A study on harvesting of PKL electricity

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Abstract

The efficiency of any electric cell or battery is very important. To keep it in mind it has been studied the columbic efficiency, voltaic efficiency and energy efficiency of a PKL (Pathor Kuchi Leaf) Quasi Voltaic Cell or Modified Voltaic Cell. It was found that the columbic efficiency data illustrated that this efficiency was lower comparing to other efficiencies may be the absence of salt bridge or separator between the electrodes. Because, our designed and fabricated PKL cell does not have any salt bridge. So that the internal resistance is lower than the traditional voltaic cell and as a result more current was found. The voltage and current changes with time and I–V characteristics for PKL unit cell, module, panel and array have also been studied. It is shown that the voltaic and energy efficiency have been studied. However, the highest efficiency was obtained for 40% PKL sap with 5% secondary salt in 55% aqueous solution, which implies that the concentration of PKL juice can play an important role regarding efficiency. It was also found that the average energy efficiency was 97.43% and it was also found that the average voltaic efficiency was 57.29%. Finally, morphological study FESEM (Field Emission Scanning Electron Microscopy) has also been performed. It is seen that the results confirmed that Zn was deposited on the Cu surface during the electro deposition process in PKL solution. Using AAS, it has been measured the concentration of $[\text{Cu}^{2+}]$ as a reactant ion and the concentration of $[\text{Zn}^{2+}]$ as a product ion those have been tabulated and graphically discussed. The variation of pH has also been studied with time and which was also tabulated and graphically discussed.

1 Introduction

PKL power is good and least expensive option today in the small power range in remote and rural areas (Akter et al. 2017; Guha et al. 2018; Hamid 2013; Hamid et al. 2016). PKL electric systems are now available everywhere for easy installation with all necessary accessories in a competitive market. These are being used along with the conventional system in many developed and developing countries (Haque et al. 2018; Hasan and Khan 2016, 2018a). In Bangladesh most of the electricity generators are run by indigenous has and generation is also very low (Hasan and Khan 2018b; Hasan et al. 2016a). The

actual demand of electricity is much higher than the electricity supplied at present PV electricity is receiving wider acceptance every year in Bangladesh especially in remote and rural areas due to their various advantages (Hasan et al. 2016b, 2017a, b, 2018; Hassan et al. 2018). For utilizing PKL energy efficiently and cost effectively optical design of the PKL systems with proper knowledge of the devices and system components is very important. Some examples of application of PKL system in our rural areas are as: education, charging cellular phone, lighting rice mill, lighting saw mill, lighting grocery shop, lighting tailoring shop, lighting clinic, lighting restaurants, bazaar, water pump, radio TV and computer train. To keep it in mind, we have studied the output behavior of the PKL bio-electrochemical cells. By analyzing the experimental data obtained from AAS, UV–Vis, pH metric analysis and visual inspection of the PKL cell we can conclude the findings as follows—from AAS, UV–Vis, and pH metric analysis it is found that both Cu^{2+} and H^{+} ions simultaneously reduces with the progress of electrochemical reaction whereas the concentration of Zn^{2+} increases rapidly. Thus we can infer that H^{+} and Cu^{2+} ions behave as reactant species i.e., act as oxidant while Zn behaves as

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reluctant species. However, the visual inspection and the reduction of weight of Zn plates also strongly support that Zn electrode is the main source of electron. On the other hand from the collected data we can decide that the potential and current flow decreases with the decrease of concentration of H^+ and Cu^{2+} ions in solutions. The researcher has also studied the characterizations for PKL electrochemical cells. The morphology of zinc (Zn) deposits was investigated as anode for aqueous PKL batteries. The Zn was deposited from zinc to PKL extract in direct current conditions on a copper surface at different current densities. The surface morphology characterization of Zn deposits was performed via field emission scanning electron microscopy.

