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Performance of Dual Chamber Microbial Fuel Cells with Waste Water for Power Production and Treatment

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Abstract: ***Dual-chamber microbial fuel cells (MFCs) have garnered significant attention in recent years due to their promising potential for sustainable energy generation from organic waste. This review provides a comprehensive overview of the advancements, challenges, and future prospects of dual-chamber MFC technology. The paper begins with an introduction to the principles of microbial fuel cells and the rationale behind the dual-chamber configuration. It discusses the design considerations including electrode materials, membrane selection, and reactor configurations, highlighting recent innovations aimed at enhancing performance and scalability. Key advancements in dual-chamber MFCs are reviewed, focusing on improvements in power output, microbial community dynamics, and substrate utilization. Strategies such as microbial enrichment, biofilm engineering, and electrode modifications are discussed in detail, showcasing their impact on MFC performance and stability. Furthermore, the review explores the application of dual-chamber MFCs in various fields including wastewater treatment, bioenergy productions.***

Keywords: PEM, Anode, Cathode, Multi-meter, Bio-electricity, Electron transfer, Waste water treatment, Aerobic, Anaerobic.

I. INTRODUCTION

Microbial Fuel Cells (MFCs) represent a cutting-edge technology at the intersection of microbiology, electrochemistry, and renewable energy. These devices harness the metabolic activity of microorganisms to convert organic matter directly into electricity through bio-electrochemical reactions. This unique ability holds significant promise for sustainable energy production, wastewater treatment, and environmental remediation. The concept of MFCs traces back to the early 20th century, with pioneering experiments demonstrating the generation of electricity from microbial metabolism. However, it was not until the late 20th and early 21st centuries that MFCs gained traction as a viable technology for practical applications. The fundamental principle underlying MFC operation revolves around the redox reactions mediated by bacteria ,known as electroactive microorganisms (EAMs). These microorganisms possess the remarkable capability to transfer electrons from metabolic processes to solid electrodes, establishing an electrical circuit and generating a usable electric current. The basic structure of an MFC typically consists of two compartments separated by a proton exchange membrane (PEM) . The anodic chamber hosts the microbial biofilm or suspension where organic matter (substrate) is oxidized by microorganisms, releasing electrons and protons. These electrons are then transferred to the anode electrode, creating an electrical current. Meanwhile, protons migrate through the membrane to the cathodic chamber, where they combine with oxygen or other electron acceptors at the cathode electrode, forming water or other reduced compounds.

A. History of MFC

The concept of microbial energy technology emerged in 1911 at the same time as M. C. Potter described the producing of energy from dirt using microorganisms. However, it wasn`t until the 1980's that research on MFCs gained momentum, with the e-book of seminal studies demonstrating microbial energy technology. showcased the feasibility of MFC technology with the useful resource of the use of generating energy using mixed cultures of bacteria in an MFC configuration.

II. METHODOLOGY

In microbial fuel cell (MFC) research, the methodology is carefully crafted to unveil the intricate processes underlying electricity generation through microbial metabolism. At the outset, meticulous design and assembly of the MFC system lay the foundation, where electrode materials and reactor configurations are selected with precision.

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With the system in place, the journey begins with inoculation and startup, introducing the microbial players into the anode chamber and providing them with the necessary substrate to kickstart their metabolic activity.

A. *MFC's setup*

Two cylindrical form containers of ability of 1 litre quantity made of plastic or fibre turned into used as anode and cathode chambers. These chambers are linked via a PEM which is known as Proton Exchange Membrane. The electrodes in each the chambers have been linked via an outside external circuit. The outside circuit is connected to a multi meter.

