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Electricity Generation From Plants

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Abstract: Living plants can yield electricity by creating an interaction between the plant and plus two distinct metals. It offers a green way to gather energy from readily available sources, therefore it has significant promise for sustainable energy production. Previous research has demonstrated that the mechanism of energy creation is attributed to the electrochemistry process. This study models and illustrates the behavior of the ions flow in the electrodes-plant system. Zn-Cu electrodes and aloe vera were utilized in an energy harvesting device for this purpose, with the electrodes submerged in the aloe vera leaf. Zinc atom oxidations were thought to happen during the energy harvesting process when an outside force is linked between the two electrodes. The zinc electrode lost 3.2 mg of mass during the course of the 72-hour harvesting operation, compared to the electrochemistry forecast of 0.0853 mg with a 1MΩ load. Nevertheless, while utilizing a lower load resistor (1kΩ), the zinc's observed mass loss grew to 6.7 mg as opposed to the 4.0452 mg estimate. This indicates that efficiency increases with lower load resistances—60.4% for 1kΩ and 2.67% for 1MΩ. This demonstrates how the load attached to the system affects the electrochemistry process. This discovery enhances our comprehension of the system's energy generating mechanism. Elektronik harus bisa diperlengkapi oleh tumbuhan hidup dengan memberi tindakbalas di antara tumbuhan dengan berbagaian logam yang berbeza. This keddah has a high potential for tenaga mampan owing to the tenaga's electronic Jana. This challenge is based on using cutting-edge technology from a resurgent punch. Researchers eventually come to the conclusion that the successful Tenaga penjaanan mechanism is the result of the electrochemical process. In this work report, the characteristics of the ion transduction system are modelled and illustrated. For this purpose, the algae-feeding system consists of Zn-Cu electrolyte and aloe vera leaves that have been soaked in water. It is hypothesized that during the penuaian tenaga process, ia penyaksidaan adalah pada atom zink sebagaimana beban disambungkan di antara dua elektrod berkenaan. In the 72-hour penuaian process, the zinc electrode experienced a zinc loss of around 3.2 mg, in comparison to the zinc loss of 0.0853 mg when 1 MΩ was used. For more sensitive readers (1k\), Jusim pengurangan diukur meningkat kepada 6.7 mg, terhadap sebagaimana ramalan iaitu sebanyak 4.0452 mg. This indicates that the system's capacity increases when more highly productive resources are used, specifically 60.4% for 1kΩ compared to only 2.67% for 1MΩ. This indicates that the electrochemical process is hampered by a Beban printing that malfunctions within the system. The entire study improves understanding of the tenaga penghasilan mechanism in the system.

Index Terms - Living plants, Electricity generation, Zn-Cu electrodes, Aloe vera, Electrochemical process, Ion flow, Energy harvesting, Sustainable energy, Zinc oxidation

I. INTRODUCTION

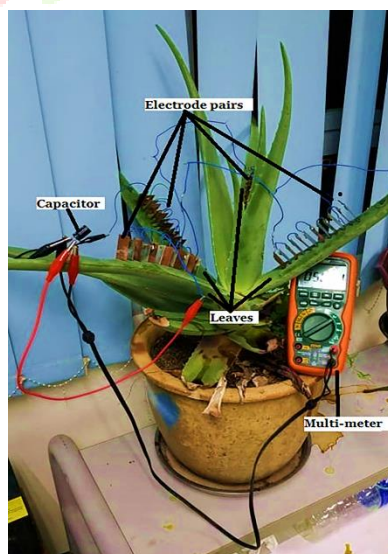
A lot of research has been done on renewable energy sources in an attempt to protect the environment and our future. From an environmental perspective, benefit management techniques are offered by converting to renewable energy sources for the production of electricity. Among the most popular choices for renewable energy sources are wind, solar, ocean, and ambient power harvesting using piezoelectric technology. A technique called "plant-based energy generation" uses live plants to produce electricity. Harvesting energy from living plants is not only economical and ecologically sustainable, but it also has a plentiful supply of energy in the area. It is possible to transform this endless supply of energy—which is present all around us—into useful electric power. Many of the safety issues related to fossil fuels are absent when using plant-based energy source.