2 Methods and materials

2.1 Theory

2.1.1 Charging process

When Zn and Cu plates dipped into the PKL extract then the charging (charge without load) reactions at anode and cathode compartments (Hossain et al. 2017; Islam et al. 2018; Khan 1998, 1999, 2008a) are given by the following:

Cathode compartment: $An + xe^- \rightarrow A(n-x) + (n \geq x)$
and anode compartment: $Bn + -xe^- \rightarrow B(n+x) +$

2.1.2 Reactions at anode and cathode

When the electrolysis process occurs via direct current, more electrons move toward the negative electrode. Within the PKL electrolytes, the negative electrodes are surrounded with Zn^{2+} and H^+ ions (Khan et al. 2018b, c, d, e, f). These ions are adsorbed onto the substrate surface via a weak Vander Waals bond, which allows surface diffusion. This diffusion results in the reduction of ions at more favorable sites. The reduction of Zn^{2+} involves gaining two electrons to form zero-valent Zn metal deposits on the Cu plate (Khan et al. 2018g, h, i, j). A simplified cell reaction can be illustrated as follows:

Oxidation process: $Zn = Zn^{2+} + 2e^-$ (1)

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

This Redox reaction concurrently occurs without changing the original composition of the PKL electrolyte and maintaining the solution more or less uniformly (Islam et al. 2018). In fact, the reduction of H^+ to form hydrogen (H_2) gas also completes with the reduction of Zn in an acidic PKL solution, which follows the Eq. (3):

Hydrogen evolution: $2H^+ + 2e^- = H_2$. (3)

The Zn metal losses electrons and the Cu metal gains electrons (Khan 2008a, b). The numbers of electrons come from the Zn metal to the Cu metal is 2. These electrons reacts with the H^+ and Cu^{2+} ions and converts into the H and Cu atoms. The H atoms then convert into H_2 and release from the Cell. The Cu atom deposits onto the Cu plate and gains more weight than the initial state.

2.1.3 Discharging process (Khan 2008b, 2009, 2018; Khan and Alam 2010; Khan and Arafat 2010; Khan and Bosu 2010; Khan and Hossain 2010; Khan and Paul 2013)

When Zn and Cu plates dipped into the PKL extract then the discharging (charge with load) reactions at anode and cathode compartments are given by the following:

Cathode compartment: $B(n+x) + xe^- \rightarrow Bn +$ and **anode compartment:** $A(n-x) + -xe^- \rightarrow An + (n \geq x)$.

The columbic efficiency (η_C) is the ratio between output charge and the input charge defined as: $\eta_C = \langle C_{\text{discharge}} \rangle / \langle C_{\text{charge}} \rangle \times 100\%$, where, η_C is the columbic efficiency, $\langle C_{\text{discharge}} \rangle$ is the charge output, and $\langle C_{\text{charge}} \rangle$ is the charge input in coulombs (C) of the PKL cell.

2.1.4 The voltaic efficiency

It is defined as the ratio between average discharge and charge voltages and is given by (Khan and Hossain 2018; Khan and Obaydullah 2018; Khan and Rasel 2018a, b; Khan and Yesmin 2019a): $\eta_V = \langle V_{\text{discharge}} \rangle / \langle V_{\text{charge}} \rangle \times 100\%$, where, η_V is the voltaic efficiency, $\langle V_{\text{discharge}} \rangle$ is the average discharging voltage, and $\langle V_{\text{charge}} \rangle$ is the average charging voltage (V) of the PKL Cell. The average charging and discharging voltages are defined as the time-integral of the voltage, where I is the current in amps as a function of the time during charging and discharging (Khan et al. 2013a, b, 2014, 2016a). Normally, the rate of charging or discharging is kept constant during testing of electrochemical PKL cell.

2.1.5 The energy efficiency

It can then be defined as the ratio between the output energy and input energy by combining the columbic and voltaic efficiencies (Khan et al. 2016b, c, 2017, 2018a): $\eta_E = \eta_C \times \eta_V = \langle V_{\text{discharge}} \rangle / \langle V_{\text{charge}} \rangle \times \langle C_{\text{discharge}} \rangle / \langle C_{\text{charge}} \rangle \times 100\% = \langle E_{\text{discharge}} \rangle / \langle E_{\text{charge}} \rangle$, where, η_E is the energy efficiency, $\langle E_{\text{discharge}} \rangle$ is the energy output, and

$\langle E_{\text{charge}} \rangle$ is the energy input of the PKL cell in terms of watt seconds (W-S).

