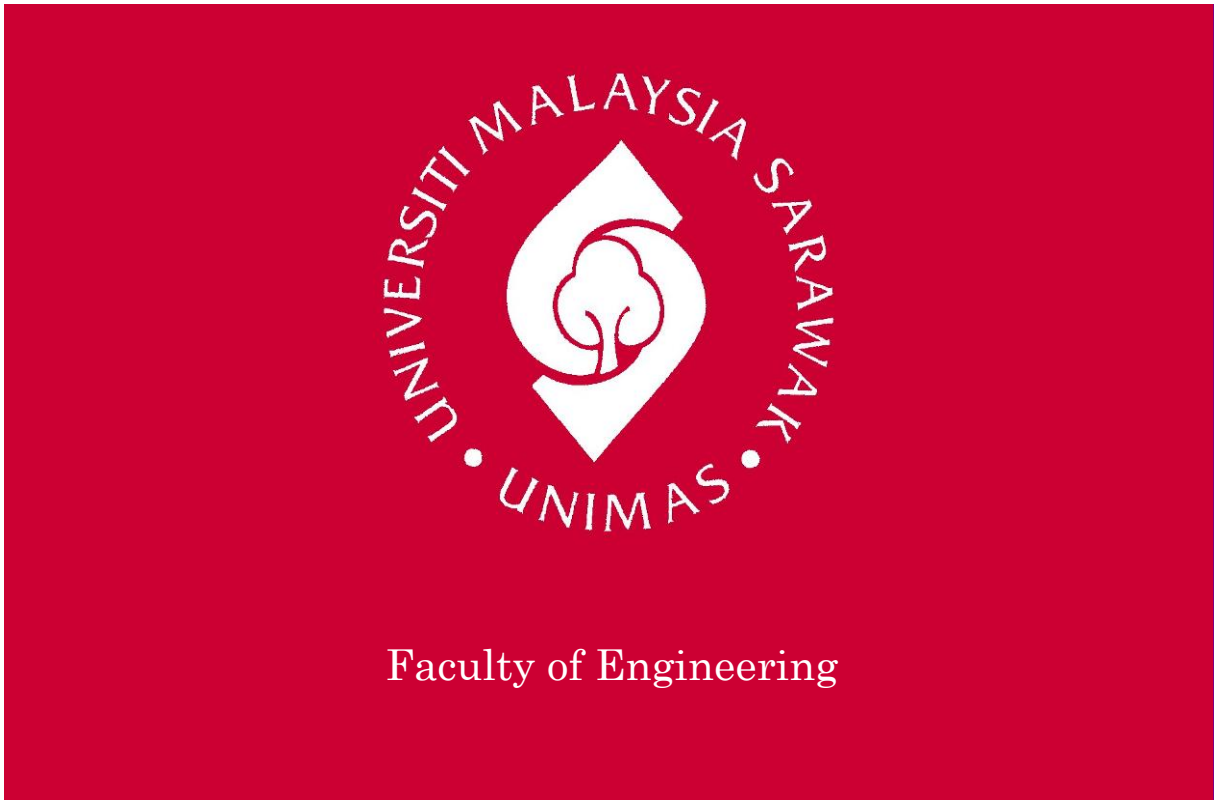

DESIGN STUDY OF MICROBIAL FUEL CELL USING PALM OIL MILL EFFLUENT AS A SUBSTRATE

Norimah Binti Amat Sailan

Bachelor of Engineering with Honours
(Chemical Engineering)
2015

UNIVERSITI MALAYSIA SARAWAK

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APPROVAL SHEET

This project which entitled **"Design Study of Microbial Fuel Cell Using Palm Oil Mill Effluent As A Substrate"** was prepared by Norimah Binti Amat Sailan (31913) is hereby read and approved by:

_____ 31st July 2015

MDM. NORAZIAH ABDUL WAHAB Date

(Project Supervisor)

DESIGN STUDY OF MICROBIAL FUEL CELL USING PALM OIL MILL EFFLUENT AS A SUBSTRATE

NORIMAH BINTI AMAT SAILAN

A dissertation submitted in partial fulfillment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Chemical Engineering and Energy Sustainability)

Faculty of Engineering

Universiti Malaysia Sarawak

2015

Dedicated to my beloved parents, who always bestow me sustainable motivations and encouragements

