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A Review of Microbial Fuel Reactor Design and Configurations for Future Energy Generation

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ABSTRACT

The energy demand in our planet is growing endlessly and this situation make the worldwide energy generation growing bigger as well as the ecological pollution from fossil fuel burned. The energy generated from fossil fuels like oil and gas are an unsustainable fuel and the by product from this operation will harm our environment. The major contributor in generating electricity are from coal, oil and gas which are the culprit of global air pollution and global warming. The new type of energy proposed to replace the conventional fuel must be eco-friendly and sustainable. One of the most promising is Microbial Fuel Reactor (MFR). MFR is produced from multiple combination of Microbial Fuel Cell (MFC). This MFR is an alternative and green energy generation that harvesting the energy from respiring microbes to change organic substrates into electrical energy. MFR is a fuel cell that will convert chemical energy to electrical energy by using oxidation reduction reaction (redox). Microbes will oxidize to produce electrons and the electron will flow to terminal electron acceptor to produce an energy. This paper intended to review on MFC reactor design which every reactor design and configuration is different in term of energy produced and its efficiency.

1. Introduction

The demand of energy around the world has been damaging our environment and the majority of the energy producing are using fossil source. These sources will be depleting in a fast rate due to energy demand are high. There is a quest for producing energy using sustainable sources. The critical part in producing the power device is to lessen the expense and producing an energy that are green and non-polluted type. Microbial fuel cell (MFC) convert chemical energy into electrical energy using the aid of microorganisms as biocatalysts [1]. The MFC offer a clean renewable and potentially autonomous energy and at the same time treating wastewater [14]. The MFC is a promising technology for production of sustainable energy due to their capability of simultaneously producing electricity and achieving wastewater treatment [6]. Although MFC generate low amount of energy

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than the hydrogen fuel cell, a combination of electricity production and wastewater treatment reduce the cost of treating primary effluent wastewater [15]. As of late, the specialist are discovering and producing many experiment to discover the energy from biotechnology. One of the promising sustainable energy is Microbial Fuel Cell (MFC). The organic material contains wastewater can produce electricity in MFC. There are various model of MFC which is every model the output of power are different. The researcher often propose a new model to make the electricity produce more efficient.

2. Microbial Fuel Cell Type

2.1 Single Chamber Microbial Fuel Cell

A single chambered MFC has many design available and different ways to make it. Basic single chamber MFC is that anode and cathode will be put in the same compartment that shown in figure 1. This basic design does not have a proton exchange membrane and they are straightforward compartment which is does not have a proper cathode chamber that using oxygen from air and let the proton diffuse through them. There are several research in making the single chamber more efficient which is application of a diffusion layer, consisting of mixture of PTFE and carbon, can be used to increase the performance of a single chamber MFC [3]. Electricity was produce in a SCMFC and it was found that large percentage of organic matter of the wastewater was removed by the process that did not produce electricity [10].

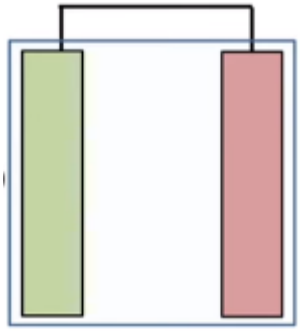

Fig. 1. Basic single chamber MFC consist of anode and cathode

2.2 Double Chamber Microbial Fuel Cell

There are many design of double chamber MFC. The famous one is H-type which consists of two compartments with anode in one compartment and cathode in the other compartment. Between these two compartments will be connected with salt bridge and anode cathode will be connected with wire to complete the circuit. The measure of power that is created in these frameworks is influenced by the surface range of the cathode with respect to that of the anode and the surface of the membrane [8]. The power output develop by this design is low because of the complex design, high internal resistance and electrode based loss [13].

