Bio Fuel Cells

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***Abstract*—This research document explores the topic of Bio Fuel cells with a focus on the design of a photosynthetic/metabolic based Bio Fuel Cell.**

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I. Introduction

This document will address the process of a Bio Fuel Cell creating electricity. It will analyze how the processes in which energy rich molecules that are broken down into usable energy by the human body relate to Bio Fuel Cell's energy production. During this analysis two different energy entrapment processes will be discussed. The energy entrapment process of Microbial Bio Fuel Cells and Enzymatic Bio Fuels Cells will be the focus. The more efficient method should be made clear. Also a recent study on the potential use of the botanic cells of cyano-bacteria as catalysts for Bio Fuel cells will be discussed.

II. Bio Fuel Cell

Bio Fuel Cells are energy devices used in the production of electricity. These cells can use naturally occurring food sources, such as energy rich carbohydrate and sugar molecules, as fuel. The way the body converts these molecules into usable energy is very similar to how Bio Fuel Cells create electricity. The electrons are collected during the metabolic process of the biocatalysts, which can be microorganisms or enzymes. In the body food molecules are broken down into digestible molecules and then transported to the Mitochondria of the cell. Once in the Mitochondria the molecules enter the Kreb's Cycle. This is when the molecules are oxidized into CO_2 with the help from redox enzymes. Through the process of respiration the redox enzymes utilize the oxygen to produce energy, water, and CO_2. During respiration the electrons are stored into energy rich molecules called Adenosine Triphosphate (ATP).

III. The Energy Entrapment Process

In Bio Fuel Cell the electrons are coupled to an external electrode during respiration unlike in the human body where the electrons are converted into ATP molecules. Electrochemical cells are used to extract the energy from the sugar molecules into electrical energy.

A. Enzymatic Bio Fuel Cell

In Enzymatic Bio Fuel Cells the redox enzymes are immobilized directly to the electrodes. There is then transfer of electrons from a mediated electron transfer mechanism, which is demonstrated in the figure below.

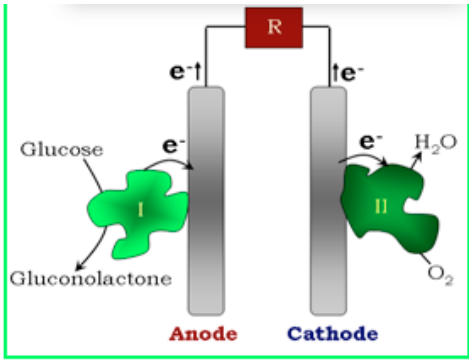


Figure 1. A schematic for a simple Glucose Oxidase/Bilirubin Oxidase based Enzymatic Biofuel Cell

In this example the circuit is an anodic enzyme reaction occurring on one side and then a cathodic enzyme reaction occurring as well. The anode reaction releases the electrons and the cathode reaction captures the produced electrons. In this example, the redox reaction of the anode enzyme is a Glucose Oxidase Reaction, which is the chemical reaction equation below:

$$\text{Glucose} \rightarrow \text{Gluconolactone} + 2\,H^+ + 2\,e^-$$

$$E^o_{(anode)} = -0.36\ \text{V (vs Ag/AgCl) at pH 7.2}$$

As you can see from the equation this reaction produces two electrons that can then be coupled to the electrode of the Bio Fuel Cell. This is the reaction that helps create the electricity.

The cathode reaction is an example of a Bilirubin Oxidase Reaction, and the chemical reaction equation is depicted below:

$$O_2 + 2\,H^+ + 2\,e^- \rightarrow H_2O$$

$$E^o_{(cathode)} = +0.58\ \text{V (vs Ag/AgCl) at pH 7.2}$$

As you can see from the equation two electrons are captured by this process and used to make water.

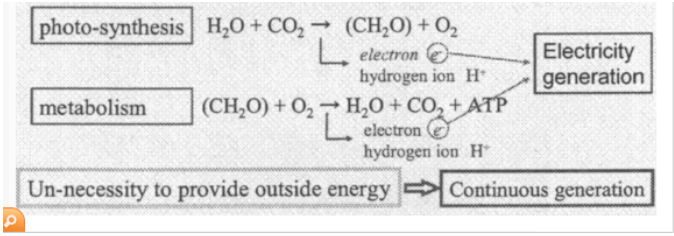
B. Microbial Bio Fuel Cell

In Microbial Bio Fuel Cells the electrochemical coupling couping process is different then in Enzymatic Bio Fuel Cell. In Microbial cells the electron's are coupled by immobiliziing the microorganizms that contain the redox enzymes needed for the process to happen. In most microbial cells there are few enzymes on the outer edge of the cell so the cell efficiency is low since it can not couple with a lot of electrons.

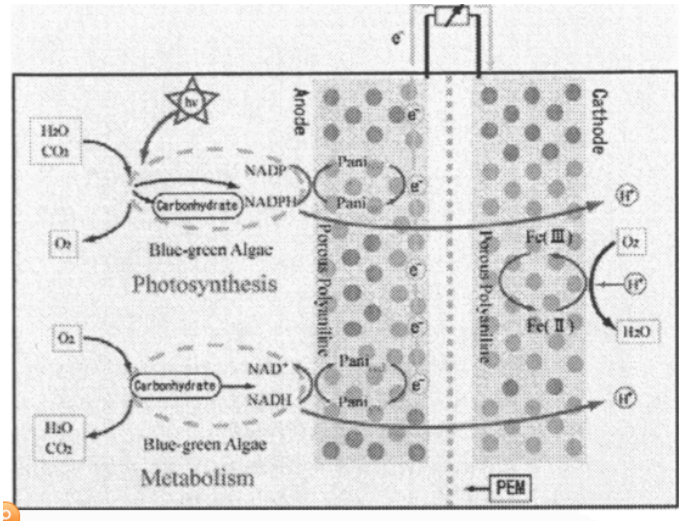
The uses of the botanic cells of cyano-bateria has been experimented as possible Mirobial Bio Fuel Cells because they collect the electrons during the metabolic process and photsysthentic process of the cyano-bateria cell.

IV. Photo-Synthetic Bio Fuel Cell

In the Photo-Synthetic Bio Fuel Cell developed my Mr. Lin, the electricity is generated by collecting the electrons that are born during the metabolic process and the photosynthetic processes inside of the botanic cells of cyano-bacteria. The chemical equations of these reactions are provided below:



As you can see from these chemical equations one electron is produced every time the cells under goes photosynthesis and completes the metabolic process. This is a very environmentally friendly alternative as a potential fuel source for the future since it is no necessary to provide outside energy for the electricity generation to occur. The cyano-bacteria have very simple cell structures since they are just bacteria, and they easy to cultivate and grow more as a catalyst for the Bio Fuel Cell proposed by Lin's team. It is also easy to collect the electrons produced using a similar anode and cathode method depicted below.



The cyano-bacteria only need solar light to live and function, making them a very sustainable and reliable source for a catalyst in a Bio Fuel Cell.

V. Moving Forward

Many impactful innovations still need to be made in this field of study before it can be feasible to have these types of Bio Fuel Cells used in future models of the Lafayette Formula Electric Vehicle. From this paper students should be able to understand the fundamentals of Enzymatic and Microbial Bio Fuel Cells and see their potential as clean energy sources for the future. Hopefully with more research and experimentation using cyano-bacteria as a catalyst for Bio Fuel Cells we find a way to sustainable and clean source of electricity.

References

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