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ABSTRACT

Research on the use of wastewater as a source of energy had been done to investigate the potential to produce electricity. The objectives of this project are to conduct electrochemical performance assessment of microbial fuel cell by different types of membranes. The research can be divided into two experiments. Experiment 1 was dealing with the design and fabrication of a MFC system that use Nafion 117 membrane. Meanwhile for experiment 2 was dealing with the design and fabrication of a MFC system that use SPEEK membrane. The characteristics of voltage and current generation as well as other wastewater parameters were also determined. The source of wastewater used was anaerobic sludge palm oil mill effluent (POME) from Bau Palm Oilm Mill Sdn. Bhd. (BAPOM). The maximum voltage attained was 14.6 mV with the current in the value of about 7.7 μA by using Nafion 117 membrane. In addition, the maximum voltage attained by using SPEEK membrane was 7.9 mV with the current in the value of about 2.8 μA. The samples of the POME effluent, for both before and after the mentioned processes, were tested on COD parameters. The test results show relatively high reduction in both parameters of COD which are 70.2% reduction for Nafion 117 membrane and 52.6% reduction for SPEEK membrane.

ABSTRAK

Penyelidikan mengenai penggunaan air sisa sebagai sumber tenaga telah dilakukan untuk mengenalpasti potensi air sisa tersebut dalam menghasilkan elektrik. Objektif projek ini adalah untuk menjalankan penilaian prestasi elektrokimia sel bahan api mikrob oleh dua jenis membran. Kajian ini boleh dibahagikan kepada dua eksperimen. Eksperimen 1 ialah berkaitan dengan reka bentuk dan fabrikasi sistem MFC yang menggunakan Nafion 117 membran. Sementara itu, bagi eksperimen 2 ialah berkaitan dengan reka bentuk dan fabrikasi sistem MFC yang menggunakan membran SPEEK. Ciri-ciri voltan dan generasi semasa serta parameter air sisa lain juga telah ditentukan. Sumber air sisa yang digunakan adalah anaerobik efluen kilang minyak sawit lumpur dari Kilang Kelapa Sawit Bau Sdn. Bhd. Voltan maksimum yang dicapai adalah 14.6 mV dan nilai elekrik yang dihasilkan ialah 7.7 μA dengan menggunakan Nafion 117 membran. Di samping itu, voltan maksimum yang dicapai dengan menggunakan membran SPEEK adalah 7.9 mV dan nilai elektik ialah 2.8 μA. Sampel efluen kelapa sawit, untuk kedua-dua proses iaitu sebelum dan selepas telah diuji dengan menggunakan parameter COD. Keputusan ini menunjukkan pengurangan yang tinggi dalam kedua-dua parameter COD yang 70.2% pengurangan untuk Nafion 117 membran dan pengurangan 52.6% bagi membran SPEEK.

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ABBREVIATIONS

AFC	Alkaline Fuel Cell
BAPOM	Bau Palm Oil Mill Sdn.Bhd.
BOD	Biochemical Oxygen Demand
CE	Coulumbic Efficiency
COD	Chemical Oxygen Demand
CPO	Crude Palm Oil
CS	Chitosan
DMFC	Direct Methanol Fuel Cell
DO	Dissolved Oxygen
EFB	Empty Fruit Bunch
FFB	Fresh Fruit Bunch
GE	General Electric
GWP	Global Warming Potential
MFC	Microbial Fuel Cell
MOFC	Molten Carbonate Fuel Cell
PAFC	Phosphoric Acid Fuel Cell
PBI	Polybenzimidazole
PEEK	Poly Ether-Ether Ketone
PEM	Proton Exchange Membrane
PEMFC	Polymer Electrolyte Fuel Cell
POME	Palm Oil Mill Effluent
POMS	Palm Oil Mill Sludge
PSF	Polysulfone

pTSA	Para-Toluene Sulfonic Acid
PVA	Polyvinvyl Alcohol
SE	Sarawak Energy
SOFC	Solid Oxide Fuel Cell
SPEEK	Sulfonated Poly Ether-Ether Ketone

NOMENCLATURE

GWh	Giga Watt hour
CO_2	Carbon dioxide
H_2	Hydrogen gas
O_2	Oxygen gas
H_2O	Water
mA	Milli ampere
g/L	Gram per liter
mM	Millimolar
mg/L	Milli gram per liter
mV	milivolt
mW	mili Watt
Pt	Platinum
NaCl	Sodium Chloride
ml	Milli liter
cm	Centimeter
mm	Millimeter
KCl	Potassium Chloride
rpm	Rotation per minute

CHAPTER 1

INTRODUCTION

1.1 Research Overview

This chapter presents an overview of the research background. The scope covers the current scenario palm oil mill effluent disposal in Malaysia. A more economical and friendly method to solve the palm oil mill effluent using microbial fuel cell to generate electricity and as well as for waste effluent treatment is explained. The problem statement and objectives of this research are presented.

