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Microbial Fuel Cell for Electrical Power Generation from Waste Water

S. Ganesh, M. Brinda, A. Devibala, S. Jayabharathi, M. Shivarekka

Abstract*: In the last decades, the microbial fuel cell (MFC) has increased great opportunity as an alternative energy source through electrochemical process for producing bio-energy. MFC has been involved in anode and cathode for electric energy generation from organic ingredients such as bacteria in waste water treatment. In this review, we discussed the different types of MFC (anode and cathode) materials with various integrations. In addition, it includes the gainful, biocompatible and exceedingly constant electrode materials with enhanced microbial fuel cell performance. Following this review, expansion in membrane materials such as hydrocarbon polymer, perfluorinated polymer, organic-organic hybrid polymer, ceramics, organic-inorganic hybrid composite, and biopolymer membranes are clarified in detail. In this paper, also highlighted the application of MFC technology and the methods used in the MFC in electricity production.

Keywords: Alternative energy, Microbial fuel cells, Wastewater treatment, Microorganisms, Electrodes, Membrane.

I. INTRODUCTION

The Microbial Fuel Cells (MFCs) consist of anode and cathode combination, proton exchange membrane and electrical components. MFC is an alternative and sustainable skill for direct conversion method in organic matter content for waste water treatment. Reduction of non-renewable energy incomes and the environmental pollutions are critical pressures facing us. Removing energy from organic or inorganic wilds can deliver an efficient resource of solving energy and environmental difficulties concurrently. Microbial fuel cell (MFC) expertise has concerned an improved number of scholars in current ages because of its potential also particularly for bio energy creation and wastewater treatment. At present, MFCs can harvest enough current to small Power electronic devices used for short periods.

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* Correspondence Author

Dr. S. GANESH*, Electrical and Electronics Engineering, SRM TRP Engineering College, SRM TRP Engineering College, Tiruchirappalli, Tamilnadu, India. Email: gauti.ganeshs@gmail.com

M. Brinda, Electrical and Electronics Engineering, SRM TRP Engineering College, SRM TRP Engineering College, Tiruchirappalli, Tamilnadu, India.

A. Devibala, Electrical and Electronics Engineering, SRM TRP Engineering College, SRM TRP Engineering College, Tiruchirappalli, Tamilnadu, India.

S. Jayabharathi, Electrical and Electronics Engineering, SRM TRP Engineering College, SRM TRP Engineering College, Tiruchirappalli, Tamilnadu, India.

M. Shivarekka, Electrical and Electronics Engineering, SRM TRP Engineering College, SRM TRP Engineering College, Tiruchirappalli, Tamilnadu, India.

The impartial of this paper was to appraisal on the recent microbiology information in electricity production. The materials and devices are used to shape the technology, and applications and the limitations for MFC expertise also emphasized. The benefits of MFC for various aspects are shown in Fig. 1.

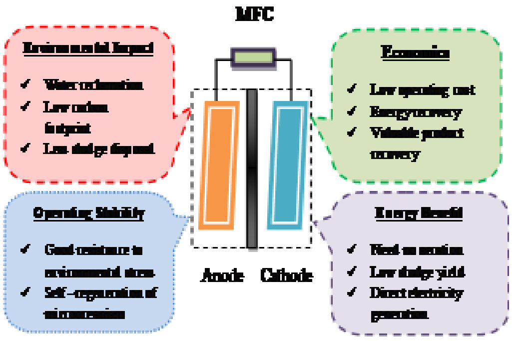

Fig. 1 Potential benefits of MFCs for energy, environmental, operational and economic sustainability

II. MFC WORKING

MFC is comprised of anode and cathode working with volume of 250ml in each chamber by separating a proton exchange membrane. The membrane is inserted in distilled water at 80-90 degree. When the membrane is washed and stored in deionized water. Anode and cathode have the inlet, outlet holes to change the solution of anolyte and catholyte, and they are constant in anaerobic and aerobic conditions. The nanoparticles coated and uncoated carbon papers of anode and cathode are placed 2cm away from either side of the membrane. To remove the dissolved oxygen the nitrogen is purged to the chamber.

Single chamber or dual chamber microbial fuel cells are mostly functional by researchers. In a single chambered moderator, less microbial fuel cells were proficient for removing Chemical oxygen demand (COD) then Biological oxygen demand (BOD). Microbial fuel cells are oxidized and decrease organic molecules. Adaptation of sunshine energy in electricity relies on a development known as electrical phenomenon impact. This is often the fundamental reason for manufacturing electricity because of electrical phenomenon impact. While the MFC operation the contact between the microbes and substrates are effective. Anode and cathode are swapped while voltage is decreased from its maximum open circuit potential. The settled down biomass was used in the subsequent cycle after 24hrs after the reactor was settled down.

The MFC working process is explained in Fig. 2.

