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Study of Generation of Electricity from Waste Food by Using Microbial Fuel Cell

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ABSTRACT: The major challenges to be faced nowadays are the excessive generation of food waste and the lack of alternative sources of energy. Current reliance on fossil fuels is unsustainable due to pollution and finite supplies. Both the challenges are of major economic andenvironmental concern. Microbial Fuel Cell (MFC) is a bio-electrochemical system that derives an electric current by using bacteria and mimicking the bacterial interactions found in nature. The easily available food waste is blended with distilled water and used to produce electric current. The idea of using microbes to produce electricity was conceived in the early twentieth century. Michael Cresses Potter initiated the subject in 1911. Potter managed to generate electricity from Saccharomyces cerevisiae, but the work received little coverage. In 1931, Barnett Cohen created microbial half fuel cells that, when connected in series, could produce over 35 volts with only a current of 2 milliamps.

In this project we have studied the working of Microbial fuel cell and its component parts also we have compiled data from various research papers for more effective construction of Microbial fuel cell so that the output achieved is better. Research papers are downloaded from various sources and are studied thoroughly to formulate result and conclusion.

It is seen that when the number of salt bridge in the model oficrobial fuel cell is 8, maximum current of 1675 micro amperes was obtained which was more than that when the number of salt bridges is less than 8. Therefore, the number of salt bridge used plays a significant role in electricity generation. Different combinations of electrodes were used, and it was found that Cu/Zn (Copper/Zinc) combination gave the best and consistent results. Acetate as a substrate was the most preferential for the generation of electricity with the highest CE (Coulombic Efficiency). The glucose-fed-MFC generated the lowest CE and greatest PD (Potential Difference) among the substrates used in the study. With the increase in molar concentration of salt in the salt bridge, the current decreases. Optimum results were obtained for salt bridge fabricated using 1M KCl and NaCl. It produced a maximum voltage 0.451 V and 0.372 V respectively. The voltage and power outputs achieved by using Waste Food as substrate is lower than MFCs fed with simple substrates like glucose and acetate but is comparable with other single chamber MFCs using waste food as substrate. Thus, this project proves that MFC can be efficiently used to tackle the problem of excessive waste food and lack of alternative sources of energy simultaneous.

I. INTRODUCTION

It is well recognized that alternative sources of energy are urgently required. Current reliance on fossil fuels is unsustainable due to pollution and finite supplies. While much research is being conducted into a wide range of energy solutions, it does not appear that any one solution alone will be able to replace fossil fuels in its entirety. As such it is likely that a few different alternatives will be required, providing energy for a specific task in specialized ways in various situations. The discovery that bacteria can be used to produce electricity from waste and renewable biomass has gained much attention. Recently the increased interest in microbial fuel cell (MFC) technology was highlighted by the naming of Geobacter sulphureousness KN400, a bacterial strain capable of high current production, as one of the top 50 most important inventions for 2009 by Time Magazine. This list was also populated with other energy related devices such as solar shingles, smart thermostats and energy reducing light bulbs, further stressing the importance currently placed on energy. The discovery that microbial metabolism could provide energy in the form of an electrical current has led,to an increasing interest and a dramatic raise in the number of publications in the field of MFC research. These systems are very adaptable and hold much promise to provide energy in a sustainable fashion, but major improvements are required if widespread applications will be feasible. This review is unable to examine the entire field of MFC research in detail but hopes to highlight some important points regarding research in the field and recent important advances. Due to the shear, number of papers currently published regarding MFCs we hope that omission of many articles will not cause offence to their authors. This review article will examine MFC's currently in use, potential future applications and the limitations to implementing those applications. We suggest methods for improving the current output of aMFC. We also examine MFC applications in which microbes accept electrons from an electrode instead of donating them. This review will hopefully highlight some of the potential of and limitations to MFC technology implementation.

The idea of using microbes to produce electricity was conceived in the early twentieth century. Michael Cresses Potter initiated the subject in 1911.Potter managed to generate electricity from Saccharomyces cerevisiae, but the work received little coverage. In 1931, Barnett Cohen created microbial half fuel cells that, when connected in series, could produce over 35 volts with only a current of 2 milli ampere. A study by DeLuca et al. used hydrogen produced by the fermentation of glucose by Clostridium bothrium as the reactant at the anode of a hydrogen and air fuel cell. Though the cell functioned, it was unreliable owing to the unstable nature of hydrogen production by the micro-organisms. This issue was resolved by Suzuki et al. in 1976, who produced a successful MFC design a year later. In the late 1970s, little was understood about how microbial fuel cells functioned. The concept was studied by Robin M. Allen and later by H. Peter Benetton. People saw the fuel cell as a possible method for the generation of electricity for developing countries. Benetton's work, starting in the early 1980s, helped build an understanding of how fuel cells operate, and he was seen by many as the topic's foremost authority. In May 2007, the University of Queensland, Australia completed a prototype MFC as a cooperative effort with Foster's Brewing. The prototype, a 10 L design, converted brewery wastewater into carbon dioxide, clean water and electricity.

