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Impact of Salt Bridge on Electricity Generation from Hostel Sewage Sludge using Double Chamber Microbial Fuel Cell

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Research Article

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ABSTRACT

For the economic development and substance of a nation's economy, energy is used as a prime mover. Future monetary development critically relies upon the long term availability of energy sources that are reasonable, accessible and environmental friendly. Microbial fuel cell represents a total approach to convert bio waste to sustainable and clean energy. In the present study, efforts are made to analyze the impact of salt bridge over the production of electricity. Various designs of salt bridge based MFC is constructed and the efficiency was tabulated. It is concluded that the number of salt bridge has an impact on energy production. The MFC was run for 20 days and readings were noted at regular intervals. In the experiment conducted by employing KCl based salt bridges, the maximum current produced was 2 volts when 1M KCl was used.

INTRODUCTION

With increasing world population, it is vital to find alternative methods of energy production, organic waste utilization that are sustainable for future [1-3]. Energy consumption has increased dramatically leading to an unbalanced energy management [4]. Biofuel cells potentially offer solution to all these problems [5]. They take readily available substrate from renewable resources and convert them into useful byproducts with the generation of bioelectricity [6-9]. The energy crisis in Pakistan has reached at alarming levels requiring immediate attention [10-15]. It is presently realized that power can be specifically produced from the degradation of natural matter in MFC, although it is the fact that the accurate systems of the process are still to be completely understood. Wastes from households, industries etc. are ideal conditions of substrates for generation of power because they contain a high amount of easily decomposable biomass [15-22]. Biomass isubiquitous in nature and has immense potential as a substrate for energy generation [23-29]. Ethanol,butanol, methanol, methane, bio-diesel and bio-hydrogen and electricity can be produced from biomass [30-35]. In the present study, attempts have been made to produce electricity by using sewage sludge, collected from Hostel of Mehran University of Engineering and Technology, Jamshoro. Investigations were done to understand the impacts of salt bridge design and capacity on achieving high energy output.

MATERIALS AND METHODS

Substrate Collection

Sewage sludge which served as the substrate of the MFC was collected from Hostel of Mehran University of Engineering and Technology, Jamshoro. 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.

MFC Components

Microbial Fuel Cell majorly constitutes Electrodes, Anodic and Cathodic Chamber and Salt Bridge as shown in **Figure1.** The Anodic chamber is an anaerobic chamber, which holds the substrate and the biocatalyst-Microorganisms. The cathodic chamber was maintained in aerobic condition. The salt bridge that forms a bridge between cathodic and anodic chamber facilitates the transfer of ions (protons). Carbon electrodes were used as anode and cathode.

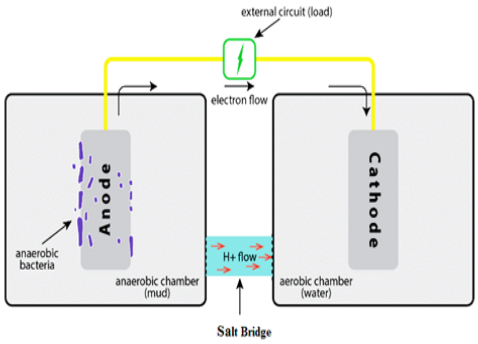

Figure 1. A dual chambered MFC with salt bridge.

MFC Construction

Salt Bridge-Immersed-Air Cathode MFC consisted of a plastic container of capacity 1 liter which served as the anodic chamber. The anodic compartment contained the substrate and the copper electrode (anode ~85cm^2). A similar copper electrode which was used as anode served as cathode. The salt cathode was immersed in the salt bridge when it was in molten stage to ensure complete surface contact. The 50% cathode surface was exposed to atmospheric air. Salt bridge employed here was made with 1M, 2M, 3M KCl and 20% Agar. The salt bridge was cast in a PVC pipe (14 cm×3 cm). Proper precautions were taken to ensure complete sealing of anodic chamber by means of applying epoxy and wax to ensure anaerobic conditions.