According to earlier research, living plants can produce bioelectricity by using the process of photosynthesis to convert sunlight into electricity. Without reliance on fossil fuels, this invention might provide an endless source of reliable, clean energy. More recently, Choo & Dayou introduced some basic methods for extracting weak power from living plants. These methods include choosing the right harvester, choosing the right kind of plant, and perhaps applying the method. By employing Flame Atomic Absorption Spectroscopy (FAAS) to further explore the source of energy production, it was discovered that the electrochemistry process is in charge of the mechanisms. In this study, the energy source is referred to as a living-plant fuel cell (LFC). By inserting a pair of electrodes into the plant, it transforms chemical energy into electrical energy. The basic concept is that living plants' organic content will be used as the electrolyte in a combination of electrodes to produce energy.

LFCs are gaining more and more interest primarily because they make it possible to directly harvest electricity from living plants. The mechanism of LFC energy production is modelled in this paper. The zinc electrode's decreased mass is measured and compared to the estimated equivalent mass in order to validate the suggested model. Section II provides an explanation of the experimental works in detail. The findings imply that the origin of the energy production in LFC may be modelled according to the principle of electrochemistry with necessary focus on the efficiency effect.

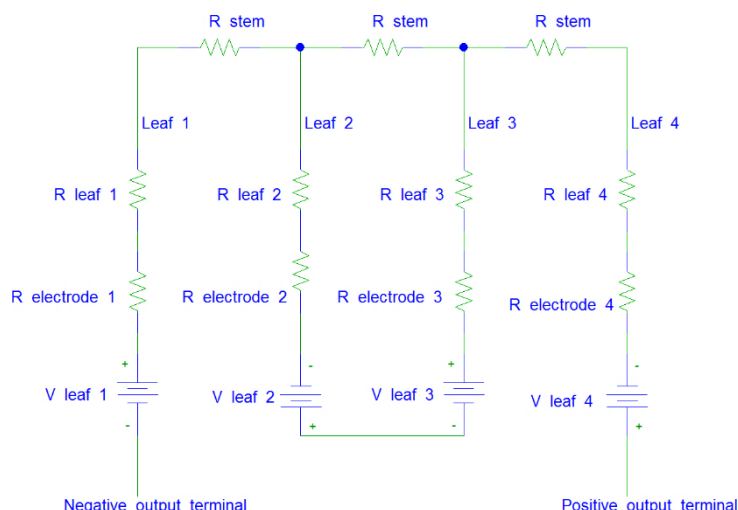
I. RESEARCH METHODOLOGY

Based on earlier research, it is assumed that electrochemistry is the source of the mechanisms generating the weak electricity in living-plant fuel cells, or LFCs. The goal of this work is to model the electrochemistry-based power generation in lithium-ion batteries (LFCs). In the experiment described in this study, an LFC system is created by embedding two clean copper and zinc electrodes within an aloe vera leaf. As seen in Figure 1, the cell is linked to a load consisting of a $1\text{M}\Omega$ resistor. At either end of the load, free end wires are provided so that a digital multimeter can measure voltage as needed.



For three days, the LFC (loaded to $1\text{M}\Omega$) was operated. Subsequently, the electrodes made of copper and zinc were thoroughly cleaned using distilled water and allowed to air dry. Sartorius TE214S was used to measure the weight before and after the experiment to the closest milligram in order to evaluate the mass

reduction, which was then compared with the theory. Measured mass loss (ML) is the reduced mass of zinc obtained by deducting the electrode's initial weight from its final weight. However, the anticipated equivalent mass (EM) is determined using Faraday's principle, which is covered in more detail in the comparison's later section.

