 1993; Wingard et al. 1982., Reimers et al. 2001., Kim H.j. et al. 2002.). In addition, the MFCs offer an environmentally friendly alternative to fossil fuels (Lovely 2006; Katz *et al*. 2003).

Initially, the concept of the electricity generation is given by M.C. Potter (Potter 1910, 1911). He stated that "the disintegration of organic compounds by microorganisms is accompanied by the liberation of electrical energy (Potter 1911). These fuel cells are based on metabolic activity of microorganisms on the organic substrates which contains sugars as the main component. Fuel cells, when used for wastewater treatment, they may provide clean energy and also be helpful in treatment of wastewater. The fuel cells are clean, safe, quiet performance; high energy efficiency; and easy to operate. Various research groups are keenly interested to improve the current density by more facile and efficient methods (Palmore and Whitesides 1994; Bond et al. 2002; Angenent et al. 2004; Pham et al. 2004). Generation of electrical energy is based on the principles of fermentation in which organic substrate undergo the biochemical reaction in the presence of microorganisms which result in the formation of the hydrogen fuel. The fuel so formed is finally converted into electrical energy and water through redox reaction. (Abdul majeed Khan, 2009).

Presently, research on MFCs using wastewater as substrate is in the initial stages of laboratory evaluation around the world. The reported work so far is mainly based on using the monoculture at laboratory level (Rabaey et al. 2003.Park et al. 2003. Larminie et al. 2003)

The use of energy is increasing day by day. Thus there is a need to search for alternatives to fossil fuel, utilizing renewable energy from waste organic source is the present trend of active research and in view of this bioelectricity generation through microbial fuel cell using variety of substrate is being studied extensively. It is well known that microorganisms can produce fuels from organic matters. In present study we have tried to generate electricity from wastewater using mixed inoculums of microorganisms i.e. using cow dung. The basic aim of the present study is to design microbial fuel cells employing low-cost materials without using toxic mediators, which will have the possibility to be implemented in the wastewater treatment plants in the economical perspective.

Materials and Methods

Two chamber MFC was fabricated in laboratory using the plastic bottles with volume of 1000 ml. The two chambers were connected with PVC pipe but separated by using natural membrane which served as proton exchange membrane .The total volume of both chambers (anode and cathode) were the same (850 ml) and the chambers were provided with sample port , wire point inputs (top), inlet and outlet ports. (Fig. 1)Proton exchange membrane was fixed in coupling using washers between two chambers. The anode electrode was of zinc (Zn^{++}) (14cm long and 0.7cm diameter), the cathode electrode was of carbon (C) (14cm long and 1.5cm diameter).Both electrodes were positioned at a distance of 7cm on either side of proton exchange membrane.The anode chamber was inoculated with 25ml fresh cow dung which is rich in mixed culture of microorganisms and preautoclaved sewage water collected from local area of Akurdi region. The cathode chamber was filled with phosphate buffer (0.2 M) had pH 7.7, no mediator was used in anodic chamber, during metabolism of organic waste in anodic chamber by bacteria the acidic condition were existed. These conditions increasing voltage output were considered as stable operation condition of MFC.

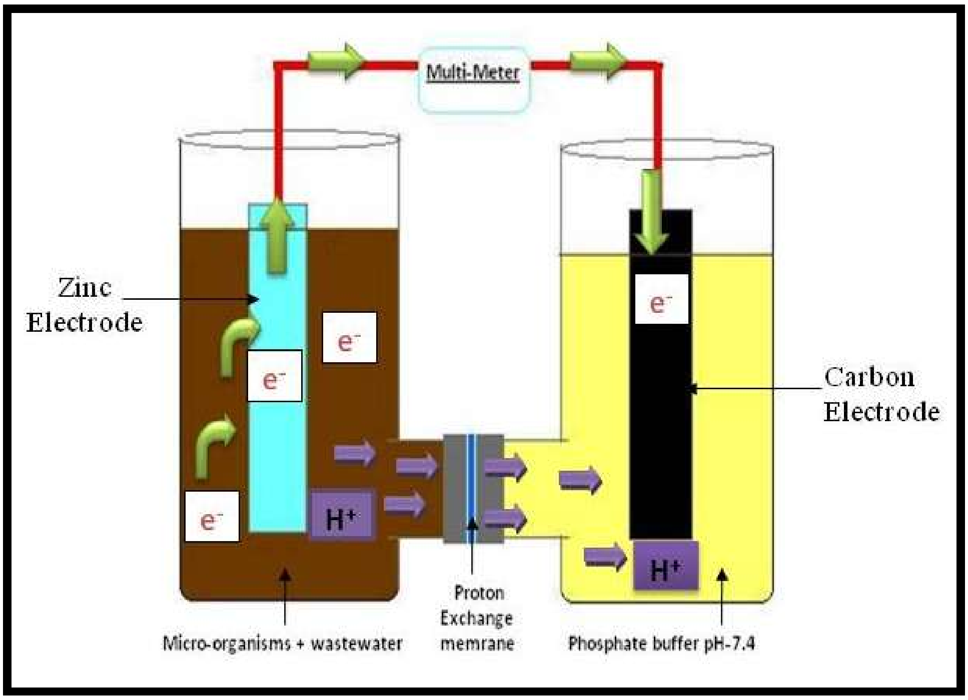

Fig.1 .Diagrammatic presentation of dual chamber MFC

RESULT AND DISCUSSION

Table 1. Voltage and Current production per day for Zinc and Carbon Electrode

Days	voltage (V)	current (A)
1	0.8	0.07
2	1	0.09
3	1	0.1
4	1.06	0.06
5	1.04	0.1
6	1.06	0.1

