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Generation of Electricity from Sewage Sludge Using Dual Chambered Microbial Fuel Cell Containing Copper as Electrodes

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Abstract: Renewable and clean forms of energy are one of the major needs at present. Microbial fuel cell (MFC)offers unambiguous advantages over other renewable energy conversion methods. Without any transitional conversion into mechanical power, fuel cells transmute chemical energy directly into electricity. The present study deals with the utilization of sewage sludge, which contains high level of readily biodegradable bio waste and is also one of the major sources of environmental pollution, as substrate in MFC. Saccharomyces cerverciae used as biocatalyst and potassium ferricyanide as an oxidizer were utilized for the conversion of sewage sludge into voltage utilizing dual chambered MFC.A maximum of voltage of 0.9-1.0V was obtained per liter of the sludge with the cathode in continuous mode and theanode in batch feed mode of operation.
Keywords: Microbial fuel cell, Sewage sludge, Energy

I. INTRODUCTION

The two major problems that have played havoc with our lives are; one is protection and perseverance of our environment and the other is energy crises. This problem is being undergone by both by developed and developing countries [1-3]. Alternative power technologies and methodologies are needed very badly at this time to address the rising power problems [5]. As requirement for energy is going up very rapidly, so there must be sought out solutions to this issue [9]. Also those methods should be and would be preferred which are cost-effective. At the same time hazards to our deteriorating environmental condition should also be taken into account so as to devise only those technologies which do not cause any hazard and harm to our environment, which now cannot afford any damage to it [8-11].For this purpose we have to sort out useable and harmless energy alternatives with minimum percent use of hydrocarbons. For example, Microbial fuel cell is an effective and safe way of producing energy if its application and use is boosted and spread throughout the world [12-15]. MFCs are devices that make the use of microorganisms (bacteria and yeast) to oxidize bio-waste. In this mechanism, yeast or bacteria interacts with electrodes using electrons, which are transferred through an electric circuit [16-19]. Yeast can also be used to produce electricity [17]. Electrons produced by yeast are exchanged to the anode and stream to the cathode [16].Mediators or shuttles can transfer electrons by the way of direct membrane associated electron transferred generated by the yeast [20].Mediator less is a type of MFC, has no external mediators are mixed to the system. It happens even though the electron transfer process remains unknown [21-24]. The defining characteristics of MFCs are microbialy electron generation at the cathode and the following electrons reduction at the cathode, when both of the mechanisms are sustainable [26]. The application of a conciliatory anode made out of a piece of Mg compound does not guarantee the framework as a MFC. It is so because for the oxidation of the fuel does notneed yeasts [25-27]. Those systems which utilize biocatalysts not specifically createdin situ by biocatalyst in a practical way are considered here as an example of enzymatic fuel cell and are decently looked into someplace else [11-13].MFC are operated more sustainably in mixed culture than those in pure cultures. Clean energy can be produced by using bio waste from MFCs [22]. There are big benefits from using MFCs from bio waste: such as; safe, high efficiency, clean, low emission, quite performance and direct voltage recovery [23].

II. MATERIALS AND METHODS

Two chamber MFC was fabricated by using the plastic bottles with the volume of 1liter. The dual chambers ware joined with polyvinyl chloride (PVC) pipe, yet isolated by using salt bride, which served as a proton exchange membrane[12-14]. The anode and the cathode was of copper (15cm long and 0.8 cm breadth), the anode terminal was additionally of (15cm long and 1.6 cm diameter). Both cathodes were situated at a distance of 8cm on either side of salt bridge. The anode chamber was inoculated with

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26ml sewage sludge which is rich in blende culture of microorganisms and sewage sludge collected from hostel. The cathode was filled with potassium ferricyanide buffer (0.3 M) had pH 7.8, during digestion system of organic waste in anodic chamber by Saccharomyces cerverciae the acidic conditions were existed. These conditions increasing voltage yield were considered as steady operation of MFC.