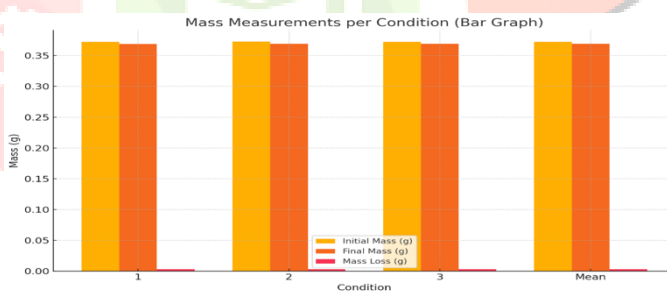


IV. RESULTS AND DISCUSSION

The zinc electrode's measured ML before and after the experiment is displayed in Table 1. It is evident that the mass loss of the remaining zinc electrode, which was running up to 3.2 mg is three days. The projected equivalent mass (EM), which is calculated as follows, is then compared to the value.

Table 1 shows the zinc electrode's measured mass in grams both before and after the experiment.

Condition	Initial Mass (g)	Final Mass (g)	Mass Loss (g)
1	0.3722	0.3690	0.0032
2	0.3726	0.3694	0.0032
3	0.3725	0.3692	0.0033
Mean	0.3724	0.3692	0.0032



The weight of materials discharged into a solution or media during the electrochemistry process is directly proportional to the current flowing through the electrochemical cell, which is often measured in grams equivalent mass, according to Faraday's law. The mass m of the zinc discharged into the media for a specific electrical current flowing in the LFC system should be expressed as where N_a is the Avogadro's number, which is given by $6.023 \times 10^{23} \text{ mol}^{-1}$, M is the molar mass of zinc, which is 65.39 g/mol , Q is the total electrical charge flowing in the circuit, which is given by the multiplication of current and time $Q = It$, or in unit coulombs. The electronic charge, e , is 1.6×10^{-19} coulombs. First, during the experiment, the voltage, V across the $1\text{M}\Omega$ load, was regularly measured to obtain Q . The results are shown in Table 2. The $Q = (v/R)t$ connection was then used to obtain Q by taking the average value, which is 0.970V . The overall charge from the zinc dissolving reaction is $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e$, which represents the zinc atoms that are discharged into the media.

With this data, (1) is used to calculate the anticipated EM, which is found to be 0.08 mg . Consequently, the measured value ML is 3.12 mg higher than the EM in comparison.

Table 2: Voltage measurements, V , over three days for $1\text{M}\Omega$ utilized

Day	Voltage (V) at 0900	Voltage (V) at 1200	Voltage (V) at 1500	Daily Average Voltage (V)
Day 1	0.959	0.968	0.959	0.962
Day 2	0.962	0.964	0.980	0.969
Day 3	0.980	0.979	0.980	0.980
Total Average	0.970			

The efficiency effect is probably the reason for the discrepancy between measured ML and projected EM. This effect describes the electrons' mobility efficiency through the load ($1M\Omega$) in the circuit and is determined by the ratio of input to output electrons. The illustrated diagram of the total electrons emitted in the media (aloe vera) and the electrons passing through the load is shown in Figure 2(a).

The living-plant fuel cell is modelled in an equivalent circuit as shown in Figure 2(b) to explain the efficiency effect. The electron input of the system is determined by the total number of electrons emitted by the zinc in the media. Conversely, the entire amount of electrons that pass through the load are known as the output electrons.

In this experiment, the electron output can be represented as the total electron charge (QO) that passes through the load. Making use of the relationship. It is discovered that the output electron charge is $QO = 0.2514C$ (all symbols are as previously stated). However, the overall electron charge (or input).

Rearranging (1) yields the charge, QI, released by the zinc electrode in the medium.

It was discovered that $QI = 9.4319C$ provides the input charge. With this data, the effectiveness is determined to be or 2.67%. It is evident that the system is not particularly efficient, and the following explanation explains why.