II. NEED OF STUDY

It has been known for almost one hundred years that bacteria could generate electricity. But only in the past few years has this capability become more than a laboratory novelty. The microbial fuel cell (MFC) is a new form of renewable energy technology that can generate electricity from what would otherwise be considered waste. The reasons for this recent interest in using bacteria to generate electricity are a combination of the need for new sources of energy, discoveries about microbial physiology related to electron transport, and advancement of fuel cell technologies.

Microbial fuel cells produce electricity from organic matters. Unlike conventional fuel cells, MFCs have certain advantages like high energy-conversion efficiency and mild reaction conditions. In addition, a fuel cell's emissions are well below regulations. MFCs also use energy much more efficiently than standard combustion engines which are limited by the Carnot Cycle. In theory an MFC is capable of energy efficiency far beyond 50%. In fact, using the new microbial fuel cells, conversion of the energy to hydrogen is 8 times as high as conventional hydrogen production technologies. In an MFC, bacteria are separated from a terminal electron acceptor at the cathode so that the only means for respiration is to transfer electrons to the anode. An MFC is thus a bio-electrochemical system that derives electricity by mimicking bacterial interactions found in nature. Microorganisms catabolize compounds such as glucose, acetate, or wastewater. It is a device that converts chemical energy to electrical energy by the catalytic reaction of microorganisms.

III. AIM AND OBJECTIVE

AIM - To study the process of electricity generation from waste food by using Microbial Fuel Cell (MFC) and provide data for effective construction of MFC model.

OBJECTIVES - The major objectives of the project are:

i. To study the working of Microbial Fuel Cells.
ii. To study the various instrument required for construction of MFC.
iii. To study the decomposition process such as aerobic and anaerobic.
iv. To study specific literature available on MFCs and materials used in them to make an efficient MFC model.
v. To derive conclusion based on the literature studied for MFCs.

PROPOSED MATERIAL AND METHODOLOGY

MFC is a promising technology for generation of electricity from organic substances. In our project we are using different research papers to study the working of Microbial fuel cell with different types of materials used for Electrode and Substrate also number of salt bridge used and impact of different salt concentration in the salt bridge on the electricity generated from Microbial fuel cell.

An MFC consist of 4 parts: the anode chamber, the cathode chamber, a salt bridge, and electric circuit. Multi-meter used for measuring the current.

The proposed methodology for this project work is given below:

- The research papers required for the study of Microbial fuel cell will be collected from the internet.

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- The shortlisted research papers will be studied to understand the functioning of Microbial fuel cell in which different materials are used for electricity generation.
- The graphs representing the amount of Electricity generated from Microbial fuel cell will be used to show the results.
- Based on the above study, project report will be prepared for submission work which will include the details of above study including result, discussion, and final conclusion.

III. LITERATURE REVIEW

Literature review of relevant literature published earlier, technical papers by various agencies is carried out. In this literature review attention is given study of microbial fuel cell on food waste for generation of electricity. The purpose of this literature review is getting an overview of new microbial fuel cell technology by used of food waste and to know various research studies to efficient and economical use of microbial fuel cell to achieve this purpose, study results given by various authors are mentioned here in this literature review.

3.1.1- A state of art review on microbial fuel cells: a promising technology for wastewater treatment bioenergy
The authors Zuweid, Hourani, Tingyu Gu (2007) stated that it has been known for many years that it is possible to generate electricity directly by using bacteria to break down organic substrates. The recent energy crisis has reinvigorated interests in MFCs among academic researchers as a way to generate electric power or hydrogen from biomass without a net carbon emission into the ecosystem .The paper includes Introduction about MFCs and the chemical reaction involved in it ,history of Microbial fuel cell development ,Microbes used in Microbial fuel cells Design of Microbial Fuel Cells Performances of Microbial Fuel cells Effects of operating conditions Effects of electrode pH buffer and electrolyte Proton exchange system Operating conditions in anodic and cathodic chambers, Applications{1.Electricity generation : MFCs are capable of converting chemical energy stored in chemical compounds in a biomass to electrical energy with the aid of microorganisms. The MFC technology has to complete with the mature methanogenic anaerobic digestion technology that has seen wide commercial applications because they can utilize the same biomass in many cases for energy productions.

