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DIRECT CURRENT PRODUCTION THROUGH INDUSTRIAL WASTE WATER BY MICROBIAL FUEL CELL TECHNIQUE

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Abstract

Microbial fuel cells (MFCs) operate by harnessing the ability of microscopic organisms to oxidize and break down organic matter. One of the key redox processes involved is bacterial gas exchange, during which electrons are continuously transferred from one location to another. Wherever this electron movement occurs, there is potential to capture electromotive force and convert it into usable electrical energy. Anaerobic microorganisms—those that thrive in oxygen-free environments—are particularly effective at generating electrons by metabolizing organic compounds such as glucose or sucrose. These electrons can be directed toward an electrode (terminal) to produce an electric current. Various wastewater sources naturally contain anaerobic bacteria. In our setup, we utilized sewage wastewater, pond sludge, and industrial effluents to generate electricity. The wastewater served as the anode half-cell, while tap water was used in the cathode half-cell. A salt bridge, prepared by solidifying a saturated solution of potassium chloride (KCl) in agar, was used to connect the two chambers and facilitate ion exchange.

Keywords: MFC, Redox reactions, Facultative anaerobes, remediation, electric current.

Introduction

Anaerobic prokaryotic microorganisms which have neither a definite nucleus with a membrane nor alternative specialized organelles, and optimum survive without oxygen. (Claret et al., 2022). These anaerobic prokaryotes have ability to provide electron by degrading organic molecules. (Obileke, 2021). Microbial fuel cells (MFCs) are bio-chemical reactors that convert carbohydrates with-in the obligations of natural issues into power through bio-catalysis of microorganisms. (*Drendel et al.,* 2018). This is regularly a bio-electrochemical cell that infers current by utilizing bacterium. (Zheng *et al.,* 2020) An MFC is a combination of electrodes that changes bio-chemical energy into electro-chemical energy by the activity of micro-organisms. (Champavert et al., 2017). Cells are made from a bio-anode and a bio-cathode. In MFC both compartments are separate from each other by a thin membrane. (Angioni et al., 2017). These compartments are anode (where loss of electron happens) and in this way the cathode (where gain of electron happens) with the moving electron there should be some electromotive force to move the electron (Mohan et al., 2014). The anode and cathode were connected by using salt bridge. KCl were used as a salt in salt bridge. (Mirza et al., 2022). The electron transition is riveted to the cathode. (*Ucar et al.,* 2017).

Typical conductor reactions are shown below glucose as example substrate: (*Kalathil* et al., 2018)

Anode:

$CH_3COOH + 2H_2O > 2CO_2 + 8e^- + 8H^+$

Cathode:

$2O_2 + 8e + 8H^+ > 4H_2O$

Overall:

$CH_3COOH + 2O_2 > 2CO_2 + 2H_2O$ + Biomass + Electricity

Electricity-producing bacteria and their electron transfer mechanisms

Power-creating microorganisms networks hypothetically, most anaerobes (or facultative anaerobes) can possibly be the quickening agent in MFC if last electron acceptors like O, NO_2 and SO_4 are missing inside (*Kracke et al.,* 2015). As of late, there has been an ascent inside the assortment of reports of electrochemically dynamic microorganisms. Nonetheless, the scope of bacterium fit for power creating action is essentially embarking to be found. Components of electron exchange electrochemically dynamic bacterium at this point surely understood to exchange electrons from the inside of the cell to associate operating conductor by means of 2 entirely half cells (Boas et al., 2022).

There are two different mechanisms by which microbes generate electron.

Mediate electron transfer (MET)

Mediate electron transfer was discuss extensively because this method of electron transfer was much better then direct electron transfer. MET has high membrane permeability. Mediators having less NO_2, SO_4, O, think to be more effective for MFC and with high redox reactors have good ability to release electron. (Ouyang et al., 2020).

Direct electron transfer (DET)

Certain micro-organisms appear to also have the adaptability to move electrons from the inside of the micro-organism cell to the surroundings. This was performing by different of enzymes. Since the outside layers microbial specie don't conduct electrons, a gathering of film contain proteins are required for motion of electron in DET, (*Immanuel et al.,* 2019)

Materials and methods

The MFC was created containing 2 chambers (Figure 1). One chamber each for anode and cathode. Three different waste waters were used as anode and tap water as cathode. These 2 separate chambers were connected by salt bridge. It was completed by introducing pure copper wires in each chamber.

