Electricity generation from PKL plant for home appliances in off grid areas

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Abstract

This study project is very inventive for global power generation systems. In off-grid locations, this kind of power may be generated in the home. It's fascinating that this DIY PKL (Pathor Kuchi leaf) electricity worked so well with a 6 V DC. The Bryophyllum pinnatum leaf is the PKL's scientific name. The research looked at the effects of variations in electrolyte concentration on maximum power (Pmax), load power (PL), load voltage (VL), and load current (IL). It is determined that this DIY PKL technology is workable and suitable for real-world application in off-grid locations worldwide. The majority of the findings have been described graphically and tabulated.

1. Introduction

In our nation, people are really interested in using solar energy. But using a battery at night has some challenges[1]. There are batteries on the market, but their lifetime is not very excellent. Storage battery issues are plaguing people[2]. One of the biggest issues facing the modern world is the energy dilemma. To fulfill the demands of the world's rapidly growing population[3], scientists and engineers are working around the clock. The traditional or current fuel sources are efficient but not very dependable due to a number of significant issues, such as carbon emissions and a lack of reservations. The must primarily switch to alternative energy sources in order to satisfy the demands of future generations and prevent pollution of the global environment[4]. This presents the idea of renewable energy, which is a form of unconventional energy. There are several types of renewable energy. These include, but are not limited to, solar, wind, hydro, and biomass. Since the power produced from biomass sources is green energy that is, ecologically friendly biomass energy has lately been the subject of analysis worldwide[5]. The Bryophyllum leaf, often referred to locally as Pathor Kuchi Leaf-PKL, is the subject of this proposed effort. This leaf's malt has the ability to generate electricity. We will conduct an electrochemical analysis of the power produced by the PKL juice or malt in the subsequent sections of the study. Bryophyllum leaf, also known as Pathor Kuchi leaf, is commonly referred to as BPL or PKL. Through chemical processes, power is produced from the juice or malt[6-11].

2. Proposed System

In this work, electricity generation by using PKL is proposed, and their outputs are compared with different concentrations of $CuSO_4$. For maximum output, the concentration of the $CuSO_4$ is as good as possible. However, the concentration cannot be decreased further beyond a certain value due to better output voltage. Therefore, to improve the output, five cases are proposed. They are explained in detail in this paper.

2.1. Electrode selection

CuSO4, BPL extract as an electrolyte, and Zn and Cu plates as electrodes were used to build a Zn/Cu-BPL bioelectrochemical cell in this suggested system. The electrolyte of the cell was a 5H2O solution. The electrons in this cell react with H+ and Cu2+ ions after the copper plate obtains electrons and the zinc plate loses them. Ions eventually transform into Cu and H_2 atoms, respectively. Following the discharge of H_2 gas from the cell, copper atoms are placed on the Cu plate. Figure 1 illustrates the configuration of the electrode.

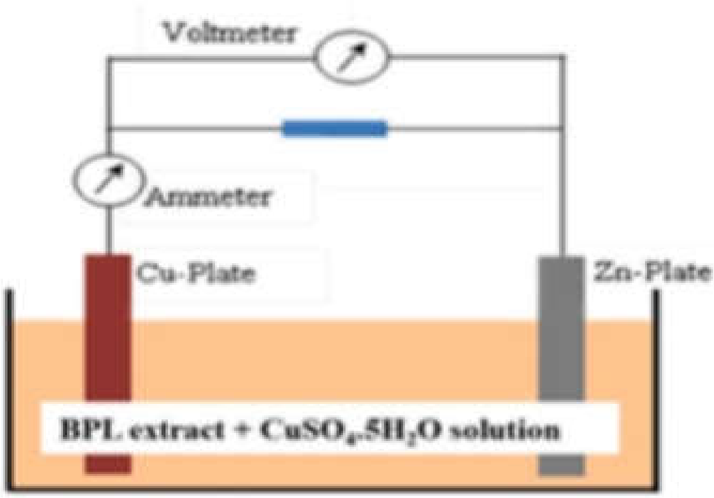


Fig1.Electrodes arrangement

2.1.1 Electrode:

Anode:

On account of its high electrolytic pressure, zinc passes into the solution as zinc ions; each ion leaves two electrons at the electrode. The process will continue until an equilibrium is reached between the electrode and the solution. At equilibrium, there will be potential difference between the electrode and the solution.