3.1.2- Electricity generation from food wastes and microbial community structure in microbial fuel cells
The authors Jeanna Jia, Yu Tang, Bing Feng Liu, et.al(2013) stated that Microbial fuel cell (MFC) was studied as an alternate and a novel way to dispose food wastes (FWs) in a waste-to-energy form. Different organic loading rate obviously affected the performance of MFCs fed with FWs. The maximum power density of 18 W/m3 (556 MW/m2) was obtained at COD of 3200 = 400 mg/L and the maximum coulombic efficiency (CE) was 27.0% at COD of 4900 350 mg/L. The maximum removals of COD, total carbohydrate (TC) and total nitrogen (TN) were 86.4%, 95.9% and 16.1%, respectively.
MFC configuration and operation -
Single-chamber air cathode MFCs with liquid volume of 28 ml (cylindrical chamber with a length of 4 cm and a diameter of 3 cm) were constructed as previous description. Cathodes (carbon cloth based) with area of 7 cm2, Pt catalyst and three diffusion layers were prepared as previously described (Cheng et al., 2006). Anodes were made of brushes (length and outer diameter are both 2.5 cm) consisting of graphite fibres and a titanium core. The volume of liquid media was about 22 ml due to the occupation by the brush anode. Six MFCs were randomly divided into three groups, which meant each test was carried out in duplicate.

IV. METHODOLOGY

STUDY OF MICROBIAL FUEL CELL BY USING WASTE FOOD

4.1 FOOD WASTE AND ITS TYPES

Food waste or food loss is food that is not eaten. The causes of food waste or loss are numerous and occur throughout the food system, during production, processing, distribution, retail, and consumption. Global food loss and waste amount to between one-third and one-half of all food produced. In low-income countries, most loss occurs during production, while in developed countries much food – about 100 kilograms (220 lb.) per person per year – is wasted at the consumption stage.

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- The various types of Food Wastes are as follows

4.1.1 Production food waste

They usually take place due to destruction caused by predator or insects or from natural disaster, ill managed government programs encouraging farmers to produce certain foods in excess, farmers aligning to selective harvesting, or inability to harvest anything because of bad crop yields or reduced market rates. Different kinds of food waste also occur at the farms during storage caused either by pest or food decay.

4.1.2 Processing food waste

Food processing wastes prime contributing factors include ineffectual processing methods for removal of edible and inedible parts of food and spillage. Also, in developed western counties large portion of processing wastes are accounted for in the inedible parts of food namely bones, skins, eyes, peels, blood and other low quality miniscule products.

In practice, the wastes generated from food processing industry have the below indicated distinct qualities:

Higher number of proteins, carbohydrates, and lipids.

Distinct quantity of suspended solids largely dependent on the source

High amount of chemical or biochemical oxygen demand.

4.1.3 Distribution food waste

These food waste categories are due to inefficient handling of food, during food packing, conveyance, overstocking of certain food stocks, and improper stock cycle. Also, larger portion of food service waste arises due to plate leftovers, significant food service waste comes from plate scraps, which in some countries are not retrieved due to food safety because of food safety criteria and larger food portion sizes

4.1.4 Consumer food waste

They occur during food acquisition, preparation, and consumption. Improper or extended storage is a pivotal cause of consumer food waste. During preparation, consumers may try to remove inedible or defective portions of foods along with edible portions such as skins to obtain desired sensory or nutritional qualities. Remnant foods may be fed to pets, decreasing the amount of unutilized food but also reducing availability of foods for humans. The availability of cheap food, particularly in industrialized nations, encourages buying in excess and stockpile habits that result in waste.

Various types of vegetables, fruits, coffee filters, eggshells, newspaper, meat, food grains, bread, dairy produce etc. can be composted. Food waste has distinctive properties as a raw compost agent. Also, as they have increased moisture contents and reduced physical structure, it becomes imperative to blend fresh food waste with a bulking agent that will absorb part of surplus moisture and in turn augment structure to the mixture. Typically, sawdust, yard waste are preferred choices of bulking agents due to their high C: N ratio.

4.2 CAUSES OF FOOD WASTE

- Lack of appropriate planning: one of the top contributors to food wastage is because of appropriate planning on the consumer part. Sometime people buy lots of food without making plans on when and how the food will be prepared for consumption.
- Purchase and preparation of two much food: most of the time food is also wasted because of purchasing or preparing too many foods.
- Over preparation of food in restaurants, hotels and the foods service industry.