The MFC reactor was designed on salt glass. It consisted of 2 chambers (1 liter capacity in unit each) for the anode and cathode compartment that were separated by a salt-bridge. The cathode chamber of MFC was full of H_2O as a catalyze. The positive chamber was full of the waste product samples. The negative and positive sites that were used and composed of wastes. The cathode and anode are connected externally by wires to complete the circuit. Each side of the anode chamber and cathode chamber are capped tightly to provide anaerobic condition and unwanted material throughout the complete MFC method (as long as ninety six hours). A processed electronic voltmeter and check the open potential difference made by the electrical flow within the MFC throughout the method. The pH worth of the waste product is discovered to spot appropriate pH conditions for microorganism growth throughout MFC operation. The MFC cell was made by testing on 3 forms of waste product samples: sewerage water: industrial waste: pond sludge. the essential steps for all 3 sorts is same.

Two MFC chambers were made at small scale about (1 liter).

1 liter of different waste water was collected at anode chambered 1litre of tap water was collected in another jar which act as cathode chamber.

Two electrodes like copper and zinc are used as cathode and anode. Copper used in cathode and zinc were used in anode. Pure copper wires were connected to these two electrodes to the flow of electron.

Then these two chambers were connected by salt-bridge. Salt-bridge were made by making a saturated solution of salt like potassium chloride (KCl) in 2% a solidifying agent like agar in distal-water then boil it and pour it "U" shape tube and allow it to solidify.

A Uni-T multi-meter was used to checked the potential difference.

Figure 1: Complete cell of MFC

Results and discussion

Three different waste water materials were used as anode to make MFC.

Sewerage-water

The open-circuit voltage recorded before adding organic solution is only 300mV. the graph's pattern shows, that voltage generation was shoots up to 920mV and starts to stabilize in 1 hour after the addition of sugar solution, which means that the electron production starts by the metabolism of organic solution Thus, the potential difference increases with times because micro-organisms metabolize organic solution and finally produced 1015mV. This potential difference remain stable for up to 3days. With the time electric voltage decreases because nutrition will decreases and production of electron will decreases. As shown in figures 2-4.

The (Elhenawy *et al.,* 2022) check the effect of current generation in leachate. They notice that the current production was 2mV in activated sludge. The current was stabilize in 10 hours. They check the effect of nefion tube at cathode side which increases the potential difference with in 96th hours of operation of mfc. The highest potential difference was 455mV.

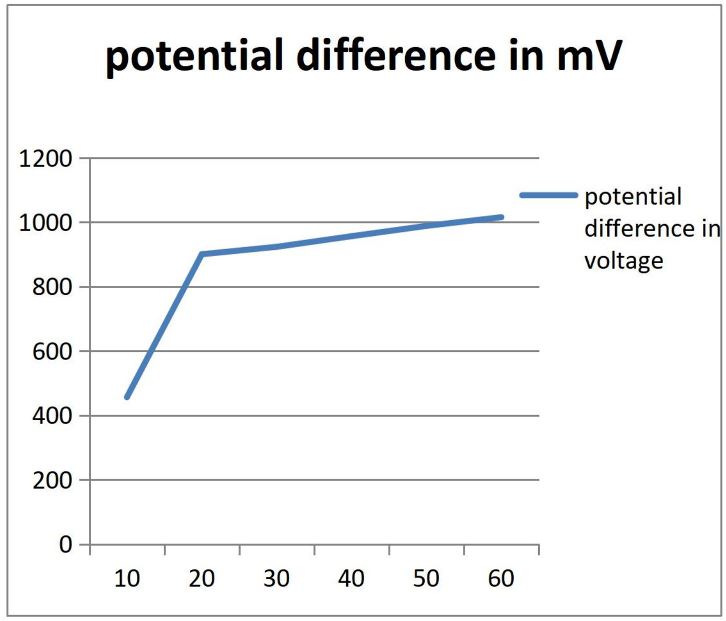

Figure 2: Microbes produce potential difference up to 1015 mV (with the increasing of time potential difference increases).

