EFFECTS OF ELECTRODE TYPES AND GLUCOSE INJECTION ON BIOELECTRICITY PRODUCTION USING MUD AS AN ANODE IN A SINGLE CHAMBERED MICROBIAL FUEL CELL

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Abstract

Microbial fuel cell (MFC) is used to study for the bioelectricity production from utilization of organic matter in waste water by the anaerobic bacteria. In this work, The simple single chambered microbial fuel cell (SMFC) using the mud under aerated pond as anodic compartment were interested for the bioelectricity production and the above aerated water applied as cathode part. SMFC was operated by using the carbon cloth anode/cathode electrodeswith synthetic waste water to imitate the real environment of waste water treated pond. Glucose with various concentrations (100, 150 and 200 g/l, 10 ml) were injected into the mud (anode compartment) to increase the substrate for microbial utilization and found that the current output was increased (200, 243 and 380 mA/m^2, respectively) comparison with 188 mA/m^2 without glucose addition. This indicated that glucose can activate the bioelectricity activities in this SMFC.

Keywords: microbial fuel cell, electricity, mud, electrode, aerated pond

Introduction

Microbial fuel cells (MFC) are a biochemical-catalyzed system, which generate electricity by oxidizing biodegradable organic matter in the presence of either fermentative bacteria or enzyme [4,7]. The microorganism generally present in anode chamber of fuel cell can produce and transfer electron to cathode through external circuit wire, while protons migrate through a proton exchange membrane (PEM) from anode to cathode[5,9]. Microbial fuel cells technology can provide the high energy amount by choosing a suitable electrode as an acceptor with the highest reduction potential [6]. The characteristics of MFCs are similar to anaerobic reactors working as traditional power sources to give electricity described as power density, electrical current output and cell voltage which change by electrochemical and biological parameters such as the substrate loading rate [3].
The waste water contained the complex mixture of organic substrates and bacteria which is the power source during their anaerobic oxidation for generation of electricity in MFCs, called electrogenesis[4,7]. In anaerobic process, the chemical energy is converted to H_2 and methane, which can be used as a fuel or to produce electricity, but in MFCs chemical energy present in the waste components is directly converted to electricity [5]. Anaerobic bacteria are often found in the sediment or mud of wastewater treatment [1]. Mud is source of natural bacteria and organic substrate which is able to be used in MFC anode part without inoculation and substrate adding [8]. However, the organic substrates as carbon source (such as acetate, glucose or lactate) are able to directly convert chemical energy into electricity

processing [2]. Especially the glucose which is the best for bacterial cultivation due to it is hydrolyzed and give the electron easily [7].

In this work, the natural bacteria in the mud from waste water treated pond were of interest and for production of the bioelectricity for rural area. The simple single chambered microbial fuel cell (SMFC) with carbon cloth anode/cathode electrode was made by using the mud as anodic compartment and the above aerated water applied as cathode part. Effect of glucose concentrations added into the mud for microbial growth and utilization was studied the highest power electricity generated by natural mix anaerobic bacteria of mud in SMFC.

Methodology

The mud in 25 cm depth from aerated treatment pond was used in this work. It normally gave the natural anaerobic bacteria mix consortia useful as anode part to produce the bioelectricity. It was stored and cultured in synthetic waste water (NH_4Cl,0.5 g/l; KH_2PO_4, 0.25 g/l; K_2HPO_4, 0.25 g/l; $MgCl_2$, 0.3 g/l;$CoCl_2$, 25 mg/l; $ZnCl_2$, 11.5 mg/l; $CuCl_2$, 10.5 mg/l; $CaCl_2$,5 mg/l; $MnCl_2$, 15 mg/l; glucose, 3 g/l; pH 5.5; COD, 3.5 g/l) at room temperature to acclimate in an anaerobic condition for two weeks prior to activate the anaerobic mix. The acclimatized mud was added in the bottom of SMFC as an anode compartment and activated the anaerobic mix culture by adding the glucose solution (5% w/v) for 2 days before MFC setting up. The acidophilic pH (5.5) was adjusted to sustain the activity of acidogenic bacteria and to inhibit the activities of the methanogenic bacteria in order to enhance hydrogen production.

The SMFC in this work was shown in Figure 1. It made with a plastic cylinder with a 10 cm diameter and a total volume of 1 litre. Four types of materials; copper sheet, carbon cloth, stainless steel and iron sheet (metal thickness of 0.35 mm, 4 x 4 cm^2) couple were stdied in SMFC to consider the best one with high conductivity and well suited for bacterial growth. Each electrode was welded to the wire using conducting copper loaded epoxy. The weldings were covered with a noncorrosive silicone rubber coating.

The acclimatized mud content ratio of 2:6 was put into the bottom of SMEC to use as the anodic compartment and the sponge (0.5 mm. thickness) was put above the mud to reduce the diffusion of mud into the cathode part. The synthetic waste water was added as a cathode part and pumped with air to be an electron acceptor through the air bubble dispenser control (at 150 vvm) by air pump machine. This SMFC was operated with synthetic waste water and uncontrolled pH at 30^oC in absence of artificial mediator, these conditions were set to imitate as same as the real environment of waste water treated pond.