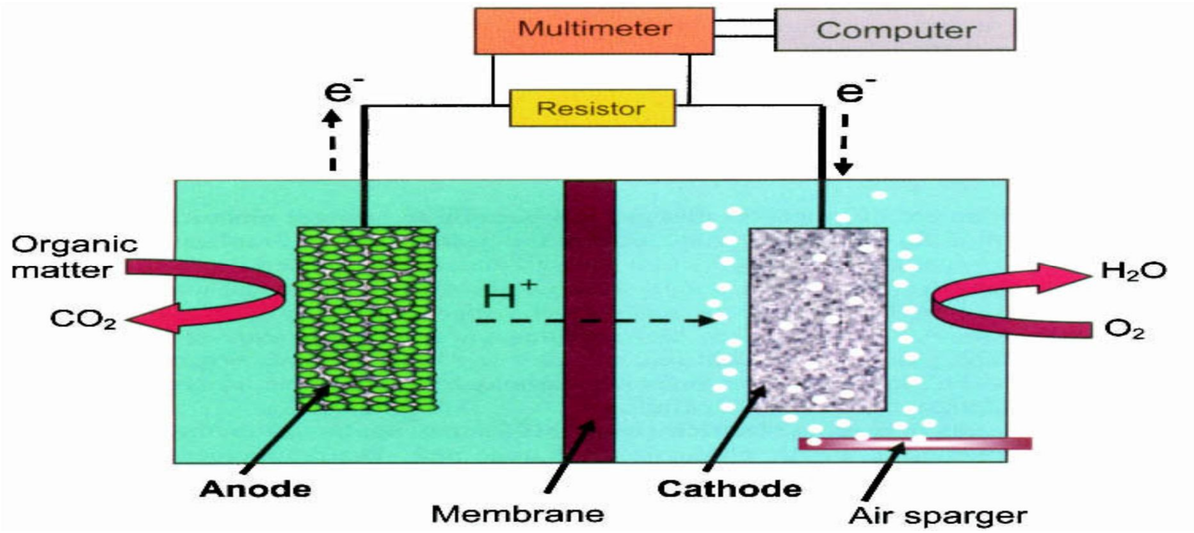

Fig. 1: Double Chambered Microbial Fuel Cell

III. RESULT AND DISCUSSION

All the experiments were done in two chambered MFC. The voltage generated from MFC was controlled put by various variables, apart from the efficiency of electron exchange frommicrobes to cathode region, safety of the chamber. The anodic exchange arrangement was in group encouraged mode and the cathode arrangement was in continues mode of operation. For the voltage generation 1000ml of sewage sludge was encountered into the MFC, which generated voltage of 1.06V (0.106µA) every 1000ml of sewage sludge. After 5 days of operation maximum voltage was generated, whereas afterwards it showed gradual decrease. This decline in voltage generation probably occurred due to the substrate limitation. This implied that maximum voltage generation was related to the amount of substrate added meaning that the substrate concentration determine the amount of electricity generation from it. The result also suggested that the selected strain of microorganism was able to readily convert the organics present in the sewage sludge at their ideal proficiency bring about the exchange of great number of electrons prompting associative voltage generation.

Time	Volts	Current	Power	Power density	Current density
(day)	(V)	(µA)	(mW)	(mW/m^2)	($\mu A/m^2$)
1	0.8	0.08	0.064	0.000711111	2.944711111
2	1	0.1	0.1	0.001111111	5.201111111
3	1	0.1	0.1	0.001111111	8.145822222
4	1.04	0.104	0.10816	0.001201778	9.253361778
5	1.06	0.106	0.11236	0.001248444	11.27960844

Table 1. Voltage, current, power, power density and current density generation per day for Copper Electrodes

Time (mints)	Volts (V)	Current (μA)	Power (mW)	Power density (mW/m^2)	Current density ($μA/m^2$)
2	0.068	0.0068	0.0004624	5.13778E-06	2.075267538
4	0.09	0.009	0.00081	0.000009	4.099819
6	0.075	0.0075	0.0005625	0.00000625	6.175086538
8	0.069	0.0069	0.0004761	0.00000529	8.07638139
10	0.067	0.0067	0.0004489	4.98778E-06	10.07415389
12	0.061	0.0061	0.0003721	4.13444E-06	18.15053528
14	0.059	0.0059	0.0003481	3.86778E-06	14.06525197
16	0.053	0.0053	0.0002809	3.12111E-06	16.05858402

Table 2. Voltage, current, power, power density and current density generation per two minutes for Copper Electrodes

A. Factors Affecting on the Generation of Electricity

1) *Impact of Oxygen Flow Rate:* Impact of oxygen flow rate on voltage generation during the running of MFC was studies using different oxygen flow rates from 20 to 200 ml/min yielding in voltage generation between 0.8V and 1.0V per 1000ml of the sewage sludge, respectively. These results suggested that the voltage generation increase as the air flow rate was increased and reached the maximum of around 1V at oxygen flow rate of 150ml/min before showing decline afterwards. This indicates that at the higher air flow rate, voltage generation ability of MFC was substantially decreased because of the higher rate of oxygen in the air diffused to the region of anode, which likely distributed of anaerobic microbes on the surface of anode.
2) *Impact of pH on Voltage Generation:* pH is a main consideration influencing the movement of generally prokaryotes. At ideal pH, microorganisms perform natural activities of growth and digestion system the most extreme rate. The maximum yield obtained at pH 8.5, when maybe the proteins emitted by the microorganisms would have been in a conductive manifestation of ionic gathering on their dynamic destinations to capacity appropriately. Reportedly, variation in the pH would bring about changes in the ionic form of the active sites, which would further change the enzymatic activity leading to the variation in the reaction rate also [15]. The results additionally recommended that at pH 6 and below, electrochemical and cellulosic activities would likely be lower when compared with the results got at higher pH. This may be because of the denaturation of celluloses, proteins or active sites under acidic conditions. This finding was in concurrence with that reported by Z. He et al. who observed that pH 7 was suitable for cellulose degraders, as acidic conditions have a tendency to repress the growth of the greater part of cellulose degrading yeasts [12].
3) *Effects of Substrate Concentration on Electricity Generation:* Voltage generation was observed to increase in concentration of substrate. Beginning from about 10% concentration of the substrate, the voltage generate at this concentration was 0.625V. At the substrate concentration of 60% voltage generation was enhance by 1.06V. Further increment in the substance concentration up to 100% resulted in the decline in voltage generation by more than 100% when it reached the value of 1.06V. This was probably due to the reduction in the activity of the enzymes owing to various factors such as pH. This also indicates that higher concentration of the substrates could actually effect the anode performance significantly resulting in simultaneous lesser voltage generation.

IV. CONCLUSION

Double chambered MFC utilizing Saccharomyces cerevisiae was tried for its performance. With the anode kept up in batch and cathode chambered kept at continues mode. The MFC generated an initial voltage of 0.8V and final voltage of 1.06V. Data was recorded after 24 hours' time interval for 5 days. Designs of MFC need enhancements before attractive product will be marketable.

Mainly anodic materials commonly utilized as a part of MFC, for example, arranged various zinc, and others are quite expensive. Enhanced electrodes for example, copper, zinc and carbon, may offer a financially choice.

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