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Applicability of Single Chamber Microbial Fuel Cell for the Electricity Generation Using Waste Water obtained from Biscuit Factory and Potato Processing Factory

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Abstract

The application of Single chamber Microbial Fuel Cell (MFC) for electricity generation has been developing recently. In recent years, researchers have shown that MFC can be used to produce electricity from water containing glucose, acetate or lactate. This research explores the application of MFC in generating electricity using different waste water samples from Jabalpur. In order to obtain the aim of this research, a system of MFC with microbes has been used. Based on the results of different waste water samples, it can be reported that the maximum voltage generated for all four substrate is 357mV at day five by vermicompost. The potential difference generated by the MFC was measured using multimeter.

Keywords: Electrodes, Salt Bridge, Single chamber MFC, Voltage, Vermicompost.

Introduction

Energy calamity in India is rising each year, as there is constant acclivity in the price of fuels and also due to depletion of fossil fuels to a larger level [1]. The demand for an alternating fuel has erupted extensive research in discovering a potential, economical and reusable source for energy manufacture. For constructing a sustainable world we require to minimize the expenditure of fossil fuels as well as the pollution generated. These two aims can be accomplished all together by treating the waste water (From disposing waste to using it). Industrial waste, agricultural waste and household waste are ideal substrates for energy productions as they are rich in organic contents.

MFC (Microbial fuel cell) can be best defined as a fuel cell where microbes act as catalyst in degrading the organic content to produce electricity. It is a device that straight away converts microbial metabolic or enzyme catalytic energy into electricity by using usual electrochemical technology [2]. In direct electron transfer, there are several microorganisms (Eg. *Shewanella putrefaciens*, *Geobacter sulfurreducens*, *G. metallireducens* and *Rhodospirillum rubrum*) that transfer electrons from inside the cell to extracellular acceptors via c-type cytochromes, biofilms and highly conductive pili (nanowires) [3]. These microorganisms have high Coulombic efficiency and can form biofilms on the anode surface that act as electron acceptors and

transfer electrons directly to the anode resulting in the production of more energy [4] [5].

In indirect electron transfer, electrons from microbial carriers are transported onto the electrode surface either by a microorganism's (*Shewanella oneidensis*, *Geothrix fermentans*) own mediator which in turn facilitate extracellular electron transfer or by added mediators. The MFCs that use mediators as electron shuttles are called mediator MFCs. Mediators provide a platform for the microorganisms to generate electrochemically active reduced products. The reduced form of the mediator is cell permeable, accept electrons from the electron carrier and transfer them onto the electrode surface [6]. Usually neutral red, thionine, methylene blue, anthraquinone-2, 6-disulfonate, phenazines and iron chelates are added to the reactor as redox mediators [7]. Various types of the microbial fuel cell exists, differing majorly on the source of substrates, microbes used and mechanism of electron transfer to the anode. Based on mechanism of electron transfer to the anode, there are two types of microbial fuel cell which are the mediator microbial fuel cell and the mediator-less microbial fuel cell.

Mediator-less microbial fuel cells are use special microbes which possess the ability to donate electrons to the anode provided oxygen (a stronger electrophilic agent) is absent [8],[9]. There are variants of the mediator-less microbial fuel cell which differ with

respect to the sources of nutrient and type of inoculum used.

Mediator-microbial fuel cells are microbial fuel cells which use a mediator to transfer electrons produced from the microbial metabolism of small chain carbohydrates to the anode [10]. This is necessary because most bacteria cannot transfer electrons directly to the anode [8]. Mediators like thionine, methyl blue, methyl viologen and humic acid tap into the electron transport chain and abstract electrons (becoming reduced in the process) and carry these electrons through the lipid membrane and the outer cell membrane [11],[12].

Material and Method

The Single chamber MFC has been represent in the Figure 1.

MFC construction

The Single chamber MFC has been represent in the Figure 1.

Electrodes

Carbon electrode was used at both the ends of cathode and anode and tightly fixed with the single container containing medium, culture and buffer.

Anodic Chamber

The 2 liters sterilized plastic bottle is used for this purpose. The bottle is surface sterilized by washing with 70% ethyl alcohol and 1% HgCl_2 solution followed by UV exposure for 15 minutes. Then the medium was filled in it. Methylene blue, waste water sample and bacteria was added to it.

Salt bridge

The salt bridge was prepared by dissolving 3% agar in 1M KCl . The mixture was boiled for 2 minutes and casted in the PVC pipe. The salt bridge was properly sealed and kept in refrigerator for proper settling. The cathode was placed over the salt bridge.

Sugar Stock (Carbon Source)

There are different types of substrates has been used. In my study, first substrates is collected from Waste water of biscuit factory Jabalpur, second is the waste water from potato processing factory Jabalpur, third substrates cow dung is collected from Jabalpur and fourth is vermicompost collected from Jabalpur has been used. It contains organic matter like starch , glucose, and sucrose which is used by bacteria for growth.

