

Production of Hydrogen Fuel from Waste Water Using Microbial Fuel Cell – A Review

S. Theerkadharshini¹, R. Hemalatha², S. Priyadharshini³

Assistant Professor, Department of Civil Engineering, Panimalar Engineering College, Chennai, India¹

UG Scholar, Department of Civil Engineering, Panimalar Engineering College, Chennai, India^{2,3}

ABSTRACT: The present world is in search of energy which is free from pollution. The objective of this project is to have a clean and healthy environment. This problem can be solved by producing hydrogen fuel from waste water using microbial fuel cell. Here we use a combined device to produce hydrogen fuel. The device consists of MFC (Microbial Fuel Cell) and device. In the MFC component, bacteria reduce organic matter in the waste water generating electricity in the process. The biologically generated electricity is delivered to the Electrolytic Separator device to assist the splitting of water that generates hydrogen and oxygen. The hydrogen thus collected can be used to run the engine in an efficient manner with zero emission of pollution. As we have large quantity of waste water, this method finds the best way for green environment.

KEYWORDS: Microbial fuel cell, Electricity, Hydrogen fuel, Electrolytic Separator, Zero pollution.

I. INTRODUCTION

Hydrogen lies in the first group and first period in the periodic table, i.e. it is the first element on the periodic table, making it the lightest element. Since hydrogen gas is so dainty, it rises in the atmosphere and is therefore rarely found in its pure form, H₂. Hydrogen is locked up in enormous quantities in water, hydrocarbons, and other organic matter. One of the encounters of using hydrogen as a fuel comes from being able to efficiently extract hydrogen from these compounds. Because pure hydrogen does not occur naturally on Earth in large quantities, it takes an extensive amount of energy in its industrial production. A microbial fuel cell (MFC), or biological fuel cell, is a bio-electrochemical system that enterprises an electric current by using bacteria and copycating bacterial interactions found in nature. A microbial fuel cell (MFC) is a device that converts chemical energy electrical energy by the action of micro-organisms. These electrochemical cells are constructed using either a bio anode and/or a bio cathode. Electrolytic Separator device that produce hydrogen in a process similar to electrolysis of water. A splint is lit and held near the opening of the tube, then the stopper is removed to expose the splint to the gas. If the gas is flammable, the mixture ignites. This test is most universally used to identify hydrogen, which ignites with a distinctive 'squeaky pop' sound.

II. MICROBIAL FUEL CELL

We know that, electricity can be generated from bacteria. In earlier period the bacteria have to be grown in laboratory for the production of electricity. As we have more amount of wastewater we can use that for generation of electricity. The bacteria already present in wastewater reduces the organic matter into electricity. Coliforms like E.coli, Enterobacter, micrococci, lacto bacilli, pseudomonads, facultative clostridia and streptococci are predominant in wastewater. These bacteria help in generation of power. The amount of energy that can be acquired by MFCs is relatively low if compared to other fuel cell technologies, but they have a unique feature in the field of fuel cells: they can harvest chemical energy from numerous classes of wastes, with the potential to effectively and directly convert into electrical energy numerous non-purified organic substrates, naturally present in different environments. Moreover, operating at room temperature and pH close to neutrality.

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MFCs could be one of the most interesting technology for application in remote areas. Only specific groups of microbes can be used to control a microbial fuel cell, due to their adaptation to donate electrons superficially during respiration, and, so, researching the physiology of these organisms can improve the efficiency of the cell. A modified microbial fuel cell can be used to perform electrohydrogenesis.

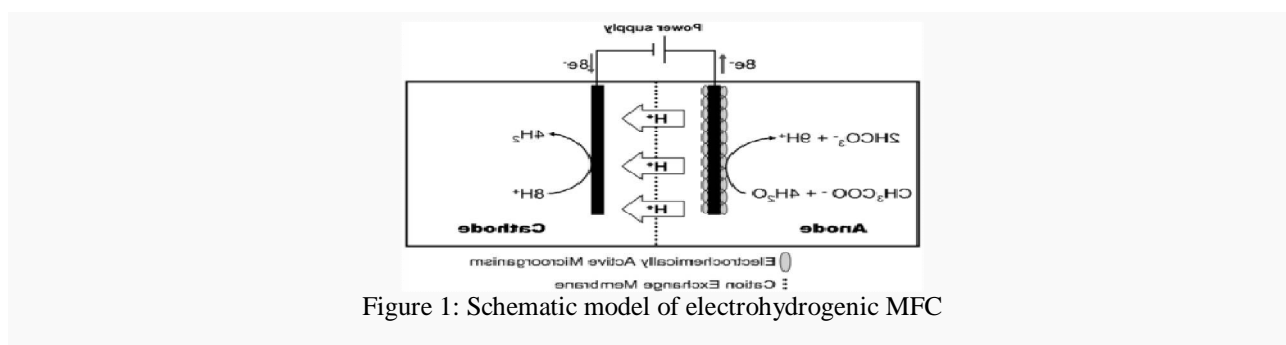
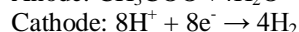
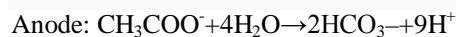