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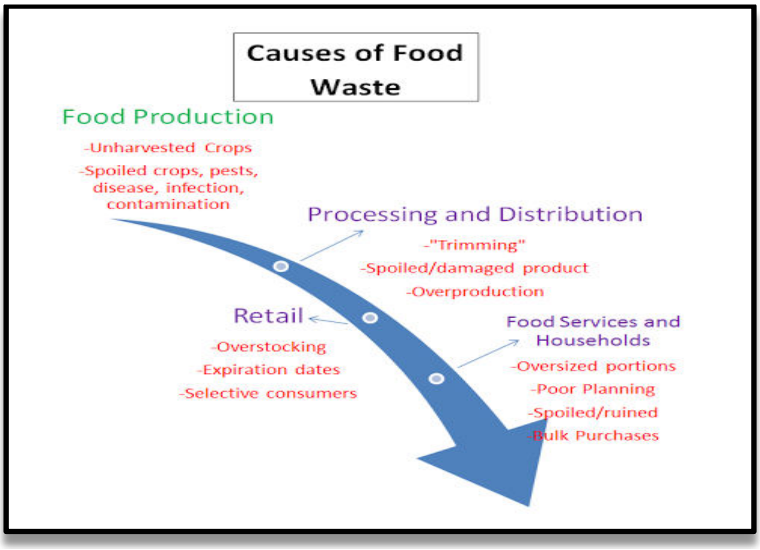
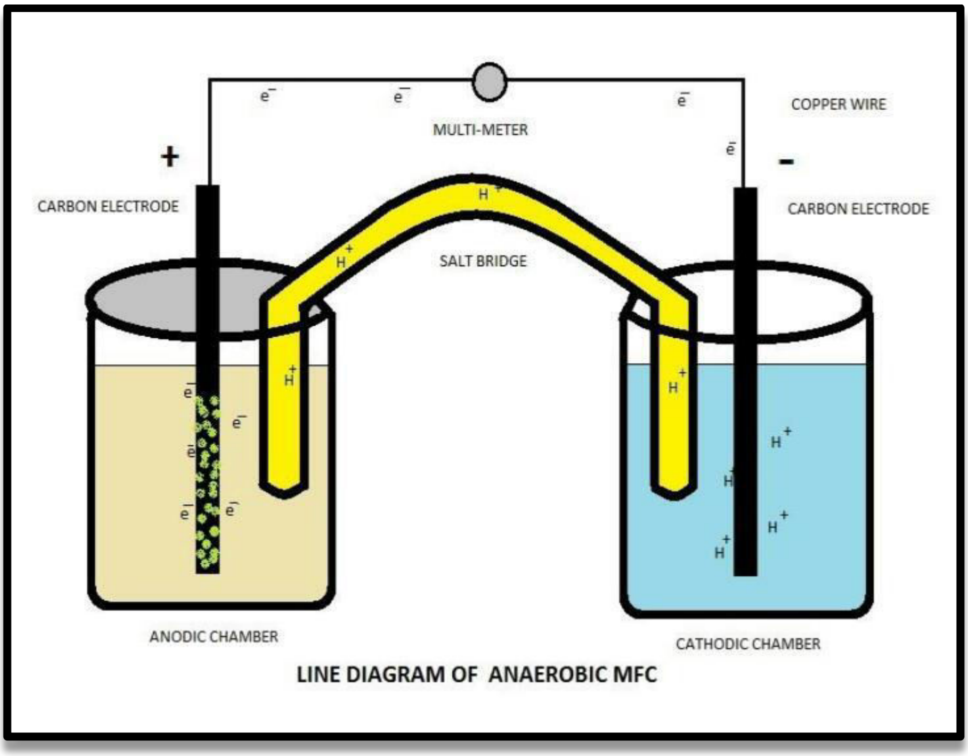


Figure 3.1 Causes of Food Waste

4.3 DECOMPOSITION PROCESS OF FOOD WASTE

- **Aerobic process:** Aerobic decomposition process is most common in nature. In aerobic composting, aerobic organisms utilize considerable amount of oxygen in decomposing organic matter. In aerobic process, when microorganisms consume a substance such as sugar in aerobic condition, they produce carbon dioxide and water.

- **Anaerobic process:** This process is done in the absence of oxygen. It is the process by which micro-organisms breaks down biodegradable materials in the absence of oxygen. The process is used for industrial or domestic purpose to manage waste or to produce fuel from research, anaerobic process gives more power or current as compared to aerobic process. In anaerobic process when microorganisms consume a substance, they produce carbon-dioxide, hydrogen ions and electrons.