2.1.6 Energy density

It is defined as the theoretical energy stored per unit volume of electrolyte (Khan et al. 2018p, q; Paul et al. 2012; Ruhane et al. 2017). This is highly dependent on maximum solubility of the active species in the solvent being used. Energy density can be defined as: $u = \text{OCV} \times \Delta c_i \Delta z_i F$, where, OCV is the open circuit potential (V) of a cell, Δc_i is the change in concentration of the active species of one half-cell (mol/L), z_i is the change in valence of that active species, and F is Faraday's constant (A-h/mol). This gives the theoretical energy density, u , in watt-hours per liter of electrolyte (W-h/L). The voltage of the PKL cell based on the Nernst equation (Khan et al. 2018k, l, m, n, o) ($E_{\text{cell}} = E_{\text{Cell}}^0 - \frac{RT}{nF} \log Q$, where, E_{cell} = cell voltage, E_{Cell}^0 = cell voltage at standard state condition, R = universal gas constant = $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, T = extract temperature, n = number of transferred electrons and F = Faraday constant = $96,500 \text{ C}$).

2.2 Description of the PKL electric unit cell, module, panel and array

2.2.1 PKL unit cell

It is shown in Fig. 1 a unit PKL cell consists of a voltmeter, two electrodes and connecting wires. Voltammeter, ammeter, voltmeter and resistance box are used for making a unit cell and then module. This unit cells are the building block of the PKL cell. PKL cell is the structural unit or building block. It is made of PKL extract/malt/juice. The voltage of the fabricated PKL unit cell is around 1.10 V. The PKL electricity depends on various parameters. The parameters are given by the following: concentration of the malt, area of the electrodes, distance between the two electrodes, the constituent elements of the electrodes, the volume of the PKL

Fig. 1 PKL electric unit cell

extract/malt/juice, the temperature of the PKL malt, the age of the PKL and pH of the PKL juice etc.

2.2.2 PKL electric module

It is made more than one unit cell. The PKL unit cells are connected by wires. The voltage of the unit cell is more than 1.1 V.

Using a voltmeter and two electrodes made a unit PKL cell. It is shown in Fig. 2 that the PKL module as a finished product. These modules have been used for practical utilizations for electricity generation. The voltage and current of the PKL module depends on number of the unit cell. In a panel PKL module can be connected by the series or parallel combination.

2.2.3 PKL electric panel

It is made of one more than one PKL electric modules by physically and electrically connected. The voltage of the PKL electric Panel is higher than the PKL electric modules. The voltage and current of the PKL panel depends on number of the modules (Fig. 3).

2.2.4 PKL electric array

It is made of one or more than one panel. In the similar way the voltage of the PKL electric array is higher than the PKL electric panel. The current, voltage and power of the array depend on number of panel and their arrangement (Fig. 4).

Fig. 2 PKL electric module

Fig. 3 PKL electric panel

(a) Design of the PKL unit cell

(b) Experimental set-up of a PKL Electric Array

Fig. 4 PKL electric array

2.3 Electrolyte of the PKL cell

PKL acts as an electrolyte. There are 4 types of PKL electric panel. Such as:

1. Early stage PKL electric panel

We consider this stage for growing of 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 of PKL within 30 days old. The conversion efficiency is higher than the early stage.

3. Pre-matured stage PKL electric panel

We consider this stage for growing of PKL within 45 days old. The conversion efficiency is higher than the Middle stage.

• Matured stage PKL electric panel

We consider this stage for growing of 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: 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 p^H of the PKL extract/malt/juice etc.

(i) 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 (Sultana et al. 2011).

(ii) Concentration of the PKL malt/juice

The voltage is generated from the PKL varies with the concentration of the PKL malt/juice. That is voltage, $V \propto \rho$, where ρ is the concentration of the juice (Khan and Yesmin 2019b).

(iii) Area of the electrodes

The voltage generation from the PKL is directly proportional to area of the electrodes. That is $V \propto A$, where, A is the area of the electrodes (Khan et al. 2018; Hasan and Khan 2019).

(iv) 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 (Khan and Rasel 2019c). It is shown that the voltage is proportional to the distance between two plates.

(v) Temperature effect of the extract.

It is shown that the voltage variation can be expressed by the following relation (Khan and Rasel 2019a):

$\Delta V = K \times \Delta T \times N_{cs}$, where, ΔV = change of voltage, K = coefficient factor, ΔT = change in temperature, N_{cs} = no. of PKL Unit cell connected in series.

(vi) Ambient temperature of the laboratory. It is shown that the efficiency is not influenced at all.

(vii) Influence of the light.

