RENEWABLE POWER SOURCE USING URINE BASED ON BIO - BATTERY

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ABSTRACT

The effect of electrode material is performance a microbial fuel cells (MFC), which utilize urea in urine at the anode chamber and plain water at the cathode chamber have been demonstrated using different size for metal electrode and also different volume for urine sample. The combination of magnesium and copper produce a promising result which can be used for hardware development. The highest output power, voltage load and current are respectively 0.9 mW, 1.11 V and 0.89 mA. The output voltage of hardware will produce more than 3volts in series connection of 3 cells of the MFC. The output voltage of hardware at no load condition was producing 4.3 V in series connection of 3 cells of the MFC. The current flow with using a red LED as a load is 0.63 mA. These result demonstrate the type of electrode have important role on the efficiency of biological fuel cell.

ABSTRAK

Kesan bahan elektrod kepada prestasi sel-sel bahan api mikrob (MFC), yang menggunakan kandungan urea yang terkandung di dalam urin pada ruang anod dan air paip di ruang katod telah didemonstrasikan dengan penggunaan pada saiz logam yang berbeza sebagai elektrod dan juga pada isipadu yang berbeza terhadap sampel urin. Hasil gabungan pita magnesium dan plat tembaga menghasilkan keputusan yang berpotensi untuk digunapakai dalam pembangunan perkakasan. Kuasa keluaran tertinggi, voltan pada beban dan arus ialah 0.9 mW, 1.11 V dan 0.89 mA. Voltan output perkakasan akan menghasilkan lebih daripada 3volts dalam sambungan siri oleh 3 sel MFC. Voltan keluaran prototaip *Bio-battery* pada keadaan tanpa beban menghasilkan 4.3 V dalam sambungan siri oleh 3 sel MFC. Arus yang mengalir semasa dengan menggunakan LED berwarna merah sebagai beban ialah 0.63 mA. Keputusan ini menunjukkan jenis elektrod mempunyai peranan yang penting pada kecekapan sel bahan api biologi.

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LIST OF ABBREVIATION AND ACRONYM

$C_6H_{12}O_6$	- Monosaccharide type of glucose (simple sugar)
Oxidant	- Oxidizing agent
Carnot cycle	- Thermodynamic cycle
Metabolism	- Chemical reactions
Anaerobic	- Without oxygen
Glucuronidase	- Enzymes
Exoelectrogens	- A Bacterium or prokaryote
Biofilm	- An aggregate of microorganism
Dextrose	- Type of glucose
Glycolysis	- Metabolic pathway
Passivation	- Material becoming passive
TWh	- Tera Watt Hour

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Battery is a device that directly converts chemical energy to electrical energy [1]. An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy [2]. Since the invention of the first battery (or "voltaic pile") in 1800 by Alessandro Volta, batteries have become a common power source for many household and industrial applications. According to the estimation in 2005, the worldwide battery industry generates US$48 billion in sales each year [3], with 6% annual growth [4]. The widespread use of batteries has created many environmental concerns, such as toxic metal pollution [5]. Battery manufacture consumes resources and often involves hazardous chemicals. Used batteries also contribute to electronic waste [6]. Batteries may be harmful or fatal if swallowed [7].

Bio battery(bio-fuel cells) are batteries that use biocatalysts, either bio molecules such as enzymes or even parts of or whole living organisms(microbes) to catalyze oxidation of biomass based material for generating electrical energy. Types of bio batteries are classified according to the nature of electrode and biochemical reactions. Their performance is critically reviewed and a variety of possible applications is considered.

After the development over the years, batteries nowadays have attained good size reduction and longevity. As power source for implantable medical devices, conventional batteries still form the biggest and heaviest part of the device, and require regular replacement, which entails surgical operation. Moreover, these batteries may contain toxic substances to acquire high performance.

Due to the constant increase of the energy demand and the consequential environmental problems, the exploration of clean, sustainable energy sources have been receiving considerable attention. One of the promising fields for substitutional energy is fuel cells. Conventional fuel cells work by catalysis. For instance, in a proton exchange fuel cell, hydrogen molecules are oxidized on the anode catalyst and dissociate into proton and electron, and on the cathode-catalyst oxygen molecules are reduced to water reacting with the electrons.

These catalysts are often expensive materials such as platinum. In living nature, microorganisms catalyze the oxidation of substrates using enzymes. Since microorganisms produce these enzymes and replace them continuously as a part of their metabolism, utilizing microorganisms in fuel cells may allow a substitutional energy source for a battery which is less expensive and does not require be recharging or replacing. This is realized in microbial fuel cells

Fuel cells are a promising technology for use as a source of heat and electricity for buildings, and as an electrical power source for electric motors propelling vehicles. Fuel cells operate best on pure hydrogen but fuels like natural gas, methanol, or even gasoline can be reformed to produce the hydrogen required for fuel cells. Some fuel cells even can be directly fuelled with methanol, without using a reformer.

