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Investigation on Performance of Grass, Orange and Potato as Substrate of Microbial Fuel Cell

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ABSTRACT
The dependence on fossil fuels is unsustainable because of its finite, depleting supplies and impact on environment. It is crying to find not only alternative energy source[1]but also environment friendly energy source. The development of Microbial Fuel Cell (MFCs) is important to the advancement of alternative fuels. Microbial Fuel Cells (MFCs) are an emerging technology that uses bacteria to generate electricity from organic waste. The objective of this study was to observe different substrate which varies in major chemical content and compare the extracted energy to choose the best to extract energy as electricity. In this case, we used carbon felt as anode and copper wire as cathode,0.1M NaCl solution as catholyte and sedimentary mud with a mixture of compost used microbe source in a double chambered mediator less type MFC. Studied substrates are grass, rotten orange and potato. We obtained maximum 368mV, 517mV and 454mV in a run of 15 days respectively from grass, orange and potato. The power density we got respectively 43.5mW/m^2, 102.9mW/m^2 and 73.7mW/m^2.

Keywords: Microbial Fuel Cell, Substrate, Catholyte, Power density

1. Introduction

Dependence on fossil fuel is leading us to the era of energy crisis. Combustion of fossil fuel also has negative impact on environment due to carbon-di-oxide emission [1]. To cope with this situation of energy scarcity and environment pollution finding of some alternative renewable energy sources is a first and foremost task to do. As an upshot of this finding is fuel cell (FC) which generates energy using high value metal catalysts according to general version [2]. Microbial fuel cell (MFC) is a type of FC.Microbial fuel cells (MFCs) employ microbes to generate electricity from organic substrates. MFC consistsof anode and cathode which are by an external circuitand separated by proton exchange membrane (PEM). Inanode chamber, organic substrates decomposed bymicrobes by which electrons (e-) and protons (H+) are generated. Electrons and protons transferred to cathode through circuit and membrane respectively [3].The reactions occur are given below [4].

Anodic Oxidation reaction:
$n(CH_2O) + nH_2O \rightarrow nCO_2 + 4ne^- + 4nH^+$
Cathodic Reduction reaction:
$4e^- + 4H^+ + O_2 \rightarrow 2H_2O$

This technology initiated by Potter in 1911 [5]. Now it has turned into a great matter of interest for the researchers. Substrate is an important component for any biological process as itserves as carbon (nutrient) and energy source. The efficiency andeconomic viability of converting substrate to bioenergy depend on the characteristics and components of the substrate. The chemical composition and concentrations of thesubstratecan be converted into products as fuels [6].For this reason, in this research we have observed weeded out grass from field, rotten orange from fruit market and rotten potato from vegetable market as substrate of MFC. All of these are organic type of waste.
MFCs can be described byelectrochemical parameters such as current density, power density and cell voltage in continuous systems [7]. We studied the substrates under same conditions and compared the electrochemical parameters to gather information on performance of these organic wastes to evaluate suitability as substrate of MFC.

2. Application

The application of MFC technology still limited due to a bunch of limitations. MFCs can be turned into biosensors, because microbial activity on the electrode, depending on environmental parameters, produces an electrical signal [8]. A new form of MFC is microbial electrolysis cell(MEC) by which assisting the potential generated by the bacteria at the anode with a small potential by an external power source (>0.25 V), it is possible to generate hydrogen at the cathode. In typical electrolysis more than 1.5 volt is needed [9,3]. The microbial desalination cell (MDC) is a newly developed technology which integrates the microbial fuel cell (MFC) mechanism and electro dialysis for wastewater treatment, water desalination and production of renewable energy [10]. In this way application of MFC technology is entering in practical application sector.

3. Materials and Method

There are varieties of design for MFC.For this experiment we choose dual chamber mediator less MFC.

3.1 Experimental setup
For the construction of dual chamber mediator less MFCplastic jars of 200ml are used as anode and cathode chamber. Salt bridge used as proton exchange membrane(PEM). Cotton fabric soaked in 0.5M NaCl

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solution and inserted into a 5cm PVA pipe having diameter 1.5 cm. Then the salt bridge inserted into drilled holes of plastic jars and attached with general purpose epoxy compound. Collected substrate samples from field and local market are cut into small pieces and then blended in blender. Sedimentary mud as microbe source collected from pond and screened after mixing with. Adding 0.5g sugar per liter mud to feed the microbes the mud kept covered for a day long. Carbon felt of dimension 6cm x 1.5cm x 1cm used as anode.

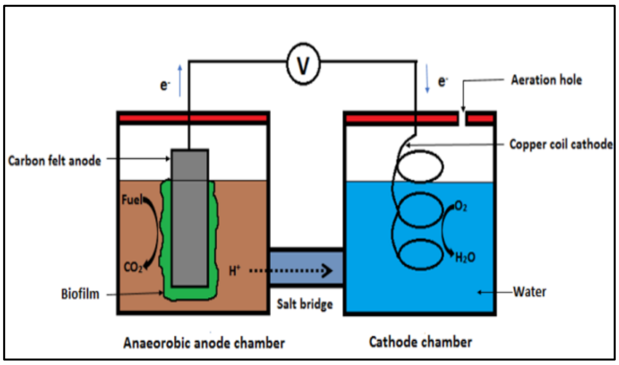

Fig.1: Experimental setup for dual chambered mediarorless MFC

Copper wire coiled of length 30 cm and diameter 0.075cm used as cathode.Maintaining 30% substrate concentration and 150 ml mixture of mud and substrate poured in anaerobic anode chamber after adjusting pH 7. As cathotyte 0.1M NaCl solution poured in cathode chamber. Lids attached with electrodes place on to the jars. Then the MFCs rested for a day long to initiate the reactions.

