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MICROBIAL ELECTRIC ENERGY HARVESTING FROM THE LIVING PLANT MICROBIAL FUEL CELL (P-MFC)

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Abstract

Living Plant Microbial Fuel Cell (P-MFC) is the kind of bio volt-photo galvanic cell which converts solar energy into green electricity. The plant synthesized Rhizo-deposit, mostly in the form of carbohydrate, at the sphere of the root through the photo-synthesis process. The microbes of the Rhizo sphere decompose the Rhizo-deposit and converts into electric energy via the Microbial Fuel Cell. The carbon blocks were used as the electrode of the microbial fuel cell. Hsin ngou Grass (*Eleusine indica*) was used to examine the performance of the plant microbial fuel cell and achieved the maximum electric power is 13.86mWm^{-2}, open circuit voltage is 0.35V and short circuit current density is 162.5mAm^{-2} as prepared cell. The open circuit voltage is fluctuated with the life time of the microbial fuel cell and the maximum open circuit voltage, 0.8V was observed at the 10th day of the fabrication of the microbial fuel cell.

Keywords: Plant Microbial Fuel Cell (P-MFC), Rhizo-deposit, microbes, Hsin ngou Grass (*Eleusine indica*), Electric energy

Introduction

The standard of society status depends on the degree of the availability of energy. The level of energy consumption by the humans on the earth in 2006 was approximately 15.8 terawatts (TW). The 84% of consumption energy is derived from fossil-fuel sources, 6.5% is from nuclear power plants, 7% is from hydroelectric and 2.5% is from wind energy [Cunningham William.P, et al]. The nuclear energy is roughly equal to hydroelectricity but we can not rely on it due to its risky situation and then the fossil fuels become primary energy source. Since fossil fuel sources become rapidly depleted and enhance the depletion of ozone layer and global warming, more and more alternative energy sources are required to be searched and our society faces the challenges of the energy crisis. One of the clean renewable energy sources is the solar energy.

Living Plant Microbial Fuel Cell (P-MFC) is the kind of Microbial Solar Cell which is a type of solar cells used for the light/electricity conversion with living phototrophic microbes serving as catalysts for the conversion of solar energy to electric energy [Logan.BE, et al]. In the (P-MFC) , photosynthetic microbes, such as microalgae and cyanobacteria, use the light energy to liberate high energy-level electrons from the water molecules and these electrons are transferred through photosynthetic electron-transport chains and finally used to fix carbon dioxides and synthesize organic molecules.

The aim of the P-MFC is to transform solar energy into electrical energy through oxidation of rhizo deposits by electrochemically active bacteria. Photosynthesis in plants occurs in its leaves whereby the solar energy is used to fix carbon dioxide in the form of carbohydrates. Depending on plant species, age, and environmental conditions up to 60% of the net fixed carbon can be transferred from its leaves to the roots. The plant root system produces and releases

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different types of organic compounds into the soil, which includes exudates of sugars, organic acids, polymeric carbohydrates, enzymes, lysates of dead cell materials, and gases like ethylene and CO_2. Summation of these released products by plants is termed as plant rhizo deposits and these process is called as rhizo deposition [Gust.D, et al].

The biochemical reactions taking place in P-MFC are as mentioned below in equation 1 and 2 and the schematic representation of plant microbial fuel cell comprising of plants is as depicted in (Figure 1).

Anode Reaction: $C_6H_{12}O_6 + 6H_2O \rightarrow 6CO_2 + 24H^+ + 24e^-$ --------1

Cathode Reaction: $6O_2 + 24H^+ + 24e^- \rightarrow 12H_2O$ ------- 2

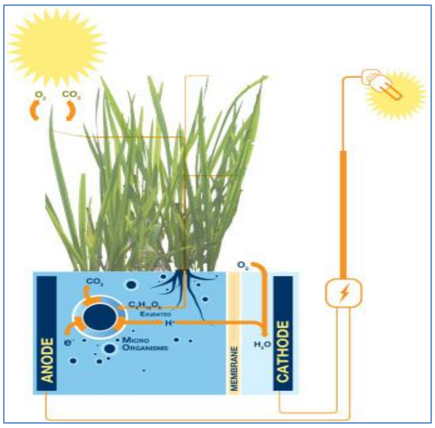

Figure 1 Schematic representation of P-MFC in power generation [Gowtham.R, et al].

Materials and Method

Materials

Agar, NaCl, Salt Bridge Substrate, Plastic Box, Carbon electrodes, Water, conducting wires, Digital multi meter and Hsin ngou Grass (*Eleusine indica*) with the soil as the biological specimen (Figure 2) are the constituents of the living plant Microbial Fuel Cell (P-MFC).