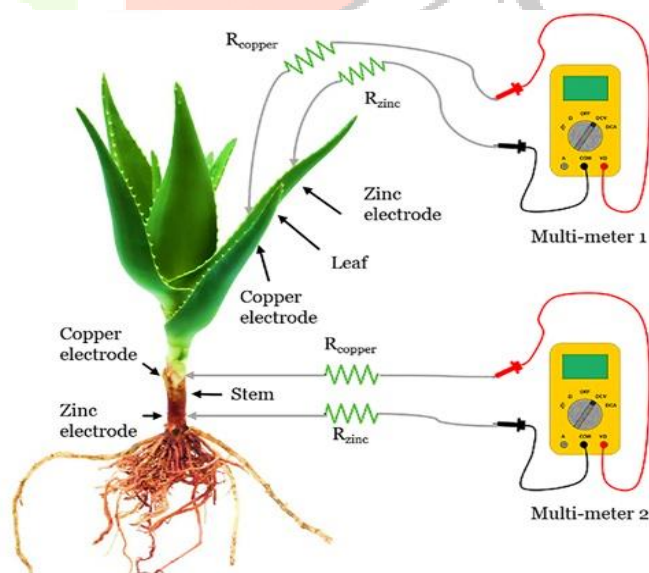
There are two types of electrons released by the zinc atom in the medium (aloe vera): conducting and non-conducting. Electrons that pass through the load are known as conducting electrons (see Figure 1). Nevertheless, some electrons—known as nonconducting electrons—move to copper through the media (aloe vera) rather than passing through the load. Only the conducting electrons—that is, the nonconducting electrons—are measured by the total charge in equation (2). Conversely, the entire dissipation of the zinc atom into the medium (aloe vera) that forms both the conducting and non-conductive electrons is the observed ML.



A



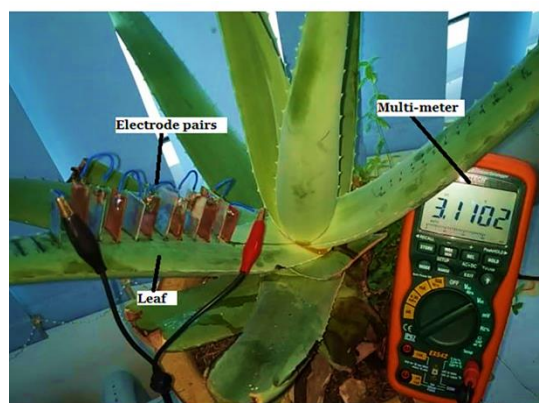
B



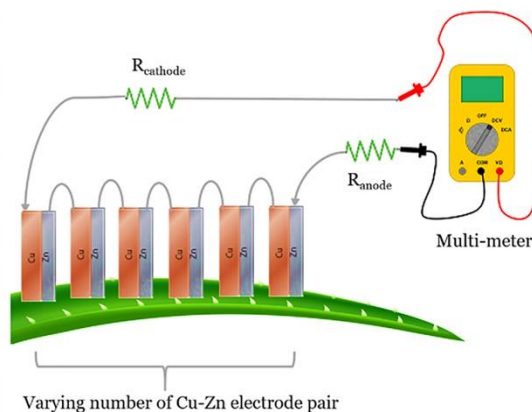
C

The resistance in the system controls the LFC's efficiency. Resistance is divided into two categories: external resistance (R_{ext}) and internal resistance (R_{int}). Where Figure 2 illustrates the former and later, which stand for the resistance of the aloe vera plant and the resistor employed, respectively. There is little resistance in the medium (aloe vera) due to the near proximity (0.5 cm) of the copper and zinc electrodes. Because the internal resistance is noticeably lower than the external resistance in this way, the observed ML is significantly larger than the anticipated EM, which is explained by more non-conducting electrons move across the area being monitored.