MFC Operation

Substrate (sewage sludge) was added in the anode chamber and was completely settled and keeps anaerobic conditions. A batch configuration was employed and readings were taken for a period of 20 days. The readings were taken on a daily basis.

Optimization of Salt in Salt Bridge

Various Strong Salts for Salt Bridge Preparation: One well-known strong salt Potassium Chloride (KCl) was tested for efficacy to transport H^+ ions in the salt bridge. A MFC with sewage sludge as substrate was setup with respective strong salt used for salt bridge fabrication.

Molar Concentration of Salt: Salt bridges were prepared with Molar concentration 1M, 2M, 3M KCl and with agar concentration of 20%. The MFC with sewage sludge as substrate were setup with above mentioned salt concentrations in salt bridge. The MFC was run for 20 days and readings were noted at regular intervals.

Measurement of Output: The output of the MFC was expressed by means of voltages (V). For this purpose multimeter was used and was calibrated each time before use. Resistance of 270~ was employed in all experiments and hence calculations were based on it.

RESULTS AND DISCUSSION

Analysis of Various Strong Salts: In the experiment conducted by employing 1M, 2M, 3M KCl based salt bridges, the maximum current produced was 2 volts **(Tables 1-4) (Figures 2-5).**

Table 1. Voltage obtained with 1M KCl.

Number of the salt bridge	Voltage (Volts)
1	1.51
2	1.52
3	1.56
4	2.00

Table 2. Voltage obtained with 2M KCl.

Number of the salt bridge	Voltage (V)
1	1.6
2	1.32
3	1.26
4	1.50

Table 3. Voltage obtained with 3M KCl.

Number of the salt bridge	Voltage (V))
1	1.31
2	1.42
3	1.46
4	1.10

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Table 4. Voltage obtained with 1M NaCl.

Number of the salt bridge	Voltage (V))
1	1.22
2	0.9
3	0.76
4	0.62

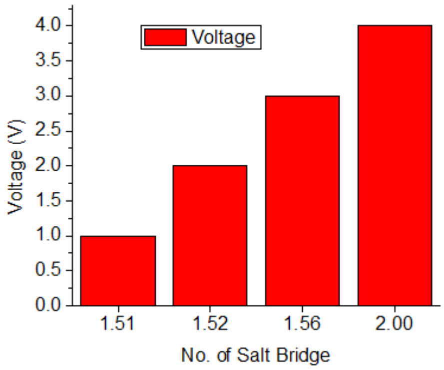

Figure 2. Voltage generation against number of salt bridge.

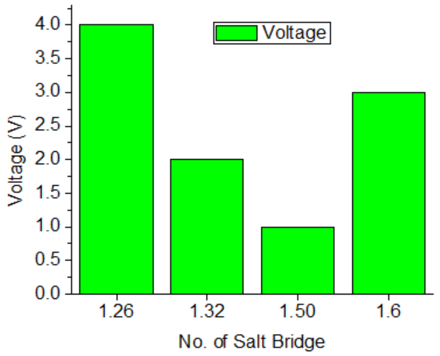

Figure 3. Voltage generation against number of salt bridge.

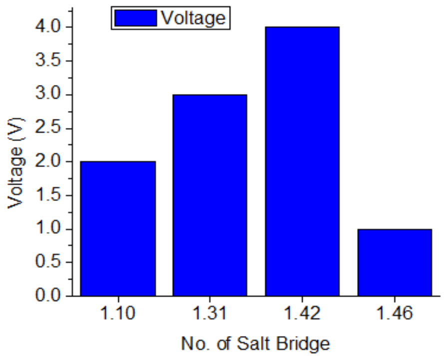

Figure 4. Voltage generation against number of salt bridge.

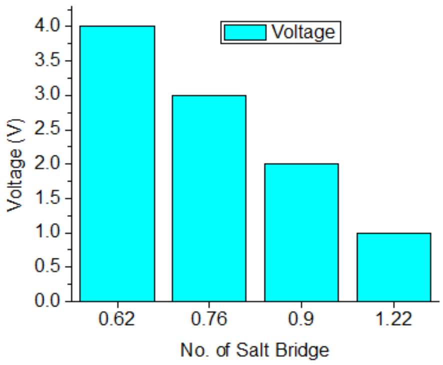

Figure 5. Voltage generation against number of salt bridge.

