WASTE WATER TREATMENT AND ELECTRICITY GENERATION USING IMMOBILIZED BIOANODE IN MICROBIAL FUEL CELL

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ABSTRACT

Treatment of waste water using electricity from fossil fuel can cause damage to the surrounding as it emits gas that can cause greenhouse effect. Besides that, fossil fuel also is a non-renewable type of energy which will be depleted if use continuously and can lead to energy crisis. Microbial fuel cell (MFC) is one of the alternative sources of energy that can use to treat waste water and produce a return of revenue in the form of electricity generation. In this study three different types of waste water which is synthetic, industrial and domestic were treated using immobilized bioanode in single chamber microbial fuel cell (SCMFC). The objective of this study was to investigate the performance of immobilized bio-anode in single chamber microbial fuel cell (SCMFC) in terms of chemical oxygen demand (COD) loss, power generation and columbic efficiency (CE). The immobilized bio-anode was first prepared using graphite as conductive material and calcium alginate immobilization method. Open circuit test was carried out first and the maximum stable voltage respectively obtained for SCMFC process in synthetic, industrial and domestic waste water were 283.8 mV, 247.2 mV and 184.65 mV. Next, waste water treatment test was carried out to determine the percentage of COD loss and columbic efficiency for every waste water based on different external resistance. Synthetic waste water and domestic waste water show significant effect of waste water treatment after open circuit test was completed with 34.83% and 54.03% respectively in terms of COD reduction but domestic waste water show and increase 27.18% of COD value. After that, the percent of COD loss and columbic efficiency was determined for every different external resistance and it was found that the percentage (%) COD loss and columbic efficiency increases with increasing external resistance. Finally, polarization curve and power curve were plotted and it was found out the highest maximum power obtained was SCMFC process in industrial waste of 0.0002531 mW/cm^3 with a corresponding current production of 0.003173 mA/cm^3.

ABSTRAK

Rawatan air sisa yang menggunakan elektrik dari bahan api fosil boleh menyebabkan kerosakan di sekitarnya kerana ia mengeluarkan gas yang boleh menyebabkan kesan rumah hijau. Selain itu, bahan api fosil juga merupakan jenis tenaga yang tidak boleh diperbaharui yang akan habis jika digunakan secara berterusan dan boleh menyebabkan krisis tenaga. Sel bahan bakar mikrob (MFC) adalah salah satu sumber tenaga alternatif yang boleh digunakan untuk merawat air sisa dan menghasilkan pulangan pendapatan dalam bentuk penjanaan elektrik. Dalam kajian ini, tiga jenis air sisa iaitu sintetik, perindustrian dan domestik dirawat menggunakan bioanod yang tersekat gerak dalam sel bahan bakar mikrobial ruang tunggal (SCMFC). Objektif kajian ini adalah untuk mengkaji prestasi bio-anod yang tersekat gerak dalam sel bahan bakar mikrobial ruang tunggal (SCMFC) dari segi keperluan oksigen kimia (COD), penjanaan kuasa dan kecekapan kolumbik (CE). Bio-anod tersekat gerak pertama kali disediakan menggunakan grafit sebagai bahan konduktif dan kaedah tersekat gerak kalsium alginat. Ujian litar terbuka telah dijalankan terlebih dahulu dan voltan stabil maksimum masing-masing diperoleh untuk proses SCMFC dalam air buangan sintetik, perindustrian dan domestik ialah 283.8 mV, 247.2 mV dan 184.65 mV. Seterusnya, ujian rawatan air sisa dijalankan untuk menentukan peratusan kehilangan COD dan kecekapan kolumbik bagi setiap air buangan berdasarkan rintangan luaran yang berbeza. Air buangan sintetik dan air buangan domestik menunjukkan kesan yang signifikan terhadap rawatan air sisa selepas ujian litar terbuka yang lengkap dengan nilai masing-masing 34.83% dan 54.03% dari segi pengurangan COD tetapi air sisa domestik menunjukkan peningkatkan kepada 27.18% COD. Selepas itu, peratus kehilangan COD dan kecekapan kolumbik ditentukan untuk setiap rintangan luaran yang berbeza dan didapati kehilangan peratusan (%) COD dan peningkatan kecekapan kolumbik adalah meningkat dengan peningkatan rintangan luaran. Akhir sekali, keluk polarisasi dan lengkung kuasa telah diplot dan didapati bahawa kuasa maksimum tertinggi yang diperolehi adalah proses SCMFC dalam sisa industry 0.0002531 mW/cm3 dengan pengeluaran semasa 0.003173 mA/cm^3.