Cathode:

At this electrode, copper ions gain electrons and are reduced to metallic copper, which is deposited at the copper electrode (Reducing Electrode) When the two electrodes are connected by a wire, the excess electrons on the zinc electrode flow along the wire in order to neutralize the positive charge on the copper electrode. This movement of electrons from zinc to copper produces a current in the circuit.

2.1.2 Electrodes Placement

For electrolytic studies, the analyzed PKL Malt/Juice/Sap put in between Zn and Cu flat parallel electrodes with various surface areas separated by say a 0.5 ± 0.1

cm gap and discharged using an external load. Using this process, we get a PKL unit cell, module, Panel & arrays.

2.2 Chemistry of the PKL Electricity

For organic reactions, it is not straightforward to assign oxidation numbers by simply looking at the formula, thus, a slightly different perspective is used. The process of oxidation involves either a loss of H or a gain of O.

$$CH_3OH \rightarrow H_2CO$$

$$H_2CO \rightarrow HCOOH$$

Reduction (either a gain of H or loss of O)

$$HCOOH \rightarrow H_2CO$$

$H_2CO \rightarrow CH_3OH$

Reactions at anode and cathode:

Oxidation process: $Zn = Zn^{2+} + 2e^-$

Reduction process: $Cu^{2+} + 2e^- = Cu$

Hydrogen evolution: $2H^+ + 2e^- = H_2$

Production of Electricity

When the connections of electrodes are ready we are at the final stage of producing electricity from PKL. At this stage the final task is to pouring the juice of PKL to the container or pot where the electrodes are placed. A chemical reaction is than taken place, which in turn, creates positive and negative potentiality around the plates. Now if we connect the zinc and copper plate through a proper load the current will flow from the cell to the external circuit. Oxidation will occur at anode (zinc) and reduction at the cathode (Cu^{2+} and H^{+}). This will create a movement of electrons from zinc to copper and will produce current in the circuit. The net cell reaction will be as $Zn + Cu^{2+} + H^{+} \rightarrow Zn^{2+} + Cu + H_2$, Where the reactant ions are Cu^{2+} and H^{+} and the product ion is Zn^{2+}. Thus metal at anode losses electrons and dissolved and metal at cathode gains electrons and grows.

Electron Transfer

The electron transfer reaction denotes the central reaction step where the electrical changes are exchanged. Current flow affords additional forces because of an energy barrier that has to be surmounted by electrons. The required additional energy is called activation energy and the dependence of reaction rates is expressed by the Arrhenius equation.

2.3 Parameters of PKL cell

2.3.1 Temperature

The Arrhenius equation in connection with the term ‘activation energy’ can explain the kinetic parameters of the PKL unit cell, which are dependent on temperature.

2.3.2 Internal Resistance

The capability of the PKL battery to handle a certain load is determined by the following relation: Ri = ∆i /∆v,where, Ri = Internal Resistance, ∆i = Current changes and ∆v = Voltage changes.

2.3.3 Capacity

Capacity means how much current you will get for how long time. The Capacity of single BPL cell is obtained by the following relation, C *Ah* = I. ∆t Ah , where, C *Ah* = Capacity in AH, I= current in amp and ρt = time in hour.

2.3.4 Age of the PKL

In the research work, it is shown that the efficiency for electricity generation from the PKL varies with the age of the PKL.

2.3.5 Concentration of the PKL Extract

The voltage generated from the PKL varies with the concentration of the PKL malt/juice/sap. That is voltage, V_{ra}, where r is the concentration of the juice and v is the voltage of the cell.

2.3.6 Area of the electrodes

The voltage generation from the PKL is directly proportional to area of the electrodes. Vra is the voltage, where r is the juice concentration and v is the cell voltage.

2.3.7 Distance between two electrodes

The voltage generation varies with the distance between two electrodes. It is shown that voltage decreases with the increase of the distance between two electrodes.

2.3.8 Temperature effect of the Extract

It is shown that the voltage variation can be expressed by the relation: $\Delta V = K \Delta \times T \times Ncs$, where, ΔV = Change of voltage, K = coefficient factor, ΔT = Change in temperature, Ncs = No. of PKL Unit cell connected in series.

2.4 Performance Study of PKL Electricity

A brief description of the tests conducted to study the electricity generation from different stages of PKL is given by the following.