Laboratory scale Dual chamber Microbial Fuel Cell (DCMFC) evolved and includes separate cylindrical form and is made of plastic. The extent of every cell is 1 litre. One cell is packed with 700ml of river water and this cell acts as anode chamber and other cell is packed with 700ml of sea water and this cell acts as cathode chamber. Therefore, these cells are separated and interlinked with a proton exchange membrane (PEM). This proton exchange membrane is used to shifting of protons (H+) from anode chamber to cathode chamber. PEM is made of 50ml of distilled water, 8grams of starch powder and 5grams of sodium alginate and gets diluted .This solution is heated at 40°C as much as 3min and is cooled to normal temperature. The cooled solution is poured into plastic pipe. The Experimental Setup displaying the Electrodes, Chambers, Proton Exchange Membrane Connection.

B. *Experimental Procedure*

The Anode, Cathode, PEM, Multi-meter and chambers has been arranged on the way to setup a dual chamber MFC. Then the sea water used as a substrate is filled inside the anode chamber and kept in an anaerobic environment. The different aspect cathode is full of river water. Same number of solutions to be taken in anode and cathode otherwise due to pressure difference diffusion can occur. The treatment gets started for 12 days and some number of electrons (e) and protons (H) are released. The released electrons are accepted and absorbed.

The received electrons store on its surface and pass to external circuit and a voltage is generated. This H+ ions are transported from anode chamber to cathode chamber through external proton exchange membrane (PEM). From PEM H+ ions are absorbed by cathode electrode and due to presence of oxygen this are converted to H_2O.

By attaining the e- and H+ ions from the MFC, potential difference is created between

the electrodes. Multi meter which is connected is used to measure the potential difference between the anode and cathode electrodes in the chamber. The redox reaction is generating from dual chamber MFC therefore, voltage and current are being generated. The power production from the DCMFC is measured and recorded 3 days interval out of 12 days. The DCMFC experimentation was continued till constant power generation is observed. After certain stage power generation is measure and recorded . The experiment was continued for a total duration from starting time till it reaches where insignificant or approximately zero current generation is observed. Therefore, no significance after zero current generation from MFC.

C. *Experiments*

The project conducted on three different samples.

1) *Sample 01:* The experimental setup, Anode chamber is filled with River water, which is used as substrate and Zinc rod is placed in it as electrode. Cathode chamber is filled with sea water and inserted a Brass rod to act as electrode. Both electrodes are connected through external circuit. Multi meter is connected to both wires from anode and cathode chambers. It enables the measurement of voltage and current generated from MFC. It was observed that 0.69V of voltage of current generation after one day of reaction occurred in dual chamber MFC.
2) *Sample 02:* The experimental setup, Anode chamber is filled with synthetic waste water, which is used as substrate and copper rod is placed in it as electrode. Cathode chamber is filled with Tap water and inserted an Aluminium rod to act as electrode. Both electrodes are connected through external circuit. Multi-meter is connected to both wires from anode and cathode chambers. It enables the measurement of voltage and current generated from MFC. It was observed that 0.62V of voltage of current generation after one day of reaction occurred in dual chamber MFC.
3) *Sample 03:* The experimental setup, Anode chamber is filled with Sea water, which is used as substrate and copper rod is placed in it as electrode. Cathode chamber is filled with Tap water and inserted a Brass rod to act as electrode. Both electrodes are connected through external circuit. Multi-meter is connected to both wires from anode and cathode chambers. It enables the measurement of voltage and current generated from MFC. It was observed that 0.25 V of voltage of current generation after one day of reaction occurred in dual chamber MFC.

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III. OBSERVATIONS & RESULTS

A. Tests on Water Sample

1) Tests for Sample 1 (River and sea water)

Table 1 : For River Water

Conducted Tests	Initial Value	Final Value
pH	06	07
TDS(Total Dissolved Solids)	422 mg/l	421 mg/l
Hardness by EDTA	102.5 mg/l	60.5 mg/l
Alkalinity by Phenolphthalein	15 mg/l	15 mg/l
Alkalinity by Methyl Orange	10 mg/l	10 mg/l