Pond sludge:

The open-circuit voltage recorded before adding organic solution is only 250mV. The pattern of the graph shows the potential difference production was shoots up to 840mV and starts to stabilize in 1 hour after the addition of sugar solution, which means that the electron production starts by the metabolism of organic solution Thus, the times of potential difference produced becomes higher because microorganisms metabolize organic solution and finally produced 912mV. This potential difference remain stable for up to 3days.With the time electric voltage decreases because nutrition will decreases and production of electron will decreases. The (Elhenawy *et al.,*2022) check the effect of current generation in activated sludge. They notice that the current production was 79mV in activated sludge. The current was stabilize in 10 hours. They check the effect of cathode which increases the potential difference with in 96th hours of operation of mfc. The highest potential difference was 396mV.

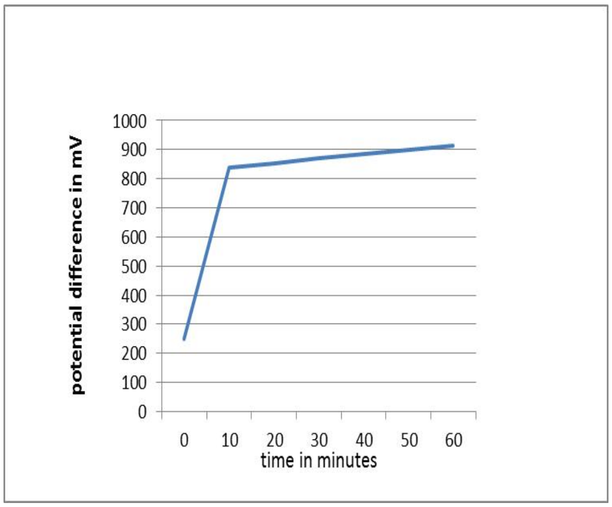

Figure 3: Microbes produce potential difference up to 912 mV (with the increasing of time potential difference increases).

Industrial waste

The open-circuit voltage recorded before adding organic solution is only 200 mV. The pattern of the graph shows the potential difference production was shoots up to 866mV and starts to stabilize in 1 hour after the addition of sugar solution, which means that the electron production stars by the metabolism of organic solution Thus, the time of electrical potential difference produced becomes higher because microorganisms metabolize organic solution and finally produce. This potential difference remains stable for up to 3 days.

The (Elhenawy *et al.,* 2022) check the effect of current generation in palm oil mill effluent. They notice that the current production was 44mV in palm oil mill effluent. The current was stabilize in 10 hours. They check the effect of nefion tube at cathode side which increases the potential difference with in 96th hours of operation of mfc. The highest voltage was 53 mV.

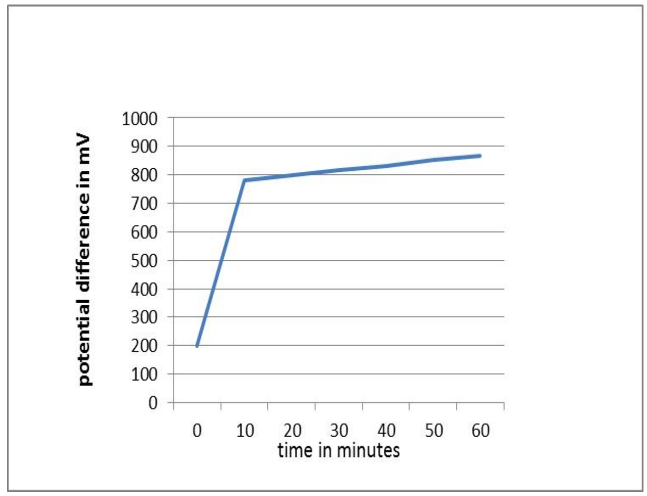

Figure 4: Microbes produce potential difference up to 866 mV (with the increasing of time potential difference increases).

Conclusion

MFCs are new sorts of bioreactors that utilization exo-electrogenic biofilms for electrochemical vitality generation. In current years, a monstrous amount of studies have been done to find microbial gas cells in numerous perspectives, for example, electron move systems, bettering vitality yields, reactor inclinations and applications. In spite of the fact that MFCs are a promising mechanical ability for inexhaustible quality generation, they face many difficulties, too. For example, they have low phases of intensity thickness, scale-up practicality, high benefit of thing materials, and monstrous inside obstruction.In the creator's assessment, combos of MFCs or MECs with various high charges with the guide of items producing methodologies have a splendid future in manageable quality research.An MFC can create power from the wastewater.While at the same time pushing off carbon and nitrogen. The most flawlessly awesome cost of voltage innovation is done when the MFC is worked sewerage water (1015 mV) trailed by method for lake slime (912 mV) and mechanical waste.

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