It is predicted that using a lower load resistance will improve system efficiency. A similar experiment is carried out, but a $1\text{k}\Omega$ resistor is used in its place to demonstrate this. Table 3 displays the voltage profile across the resistor over the course of three days, and Table 4 shows the corresponding measured ML. Equation 1-4 predicts that the EM for $1\text{k}\Omega$ load will be 4.05 mg , which is 50 times more than the EM for $1\text{M}\Omega$ load, which is 0.0852 mg . The ML is 2.65 mg greater than the EM for the $1\text{k}\Omega$ load (see Table 4). This works out to 60.4% , which is far more than the 2.67% that would be obtained with a $1\text{M}\Omega$ load. This indicates that when reduced load resistance is employed in LFC, more electrons flow through the load.



A



B

Table 3: Voltage measurements, V, over a three-day period for $1\text{k}\Omega$ utilized

Day	Voltage (V) at 0900	Voltage (V) at 1200	Voltage (V) at 1500	Daily Average Voltage (V)
Day 1	0.067	0.070	0.059	0.065
Day 2	0.031	0.040	0.042	0.038
Day 3	0.037	0.028	0.037	0.034
Total Average	0.046			

Table 4: displays the zinc electrode's ML in grams both before and after the experiment with a $1\text{k}\Omega$ load.

Condition	Initial Mass (g)	Final Mass (g)	Mass Loss (g)
1	0.3817	0.3751	0.0066
2	0.3816	0.3752	0.0064
3	0.3817	0.3748	0.0069
Mean	0.3817	0.3750	0.0067

Table 5: Summary of Results at $1\text{M}\Omega$ and $1\text{k}\Omega$

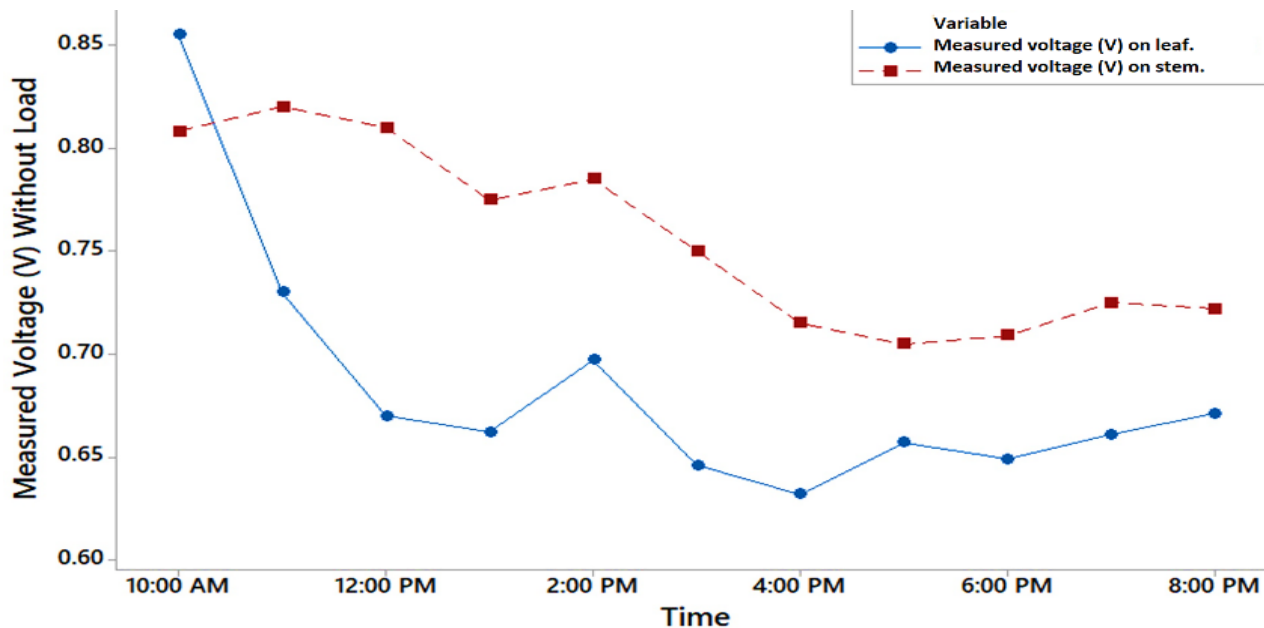
Resistor	Measured Mass Loss (mg)	Predicted Mass Loss (mg)	Input Charge QIQ_I (C)	Output Charge QOQ_O (C)	Efficiency (%)
$1\text{M}\Omega$	3.2	0.0853	0.2514	11.9232	2.67
$1\text{k}\Omega$	6.7	4.0452	9.4319	19.7481	60.4