3.2 Electrochemical monitoring

Output voltage, current density and power density were adopted to analyze experiment.All measurements have taken at room temperature and ambient pressure.

Output voltage(V)measured with a digital multimeter of model DT-9205A. The voltage obtained by multimeter through an external resistor, without external resistor and internal resistance are respectively V, E and R. We've used external resistance of 100kΩ. Internal resistance calculated by equation (1). Current density(I) calculated by equation (2) and (3).

$$E/V = R_{ext}/(R+R_{ext}) \qquad (1)$$

Where, R_{ext} = external resistance.

$$i = E/R \qquad (2)$$

$$I = i/A \qquad (3)$$

Where, i = current, R = internal resistance and A = surface area of anode.

Power density (P) calculated by equation (3).

$$P = EI \qquad (4)$$

Thus all electrochemical parameters are measured and calculated [2,3,11].

4. Result and Discussion

The observation of 15 days summarized in Fig.2,3 and 4.

The internal resistance of MCFs with substrate orange potato and grass are respectively 787Ω, 848 Ω and 943Ω.The maximum voltage obtained from the MFCs is respectively 517mV, 454mV and 368mV. The change in output voltage has gone through many ups and downs with time due to change in room temperature [12]. The maximum current density obtained respectively 199mA/m^2, 162mA/m^2 and 118mA/m^2. The maximum power density obtained respectively 102.9mW/m^2, 73.7mW/m^2 and 43.5mW/m^2. Comparatively orange performed better than potato and grass. Potato performed quite well too. Comparing with other researches overall these three substrates are quite potential.

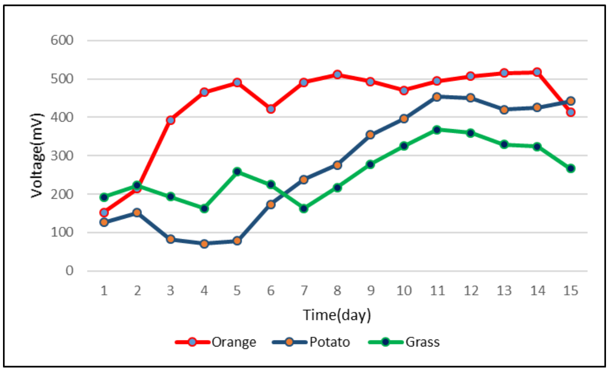

Fig.2: Voltage as function of time

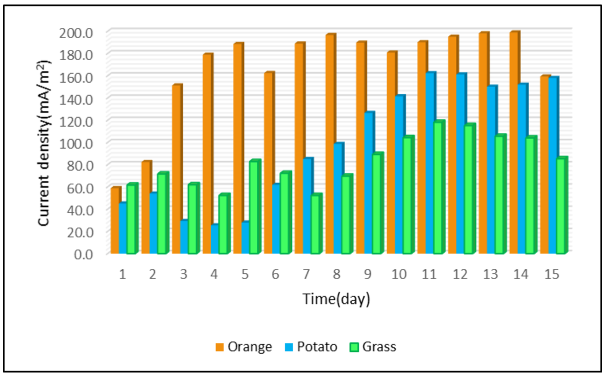

Fig.3: Current density as function of time

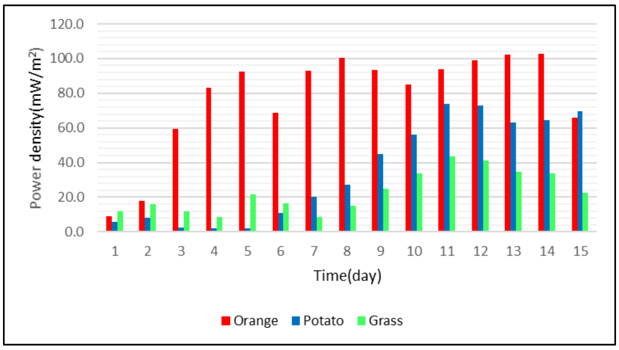

Fig. 4: Power density as a function of time

Liu et el. (2016) reported that with an effective volume 1260ml, carbon cloth cathode covered with Pt/C catalyst. carbon rod anode got maximum 14.7mW/m^2 from a single cell with 3000 Ω internal resistance [11]. But in comparison we jumped ahead with MFCs of 150ml effective volume.Researches using pure glucose as substrate and carbon paper anode obtained maximum power density 40.3±3.9mW/m^2[13,14]. Our substrates performed far better. Qian et el. (2009) using carbon felt as cathode obtained maximum power density 77mW/m^2, maximum current density 0.006 mA/m^{2}and maximum voltage 575mV [15]. Comparing with this our MFCs has given better power density and current density with carbon felt anode.

5. Limitation

At present because of prohibitive costs, MFC technology is economically competitive [16]. There is a lot lack of information about structure & catalytic activity of microbial communitiesΩ. This limits the understanding the behavior of MFC too.MFC produces a very low voltage output. In a study the maximum achieved voltage was 0.62 V. It was significantly less than the maximum theoretical voltage output of 1.1 V, resulting in a voltage output difference of 44% [3].With or without the PEM, the internal resistance still remains as a major a limiting factor [16].

6. Conclusion

To cope with upcoming crisis of energy source and manage the bio wastes MFC technology can be an arm to survive. But to take this technology at that height we have to overcome the drawbacks. Without overcoming these limitations MFC will not be capable to stand like knight to save us from energy crisis. To explore more efficient substrate and overcome the limitations more and more research is needed.

NOMENCLATURE

E : voltage without external load, mV
V : voltage with load, mV
R : internal resistance, Ω
i : current, mA
I :current density, mA/m^2
P : power density, mW/m^2
R_{ex} : external load, Ω
A : surface area of anode, m

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