Table 2 : For Sea water

Conducted Tests	Initial Value	Final Value
pH	7 mg/l	7.4 mg/l
TDS(Total Dissolved Solids)	491 mg/l	237 mg/l
Hardness by EDTA	52 mg/l	129.5 mg/l
Alkalinity by Phenolphthalein	0 mg/l	0 mg/l
Alkalinity by Methyl Orange	10 mg/l	7.5 mg/l

Table 3 : Power generation

Retention time (DAYS)	River Water & Sea water		
	Voltage (mV)	Current (mA)	Power Density (mW/m2)
DAY 01	0.69	0.69	0.4761
DAY 03	0.75	0.75	0.5625
DAY 06	0.86	0.86	0.7396
DAY 09	0.93	0.93	0.8649
DAY 12	0.96	0.96	0.9216

2) Tests for Sample 2 (Synthetic waste water and Tap water)

Table 4: For synthetic waste water

Conducted Tests	Initial Value	Final Value
pH	03	06
TDS(Total Dissolved Solids)	144 mg/l	929 mg/l
Hardness by EDTA	22.5 mg/l	15.5 mg/l
Alkalinity by Phenolphthalein	30 mg/l	50 mg/l
Alkalinity by Methyl Orange	25 mg/l	300 mg/l

Table 5 : For Tap water

Conducted Tests	Initial Value	Final Value
pH	06	07
TDS(Total Dissolved Solids)	466 mg/l	537 mg/l
Hardness by EDTA	7 mg/l	10.2 mg/l
Alkalinity by Phenolphthalein	25 mg/l	25 mg/l
Alkalinity by Methyl Orange	20 mg/l	15 mg/l

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Table 6: Power generation

Retention time (DAYS)	Synthetic waste water & Tap water		
	Voltage (mV)	Current (mA)	Power Density (mW/m2)
DAY 01	0.62	0.62	2.42
DAY 03	0.69	0.69	3.06
DAY 06	0.74	0.74	4.35
DAY 09	0.76	0.76	4.59
DAY 12	0.76	0.76	4.59

3) Tests for Sample 3 (Sea water and Distilled water)

Table 7: For sea water

Conducted Tests	Initial Value	Final Value
pH	7	7.6
TDS(Total Dissolved Solids)	491 mg/l	489 mg/l
Hardness by EDTA	52 mg/l	3 mg/l
Alkalinity by Phenolphthalein	0 mg/l	0 mg/l
Alkalinity by Methyl Orange	10 mg/l	80 mg/l

Table 8 : For Distilled water

Conducted Tests	Initial Value	Final Value
pH	7	7.2
TDS(Total Dissolved Solids)	73 mg/l	291 mg/l
Hardness by EDTA	0 mg/l	25 mg/l
Alkalinity by Phenolphthalein	65 mg/l	130 mg/l
Alkalinity by Methyl Orange	30 mg/l	80 mg/l

Table 9: Power generation

Retention time (DAYS)	Sea water & Distilled water		
	Voltage (mV)	Current (mA)	Power Density (mW/m2)
DAY 01	0.25	0.25	6.25
DAY 03	0.20	0.20	4.00
DAY 06	0.17	0.17	2.89
DAY 09	0.14	0.14	1.96
DAY 12	0.13	0.13	1.69