The final summary for the two resistances tested, measured ML, expected EM, input charges (QI), output charges (QO), and efficiency is shown in Table 5. According to Table 5, the measured ML at $1\text{M}\Omega$ is roughly twice as low as $1\text{k}\Omega$. Since resistance is an obstacle to the flow of electrons, a higher resistance corresponds to a lesser flow of electrons. When a $1\text{M}\Omega$ resistor is loaded, eventually less conductive electrons are induced along the wire. As a result, the rate of subsequent oxidation is slowed down at the zinc electrode due to a group of stranded electrons becoming saturated (Figure 3). However, when $1\text{k}\Omega$ was utilized, the LFC was in its non-saturated state, which led to a greater successive rate of oxidation, higher ML, and higher efficiency.

The general electrochemistry-based model of the LFC is shown in Figure 4. In the process of electrochemistry, the direction of the relative ease of oxidation of the electrode materials influences flow in a cell. Because zinc is more reactive than copper, it releases electrons more easily. As a result, electrons go from zinc to copper via an external wire. Because of the system's faster oxidation rate than electron transport, a cluster of stranded electrons accumulate at the zinc electrode.

Electrons that traverse the wire are conductive (shown by red) and nonconductive (represented by yellow) as they pass through the aloe vera gel. The system's sequential rate of oxidation controls the efficiency effect.

Graphs



Literature References

Sustainable and renewable energy sources have become a topic of critical research for the environmental problems that fossil fuel use has generated. Among the new alternatives is electricity generation from living plants, referred to as living-plant fuel cells (LFCs). It seeks not only to harness bioelectricity in an eco-friendly manner but also to create a new alternative electricity generation method by tapping the electrochemical interactions that take place between plant tissues and metal electrodes.

Choo and Dayou's earlier research showcased the possibility of weak unaided electrical energy extraction from plants when appropriate electrode materials and configuration techniques are employed. Their modeling of the electrochemical nature of plant-based systems provides an elementary understanding of LFC mechanisms. Likewise, Kaku et al. studied electric power production in rice paddy fields, emphasizing the relationship between the plant roots and microbial community responsible for enhancing the electrochemical activity. These studies lay down the feasibility of plant-microbes interaction and ionic interchanges to be pertinent mechanisms for bioelectricity generation.

The new research has mainly focused on optimizing electrode materials and configurations. Zinc and copper electrodes are commonly used for their advantageous redox characteristics. The electrochemical reaction, predominantly zinc oxidation, was recognized as the principal reaction contributing to the flow of the electrons from these electrodes into the plant tissues like the aloe vera plant. The efficiencies achieved in such systems are greatly dependent on external load resistance, which affects electron conduction rates and the measurable mass loss from the electrodes.

By experimenting on Zn-Cu electrodes immersed in aloe vera to mass loss measurement with time concomitant with the theoretical values obtained from Faraday's laws, this provision would be further strengthened. Analysis of different load resistances-resistances of 1 M Ω and 1 k Ω -will establish that less resistance guarantees improved efficiency thus, proving electrochemical modeling as a predictive tool for LFC performance.

II. ACKNOWLEDGMENT

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