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V. CONCLUSION

From this study we conclude that,

1. The working of Microbial fuel cell was studied, and the various instruments required in its construction were also studied.
2. When the number of salt bridge in the model of Microbial fuel cell is 8, maximum current of 1675 micro amperes was obtained which was more than that when the number of salt bridges is less than 8. Therefore, the number of salt bridge used also plays a significant role in electricity generation.
3. Different combinations of electrodes were used, and it was found that Cu/Zn (Copper/Zinc) combination gave the best and consistent results.
4. Acetate as a substrate was the most preferential for the generation of electricity with the highest CE (Coulombic Efficiency). The glucose-fed-MFC generated the lowest CE and greatest PD (Potential Difference) among the substrates used in the study.
5. With the increase in molar concentration of salt in the salt bridge, the current decreases. Optimum results were obtained for salt bridge fabricated using 1M KCl and NaCl. It produced a maximum voltage 0.451 V and 0.372 V respectively.
6. When waste food is used in the MFC, the voltage rapidly increased to higher than 0.54V in 6 h, and then remained stable at an average voltage of 0.51 V until the 116th hour when the voltage began to dramatically decrease. The voltage and power outputs achieved by using Waste Food as substrate
   is lower than MFCs fed with simple substrates like glucose and acetate but is

REFERENCES

1. *Zuweid, Hourani, Tingyu, "A state of art review on Microbial Fuel Cells : A promising technology for wastewater treatment and bioenergy" ,2007, Biotechnology advances 25, PP. 464-482.*

2.JiannaJia. Yu Tang, Bing Feng Liu, Di Wu, NanqiRen, Defeng Xing, "Electricity generation from food wastes and microbial community Structure in microbial fuel cells",2013, Bioresource Technology 144, PP. 94-99.

3. S Kalathil, SA Patil, D Pant, "Microbial Fuel Cells: Electrode Materials", 2018, Elsevier Inc..

4. Edward M. Milner, Dorine Popescu, Tom Curtis, Ian M. Head, Keith Scott. Eileen H. Yu, "Microbial fuel cells with highly active aerobic biocathodes",2016, Journal of power sources 324, PP. 8-16.

5. SurajbhanSevda& T. R. Sreekrishnan, "Effect of salt concentration and mediators in salt bridge microbial fuel cell for electricity generation from synthetic wastewater",2012, Journal of Environmental Science and Health, Part A 47, PP. 878-886.

6. A.Muralidharan&K.Ramaswamy , " Impact of salt bridge in Sewage water based Microbial Fuel Cells" ,2012,Research Journal of Pharmaceutical, Biological and Chemical science's. 3 ,Issue 1, PP. 78-82.

7. Kyu-Jung Chae, Mi-Jin Choi, Jin-Wook Lee, Kyoung-Yeol Kim, In S.Kimnin, " Effect of different substrates on the performances, bacterial diversity, and bacterial viability in microbial fuel cells",2009, Bioresource Technology 100, PP. 3518-3525.

8. Deepak Pant, Gilbert van Bogaert, Ludo diels, Karolienvanbroekhoven, "A review of Substrates used in Microbial Fuel Cells for sustainable Energy Production",2010, Bioresource Technology 100, PP. 1533-1543

9. HandojoDjatiUtomo, Li Si Yu, Daniel Choong Zhi Yi, Ong JieJunIn, "Recycling solid waste and bio-energy generation in MFC dual chamber model",19-21 July 2017, Energy Procedia 143, PP. 424-429.

10. Chengshuo Xia, Daxing Zhang, Witold Pedrycz, Yingmin Zhu, Yongxian Guo, "Models for Microbial Fuel Cells: A critical review",2018 Journal of Power Sources 373, PP. 119-131.

11. Hadagali Ashoka, Shalini. R, Pratima Bhat, "Comparative Studies on Electrodes for the Construction of Microbial Fuel Cell", 2012 International Journal of Advanced Biotechnology and Research, Vol 3, Issue 4, 2012, pp 785 -789.

12. Anand Parkash*, Shaheen Aziz, Soomro SA, "Impact of Salt Concentrations on Electricity Generation using Hostel Sludge Based Dual Chambered Microbial Fuel Cell", 2015 Journal of Bioprocessing & Biotechniques, Volume 5, Issues 8.

13. Hui Li, YU Tian, Wei Zuo, Jun Zhang, Xiaoyue Pan, Lipin Li, XinyingSu, "Electricity generation from food wastes and characteristics of organic matters in Microbial Fuel Cell", 2016 Bioresource Technology 205 , PP. 104-110.

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