Researchers consider the human urine urea potentially valuable sources of power because they occur naturally and easily accessible. Moreover, bio batteries are rightly termed as the answer to our future energy crises due to their eco-friendly nature and inexpensive sources. Fuel cells are devices which can directly convert chemical energy into electricity with high efficiency. Urea fuel cells would be an efficient method of generating power from fertiliser urea, urine and waste water. Potentially, urea fuel cells can use urine as the fuel. In this case, urine, a product of human or animal excretion, is not a waste, but an energy source. If an adult human produces 1.5 L of urine containing 2 % urea, it would produce 11 kg of

urea each year which is equivalent to the energy in 18 kg of liquid hydrogen that can be used to drive a car for 2700 km powered by a urea fuel cell.

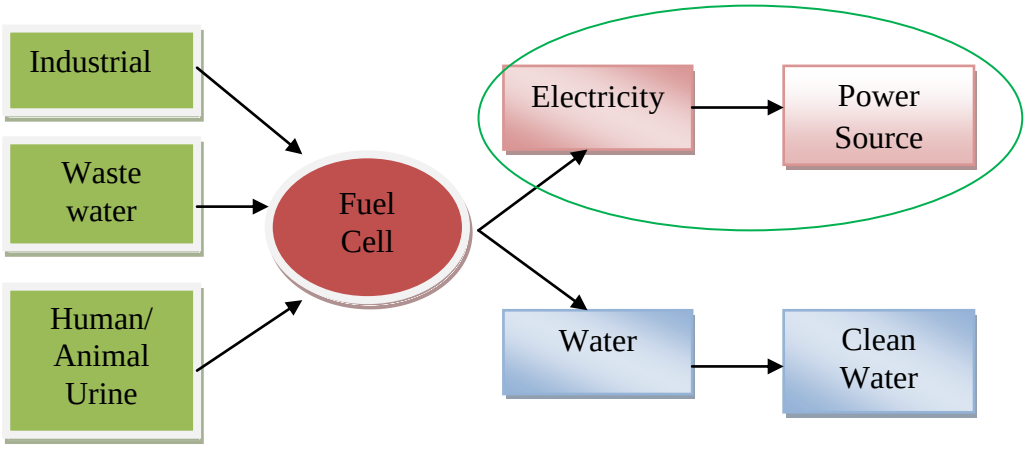


Figure 1.1: Schematic diagram of applications of urea fuel cells

1.2 Problem Statement

Electricity defines the modern world. Everything that we think of as modern, from electric light, through radio and television to home appliances, electronics devices, computers and all the paraphernalia of the information age depends for their operation, for their existence, on electricity.

The electricity demands of Malaysia will increase by 4.7 per cent per year over the outlook period, to reach 274 TWh in 2030. The electricity consumption in Malaysia come from 27.4 million people a day to watch television, surf the internet using a computer, cool drinks through a refrigerator or under running freshen the air conditioning . How much energy is wasted through misuse of power, released without control? Figure 1.2 shows the electricity consumption by users in Malaysia respectively and Table 1.1 show the estimations cost per month.

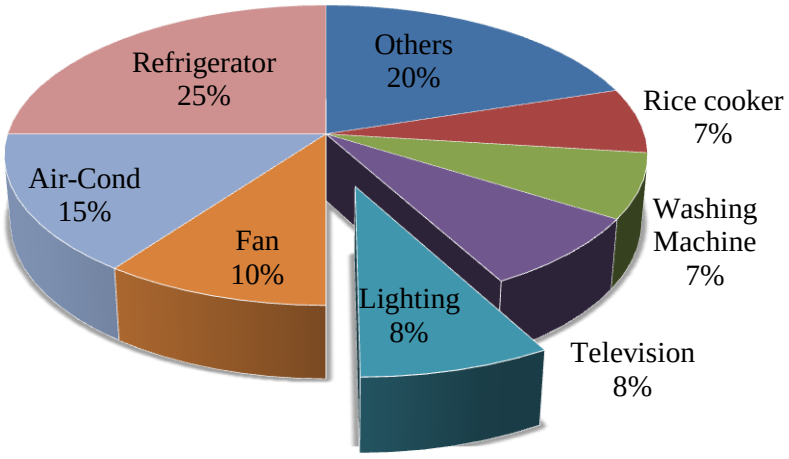


Figure 1.2: The electricity consumption by users in Malaysia respectively

Table 1.1 Estimation cost per month

Area	Type of House					
	Lower Cost		Medium		Bungalow	
	RM	%	RM	%	RM	%
Kitchen	30	45	46	38	136	40
Living Room	20	30	40	32	135	39
Bathroom	10	14	14	18	55	16
Others	7	10	10	12	16	5
Total	67	100	123	100	342	100

In an attempt to minimize their impact to the environment, using the urine as the material of the battery will become one of the way to support the electricity consumption. And overcome the most promising in term of electricity generation as it gives power to cost ratio.

