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ELECTRICITY GENERATION WITH MICROBIAL FUEL CELL

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Abstract : Microbial Fuel Cells (MFCs) offer promising prospects in the field of renewable energy since green electrical power is produced by the microbial activity and wastewater is treated simultaneously. MFCs are complex devices whose study requires an interdisciplinary approach as many processes of a diverse nature are involved. Interest in MFC has significantly increased in recent decades, and much scientific effort has been dedicated to making this technology more efficient. However, the focus has been on experimental work, and MFC modeling has tended to be neglected, and only recently has it received more attention with a consequent rise in the number of new MFC models available. Modeling is an effective tool for gaining a better understanding of MFCs, since it has many advantages in terms of cost and time savings. The current article aims to focus the use of Microbial Fuel Cells as a renewable source of energy along with other applications. We also explained the design and applications of these cells along with the current research going on to improve the usage of these cells.

Keywords: *Microbial fuel cell, renewable energy.*

I. INTRODUCTION

Many research and technological advancement have been made in the renewable source of energy and technology. This is due to rapid exhaustion of fossil fuel energy based resources which continuous increase in cost. There has been significant Shift of focus towards Renewable energy at this stage; from wind energy to wave energy, from solar to nuclear energy. This is indicative approach to shift to renewable source of energy for generating power and there are such legislations and directives in such order to reach the goal of reducing the emission of Nonrenewable source of energy.

Another potential area of renewable energy source which has resurfaced in recent times as modern technology begins to accommodate and to explore its possibilities; is the generation of power using bacteria. Accordingly, Microbial fuel cells (MFCs) facilitate this process and have gained a lot of attention recently as a mode of converting organic matter into electricity. It takes advantage of the sheer amount of micro-organisms breaking down substrates found in places such as wastewater, sludge, sediments under the sea and any other places where bacteria growth is abundant. It is the concept of utilising microbes as catalysts in fuel cells. However, it is only recently that microbial fuel cells with an enhanced power output have been developed providing possible opportunities for practical applications.

The microbial fuel cell is a bio-electrical system in which bacteria is used to convert organic material into electricity. The fuel cell itself is made up of four parts; the anode, the cathode, the proton exchange membrane and the external circuit. The electrons are pulled out as released energy during the oxidation process and into the electron acceptor via an external circuit. The protons pass through the ion/ proton exchange membrane and react with the electrons during the reduction process in the cathode thus completing the circuit. This simple process which is common and found in most fuel cells i.e. battery cells, hydrogen fuel cells can be optimised for an efficient current generation. The exploration of various materials used in electrodes that balances efficiency and cost-effectiveness is the key to the potential large scale use of MFC particularly in wastewater treatment plants which is hoped to be a power generating plant as opposed to a power consuming plant.

II. REVIEW OF LITERATURE

Premier G C, Lee T H, Kim C and Sloan W T Sustainable wastewater treatment: how might microbial fuel cells contribute 2010 Biotechnol. Adv. 28 871–81, they studied the application of microbial fuel cells in waste water treatment.

Rahimnejad M, Adhami A, Darvari S, Zirepour A and Oh S E Microbial fuel cell as new technology for bioelectricity generation: a review 2015 AEJ 54, 745–56. A microbial fuel cell (MFC) is a device that converts chemical energy into electricity through the catalytic activities of microorganisms. Although there is great potential of MFCs as an alternative energy source, novel wastewater treatment process, and biosensor for oxygen and pollutants, extensive optimization is required to exploit the maximum microbial potential. In this article, the main limiting factors of MFC operation are identified and suggestions are made to improve performance.

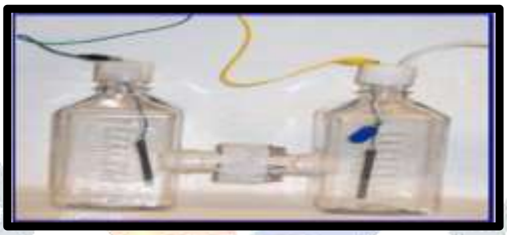
Peighambardoust S, Rowshanzamir S and Amjadi M Review of the proton exchange membranes for fuel cell application 2010 Int. J. Hydrog Energy 35 9349–84., distinguished by their historical development and mechanisms of electron transfer, were compared. Gen-I utilised synthetic redox mediators combined with Escherichia *coli*. In contrast, the Gen-II exemplarutilised the natural mediating properties of sulphate/sulphide with the sulphate reducing species Desulfovibrio desulfuricans. Gen-III MFCs were based on the anodophillic species Geobacter sulfurreducens and required no soluble mediator. Each type of MFC was operated under similar environmental conditions.

Gude V G Energy and water autarky of wastewater treatment and power generation systems 2015 Renew. Sust. Energy Rev 45 52-68. Application of MFC for various processes were studied and an article was published under the author's name.