Figure 1: Schematic model of electrohydrogenic MFC



This is commonly referred to as biocatalyzed electrolysis and operates under strictly anaerobic environments. The generation of hydrogen has been shown to be a highly efficient process at 8-9 mol H₂/mol glucose or 2.9 mol H₂/mol acetate and presents an alternative to expensive chemical purification processes to obtain pure hydrogen. The electrochemical operation of the modified MFC is identical to the original, except that an external power source must be present to reduce the protons to H₂ at the cathode. The collected hydrogen gas can be compressed and made into hydrogen fuel cells.

III. PRINCIPLE

MFC consist of an anode and cathode compartment separated by a salt bridge. The anode and cathode are externally connected by wires. The microorganisms present in the anode oxidize the organic matter in wastewater and transfer the electrons to the anode. The hydrogen ions produced by the oxidation half reaction pass through the membrane to the cathode compartment where they reduce oxygen to water. As the result of these two reactions, potential difference is created and an electric current flows.

IV. COMPONENTS

- Rectangular plastic container – 2 nos.
- Plastic pipe for salt bridge
- 3g Agar
- 11.8g salt, dissolved in 150ml of distilled water
- Stainless steel mesh
- Coated copper rod
- Glue gun
- Aquarium air pump
- Multimeter
- Sediment from bottom of lake
- Waste water from Rice mill

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V. CONSTRUCTION STEPS

Firstly, the anode and cathode are assembled, as this plays a major role in MFC. The copper wire which makes the electrode are prepared. The holes are then drilled in rectangular plastic container. The holes are meant for inserting the electrodes and for air pump. The air pump is placed only in cathode. Stainless steel mesh is being cut into four equal pieces. Those cut pieces are then attached to electrodes. The salt bridge is then prepared by heating water, 30g agar and salt. The prepared solution is left for about few to get solidified. The conductive solution is poured in cathode compartment. The electrode and air pump are inserted in cathode compartment. The anode compartment is made ready by placing benthic mud into it. These two compartments are being connected by salt bridge. The setup left undisturbed for some time. The electrodes are the connected to multimeter to record the current flow. At the initial stage there may some fluctuation ignoring that after few minutes we may get stable current flow. This determines the efficiency of Microbial Fuel Cell.

VI. ADVANTAGES

MFC is the big source of energy due to its cost efficiency and eco – friendly. Generally we harvest renewable energy from solar energy, geothermal energy, and wind or water energy. But using MFC we can extract electricity from waste water. We actually spend large amount of money in cleaning the waste water if we make use of MFC and waste water we can save money.

VII. ELECTROLYSIS OF WATER

Electrolysis of pure water is the decomposition of water (H_2O) into oxygen (O_2) and hydrogen gas (H_2) due to an electric current being passed through the water. The reaction has a standard potential of -1.23 V, meaning it ideally necessitates a potential difference of 1.23 volts to split water.

This technique can be used to make hydrogen fuel (hydrogen gas) and breathable oxygen.

VIII. PRINCIPLE

A DC electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum, stainless steel or iridium) which are positioned in the water. Hydrogen will appear at the cathode (where electrons enter the water), and oxygen will appear at the anode. Assuming ideal faradaic efficiency, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells opposing side reactions occur, resulting in different products and less than ideal faradaic efficiency.

Electrolysis of pure water requires excess energy in the form of over potential to daze various activation barriers. Without the excess energy the electrolysis of pure water occurs very slowly or not at all. This is in part due to the partial self-ionization of water. Pure water has an electrical conductivity about one millionth that of seawater. Many electrolytic cells may also lack the requisite electro catalysts. The effectiveness of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electro catalysts.

IX. ELECTROLYTIC SEPARATOR

The Electrolytic Separator is an appliance that produces oxygen and hydrogen from water and electricity. Hydrogen is used in Hydrogen Generators to generate electricity, Hydrogen can be stored in Storage Tanks or connected directly to the Hydrogen Generator. The Electrolytic Separator sends controlled amounts of direct current into a fluid, causing the atoms in the fluid to break their bonds. This process of electrolysis is used to generate some very useful gases from some rather ordinary fluids.

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The Electrolytic Separator requires a constant supply of power and must have a source of an appropriate liquid in order to produce the gases. As the liquid is electrolyzed, the component gases will be stored in its internal tanks. Should either tank fill completely, the Separator will turn off. Connecting a Pressurized Tube or other well-suited pipe to both tanks will remove the gas. If you are only using a single gas, selecting "dump" for the unexploited gas will vent it to the environment, preventing that internal tank from filling completely and stopping the Separator.