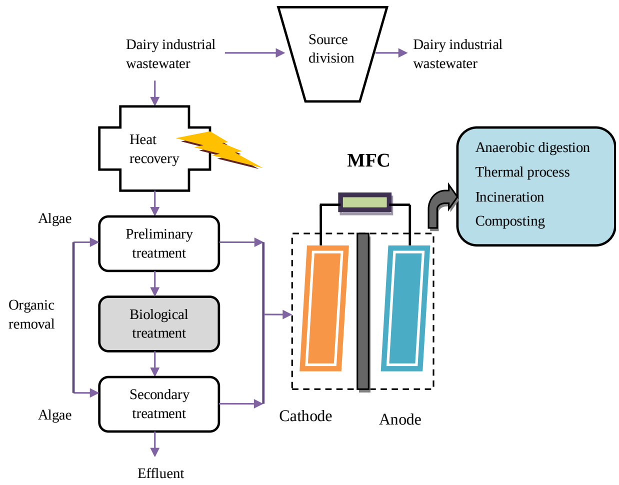

Fig. 2 Working Process of MFC

III. LITERATURE REVIEW

In [1], reported to assemble the desired chemicals by merging enzymatic catalysis and electro-chemical process for the enzymatic electro-synthesis method. It has a very important impact because the given input is unpolluted electricity and highly specific enzyme biocatalyst. For the synthesis of high-value products use of CO2 is reduced and N2 is used. The microbial and chemical are integrated into the enzyme-based hybrid system. In [2], offered a program on energy and signal transfer at the nano-bio interface by introducing nanowire bios system, nano material-bacteria hybrid, nano-bio hybrid, semi conductor nano-wire embedded nano-electronics with lump cell and tissue for electrophysiological signal recordings and conveyed by assimilating semiconductor nano-material. This is done by living cells that could function as a platform of giving energy by sending a signal between living and non-living system.

In [3], explores the mixture of photoelectric cells (PECs) and microbial fuel cells (MFCs), including Photosynthetic MFC. Photo-anodes and photo-cathodes united with electro-genic and photoelectric microbes. MFCs use electrodes that turning light into energy produces more energy than the dark reaction during an MFC alone. In this research, hydrogen, methane and other bio-electric solar fuels are used hybrid reactors composed of imitation photosensitive materials Electrodes and microbes.

In [4], examined a micro fabricated polydimethyl siloxane microbial fuel cell (PDMFC) with embedded micropillar electrodes. It is a more flexible and compatible structure for body implantation. The MFC can exchange blood and CO2 between the fuel cell, and prevent bacteremia to the bloodstream. It adapts chemical energy in the bloodstream to electrical energy. Nafion 117 proton exchange membrane is the medium of PDMS anode and cathode. This device provides new medical therapies for patients who suffered from chronic diseases. And also it uses an embedded micropillar structure for increasing electrical output.

In [5], MFC is considered as waste to energy conversion of organic waste during bio anode and proton reduction during photocathode. By absorbing light cu20 is exhibit hydrogen due to the stability of p-type cu20. We coated skinny film of Ni oX for stability cu20/Ni oX for stability's is more stable but the photocurrent is lower because of the thin film on Cu20. It produces 5.09 h/cm^2 of H_2 by giving continuous illumination with 0.2V. For the simultaneous process of organic conversion and energy storage from wastewater and solar light. Also need to tune the synergistic effect of bio anode and photocathode.

In [6], various microorganisms of different species are taken and their advantages are noted. In previous, the metal sulphates are used as the semiconducting material. Essentially bacteria and other microorganisms are converting into dissolved sulphate ions into reduced sulphates. The insoluble metal sulphate is obtained by sulphate anions reacts with soluble metal captions. Various biosynthesis is inspected for application as photo catalysis. In [7] used the new technology has more advantages compared to others because the hydrogen generation is completely from H_2 gases. It improves hydrogen production and low input energy. This method needed for development in MFC design and cost-efficient.

In [8] through the metabolic activity of bacteria, MFC can produce electrical power. This could be environmentally effective and economically and this MFC provide autonomous solution for waste water treatment. This principle is rather alike to a classical hydrogen fuel cell. In [9], the grouping of photosynthesis & MFC of five approaches were established. It doesn't give any clear idea about direct electron transfer. They change photosynthetic harvests indirectly to get sufficient current from either electro catalyst or heterotrophic bacteria from sunlight. The best way of converting hydrogen one electro catalytic bio electrochemical system, this also alters organic from cyano bacteria are plants for a good oxygenic bio cathode it provides oxygen.