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LIST OF ABBREVIATIONS

MFC	-	Microbial Fuel Cell
SCMFC	-	Single Chamber Microbial Fuel Cell
COD	-	Chemical Oxygen Demand
BOD	-	Biochemical Oxygen Demand
TSS	-	Total Suspended Solid
CE	-	Columbic Efficiency
UTM	-	Universiti Teknologi Malaysia
ANOVA	-	Analysis of Variance
ATP	-	Adenosine Triphosphate
DOC	-	Dissolved Organic Carbon

LIST OF SYMBOLS

V	-	Voltage
I	-	Current
v	-	Working Volume
v	-	Velocity
%	-	Percent
Δ	-	Change
Wat	-	Watt
t	-	time
cm^3	-	centimetre cube
mg	-	milligram

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Generation of electricity through fossil fuel to treat waste water poses several disadvantages as it is a non-renewable type of energy making it a limited source of energy and will be depleted in the future. Utilizing fossil fuel as a source of energy can cause harm to the environment as its burning release gases lead to global warming that trigger greenhouse effect. Besides that, the continuous depletion of fossil fuel as source of energy will lead to energy crisis that can cause the price fossil fuel to increase and this will lead the cost require to treat waste water to become more expensive (Rahimnejad, 2015).

Microbial fuel cell (MFC) is a promising mechanism in treating waste water and using microorganism to convert chemical energy to generate electricity. There are several advantages in utilizing microbial fuel cell as a source of energy to treat waste water such as it is a sustainable source of energy as the component require in microbial fuel cell are the microorganism and organic material that exist in the waste water. MFC also causes no harm to the environment in generating electricity as only water is only release to the surrounding as part of oxidation between the electron and oxygen (Zhuwei, 2007). Next, MFC will just not eliminate the cost consumption to treat waste water and as it can also reduce the overall cost of electricity consumption as the electricity generate can be used for other activities. The principal behind MFC in treating waste water application is the bacteria that will consume the existing organic material in the waste water and deliver electron to the anode terminal. The electron will travel through an external circuit to the cathode terminal and will result in production of electricity (Gude, 2016).

There were many efforts that have been done in order to improve the efficiency of MFC electricity generation which include modifying the operating condition such as pH and temperature, the design and the substrate used. Bio-anode is one of the approaches that have been carried out in terms of design to improve the microbial fuel cell efficiency. However, there are also several factors that can affect the performance of the bio-anode such as electron conductivity between the anode and the cathode, the ohm loss due to the resistance existence and mass transfer between the substrate and the electrode. Cell immobilization is one of the approaches that can be done to increase the efficiency of microbial fuel cell as it can stabilize the cell and enhance the kinetics performance of mass transport between the electrode and bacteria. Besides that, cell immobilization also increases the lifetime of the functional microorganism (Pham, 2009).

1.2 Problem Statement

MFC is an alternative method of treating waste water which are less harmful to the environment and cost efficient. However, the application of MFC is currently being limited by its application to different type of waste water (Rahimnejad, 2015). Therefore, in this study the immobilized microbial fuel cell was used to treat three types of different types of waste water which was domestic, synthetic and industrial by reducing its COD value. Besides that, the amount of electricity generated from different type of waste water also was determined from this study.

Next, various studies on MFC have been done to improve the MFC performance through increasing electron conductivity between the anode and the cathode, the ohm loss due to the resistance existence and mass transfer between the substrate and the electrode (Pham, 2009). Therefore, in this study immobilization method was used improve the efficiency for microbial fuel cell to generate electricity as it can stabilize the cell and enhance the kinetics performance of mass transport between the electrode and bacteria.

1.3 Objective of Study

The objective of this research is:

- To investigate power production and waste water treatment using single chamber microbial fuel cell (SDMFC) with immobilized bioanode

1.4 Scope of Study

There were several scopes that need to be highlight in order to fulfil the objective of this study:

1. The immobilization of bio-anode was done using calcium alginate entrapment technique.
2. The performance of SCMFC was evaluated based on:
    i. Power production.
    ii. Waste water treatment in terms of percentage (%) COD loss.
3. Three different type of waste water was used for MFC waste water treatment process which was synthetic waste water, domestic waste water and industrial waste water.

1.5 Significant of Study

The findings of this study can be used to understand more about waste water treatment process using immobilize system. After that, three different type of waste water used in this study for MFC process can reflect the flexibility of MFC system for different situation of MFC process for waste water treatment.

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