2.4.1 Energy Efficiency of the PKL Electricity

The efficiency of the different types of PKL have been studied. The conversion efficiency of different stages PKL electric panel have been given by the following:

The, Energy Efficiency = E_D/Ec , Where, E_D = Total energy during charging, E_C = Total energy during discharging Now if V_C = Charging Voltage (Volt), I_C = Charging Current (Ampere), TC = Charging time (Hour), Then $E_C = V_C I_C T_C$ Again if V_D = Discharging Voltage (Volt), I_D = Discharging Current (Ampere), T_D = Discharging time (Hour). Then $E_D = V_D I_D T_D$. Therefore, we can write, the energy efficiency= $(V_D I_D T_D)/(VcIcTc) = (V_D/Vc)(I_D T_D/IcTc)$. where, Voltage efficiency = (V_D/Vc) and Coulomb efficiency = $(I_D T_D/IcTc)$. At the beginning of charge cycle of a lead acid battery Coulomb Efficiency is near about 100%. But near end of charge cycle Coulomb Efficiency reduces due to electrolysis of water. If we consider the, Voltage Efficiency = 88% and Coulomb Efficiency = 90%. Then overall Energy Efficiency = (88%) × (90%) = 79%.

A single PKL module made by Zn/Cu based electrodes. There are 6 compartments in the PKL module that are connected in series combinations. The Zn and Cu plates are connected in parallel within each compartment. The plates are connected by copper wires. It is fabricated by two PKL modules that are connected in series combinations. The box of each PKL module is made of insulated plastic. Series combinations link the PKL modules together.

2.5 Electrolyte of the PKL cell

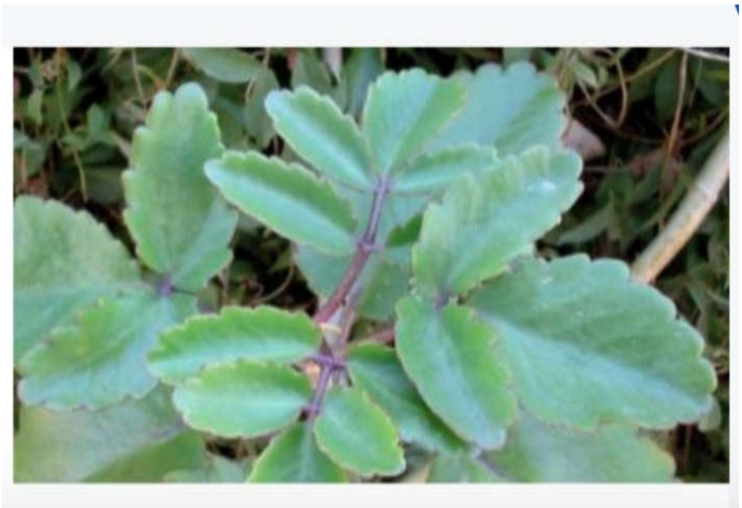
PKL acts as an electrolyte. There are 4 types of PKL electric panels. Such as:
1. Early stage PKL electric panel : We consider this stage for growing PKL within 15 days old. The conversion efficiency is low at this stage.

2. Middle stage PKL electric panel: We consider this stage for growing PKL within 30 days old. The conversion efficiency is higher than in the early stage.

3. Pre-matured stage PKL electric panel: We consider this stage for growing PKL within 45 days old. The conversion efficiency is higher than the middle stage.

4. Matured stage PKL electric panel: We consider this stage for growing PKL within 60 days old. The conversion efficiency is higher than the premature stage.

The maximum output of the PKL electric panel depends on different parameters. Such as the age of the PKL, concentration of the PKL extract/malt/juice, area of the electrodes, distance between two electrodes, temperature of the extract/malt/juice, ambient temperature of the laboratory, influence of the light, and pH of the PKL extract/malt/juice, etc.



2.5.1 PKL juice preparation

20 g of fresh BPL was washed thoroughly with tap water and then with deionized (DI) water several times. Then clean leaves were crushed to make a fine paste. Thereafter, 100 ml of DI water was added to the leaf paste, and the solution was filtered to eliminate residual solids.

At first we took Pathor Kuchi leaf and blended it with water in a blender machine. Consequently, we prepared a 50% solution of PKL juice, sap, and malt. This solution of PKL Juice/Sap/Malt has been used for electricity generation. Once a mixture is prepared for producing electricity, it serves the purpose for 6 months continuously.

2.5.2 Juice mixing with secondary salt

The juice was made with different concentrations: 0.4002M, 0.6002M, and 0.8002M. To get better performance, $CuSO_4$ was mixed with prepared juice, which acts as an electrolyte.