In [10], In order to interrupt organic compounds, we can generate electricity by using bacteria directly. The recent research is about to get electricity from biomass without the emission of carbon to the environment. To display oxygen demand biosensor has been considered and to decrease the low power density of MFC is working currently. This reports the recent type of MFC & their working. In [11], the microbial cell (MFC) technology, the electro active bacteria decrease to organic molecules for bioelectricity manufacture. MFC is possibly useful method for wastewater treatment. The waste water treatment used for sludge volume lessening, energy sustaining, and bioenergy generation. MFCs are combined with physical, chemical, and then biological processes for wastewater treatment. The hybrid systems are brighter related with standalone MFCs. This complete review discusses different MFCs using different working principles, designs, operating parameters and their performances. These systems contain bio electro-Fenton-MFC, the microbial desalination cell and MFC electro sorption cell, microbial solar cell and microbial reverse electro dialysis cell, plant-MFC and constructed wetland MFC. MFC-hybrid systems are brighter than standalone MFCs, far more research is required to exhausted important hurdles for real-world deployment.

In [12] inspected the substantial position to develop renewable and environmentally approachable skills for sustainable wastewater treatment and energy recovery. MFC is a bio electrochemical structure, it can treat wastewater and crop energy concurrently.

The functional submissions of MFC are high cathodic potential, slow chemical lack rate, and low power output. In this knowledge, a photo electrocatalytic microbial cell (photo-MFC), was used to decrease a model dye, and to get electricity concurrently. This photo-MFC obtainable a MO elimination productivity of 84.5% and maximum output power density of 0.119 W/m2 inside 36 h, which were dual of individuals of the expectable MFC with a carbon paper cathode. This description could deliver a spare technique for wastewater treatment, and branch attention in using the photo-MFC for treating colorant wastewater and gathering energy concurrently.

In [13] the target of the work was to proposal some first vision into an engineering-oriented method to MFC design by that, “specialize in anode optimization”. The first phase occasioned within the description of a group of ideal parameter values. Inside the second phase, an ideal anode was formed through a half-cell under the defined optimum conditions. A numerical tactic was then established to calculate the academic maximum power that anode could deliver in a perfect MFC. The idea of “perfect MFC” familiarized here suitable the academic maximum power to be calculated on the only basis of the kinetic characteristics of the anode. Finally, a MFC projected within the purpose of future such ideal circumstances created stable power densities of 6.0 W m−2, which were among the very finest values reported thus far. The divergence between the theoretic maximum (8.9 W m−2) and therefore the experimental results acknowledged some limit thanks to the source of inoculums and optional possible paths to improvement.

In [14], Bio Electrochemical Systems (BESs) are used. These are exceptional schemes and accomplished of adapting energy into electricity while employing microbes as catalysts. Such organic wastewaters and biomass were distorted into electricity by microbial fuel cells (MFCs). BES was also designed to recover nutrients, the range on microbial and enzymatic substances obtainable logically permits a variety of potential proposals. As associated with standard fuel cells, BESs activate less classy valuable metals as catalysts. These newer concepts in the submission of other resources for electrodes and separator side innovative designs have made BES a very promising skill. This text discusses the recent developments in BESs thus far, with the beyond electricity generation and resultant presentations also as existing restrictions. In [15], explored the Microalgae Microbial Fuel Cells (mMFCs) stand an method that can adapt solar energy towards electrical energy over biological paths. This appraisal lists new exploration and expansion work on microalgae procedures and MFC processes and combined mMFC. The considerable improvement and technical progression are highlighted, with a conversation on the contests and prospects for conceivable commercialization of mMFC technologies.

In [16] informed the field of bio electrochemical research includes a wide range of developing technologies that utilize microbes as a catalyst anodic or cathodic reaction in a fuel cell setup, and has developed greatly within the last 2–3 years. While the massive mainstream of BESs exploit organic substrates as a fuel source (e.g. MFC). In this review, a specific bio photovoltaic systems (BPVs) are used. BPVs exploit, to gain light energy to get current. Here we deliberate the light-harvesting BESs and photovoltaic exploration. We associate this scheme that uses heterotrophic microbes with those cyanobacteria-based BPVs. Finally, we estimate the achievable power outputs of this emerging technology.

In [17] examined the microbial fuel cells (MFCs) convert the chemical energy in wastewater into electrical energy using bacteria as a biocatalyst. This is conquered when bacteria distribution electrons to an electrode in its dwelling of on to an electron acceptor. MFCs could provide a source of “green electricity” by manipulating domestic and industrial waste to produce power. By using organic matter in wastewater, contaminants are far away from water while generating electricity. The use of cheap materials, like ceramic membrane, makes it possible to get a practicable device to supply electricity. Therefore, the wastewater treatment efficiency of MFCs, reducing their cost. In this article, MFC technology is provided, new anode and cathode materials, sorts of membranes their application in the treatment of various sorts of wastewaters. The different types of MFC with input and output are compared in Table I.