Mediator

Methylene blue is a redox indicators act as electron shuttles that are reduced by microorganisms and oxidized by the MFC electrodes thereby transporting the electrons produced via biological metabolism to the electrodes in a fuel cell.

Circuit Assembly

Single chamber was internally connected by salt bridge and externally the circuit was connected with

wires which were joined to the two electrodes at its two ends and to the multimeter by another two ends. The potential difference generated by the Fuel Cell was measured by using multimeter.

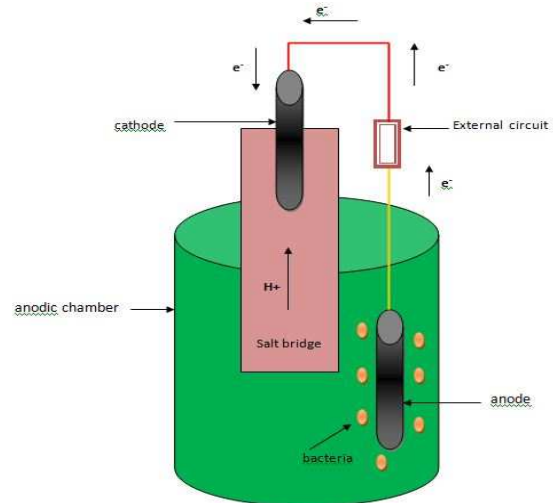


Fig.1- Schematic diagram of Single chamber MFC

Operation

This research intends to utilize the waste water to generate electricity in Single chamber Microbial Fuel Cell system. The micro organisms are used as biocatalyst. The bacteria will convert sugar components in the waste water into Carbon dioxide, where in the intermediate process will be released electron generating electricity in MFC system. The salt bridge was cast in a PVC pipe. The cathode was placed over the salt bridge. The substrates (waste water) were added in the anodic chamber. The anodic chamber was completely sealed to maintain anaerobic condition. The MFC was run for 7 days and readings were noted at regular intervals. The MFC set up was kept at static conditions.

Results

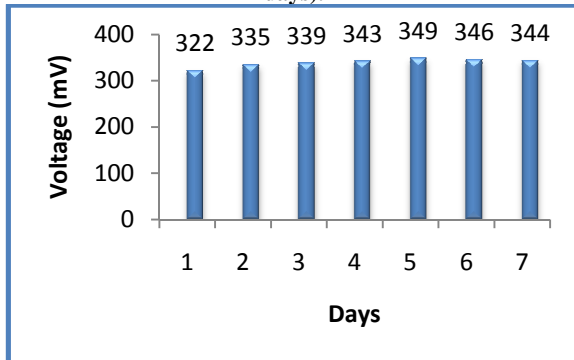
Voltage generated by use of Biscuit factory Substrate

The voltage generation was recorded per day throughout the week for the substrate obtained from biscuit factory. There was a definite increase in the voltage till the day 5 and after that it decreases, as shown in Table-1.1. The results reveal the fact that on day 5 the maximum potential that obtained was 346mV, whereas it was 322mV on day 1. The maximum current measured was found 0.30 mA on day 5.

Table-1.1: Maximum Voltage generated with Waste water from biscuit factory.

Days	Maximum voltage generated in (mV)
1	322
2	335
3	339
4	343
5	349
6	346
7	344

Graph-1.1: Graph representing voltage generated with Waste water of biscuit factory with respect to time (in days).



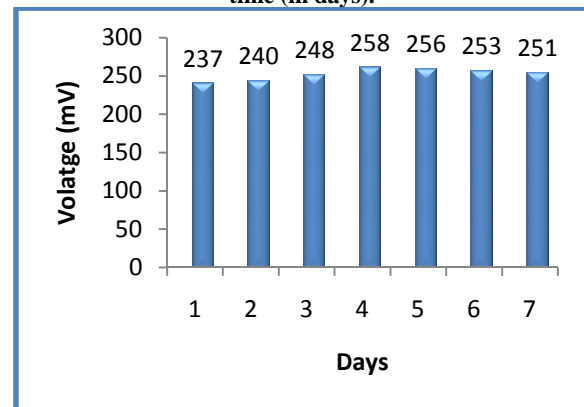
Voltage generated by use of Potato processing factory Substrate

The voltage generation was recorded per day throughout the week for the substrate obtained from potato processing factory. There was a definite increase in the voltage till the day 4 and after that voltage decreases, as shown in Table-1.2. The results reveal the fact that on day 4 the maximum potential that obtained was 258mV, whereas it was 237mV on day 1. The maximum current measured was found 0.27 mA on day 4.

Table-1.2: Maximum Voltage generated with Waste water from Potato processing factory.

Days	Maximum voltage generated in (mV)
1	237
2	240
3	248
4	258
5	256
6	253
7	251

Graph -1.2: Graph representing voltage generated with Waste water of Potato processing factory with respect to time (in days).