The mixture of organic acid and Cu salt (Cu-citrate) of that organic acid in solution acts as a buffer solution. Because weak acid and it's salt are buffer solutions.

Copper (Cu) electrodes can help speed up the process of breaking down organic acids. Catalytic activities of metal: Pb-Sn-Zn-Cu-Ag-Fe-Ni-Pd-Pt. The electrochemical series is given by the following: Li-K-Ca-Na-Mg-Al-Zn-Fe-Sn-Pb-H_2–Cu-Hg-Ag-Au.

3. RESULTS AND DISCUSSION

In our proposed work the various cases were analyzed to get maximum output. The results are taken for the following cases.

CASE 1:

In this case pure PKL extract is taken as an electrolyte with a load of a resistor. Voltage and current values are tabulated for three different quantities of electrolyte.

PKL EXTRACT(ml)	VOLTAGE(V)	CURRENT(mA)
100	0.80	0.91
200	0.74	1.16
500	0.71	1.36

Table 3.1

CASE2:

10 0 ml of

PKL EXTRACT(ml)	$CuSO_4.5H_2O$ (ml)	VOLTAGE (V_L) in V	CURRENT (I_L) in mA
100	5ml,(0.4M)	0.72	8.50
100	5ml,(0.6M)	0.75	10.25
100	5ml,(0.8M)	0.73	14.35

PKL extract, 5 ml of $CuSO_{4\cdot 5H_2O}$ solution with different concentrations with a load of 1Ω resistor. We do an observation on 100 100ml of PKL extract with copper sulfate on various concentrations (0.4, 0.6, 0.8).

Table 3.2

CASE 3:2 00 ml of PKL Extract,5 ml of $CuSO_4.5H_2O$ solution with different concentration with load of 1Ω resistor.

PKL EXTRACT(ml)	$CuSO_4.5H_2O$ (ml),different concentration	VOLTAGE (V)	CURRENT (mA)
200	5ml,(0.4M)	0.77	9.74
200	5ml,(0.6M)	0.71	12.1

200	5ml,(0.8M)	0.73	15.12

Table 3.3

CASE4: 5 ml of $CuSO_4.5H_2O$ solution with different concentration

$CuSO_4.5H_2O$ (ml),different concentration	**VOLTAGE (V)**	**CURRENT (mA)**
5,(0.4M)	0.70	1.95
5,(0.6M)	0.83	4.2
5,(0.8M)	0.67	2.66

Table 3.4

CASE 5: Two set of electrodes with different concentration of copper sulphate solution on 200ml of PKL extract

PKL extract (ml)	$CuSo_4$ (ml)	Voltage (V)	Current (I)
200	-	1.71	3.03
200	5ml (0.4M)	1.93	4.75
200	5ml (0.6M)	1.99	6.96
200	5ml (0.8M)	1.99	6.80

Table 3.5

3.1 Comparison of cases

Cases	**Solution**	**Voltage (V)**	**Current (mA)**
Pure Extract	100	0.80	0.91
	200	0.74	1.16
	500	0.71	1.36
100 ml Extract	0.4 M $CuSO_4$	0.72	8.50
	0.6 M $CuSO_4$	0.75	10.25
	0.8 M $CuSO_4$	0.73	14.35
200 ml Extract	0.4 M $CuSO_4$	0.77	9.74

	0.6 M $CuSO_4$	0.71	12.1
	0.8 M $CuSO_4$	0.73	15.12
200mlExtractwith	0.4 M $CuSO_4$	1.93	4.75
	0.6 M $CuSO_4$	1.99	6.96
	0.8 M $CuSO_4$	1.99	6.80
5 mlwith H_2O	0.4 M $CuSO_4$	0.70	1.95
	0.6 M $CuSO_4$	0.83	4.2
	0.8 M $CuSO_4$	0.67	2.66

4. CONCLUSION

Both electrical and chemical parameters have been studied for different concentrations of the PKL juice. The effect of the secondary salt (copper sulfate) has been studied. It is shown that the efficiency varies with the variation of the concentration of juice and the percentage of copper sulfate in the PKL juice. Here we conclude that the voltage and current rating are increased in the $CuSO_4$ mixed solution when compared to pure PKL extract. The 0.6M concentrated copper sulfate solution mixed extract will give better results when compared with others.

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