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IV. CONCLUSION

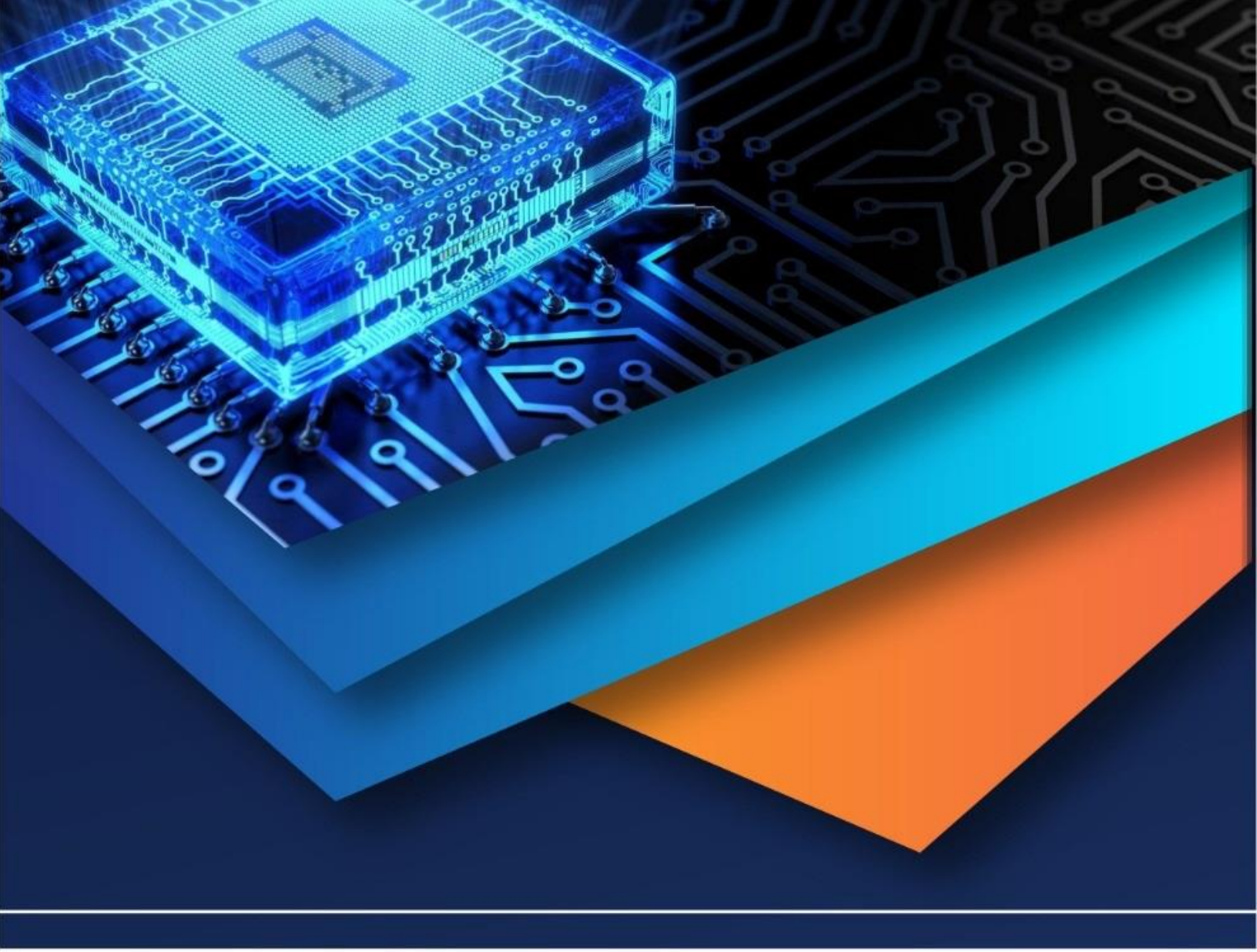
The present study has been made to examine the overall performance of a Dual chamber MFC with low price electrodes for the treatment of water samples . The water samples characteristics taken into consideration for the evaluation of overall performance of the MFC are pH, alkalinity ,EDTA and TDS that are the primary parameters commonly used for the overall performance of the treated water. The experiments have been carried out the use of the twin chamber MFC and for every new release the duration of experimentation is round 12 days . During the experimentation the water sampling and parameter estimation for characterization of water turned fresh water.

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The observations made for the duration of the experimentation have been supplied . Using the observations, the water samples pH, alkalinity, EDTA and TDS elimination performance indicating the water remedy with the aid of using MFC study period has been determined . Using the observations the energy parameters such are Current, Power, Voltage, Internal resistance, Power density producing from each the MFC`s have been decided for the duration of the examine duration. The overall performance of MFC for water samples is also studied to evaluate the elimination performance of the pH , EDTA , TDS and alkalinity of the dealt with effluents trails

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