Molar Concentration of Salt: Maximum current of 2 volts was obtained when using 1M concentration of KCl in salt bridge **(Table 1 and Figure 2).** The current study proved that the number of salt bridge which conducts protons to the anode plays a role. In different designs of MFC's salt bridges, the MFC with four salt bridges produced 2 volts.

DISCUSSION

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. So people are looking for high proficient power transmissions and approach to use the alternative energy sources. MFC is an essential part in the research. The fundamental parts of an MFC exploration are to lessen the expense and improving execution conditions. In recent years people are moving toward biotechnology and microbiology to sort out the solution. MFC can be a power module and along these lines assume a critical part in energy preservation and substitute fuel usage. There are distinctive parts of MFC and diverse sorts of power module. MFC can be utilized for diverse purposes, for example, power production, bio-hydrogen production, biosensors and waste water treatment. The majority of the research performed on the MFCs is concerned with the enhancement of the power density of the system with respect to the anode surface area; little research has been carried out on examining the effects of voltage generation in correlation on fluctuating energy MFC parts. MFC relies upon the essential principle during which bioenergy is reborn into power. Utilization of substrate (sewage sludge) by microorganisms (*Saccharomyces cerverciae*) in oxygen over whelming condition turn out dioxide and water. On the off chance that the terminal electron acceptor oxygen is supplanted by mediator then the electrons are going to be unfree by go between, which has the capacity get diminished and transport electrons to the anode chamber. When oxygen is not present then they turn out dioxide, proton and electrons. For present study, two plastic bottles (each of 1 L) were used for making the anodic and cathodic chamber. In Cathodic chamber salt solution was used as the electrolytic solution was used as catholyte. Methylene blue as mediator and carbon source (sewage sludge) respectively in the anodic compartment. The function of Methylene blue is to transfers electrons to the final electrode. In this experiment conducted by employing strong salts like KCl in 1M, 2M and 3M and NaCl in 1M concentrations were used for fabricating salt bridge. The results obtained were comparable with the previous results. KCl was most efficient in transporting H^+ ions in the cathodic chamber. It was observed that initially the voltage rises rapidly but soon the voltage starts falling down. Substrate sewage sludge (1000 ml) collected from Hostel of Mehran University of Engineering and Technology, Jamshoro, was used. Maximum current of 2 volts was obtained when using 1M concentration of KCl in salt bridge. The current study proved that the number of salt bridge which conducts protons to the anode plays a role. In different designs of MFC's salt bridges, the MFC with four salt bridges produced 2 volts. During this study, it was noted that initially the voltage rises rapidly but soon voltage starts falling down. It was also noted that salt bridge generates more voltage which contains KCl salt than salt bridge which contains NaCl salt. This study shows that KCl salt is more efficient than NaCl for the generation of voltage from different bio wastes by using MFCs.

CONCLUSION

MFC was tested with in the laboratory employing a fixed resistance, which might be thought about to be connected serial with the external resister. The voltage output from the MFCs has increased dramatically in the past few years, thanks to optimized style that lowers its internal resistance. Rescale can only be conservative if volumetrically loading rate can be expanded while not decrease in columbic efficiency. Generation of electricity is controlled by factors with proficiency of electron change within the electrode chamber. Thus, it's clear from the given studies that increasing production of power in MFCs needs innovative flow patterns and conductor orientation that minimizes internal resistance and findings strategies for improved cathode potential. The price of materials utilized for development of MFC is a key issue for application of the technology at the massive scale. Hence, developing a value effective procedure that is environmentally sound and property owing to due utilizing of biodegradable sludge as substrate within the MFCs. In this study double chambered MFC utilizing *Saccharomyces cerevisiae* was tried for its performance. Different salt bridges were tested. The MFC generated maximum voltage of 2 volts. The MFC was run for 20 days and readings were noted at regular intervals.

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