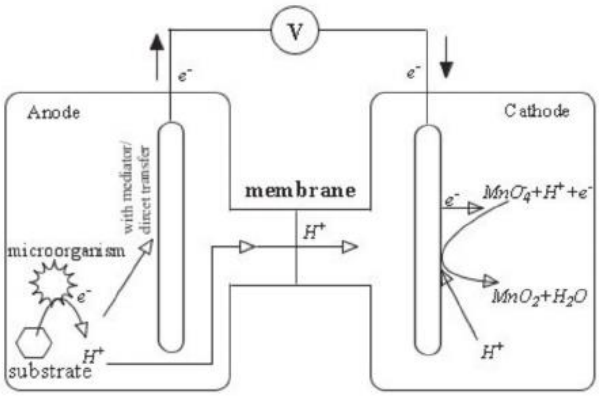

Fig. 2. double chambered MFC

2.3 Up-flow Microbial Fuel Cell

Up-flow microbial fuel cell is one of the design that can generate electricity while simultaneously treating wastewater. The design of this type MFC is in cylinder shape which the anode at the bottom and cathode at the top and this electrode is separated by a proton exchange membrane as shown in figure 3 . The water will be flow from the bottom and pass upward to the cathode and exit at the top of reactor [4]. The main advantages of this reactor is the wastewater treatment by this reactor is high but the electricity produce are low [7].

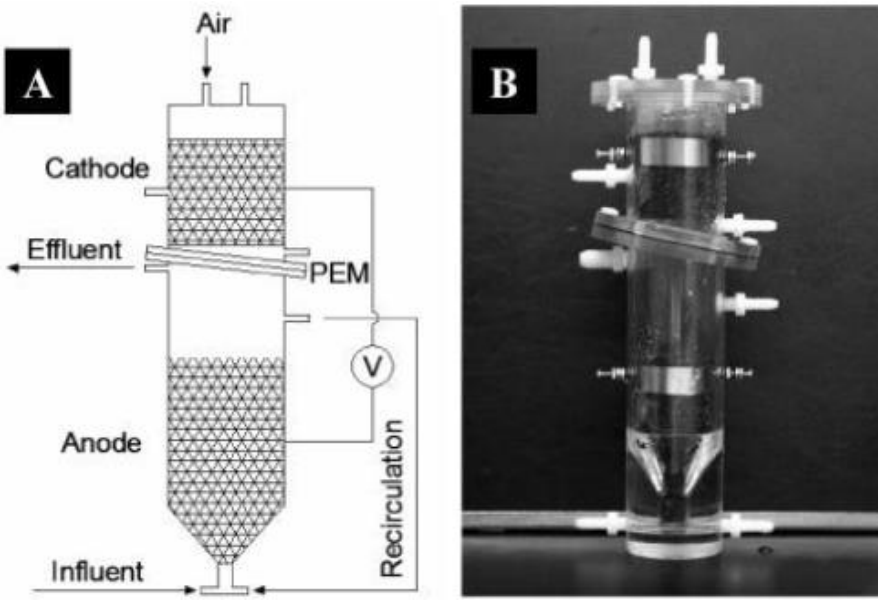

Fig. 3. schematic (A) and picture of lab-scale UMFC (B)

2.4 Stacked Microbial Fuel Cell

The stacked MFC are one of the development of model after the researcher research the MFC. Stacked MFC is a single chamber that stacked together with many single chamber. There are many design of stacked MFC. This sort of development don't influence the cell's coulumbic proficiency but in together it expands the yield of by to be similar to ordinary force as appeared in figure 4 [8]. The stacked MFC are often connected in series so the voltage is high. It has been reported that when more than one individual MFC is connected in stack or multi-electrode, the voltage and current increase, depending on the connection mode (series or parallel) [5]. It has been said that series-parallel connection in stacked MFC was proved to be better among other configurations in terms of electricity generation and stable power output (Aranganathan, 2018). The continuous mode and the prevent of the energy losses during the series mode need to be researched. The stacked MFC provided high power density at enhanced current and voltage and during the connection of stacked in series, large difference of individual single chamber voltage could be noted when current increased.