1.3 Objectives

i. To investigate the urea in urine as source of electricity from previous related works or literature.
ii. To develop a bio battery that generates electricity from urine utilizing urea as its catalyst to supply load such as led light and small electronic equipment.
iii. To measure a performances of different urine samples for voltage, current and power with various volumes of urine samples.

1.4 Project of Scopes

i. Use the human urine as a source to generate the average power 0.8mW.
ii. Generates electricity from urine utilizing urea as its catalyst using salt bridge, urine, plain water and electrode (copper and magnesium).
iii. The samples were taken from five different people with specific range volume for 20 mL, 40 mL, 60 mL, 80 mL and 100 mL to be use for a day (24 Hours).

Figure 1.3: The setup for the bio battery using urine

1.4 Report Structure

The report consist five chapters described as follows.

- Chapter 1 is an overview of the project, the main objectives of the project being carried out. It consists of the scope of work covered and methodology of the project.

- Chapter 2 illustrates the MFC concept and type of electrode for the literature review of this project. It also gives a brief explanation on the characteristic and parameters of electrode for better understanding of this project.

- Chapter 3 reveals the development process of the hardware which starts from the design of experiment and development of Bio-Battery prototype.

- Chapter 4 emphasizes discussion according to the analysis obtained from the experiment and laboratory testing in the previous chapter. The final part of this chapter will explain about the results obtained.

- Chapter 5 discussion and conclusion of this project and recommendation for the future work will discuss in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

In this chapter, the basic theory behind the experimental work of this project will be introduction and discussion. The theoretical background consists of several definitions, which will used to analyze the experimental data. It involves all the aspects which can be linked to the project or research which is available in the outside world. The research is not mainly focusing directly to research which is already performed but also focused on factual research and references of studies.

The source and information can be available from the internet, library, and also from the person who has a high knowledge about the research. This research is important because it resembles the starting point to creating, upgrade and producing a quality research which have accurate results.

Through the past research that had been done, a lot of knowledge can be obtained such as the equipment needs to be used, type of the disadvantages can be expected, the basic knowledge required to be learned so that the experiment can be executed and the expected result can be obtained. This will help to reduce the time and cost used to perform the research.

2.1 Battery Overview

The battery is a device containing an electric cell or a series of electric cells storing energy that can be converted into electrical power in form of direct current. It is small, compact and easy to handle and relatively low installation cost. Although it has the advantage, the battery also have their own weaknesses that they are not designed for heavy cycling which mean they may have a shorter life span than other types, depending on how heavily they are cycled. In general, there are two types of batteries [11]. Firstly is primary batteries or disposable batteries, which are designed to be used once and discharged and the second type is secondary batteries or recharged batteries, which are designed to be recharged and used multiple times.

It should be mentioned that there are two main types of batteries primary and secondary batteries. In primary batteries, the chemical energy stored in the cell can be used only once to generate electricity, that is, once the cell is fully discharged it cannot be of further use. In secondary batteries the reverse redox reaction (also referred to as electrolysis and charging) can occur when the current is applied at a potential higher than the cell potential and the battery can be used reversibly many times. During charging, electrons flow to the anode through the external circuit and cations from the cathode diffuse through the electrolyte to the anode.

Figure 2.1 shows the schematic diagram of a urine-activated paper battery consisting of a copper (Cu) layer, copper chloride (CuCl)-doped filter paper and a magnesium (Mg) layer. The whole assembly is sandwiched between two plastic layers and later laminated into a urine-activated paper battery by passing it through heated rollers at120◦C.

