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

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**(8014)**



**Degree of Master of Science**

**Department of Chemical and Process Engineering**

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# 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.

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Supervisor

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

# 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 ($m^2s^{-1}$),μ viscosity ($kgm^{-1}s^{-1}$),ρ density ($kgm^{-3}$) ,d distance between the two electrodes (m), h height of the electrode (m), g gravitational constant ($ms^{-2}$) and α, 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.