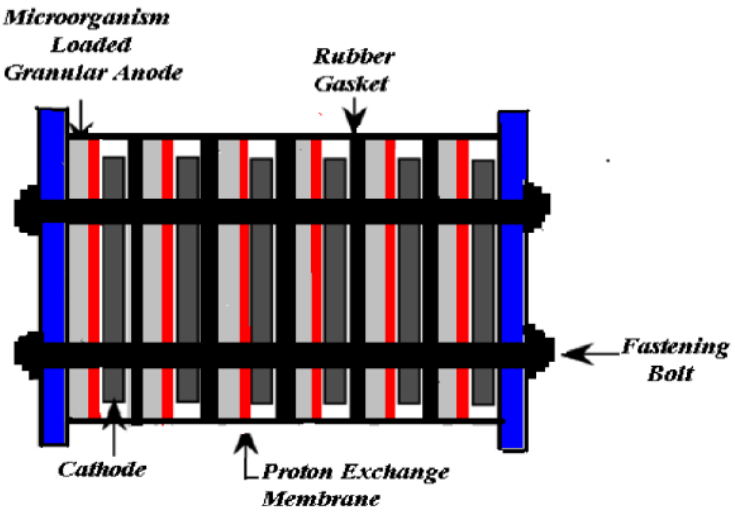

Fig. 4. A stacked MFC

2.5 Cassette-electrode Microbial Fuel Cell (CEMFC)

CEMFC is another design that can enhance the power density production of MFC. It is a highly scalable design which consisting of many cassette electrode (CE) that has been put together in a compartment. A single cathode electrode consist of two air cathode in both sides sandwich together with proton exchange membrane and two anode as shown in figure 5. This design of cassette electrode allows the design of the modular of MFC reactor to be flexible in term of shape, size and number of units [12]. Slalom- flow cassette electrode MFC is one of the CEMFC design that manipulating the CE board to create a flow of water to all the CE's as shown in figure 6. This new type of MFC could successfully treat a wastewater with a high removal efficiency rate [11]. The electric output and organic treatment efficiency of CEMFC are high and the microbial communities established in CEMFC exhibited the unique community structure [9].

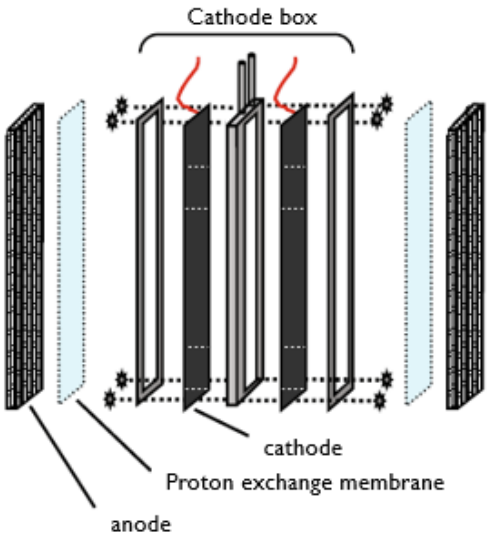

Fig. 5. A single cathode electrode of a CEMFC

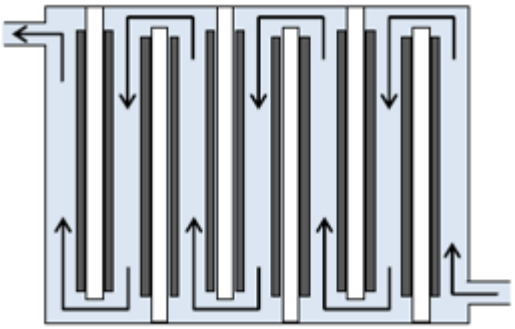

Fig. 6. Water flow of the Slalom flow CEMFC

3. Conclusion

From all the presented MFC designs, the CEMFC the most promising reactor design in terms of highly scalable and modular design. This offer higher MFC capacity and flexibility. The compact design when comparing to chambered or stacked type, that will enhance the suitability in micro-spacing so it can compromise bigger generation capacity with smaller spaces.

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