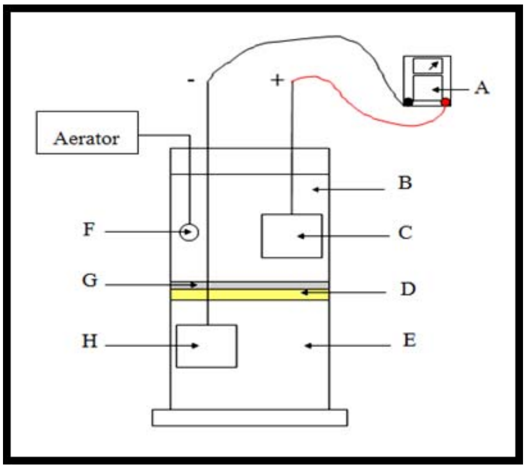

Figure 1 Single chambered microbial fuel cell (SMFC) with mud anode in this work; Multimeter (A), Waste water (B), Cathode electrode (C), Sponge (D), Mud (E), Air Dispenser (F), Gravel (G), Anode electrode (H)

Glucose with various concentrations (5, 10 and 15 g/l, 10 ml) were injected by a needle on syringe into the middle of mud (anode compartment) for microbial utilization. The current output, I (mA), was evaluated by basis equation of V = IR, when voltage, V (mV) was monitored by multimeter at minimum resistance (R, mΩ). Current Density (mA/m^2) was calculated from an equation of I/A; when A was the surface area on two sides of anodic electrode (0.0032 m^2). The power density (mW / m^2) was calculated from IV/Sv; when Sv was mud volume (m^3) in anode compartment, $2\pi r^2$ x height of bottle (=0.00121 m^3).

Results

Influence of various electrode types (made from copper, stainless steel, carbon-cloth,and iron sheet, 16 cm^2) were shown in Figure 2. It was found that the carbon cloth is the best one that could generate the highestcurrent density about 188 mA/$m^2$and power density of 2,400 mW/ m^3).Data for the other material types of electrode are not shown here.

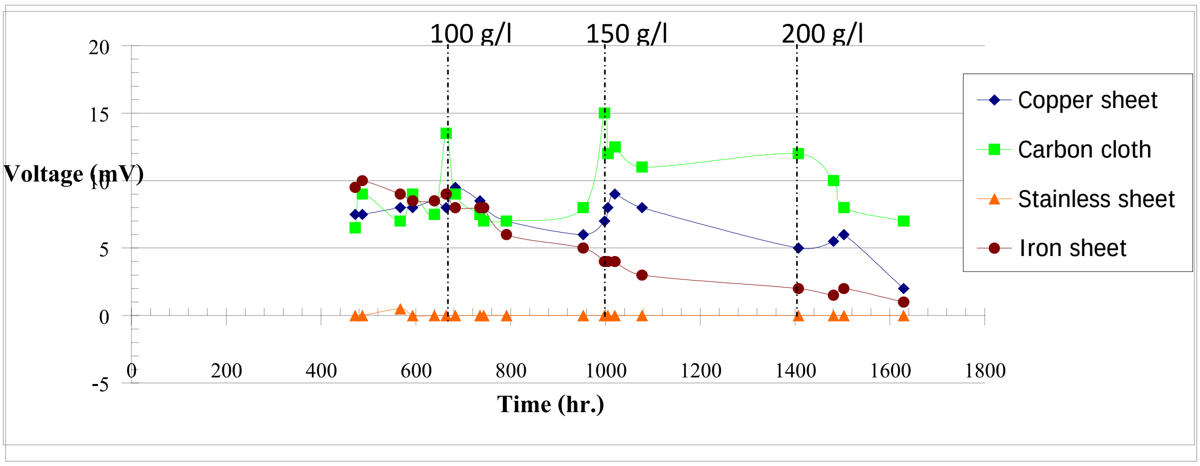

Figure 2 The effect of glucose addition (100, 150 and 200 g/l, 10 ml) on the bioelectricity output (Voltage, mV) of SMFCs with various electrodes at mud. (green line is carbon cloth anode/cathode electrodes)

Effect of glucose concentrations (100, 150 and 200 g/l, 10 ml) injected into mud (anode compartment) of SMEC only with carbon cloth electrodeswere shown in Table 1. the current output were increased (188, 200 and 243 mA/m^{2}or 3,110, 4374, 6998 mW/m^3 respectively) when glucose were injected comparison with188 mA/m^2(2,400 mW/m^3) without glucose addition. This indicated that glucose can activate the bioelectricity activities in this SMFC.

Table 1 Effect of various glucose concentrations on the bioelectricity output (Current density, mA/m^2 and Power density (mW/m^3) of SMFCs with carbon cloth anode/cathode electrodes(4 x 4 cm^2)

Glucose concentrations (g/l)	Current density (mA/m^2)	Power density (mW/m^3)
0	188	2,400
100	200	3,110
150	243	4,374
200	380	6,998

Discussion and Conclusion

Maximum current density (380 mA/m^2) was generated when the glucose solution (200 g/l) was injected in SMFC. The more concentration of glucose was injected, the higher current density and power density was found since glucose is carbon source for microbial cultivation and it can support the microbial growth and give electron. So it is the possibility of electricity harvesting from mud enriched with microbe. This indicated that glucose can activate the bioelectricity activities in this SMFC. This MFC should bestudied to be a model for application in the real condition of the rural area enriched of natural bacteria (such as in bottom of the pond, canal, river or sea etc.) which might be used as anodic compartment with using the above waterthat air circulation as electron acceptor as cathode in the future. The carbon cloth anode/cathode electrode was considered as the best to use due to its availability, economical and endurance. Mud might be a substrate to generate electricity as a sustainable and also as a substitute for fossil fuels.

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