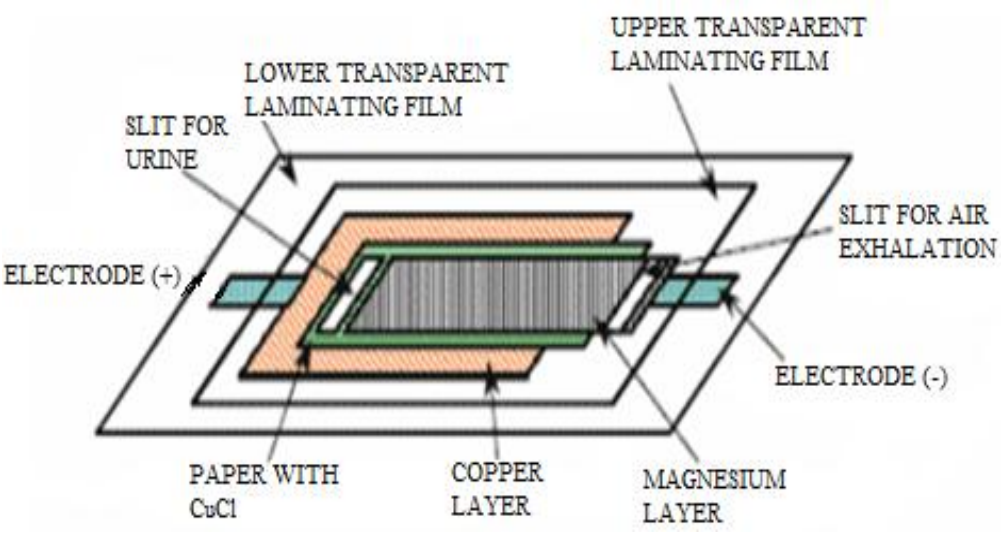
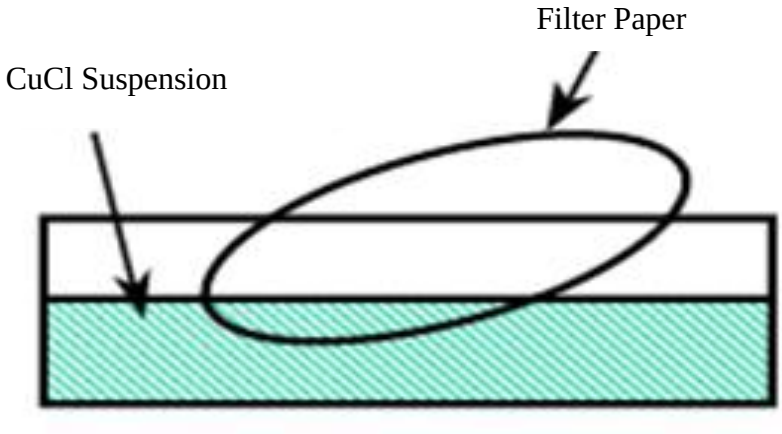
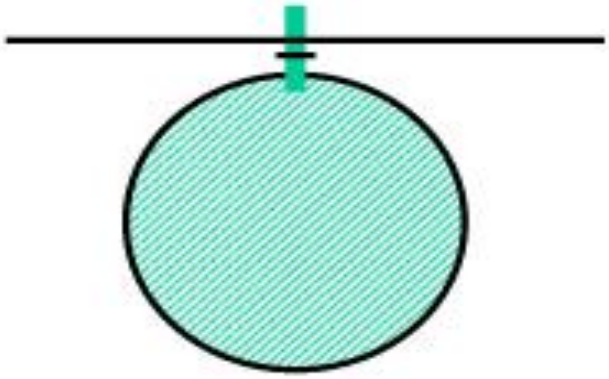


Figure 2.1: The schematic diagram of a urine-activated paper battery

Figure 2.2 shows the operation principle of the urine-activated battery. Magnesium and copper chloride are used as the anode and the cathode, respectively. The Cu layer acts as an electron-collecting layer. When a droplet of human urine is added to the battery, as shown in Figure 2.2, the urine soaks through the paper between the Mg and Cu layers. The chemicals dissolve and react to produce electricity. Even though urine contains other minor electrolyte chemicals such as uric acid [10], CuCl, as shown in figure 3, is the major chemical used for the generation of electric power in these batteries.



(a) Soaking filter paper in CuCl suspension



(b) Drying and cutting the paper in air

Figure 2.2: (a) Preparation of the CuCl-doped filter paper. (b)After soaking, the copper chloride-doped filter paper is dried in air and cut into small pieces.

The chemical reactions for the battery at the anode (oxidation) and cathode (reduction) are represented as equations (1) and (2), respectively [9, 10]:

$$Mg \rightarrow Mg^{2+} + 2e^{-} \quad (2.1)$$

$$2CuCl + 2e^{-} \rightarrow 2Cu + 2Cl^{-} \quad (2.2)$$

, and the overall reaction is

$$Mg + 2CuCl \rightarrow MgCl2 + 2Cu \quad (2.3)$$

The theoretical voltage of this battery is a direct function of the anode and cathode materials. The standard potential can be calculated as 2.49 V from the standard electrode potentials as the sum of the anode potential and the cathode potential [9, 14].