1.2 Energy Needs

There are more that six billion people with estimated population of 9.4 billion in 2050 (Logan, 2008). Fossil fuels have supported the industrialization and economic growth of countries during the past century, but it is clear that fossil fuels cannot sustain a global economy in the future (Logan, 2008). In Malaysia, electricity consumption increased by approximately 200 percent from 20867 gigawatt hours (GWh) in 1990 to 63 16 GWh in 2000 (Sulaiman *et al.*, 2014).

It is expected that the electricity demand will increase by 4.7 percent per annum by the year 2030 (Ali *et al.*, 2012). Like many other developing countries in the region, electricity in Malaysia is still generated using fossil fuels such as coal, oil and gas. Fossil fuels are one of the non renewable energy but are unfortunately also a source of pollution, including CO_2 emission and global warming. Currently, with continuous economic growth and rapid industrialization, more energy is needed including electricity. However, the main raw sources of energy which are fossil fuels are not suitable and give negative impact on the environment (Sulaiman *et al.*, 2014).

Renewable energy sources are plentiful; many still not fully exploited and are environmentally friendly. They have high potential to contribute to the energy needs

for both developed and developing countries (Oh *et al*., 2010). Some sources of renewable energy that act as alternative fuel include hydropower, wind, biomass, wind and geothermal energy. Many policies and financial support schemes have been implemented to increase the consumption of renewable energy sources. One of the major significant policies was diversification of fuel mix used in electricity generation.

Renewable energy was introduced as the fifth fuel after oil, gas, coal and hydro in electricity generation through Fifth Fuel Policy in 2001 (Sulaiman *et al.*, 2014). The biomass sector in Malaysia has shown significant improvement, in relation to its positive carbon balance with regards to fossil fuels, and sustainability and economic growth due to consumption of locally renewable material (Osman *et al.*, 2014).

1.3 Fuel Cell

Fuel cells generate electricity and heat during electrochemical reaction which happens between the oxygen and hydrogen to form the water. Fuel cell technology is the promising way to provide energy for rural areas where there is no access to the public grid or where there is a huge cost of wiring and transferring electricity (Mekhlilef *et al.*, 2012). There are a number of different fuel cell technologies that can be used for a variety of large and small applications.

Table 1.1 shows different types of fuel cell includes Alkaline (AFC), Phosphoric Acid (PAFC), Solid Oxide (SOFC), Molten Carbonate (MCFC), Polymer Electrolyte (PEM) and Direct Methanol Fuel Cell (DMFC). Generally, the electrodes are permeable or contain channels that act to distribute hydrogen or other substances and oxygen. A fuel cell is an electrochemical device which is similar to a battery that usually combines with hydrogen from different sources and oxygen. The proton travels directly across a membrane and combines with an oxygen atom to form water. Meanwhile, the free electron is routed through an external circuit known as electricity (Roman, 2008).

Table1.1: Different Type of Fuel Cell (adapted from Hajimolana *et al.*, 2011)

Fuel Cell Type	Common Electrolyte	Operating Temperature (^{o}C)	Electrical Efficiency (%)	Application
Alkaline (AFC)	Aqueous solution of potassium hydroxide soaked in a matrix	90-100	60	1. Military 2. Space
Phosphoric Acid (PAFC)	Liquid phosphoric acid soaked in a matrix	150-200	>40	1. Distribution generation
Solid Oxide (SOFC)	Yttria stabilized zirconie	600-1000	35-43	1. Auxiliary power 2. Electric utility 3. Large distributed generation
Molten Carbonate (MCFC)	Liquid solution of lithium, sodium, and/or potassium carbonates, soaked in a matrix	600-700	45-47	1. Electric utility 2.Large distributed generation
Polymer	Solid organic polymer poly-	50-100	53-58	1. Backup power