WASTE BIOMASS SUBSTRATES AS FEED STOCK OPTION FOR MICROBIAL FUEL CELL AND SCALING UP FACTORS

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Degree of Master of Science

Department of Chemical and Process Engineering

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Thesis submitted in partial fulfillment of the requirement for the degree of Master of Science

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Sri Lanka

August 2011
DECLARATION

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated. It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree or diploma in any university the best of my knowledge and belief it does not contain any material previously published, written or orally communicated by another person.

M. P. Gunathilake

15th August 2011

I endorse the declaration by the candidate.

........................................

Supervisor
ACKNOWLEDGEMENT

It is a great pleasure to express gratitude to those who were behind me in completing my works successfully.

Thanks are due first to my supervisors, Professor Ajith de Alwis and Dr. (Mrs). Sanja Gunawardane, Department of Chemical & Process Engineering, University of Moratuwa, for their great insights and perspectives. Then I must offer my sincere thanks to Dr. Darshan de Silva, Gentech Pvt Ltd. and Dr. Shantha Walpolage, Senior Lecturer, Department of Chemical & Process Engineering, University of Moratuwa, for the valuable comments given, as my progress review committee members.

Special thanks goes to Mrs. Thamara de Silva, Head of the Department of Mathematics and Prof. (Mrs.) Nazeera Salim, Professor at the Department of Botany, University of Jayewardenepura, Nugegoda for helping me with my research.

Then I am very much grateful to the University Research Grants for providing me the research funding and Post Graduate Studies Division, University of Moratuwa for approving my research project.

Ms. Amali of Food & Microbiology laboratory and all the staff of Energy Engineering, Chemistry, Polymer Engineering, Environmental Engineering laboratories, Department of Chemical & Process Engineering, University of Moratuwa are reminded with heartful of thanks for their support given me in various occasions.

Finally I would be thankful to all my colleagues Ms. Sudeepama Walliwala, Ms. Nimalika Perera, Ms. Gayanee Karunarathna and very specially Ms. Irosha Kularathna, who were with me and gave the best support me to successful this event by making the research period pleasant and enjoyable.
# TABLE OF CONTENT

DECLARATION i  
ACKNOWLEDGEMENT ii  
LIST OF TABLES vi  
LIST OF FIGURES vii  
ABBREVIATIONS ix  
ABSTRACT x  

## CHAPTER 1: INTRODUCTION 1

1.1 BACKGROUND 1  
1.2 RENEWABLE ENERGY OPTIONS FOR SRI LANKA 2  
1.3 OBJECTIVES 4  
1.4 SCOPE 4  
1.5 STRUCTURE OF THE THESIS 5  

## CHAPTER 2: LITERATURE REVIEW 6

2.1 INTRODUCTION 6  
2.2 ELECTRICITY GENERATION FROM FUEL CELL SYSTEMS 6  
2.2.1 Proton Exchange Membrane (PEM) Fuel Cell 6  
2.2.2 Alkaline Fuel Cell (AFC) 7  
2.2.3 Phosphoric Acid Fuel Cell (PAFC) 7  
2.2.4 Solid Oxide Fuel Cell (SOFC) 7  
2.2.5 Molten Carbonate Fuel Cell (MCFC) 8  
2.2.6 Biological Fuel Cell 8  
2.2.7 Characteristics of fuel cell power generation 9  

2.3 MICROBIAL FUEL CELL (MFC) TECHNOLOGY 9  
2.3.1 General Principles of Microbial Electricity Generation 10  
2.3.2 Mechanisms of Electron transfer from Microbe to Anode 11  
2.3.3 Electricity producing microorganisms in MFCs 13  
2.3.4 Waste substrates tested on MFCs 15  
2.3.5 Types of Anodes and their modifications 16
LIST OF TABLES

Table 1.1: Quantities of wastewater generated by some of the food processing sectors 3
Table 4.1: Comparison of Substrates used in batch type MFC 45
Table 7.1: Physical parameters (Relevant list) for the MFC scaling up 60
Table 7.2: Dimensionless groups 63
LIST OF FIGURES

Figure 2.1: Microbial electricity Generation 10
Figure 2.2a: Scanning electron micrograph (SEM) of wild type Shewanella oneidensis and nanowires that connect to each other cells 12
Figure 2.2b: The anode from MFC colonized by nanowires producing S. oneidensis 12
Figure 2.3: Mediated Electron transfer using Methylene blue 13
Figure 3.1: Batch Type MFC developed for the 28
Figure 3.2 A: Dimensions of a compartment of a cell 28
Figure 3.2 B: Cross section of the top of the compartment 28
Figure 3.2 C: Cross section of the point which connect the two compartments through the membrane 28
Figure 3.3: Experiment setup for batch cell for cow dung 30
Figure 3.4: Cow dung in anode 30
Figure 3.5: Aerated cathode 30
Figure 3.6: Experimental setup for batch cell for coconut water (canteen) 31
Figure 3.7: Experimental setup for batch cell for coconut water (dry matured) 31
Figure3.8: E.Coli inoculum 31
Figure 3.9: Growth media (LB media) 33
Figure 3.10: Growth media and defined substrate 33
Figure 3.11: Batch type MFC fed with pure substrate 33
Figure 3.12: E.coli grown in pure substrate 34
Figure 3.13: K$_3$Fe(CN)$_6$ in Phosphate buffer 34
Figure 4.1: Mean value of OCV for each operating day of MFC for the cow dung experiment 1 35
Figure 4.2: Dotplot of OCV indicating the number of readings for a particular voltage throughout the range of obtained readings for cow dung experiment 1 36
Figure 4.3: Mean value of OCV for each operating day of MFC for the cow dung experiment 2

Figure 4.4: Dotplot of OCV indicating the number of readings for a particular voltage throughout the range of obtained readings for cow dung experiment 2.