Bruce E. Logan,Maxwell J. Wallack,Kyoung-Yeol Kim,Weihua He, Yujie Feng,Pascal E. Saikal et.at.(2015)Different microbial electrochemical technologies are being developed for many diverse applications, including wastewater treatment, Biofuel production, water desalination, remote power sources, and biosensors. Current and energy densities will always be limited relative to batteries and chemical fuel cells, but these technologies have other advantages based on the Self-sustaining nature of the microorganisms that can donate or accept electrons from an electrode, the range of fuels that can be used, and versatility in the chemicals that can be produced.

III. DOUBLE CHAMBERED MICROBIAL FUEL CELL

This MFC configuration is the most widely used consisting of two compartments with the anode and cathode separated by the proton exchange membrane. The anode chamber is kept oxygen free for anaerobic breakdown process to occur, which is usually purged with nitrogen. Although the H-type or dual-chambered microbial fuel cells is the most common in laboratory use, it is the most challenging to scale up due to the impractical configuration. The single-chamber is the easiest to scale up as it uses air directly as the oxygen source and also due to less material is required thus less overall cost. This set up can accommodate various electrode shapes, i.e. plane, granular and brush as it has a dedicated chambers for the anode and cathode. It can also use other catholyte besides air, which is any source of oxygen. According to a recent research document, use of algae (seaweed) enhances the oxygen production due to photosynthetic process in the plant which can be facilitated by this type of MFC configuration



IV. METHODOLOGY

1.) Wastewater sludge from ponds was collected as the useful bacteria was present in it.
2.) The collected wastewater sludge was fed into the anodic compartment of MFC for anaerobic reaction.
3.) Tap water was used in the cathodic compartment.
4.) Salt Bridge was then added between the two compartments.
5.) When the circuit was completed, the reaction took place and a potential difference was generated.
6.) This Voltage was varying with time.
7.) This potential difference was measured using a multi meter.

V. APPLICATIONS

FUEL CELLS BIOELECTRICITY GENERATION:

The main feature of an MFC is the utilization of organic carbohydrate substrates from biomass obtained from agricultural, industrial, and municipal wastes for the production of bioelectricity. Another advantage of MFCs is the direct conversion of fuel molecules into electricity without the production of heat (Du et al., 2007). MFC technology can be used as a potential sustainable source of energy. MFC technology can also be applied toward the construction of bio-batteries. The primary and basic design of an MFC can be modified in different ways to provide a base for further construction of new ideas and applications.

WASTEWATER MANAGEMENT:

Wastewater effluent from industrial, municipal, and other sources acts as a prime source for energy harvesting. It is also a suitable substrate for bio remediation. Microbial fuel technology proves to be an ideal solution to wastewater management. The three primary parameters on which the efficiency of MFC technology are based are maximum power density, Columbic efficiencies, and chemical oxygen demand (COD).

MICROBIAL FUEL CELLS IN HYDROGEN PRODUCTION:

MFCs can also be modified to produce hydrogen gas (H2) by removing oxygen at the cathode and adding in a small voltage via the bio electrochemically assisted microbial reactor (BEAMR) process or the bio catalyzed electrolysis process. Bacteria produce an anode working potential of –0.3 V. The protons and electrons that are produced at the anode can combine at the cathode to produce H2 with only an additional total cell potential of 0.11 V. In practice, however, 0.25 V or more must be put into the circuit to make H2, because of over potential at the cathode.

VI. RESULT

TIME(MIN)	VOLTAGE(V)
0	0.128
30	0.193
60	0.235
90	0.256
120	0.295

VII. CONCLUSION

Although the microbiology of microbe electrode interactions is fascinating from a purely biological perspective, most research in this area is ultimately justified by the hope of increasing the power output o1 microb1al fuel cells or developing additional microbe-electrode applications Just as there is a wide phylogenetic diversity of microorganisms capable of extracellular electron transfer, it is likely that there is an equally diverse range of microorganisms capable of interacting with electrodes If the appropriate strategies can be devised, it may be possible to recover microorganisms capable of higher rates of electron transfer between microorganisms and electrodes than currently available strains. Genome-scale metabolic modeling coupled with genetic engineering may yield strains that can enhance current production .The capacity to produce current appears to be a fortuitous reaction with no direct natural analog and placing the appropriate pressure to favor the selection of mutations that enhance current production is a promising approach for increasing the power output of microbial fuel cells. Furthermore, as the understanding of the range of reactions that microorganisms can carry out with electrodes serving either as the electron donor or the electron acceptor continues to expand the application of microbe-electrode interactions to novel areas such as environmental restoration and production of commodity chemicals may eclipse power production as the most promising uses of this technology.

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