Figure 2 Hsin ngou Grass (*Eleusine indica*) with the soil as the biological specimen.

Double Chambered P-MFC

The Plastic box of size, 15cm × 10cm× 5cm, was portioned to be two chambers, (10cm×10cm) and (5cm×10cm) by the Agar salt bridge. The large chamber is the Anode Chamber .The carbon electrodes ($2.5\times10^{-3}m^2$) were fixed to the each side of the salt bridge of the two chambers. Conducting wire was fixed on the carbon electrodes. In the anode compartment, the plants having fibrous roots, Hsin ngou Grass (*Eleusine indica*), with the cultured soil of plant and some drainage water was added.

Cathode compartment was containing only water and carbon electrode. Both the compartments were connected to the external circuit having external variable resistance (10KΩ) with the help of conducting wire. The current-voltage readings were taken with the help of digital multi meter (Figure 3).

Figure 3 Experimental Setup of the double chambered P-MFC.

Salt Bridge

The simple low-cost salt bridge, (Figure 4), was prepared to be served as the proton exchange membrane by the 300ml gelatin agar powder, 75g table salt, 200ml water to make agar solution. Then, it was boiled and solidified in salt bridge substrate [Gude.V].

Figure 4 Agar gelatin Salt Bridge for the proton exchange membrane.

Results and Discussion

The double chambered living plant microbial fuel cell (P-MFC) was set up as in the Figure-3 and the investigation of the current-voltage characterization was conducted using a digital multi-meter for a period of 10days.

The results are as depicted in the (Figure - 5 and 6) of the electrical characterization of double chambered living plant microbial fuel cells. Living Plant microbial fuel cell(P-MFC) was achieved the maximum electric power is 13.86mWm^{-2}, open circuit voltage is 0.35V and short circuit current density is 162.5mAm^{-2} for the as prepared cell. The open circuit voltage is fluctuated with the life time of the microbial fuel cell and the maximum open circuit voltage, 0.8V was observed at the 10th day of the fabrication of the microbial fuel cell.

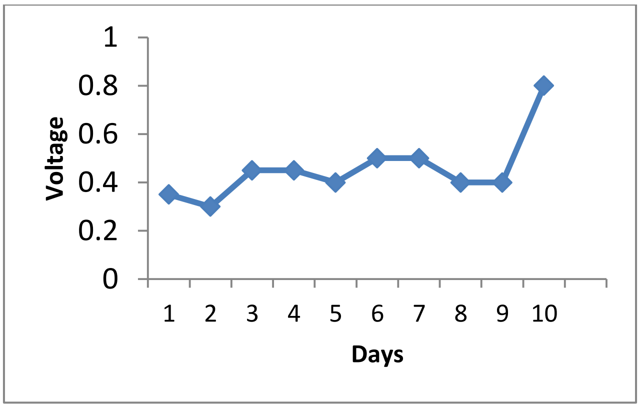

Figure 5 Voltage Fluctuation of double chambered P-MFC for the 10 days.

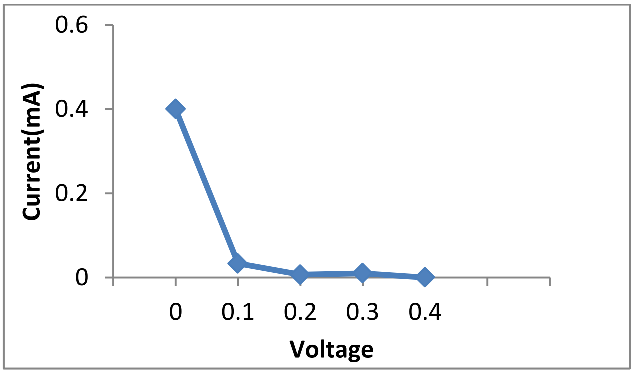

Figure 6 Current-Voltage characteristic of the as prepared double chambered P-MFC.

Conclusion

Soil microbes in the rhizo-deposits of the Hsin ngou Grass (Eleusine indica) are able to convert the solar energy into electricity through the Photosynthesis process. Although the voltage output of the living plant microbial fuel cell (P-MFC) was fluctuated with the days of life time, the maximum open circuit voltage of 0.8V was attained on the 10th day by using Hsin ngou Grass (Eleusine indica) P-MFC. Further optimizations in terms of area of the electrode, salt bridge composition, etc are needed to increase the efficiency of P-MFC.

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