Typically the first solicitation of the Electrolytic Separator is in the electrolyzing of water into Hydrogen and Oxygen. The oxygen is usually dumped into the environment, but the hydrogen is used for satisfying a Jetpack and/or for feeding into a Gas-Burning Generator (previously known as the Hydrogen Generator) as a significant source of power for a growing base. Oxygen can be peeped from the red tank side of the Electrolytic Separator, and hydrogen is delivered out the blue tank side.

X. COMPONENTS

Glass tube – 2 nos. 10cm diameter, 50cm length
Stainless steel sheet 6cm * 20cm
Bolts and Nuts
Plumbing fittings
Glue gun
Caustic potash
Distilled water

XI. CONSTRUCTION STEPS

In electrolytic separator, tubes are being connected by U – shaped plumbing fittings. The plumbing fittings are attached to the glass tube by glue. The stainless steel sheets are being cut as per the required dimensions. The holes are then drilled in stainless steel plates. The sheets are then interconnected by using bolts and nuts. This type of arrangement is placed in both glass tubes. The u- shaped arrangement has to be placed in a stand where it can be stable in a position. The water is then filled in glass tube then little quantity of caustic potash is added in water. The external power is given by MFC to the electrolytic separator. As a result electrolysis process starts, and there will be generation of hydrogen from water. This is then collected in a separate container for future use.

XII. CONCLUSION

The ultimate aim of hydrogen production is thus achieved. This clean energy is being achieved by combining MFC and Electrolytic Separator. The waste water used in MFC is being cleaned. Thus, this project also finds a solution in reducing the turbidity of waste water. The produced hydrogen is used for running the engines. As the fuel is being produced directly from water it does not create any pollution when it is being used. Thus we can have clean environment.

REFERENCES

- [1] Venkata Mohan, S.; Veer Raghuvulu, S.; Srikanth, S.; Sarma, P.N. "Bioelectricity invention by mediatorless microbial fuel cell (MFC) under acidophilic condition using wastewater as substrate: influence of substrate packing rate" (2007).
- [2] Ashlynn S. Stillwell, David C. Hoppock and Michael E. Webber "Energy Recovery from Wastewater Treatment Plants in the United States: A case study of the energy – water nexus" (2001).
- [3] Lithgow, A.M., Romero, L., Sanchez, I.C., Souto, F.A., and Vega, C.A. Interruption of electron-transport chain in bacteria with hydrophilic redox mediators (1986).
- [4] Pham, C. A.; Jung, S. J.; Phung, N. T.; Lee, J.; Chang, I. S.; Kim, B. H.; Yi, H.; Chun, J. "A new electrochemically dynamic and Fe (III)-reducing bacterium phylogenetically related to *Aeromonas hydrophila*, isolated from a microbial fuel cell". FEMS Microbiology Letters (2003).
- [5] Mediator-less microbial fuel cell schematic + explanation Archived March 10, 2011, at the Wayback Machine.
- [6] "Environmental Technology". Wageningen UR.
- [7] Leelon Scott - Capturing Energy in Wastewater Treatment Plants

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

- [8] "Advanced Water Management Centre". Advanced Water Management Centre.
- [9] Carlyn McGill- Power Generation from Wastewater Treatment (December 21, 2015).
- [10] Iwona Gajda, John Greenman, Chris Melhuish and Ioannis A. Ieropoulos "Electricity and disinfectant production from wastewater: Microbial fuel cell as a self-powered electrolyser" (2016).
- [11] Xu, Bojun; Ge, Zheng; He, Zhen "Sediment microbial fuel cells for wastewater treatment: challenges and opportunities," Environ. Sci.: Water Res. Technol. The Royal Society of Chemistry (2015).
- [12] Clark, Helen "Cleaning up wastewater from oil and gas operations using a microbe-powered battery" (March 2, 2015).
- [13] Elizabeth, Elmy "GENERATING ELECTRICITY BY "NATURE'S WAY". SALT 'B' online magazine (2012).
- [14] Strik, David; Ruud A. Timmers; Marjolein Helder; Kirsten J.J. Steinbusch; Hubertus V.M. Hamelers; Cees J.N. Buisman "Microbial solar cells: applying photosynthetic and electrochemically active organisms". Trends in Biotechnology (2011).
- [15] Skeet Arasmith - Electrical Fundamentals for water and wastewater
- [16] Pasternak, Grzegorz; Greenman, John; Ieropoulos, Ioannis "Comprehensive Study on Ceramic Membranes for Low-Cost Microbial Fuel Cells". ChemSusChem (2016-01-01).
- [17] T Bak, J Nowotny, M Rekas, C.C Scorrell - International Journal of Hydrogen Energy "Photo – electrochemical hydrogen generation from water using solar energy" Vol.27, Issue 10, (2002)
- [18] Science - John A. Turner "Sustainable hydrogen production" Vol. 305, Issue 5686, (August 13, 2004).