TABLE I
COMPARISON OF DIFFERENT TYPES OF MFC

No	Year	Source	Input	Output
1	2008 [4]	Polydimethylsiloxane MFC	15-μL droplet of human plasma.	Normal power density of 42.4 nW/cm^2
2	2008 [7]	From biomass (unused) to electricity. (MFC)	1000 tons per year of biomass at the concentration of 1g/l	4.5 MWh
3	2015 [6]	Domestic Waste water treatment in MFC.	Liquid flow rate of 0.39mL/min.	Generation of 84Ma electricity.
4	2016 [2]	Continuous Flow Microbial Fuel Cell Treating Actual Wastewater: Influence of Biocatalyst Type on Electricity Production.	250mA .(inoculated mixed culture)	270 mW/m^2
5	2015 [15]	Flat plate Microbial Fuel cell.(FPMFC)	Domestic waste water at 2.0h HRT	146+8mW/m^2
6	2016 [10]	Microbial fuel cells in bioelectricity production.	18W/m^3.(salt bridge as NaoH used)	Power density of 84.99mW/m^3
7	2019 [11]	Treating Industrial Wastewater in MFC.	2.42mA(diary and leather used as a substrate)	Diary(0.67m A0.57v) leather(0.58M a,0.52v)

8	2015 [16]	Electricity production coupled with waste water treatment using MFC.	BOD concentration of diary waste water(30.1mg /L)	71 micro A(power) 351micro A(voltage)
9	2015 [17]	Floating air cathode MFC	Ag/Agcl vs=0.2v(three electrode and anode potential)	250 to 500mA/m^2 at power density.
10	2016 [12]	MFC with mediator using kitchen waste as a substrate.	$KMNO_4$ mediator($K_3Fe(CN)_6$	Power density 24.79mW/m^2.

Fig. 3 shows the growth of MFC publication in international journal indexed by Scopus.

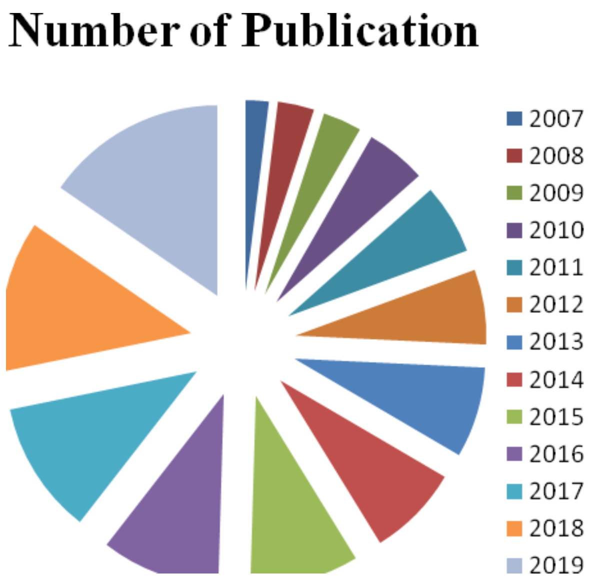

Fig. 3 Number of Publication Vs Year

IV. CONCLUSION

Nowadays, Microbial Fuel Cell is a new innovation method, is an attractive, cost-effective and renewable an optional energy source a newborn capable researchable area. The MFC methodology engages the biochemical process of organic and inorganic substrate into electric energy through an anaerobic process. The effectiveness of the process depends on various aspects like domestic and industrial waste water as a foundation of organic and inorganic substrate which are efficiently transformed into electrical energy. Different methods and rules of MFC have been utilized to improve the effectiveness of the MFC and diminish the boundaries in the MFC. This review clearly shows the maximum power generation from MFC with the treatment of dairy wastewater was very high compared to the other sources and also the light-enhanced microbial fuel cells can produce more electric power than it is probable with the common MFCs.

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AUTHORS PROFILE

Dr. S. GANESH received the Ph.D. degree in Electrical Engineering from Anna University, Chennai, India in 2019. He is currently an assistant professor of electrical and electronics engineering at SRM TRP Engineering College, Trichy, India. His research interests include power systems optimization, smart grid, renewable energy and power quality.

M. BRINDA currently pursuing BE in the major of Electrical and Electronic Engineering at SRM TRP Engineering College, Trichy, Tamil Nadu, India. Her interest and research include power system, solar power and waste water management.

A. DEVIBALA currently pursuing BE degree in Electrical and Electronics Engineering at SRM TRP Engineering College, Trichy, India. Her research interested includes waste water management, power Electronics and Renewable energy.

S. JAYABHARATHI currently pursuing BE degree in Electrical and Electronics Engineering at SRM TRP Engineering College, Trichy, India. Her research interested includes power systems, solar panels and waste water management.

M. SHIVAREKKA currently pursuing BE degree in Electrical and Electronics Engineering at SRM TRP Engineering College, Trichy, India. Her research interested includes power plants, Fuel cells, power electronics.