2.1.1 Primary Batteries

Primary batteries can generate current immediately on assembly. They are intended to be used once and discarded. These are most commonly used in portable devices that have low current drain, are only used intermittently, or are used well away from an alternative power source, such as in alarm and communication circuits where other electric power is only intermittently available. Disposable primary cells cannot be reliably recharged, since the chemical reactions are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against attempting recharging primary cells [11].

2.1.2 Secondary Batteries

Secondary batteries must be charged before use which they are usually assembled with active materials in the discharged state. Rechargeable batteries or secondary cells can be recharged by applying electric current, which reverses the chemical reactions that occur during its use. The devices to supply the appropriate current are called chargers or rechargers [11]. The most common secondary battery used in communication devices, such as cellular phones, is the lithium ion battery. Batteries are also sometimes classified in terms of the mode in which they are used:

i. Portable batteries: These cover a wide range of batteries from those used in toys to those used in mobile phones and laptops.

ii. Transport batteries: The largest application of these is in the starting, lighting, and ignition (SLI) for cars or in electrical vehicles (e.g., in e - scooters and hybrid electrical vehicles).

iii. Stationary batteries: Include applications for standby power, backup in computers, telecommunications, emergency lighting, and for load leveling with renewable energy, such as solar cells, during darkness, and wind during very calm weather.

Thus, batteries are correctly perceived as a critical enabling technology and future improvements are continuously sought.

2.2 Fuel Cell

A fuel cell is a galvanic device or energy conversion device that continuously converts that chemical energy of fuel cell and oxidant directly into electricity without any immediate thermal or mechanical processes. Fuel cells convert this energy electrochemically and are not subject to the Carnot cycle limitation of thermal engines, thus offering the potential for highly efficient conversion.

In a fuel cell, the fuel and the oxidant are supply continuously from an external source when power is desired. The fuel cell can be produce electrical energy as long as the active materials are fed to the electrodes. The electrode materials of the fuel cell are inert in that they are not consumed during the cell reaction, but have catalytic properties, which enhance the electro reduction or electro oxidation of the reactants.

The anode active materials used in fuel cell are generally gaseous or liquids fuels such as hydrogen, methanol, hydrocarbons, natural gas, which are fed into the anode side of the fuel cell. Oxygen, most often air is the predominant oxidant and is fed into the cathode. Fuel cell technology can be classified into two categories; the first category is the direct systems where fuels, such as hydrogen can react directly in the fuel cell and the other one is an indirect system in which the fuel, such as natural

gas which is then fed into the fuel cell. Fuel cell systems can take the number of configuration depending on the combinations of fuel and oxidant, the type of electrolyte, temperature of operation [12].

2.2.1 Urine: The Energy Source

Urine is a liquid produced by the kidneys to remove waste products from the bloodstream. Human urine is yellowish in color and variable in chemical composition. Figure 2.3 shows the human urine consists primarily of water, with organic solutes including urea, creatinine, uric acid, and trace amounts of enzymes.

Figure 2.3: The composition in urine [15]

2.2.2 Reaction of Mechanisms in the Fuel Cell

In the fuel cells, there are three parts of reactions that will occur in each fuel cell components. The reaction will start in anode or fuel electrode. It provides a common interface for the fuel and electrolyte, catalyst the fuel oxidation reaction and conduct

electrons from the reaction site to the external circuit. Then, the second part is cathode or oxygen electrode where it provides a common interface for the oxygen and the electrolyte, catalyst the oxygen reduction reaction and conduct electrons from the external circuit to the oxygen electrode reaction site. Meanwhile in the electrolyte or salt bridge, it acts as the transports of the ionic species involved in the fuel and oxygen electrode reactions while preventing the conduction of electrons [13].

2.3 Electron Transfer in Bio Battery

In bio battery, electrons are transfer from anode compartment to the cathode compartment through load or circuit. Once electrons have left the cell, they must be transferred to an electrode to produce current. In a bio battery there are three main mechanisms for microorganisms to transfer electrons to an exocellular electrode. The transfer can occur with the addition of replica mediators, self-produced mediators and or direct contact with the electrode. The all urea can achieve this extracellular transfer; some can only use to dissolve compounds such as sulphate that spread through the cell membrane to receive electrons. The field of bio battery technology has been called urea that can directly transport electrons outside of the cell “exoelectrogens” [13]. This urea is significant to bio battery technology because without the exocellular electron transfer, no power could be produced.