Figure 4.5: Mean value of OCV for each operating day of MFC for the coconut water (Canteen sample) experiment 1

Figure 4.6: Air bubble formation at the anode

Figure 4.7: Dotplot of OCV indicating the number of readings for a particular voltage throughout the range of obtained readings for coconut water experiment 1

Figure 4.8: Mean value of OCV for each operating week of MFC for the coconut water (dry matured coconut sample) experiment 2

Figure 4.9: Black Funguses

Figure 4.10: White Funguses

Figure 4.11: Yellow Funguses

Figure 4.12: Dotplot of OCV indicating the number of readings for a particular voltage throughout the range of obtained readings coconut water experiment 2

Figure 4.13: Mean value of OCV for each operating day of MFC for the experiment on defined substrate with *E.Coli*

Figure 4.14: Dotplot of OCV indicating the number of readings for a particular voltage throughout the range of obtained readings for the experiment on defined substrate with *E.Coli.*

Figure 6.1: A cathodic \(E^{\text{cathode}}\) and anodic \(E^{\text{anode}}\) polarization curve indicating the region of activation losses (region A), the ohmic losses (region B) and mass transfer losses (region C).
## LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AFC</td>
<td>Alkaline Fuel Cell</td>
</tr>
<tr>
<td>BEAMR</td>
<td>Bio-electrochemically assisted microbial reactor</td>
</tr>
<tr>
<td>BP</td>
<td>British Petroleum</td>
</tr>
<tr>
<td>CE</td>
<td>Coulombic Efficiency</td>
</tr>
<tr>
<td>CEA</td>
<td>Central Environmental Authority</td>
</tr>
<tr>
<td>CEB</td>
<td>Ceylon Electricity Board</td>
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<tr>
<td>CNT</td>
<td>Carbon nanotube</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical oxygen demand</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>L</td>
<td>Liter</td>
</tr>
<tr>
<td>MCFC</td>
<td>Molten Carbonate Fuel Cell</td>
</tr>
<tr>
<td>MFC</td>
<td>Microbial Fuel Cell</td>
</tr>
<tr>
<td>MTOE</td>
<td>Million Tonnes of Oil Equivalent</td>
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<tr>
<td>OCV</td>
<td>Open Circuit Voltage</td>
</tr>
<tr>
<td>PAFC</td>
<td>Phosphoric Acid Fuel Cell</td>
</tr>
<tr>
<td>PANI</td>
<td>Polyaniline</td>
</tr>
<tr>
<td>PEM</td>
<td>Proton Exchange Membrane</td>
</tr>
<tr>
<td>Rs.</td>
<td>Sri Lankan Rupee</td>
</tr>
<tr>
<td>SEM</td>
<td>Scanning electron micrograph</td>
</tr>
<tr>
<td>SOFC</td>
<td>Solid Oxide Fuel Cell</td>
</tr>
<tr>
<td>TWh</td>
<td>Terawatt hours</td>
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ABSTRACT

The waste biomass substrates for microbial fuel cell (MFC) were tested using a batch type MFC. The performances of each cell were measured individually by recording the Open Circuit Voltage (OCV) against time using three different substrates; cow dung, coconut water and glucose. The cell was operated using an aerated cathode for waste substrates. A chemical cathode was used for defined substrate. The relationship for the voltage generation with the nutrients (in terms of Chemical Oxygen Demand (COD)) and the availability of electricigens was discussed for both defined and waste substrates. The highest of the average of mean OCV was observed for glucose (0.35V) and for waste substrates it varied from 0.18V to 0.28V. Coconut water had a higher COD compared to cow dung even though the availability of the electricigens was unknown.

Each step in electricity generation in MFC was studied and the parameters which affected power generation were identified. Dimensional analysis was done to the selected parameters using the “Buckingham Pie” theorem and a set of dimensionless groups was calculated. The physical meaning behind each of the dimensionless groups was analysed. Using the dimensionless groups, a polynomial equation was developed as follows:

\[ D^a = \alpha (\mu/\rho)^a (d^3 g \rho^2/\mu^2)^b (h/d)^c \]

Where, \( D \) is the mass diffusivity (\( m^2s^{-1} \)), \( \mu \) viscosity (\( kgm^{-1}s^{-1} \)), \( \rho \) density (\( kgm^{-3} \)), \( d \) distance between the two electrodes (\( m \)), \( h \) height of the electrode (\( m \)), \( g \) gravitational constant (\( ms^{-2} \)) and \( \alpha, a, b, c \) are constants.

This equation is useful in finding the relationship between the operational parameters when the MFC is operating at its highest power density with no forced convection of the electrolyte. Using a set of experiments, the values of the constants can be found, with those values the equation is important in the process of scaling up of the microbial fuel cell.