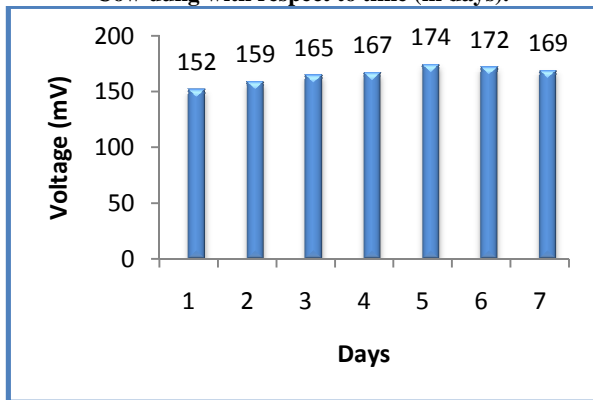
Voltage generated by use of Cow dung

The voltage generation was recorded per day throughout the week for the substrate of cow dung. There was a definite increase in the voltage till the day 5 and after that voltage decreases, as shown in Table-1.3. The results reveal the fact that on day 5 the maximum potential that obtained was 174mV, whereas it was 152mV on day 1. The maximum current measured was found 0.18 mA on day 5.

Table-1.3: Maximum Voltage generated with Cow dung.

Days	Maximum voltage generated in (mV)
1	152
2	159
3	165
4	167
5	174
6	172
7	169

Graph -1.3: Graph representing voltage generated with Cow dung with respect to time (in days).



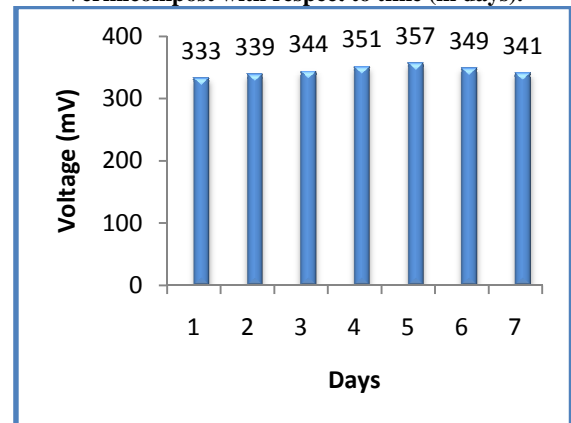
Voltage generated by use of Vermicompost

The voltage generation was recorded per day throughout the week for the substrate of vermicompost. There was a definite increase in the voltage till the day 5 and after that voltage decreases, as shown in Table-1.4. The results reveal the fact that on day 5 the maximum potential that obtained was 357mV, whereas it was 333mV on day 1. The maximum current measured was found 0.41 mA on day 5.

Table-1.4: Maximum Voltage generated with Vermicompost.

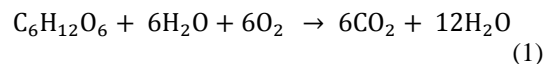
Days	Maximum voltage generated in (mV)
1	333
2	339
3	344
4	351
5	357
6	349
7	341

Graph -1.4: Graph representing voltage generated with Vermicompost with respect to time (in days).

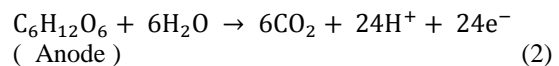


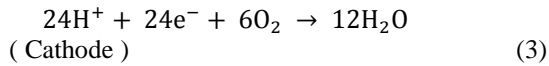
Discussions

Microbial fuel cell is based upon the basic principle in which biochemical energy is converted into electrical energy. Consumption of organic substrate (e.g. glucose) by microorganism in aerobic condition produce CO₂ and H₂O.



If the terminal electron acceptor oxygen is replaced by mediator then the electrons will be trapped by mediator, which will get reduced and transport to electrons to the electrode at anodic chamber .However when oxygen is not present (anaerobic condition) they produce carbon dioxide, protons and electrons as described below.





Based on the result, it was found that maximum voltage (359mV) was generated by waste water of biscuit factory, maximum voltage (258mV) was generated by waste water of potato processing factory, maximum voltage (174mV) was generated by cow dung and maximum voltage (357mV) was generated by vermicompost. The MFC was run up to one week and the voltage was recorded daily basis in presence of mediator. The maximum voltage generated among all the four substrates is 357mV was generated by vermicompost.

Conclusions

Microorganisms that can combine the oxidation of organic biomass to electron transfer to electrodes put forward the self-sufficient systems that can successfully convert waste organic matter and reusable biomass into electricity. Oxidation of these newly rigid sources of organic carbon does not supply net carbon dioxide to the environment and unlike hydrogen fuel cells, there is no requirement for wide pre-handing out of the fuel or for costly catalysts. With the suitable optimization, microbial fuel cells might be able to power an extensive collection of broadly used procedure. Technology of Microbial Fuel Cell is one alternative of energy production using renewable resource.

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