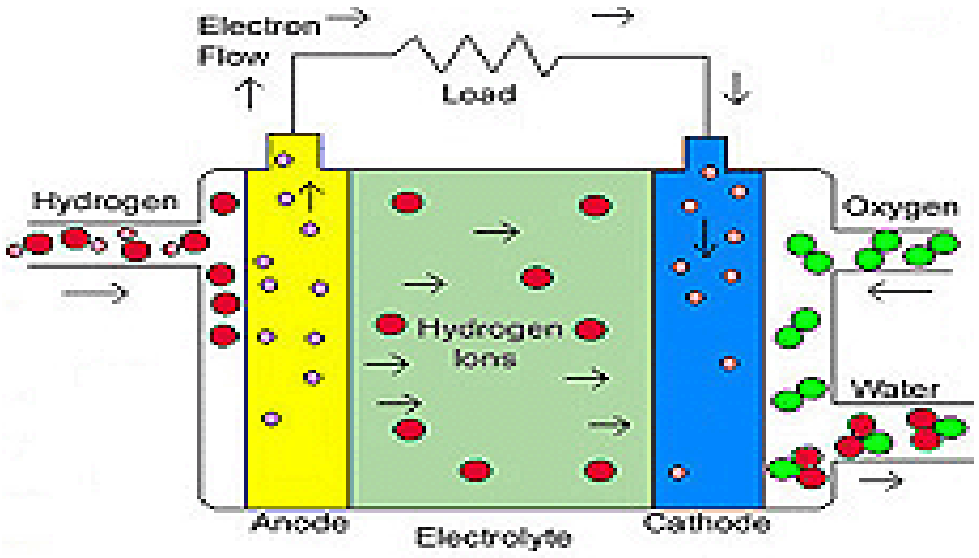


Figure 2.4: Electrochemical cell using combination of two electrodes

Figure 2.4 show the scientifically batteries are referred to as electrochemical or galvanic cells, due to the fact that they store electrical energy in the form of chemical energy and because the electrochemical reactions that take place are also termed galvanic. Galvanic reactions are thermodynamically favorable (the free energy difference, is negative) and occur spontaneously when two materials of different positive standard reduction potentials are connected by an electronic load (meaning that a voltage is derived).

The material with the lower positive standard reduction potential undergoes an oxidation reaction providing electrons by the external circuit to the material with the higher positive standard reduction potential, which in turn undergoes a reduction reaction. These half reactions occur concurrently and allow for the conversion of chemical energy to electrical energy by means of electron transfer through the external circuit. It follows that the material with the lower positive standard reduction potential is called the negative electrode or anode on discharge (since it provides electrons), while the material with the higher positive standard reduction is called the positive electrode or cathode on discharge (since it accepts electrons).

2.4 Type of Electrode

In the MFC, an electrode is referred to as either an anode or a cathode. The anode is defined as the electrode at which electrons leave the cell and oxidation occurs, and the cathode as the electrode at which electrons enter the cell and reduction occurs. Each electrode may become either the anode or the cathode depending on the direction of current through the cell. The type of electrode also have affect to a value of voltage that will produce.

The electrode kinetics, which as was previously shown affect the voltage, will be elaborated on. Thermodynamics expressed in terms of the electrode potentials can tell us the theoretical and open circuit cell voltage, as well as, how feasible it is for a cell reaction to occur. However, it is necessary to consider kinetics in order to obtain a better understanding of what the actual cell voltage may be, since the charge transfer and the rates of the reactions at the electrodes are usually the limiting factors. In continuing, therefore, the main kinetic issues that affect battery performance are summarized.

2.4.1 Magnesium Tape

Magnesium used is both strong and light. This makes it ideal for use in automobile and truck parts. It is often alloyed with other strong metals such as Aluminum .Due to its low weight and good mechanical and electrical properties, magnesium is used to manufacture cell phones also called mobile phones, laptops and cameras. It can also be used to make some other electrical components and can be used as reducing agent producing uranium from its salt. Besides that, it is a highly flammable metal, but while it is easy to ignite when powdered or shaved into thin strips and it is difficult to ignite in mass or bulk [17].

2.4.2 Copper Plate

In electrical conductivity aspect, copper has the highest conductivity of the engineering metals. Pure copper is soft and malleable; an exposed surface has a reddish-orange tarnish. It is forms a rich variety of compounds with oxidation states +1 and +2, which are often called cuprous and cupric, respectively [16]. It does not react with water, but it slowly reacts with atmospheric oxygen forming a layer of brown-black copper oxide.