Table 2: The voltage output with respect to time (per two minutes)

Time (mins)	Volts (V)
2	0.068
4	0.069
6	0.075
8	0.069
10	0.067
12	0.061
14	0.059
16	0.053

Time (mins)	Volts (V)
18	0.051
20	0.047
22	0.045
24	0.046
26	0.043
28	0.040
30	0.037

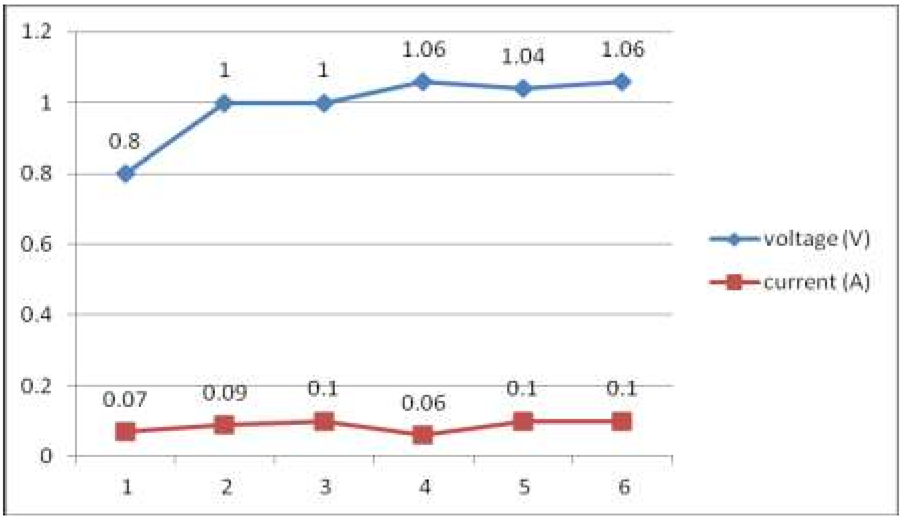

Fig 2. Current (A) and voltage (V) production per day

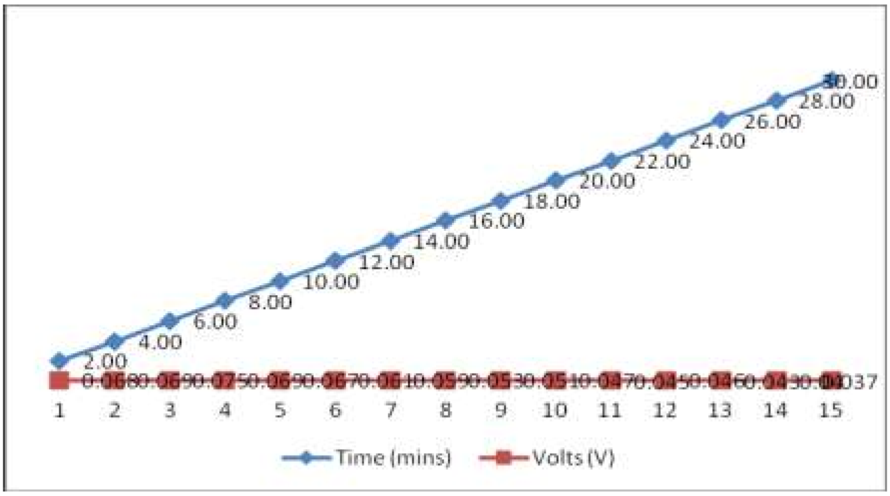

Fig 3. Linear voltage production Vs constant time interval (min)

DISCUSSION

The success of specific MFC applications in wastewater treatment will depend on the concentration and biodegradability of the organic matter in the wastewater, and the absence of toxic chemicals. The MFC yielded an initial voltage of 0.8 V and final voltages of 1.06 V (tab.1). Data was recorded after 24 hours time interval for 6 days. The succeeding records show a variation in current and voltage generated by the MFC (fig 1, fig.2), MFC designs need improvements before a marketable product will be possible (Rabaey et al.2005, Logan et al.2006.) Mainly anodic materials commonly used in MFC reactors, such as graphite foams, reticulated vitreous carbon, graphite, and others, are quite expensive. Simplified electrodes, such as carbon and zinc, may offer a cost effective option. The use of expensive catalysts for the cathode must also be avoided.

So far, electron transfer without mediators has always been described as not feasible. With electron mediators the power output is found to be increased significantly (Park and Zeikus, 2002).In our study the voltage obtained was consistent for more than three days with a mediatorless fuel cell. The current and power output obtained is comparable with pure cultures that have been used by various experiments (Schroder et al., 2003, Niessen et al., 2004,Kim et al., 2000, , Kim et al., 2002, Chaudhuri and Lovley, 2003, Rabaey et al., 2005).A power density of the proton exchange membrane MFC is up to two orders of magnitude larger than salt bridge MFC if operated under similar experimental conditions (Min et al., 2005)

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