2.4.3 Zinc Plate

Zinc is an essential mineral of exceptional biologic and public health importance [15]. It is deficiency affects about two billion people in the developing world and is associated with many diseases [15].Besides that, it is, in some respects, chemically similar to magnesium, because its ion is of similar size and its only common oxidation state is +2.Corrosion-resistant zinc plating of steel (hot-dip galvanizing) is the major application for zinc. Other applications are in batteries and alloys, such as brass. It also deficiency is crop plants' most common micronutrient deficiency; it is particularly common in high-pH soils.

2.4.4 Iron Plate

Iron is also the metal used at the active site of many important redox enzymes dealing with cellular respiration and oxidation and reduction in plants and animals. It is the most common element by mass forming the planet Earth as a whole, forming much of Earth's outer and inner core. It is the fourth most common element in the Earth's crust [17].

2.4.5 Tin Plate

Tin is a malleable, ductile and highly crystalline silvery-white metal. When a bar of tin is bent, a crackling sound known as the tin cry can be heard due to the twinning of the crystals [18].In modern times tin is used in many alloys, most notably tin/lead soft solders, typically containing 60% or more of tin. Another large application for tin is corrosion-resistant tin plating of steel. Because of its low toxicity, tin-plated metal is also used for food packaging, giving the name to tin cans, which are made mostly of steel.

2.4.6 Lead Plate

Lead is a main-group element in the carbon group and it is a soft, malleable poor metal. It is also counted as one of the heavy metals. It also used in building construction, lead-acid batteries, bullets and shots, weights, as part of solders, pewter's, fusible alloys and as a radiation shield [18].

2.4.7 Aluminium Plate

Aluminium is a soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to dull grey, depending on the surface roughness. It is nonmagnetic and does not easily ignite and too reactive chemically to occur natively. It is also remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation and it is a good thermal and electrical conductor, having 59% the conductivity of copper, both thermal and electrical. Besides that, it is capable of being a superconductor, with a superconducting critical temperature of 1.2 Kelvin and a critical magnetic field of about 100 gauss [15].

2.5 Measurement Result

The potential between anode and cathode was measured using a multi-meter and recorded every two hour intervals. An open circuit (OC) was used to measure potential (V) while current was measured in close circuit (CC) configuration.

2.5.1 Mean

In statistics, the mean is the mathematical average of a set of numbers. The average is calculated by adding up two or more scores and dividing the total by the number of scores [22].

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots\ldots + x_n}{n} \tag{2.4}$$

$X_{1,,}\ X_{2,}\ X_{3,}\ X_n$ = Samples

$\overline{X}$= Mean/Average

N=Total number of the sample

2.5.2 Standard Deviation

The standard deviation is a measure of the numbers or data are spread out or measure of dispersion of the numbers or data. If the standard deviation of a set of data is large that means that the data are widely scattered. If the standard deviation of a set of data is small that means that the data are tightly clustered [23].

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2} \tag{2.5}$$

s= Standard deviation

N= Total number of the sample

x_i= The sample(i=1,2,3,4,5…n)

$\overline{x}$= Mean of the sample

2.6 Previous Research

The development of artificial gill to supply oxygen to a submerged microbial fuel cell had been purposed by M.J Stanway [2004]. The objective of this research is to demonstrate the feasibility of a simple membrane-based artificial gill. The MFC will serve as a demonstration load for the gill, one that has a potential application in marine industry. At the end of this research, the gill and fuel cell have been demonstrated to work independently (The counter current gill provides seven order of magnitude more than required by the modified MFC). A more sophisticated gill will need to be developing in order to sustain these industrial-strength MFCs.

Erika Parra and Liwei Lin [2009] proposed the microbial fuel cell based on electrode-exoelectrogenic bacteria interface. In this work, they demonstrated the compatibility of the organism's microbiology. This result in low efficiency as current density is lost through the long diffusion process and mediator compromise the microorganism's viability. They also have adapted Geobacter sulfurreducens as their preferred organism. The prototype fuel cell anode geometry was designed to conform to the bacteria and biofilm dimension. After the demonstrate, further performance improvement are possible by allowing the bacterial biofilm to fully cover the anode, increasing the electrode surface area, enhancing the connectivity of the bacteria to the electrode and the system presented harvested energy for over a week.

GusphyA.Justin, Yingze Zhang, Mingui Jun and Robert Selabassi [2004] proposed "Bio-fuel Cell: A possible power source for implantable electronic devices". The objective of this experiment is to design a BFC which utilize white blood cells as electron donors as opposed to microbial organism such as E. coli. At the end of this experiment, bio-fuel cells incorporating E. coli as a bacteria and methylene blue as an electron mediator do generate electricity. A maximum electric

potential of 0.326V was recorded which decreased to 0.215V by the end of the experimental period.

Kong Xiaoying, Sun Yongming, Li Lianhua, Liying and Yuan Zhenhong [2010] proposed the Electricity generation comparison of two-chamber microbial fuel cell with different membranes. In this journal, they seek alternative and cheaper membranes which can be replace proton exchange membrane, this paper select two kinds of cheap membranes for experimental study. The cost-performance comparison was made with the performance of proton membrane exchange membrane cells for the large scale application of microbial fuel cells to provide some experimental guidance. After the comparison, that film have larger diffusion coefficient, easy to dissolved oxygen into the anode chamber, causing the consumption of substrate and reducing the coulomb efficiency.

Chemistry specialists at the University of West England Bristol have discovered that urine can be used as a fuel source to power microbial fuel cells (MFCs), which are devices that generate electricity from microorganisms. The team of researchers, lead by Ioannis Ieropoulos, the urine utilization by microbial fuel cells which is published in Physical Chemistry Chemical Physics that this is the first time that the viability of urine as a potential fuel for MFCs has been studied. Microbial fuel cells typically consist of an anode and a cathode, which are separated by an ion selective membrane. Microorganisms like bacteria live in the anode side, where they oxidise fuel sources to generate electrons and protons through anaerobic (without oxygen) respiration. Those subatomic byproducts transfer into the cathode, combining with oxygen to generate electricity.

That fuel source is something biodegradable and organic like wastewater, sugars, glucose, starch and cellulose. In Ieropoulos's experiment, urine is used. It is seen as a good source of fuel because it rich in organic compounds like carbohydrates, nitrogen, potassium, urea and phosphorous. The discovered that pee-power can be used as a fuel source, and found its MFCs were producing small amounts of energy. They believe that by shrinking down the MFCs and stacking them together, it may be possible to produce useful levels of power. Plus, the process inside the MFCs effectively cleans the urine so it can be sadely discharged into the environment, without the need for conventional treatment processes.

Bio-fuel cell (BFC) using baker's yeast was constructed to examine electricity production. Glucose was used as fuel and electricity was produced by the overall

redox reaction in the cell. NeoseptaR membrane was used as proton exchange membrane for separating an anodic compartment and a cathodic compartment. As electron mediator, methylene blue was used for transporting electron from yeast to electrode. Besides, carbon fiber cloth and carbon paper were used as electrodes for comparing the cell performance. Combination of two types of electron acceptor at the cathodic compartment, i.e. potassium ferricyanide and oxygen, were used to optimize efficiency of the system. It was found that electron acceptor affected the voltage generated by the BFC. The best performance was obtained from the system using carbon fiber cloth electrodes and two types of electron acceptors. Open circuit voltage of 450 mV and short circuit current density higher than 165 mA/m2 were obtained. Power density of 18 mW/M2 was obtained at 750 Q load

Rong Lan,, Shanwen Tao and John T. S. Irvine (2010) were has demonstrated the direct urea/urine fuel cells based on low-cost alkaline membrane electrolytes and non-noble catalysts such as nickel, silver and MnO2. Wet air was used as an oxidant at the cathode. For stationary power generation from urine or waste water, high power density is not a stringent requirement as long as the cost of the cell itself is low. High power can be achieved by using an enlarged fuel cell area or increased numbers of single cells. However, for transport applications, higher power density is required. It should be noted that the development of low temperature direct urea fuel cells based on inexpensive materials is still at an early stage. With further optimization, hopefully the power density will be significantly improved. Urea fuel cells have the potential to be used for stationary, portable, transport, space shuttles, submarines and other applications. They can also be used to clean up municipal waste water and generate electricity. Based on this work, it is possible to develop renewable and sustainable urine fuel cells

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will describe the implementation of project. To understand the procedure of project, flow chart is presented as in figure .In this chapter, it will concentrate on experiment to determine which type of metal suitable to use in the process to build prototype of project. There are several ways in gathering information such as thing a cross references from the books and the most important references are referred to related journal, proceedings paper and conference papers. The suitable or relevance testing method or experimental procedures are identifying based on the available equipment or apparatus in the Chemical Laboratory, Faculty of Science, UTHM.

3.2 Overall Experiment

Methodology is an important aspect that needs to be considered to meet the objectives of the project as stated in objectives section. Figure 3.1 show the flowchart has been used to visualize the process flow of the project. The overall experiments of the project are as shown in the flowchart of Figure 3.1.

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