The constitute compounds of the PKL are citric acid, iso-cytric acid and malic acid. In presence of the sun light the performance is less than the absence of the sun light. So that PKL cell acts equally in the day and night time. But the solar cell does not act properly in the rainy season and does not act totally in the night time.

(viii) p^H of the PKL extract/malt/juice

The performance of the PKL cell varies with the p^H value of the PKL extract/malt/juice. The performance is better for the higher value of the p^H value of the PKL extract/malt/juice and vice versa (Khan and Rasel 2019b).

2.4 Define different parameters

- (i) *Open circuit voltage* The voltage without load is called Open circuit Voltage. Generally, it is denoted by V_{oc} .
- (ii) *Short circuit current* The current without load is called short circuit current. Generally, it is denoted by I_{sc} .
- (iii) *Fill factor (FF)* It is defined as, $FF = (V_m I_m) / (V_{oc} I_{sc})$, where, V_m = useful voltage, I_m = useful current, V_{oc} = open circuit Voltage, I_{sc} = short circuit current.
- (iv) *Energy efficiency (η_c)* It is defined as, $\eta_c = P_{out} / P_{in} = V_d I_d / V_c I_c$, where, V_d = discharge Voltage, I_d = discharge current, V_c = charging voltage and I_c = charging current.

3 Results and discussion with graphical analysis

The aim of this project is production of Electricity by Pathor Kuchi Leaf (PKL). The PKL cell was run both day and night time after starting the chemical reaction in the PKL cell but data was collected during day time.

From Fig. 5, it is shown that the current decreases with the voltage increases directly for the range of voltage between (0.05 and 0.08) V. The current almost constant for voltage range (0.08–0.27) V. Finally, it is shown that after 0.27 V current decreases with the voltage increases.

From Fig. 6, it is shown that the open circuit voltage of PKL module was 12 V and when a LED Lamp was connected as a load, the voltage of the PKL module suddenly decreases to 7.24 V. It is shown that the voltage after 2 months interval is almost equal for long time.

Figure 7 shows the variation of the consuming voltage (volt) with the variation of the consuming time (seconds). The consuming voltage was taken by 10 days interval and it is seen that the consuming voltage decreases directly

Fig. 5 Current versus voltage relation for PKL electricity

Fig. 6 Variation of load voltage with the variation of local time (month)

Fig. 7 Consuming voltage (volt) versus consuming time (day)

Fig. 8 Consuming voltage (volt) versus consuming time (min) VS

with the increasing of consuming time and after 20 days, the consuming voltage increases with the increasing of consuming time.

Figure 8 shows the charging behavior of the lead acid battery by PKL electric cells. It is shown that the voltage difference between the PKL electric cells and lead acid battery is almost equal. The charging characteristics of the PKL electricity and the lead acid battery are exponentially increasing with time.

Figure 9 shows the minimum voltage variation with the variation of the different dates of the month for different

Fig. 9 Charging behavior of the lead acid battery compare to PKL electric cells

Fig. 10 Variation of minimum voltage with load with the variation of date of the month of the year

loads. It is very interesting that after 2nd days, the voltage is increasing almost linearly with the increasing of local time.

Figure 10 shows the variation of the PKL module voltage with the variation of different dates for a LED lamp as a load. It is shown that for 1st day the voltage of the PKL module decreases and from the 2nd days the voltage of PKL module almost linearly increasing with the increasing of the local time.

Figure 11 shows the variation of voltage with the variation of local time for without load. It is shown that the voltage without load decreases

With local time exponentially for a few minutes and after a few minutes the voltage varies almost linearly with the increasing of the local time.

Figure 12 shows the variation of the consuming voltage by LED lamp with the variation of the local time of a day. It is shown that the consuming voltage is almost constant for each time of the day. It does mean the PKL electric module supplies constant voltage to the load.

Figure 13 shows the variation of consuming voltage by LED lamp with the variation of local time of a day. It is

Fig. 11 Variation of PKL module voltages with the variation of different dates of the month for LED lamp as a load

Fig. 12 Variation of voltage with the variation of local time (h) for without load

Fig. 13 Variation of consuming voltage by LED lamp with the variation of local time of a day

shown that the consuming voltage was almost constant with the variation of time.

Table 1 shows the method of the determination of the voltaic efficiency of a PKL electrochemical cell. The data has been collected with calibrated multi meter and tabulated carefully.

It is shown (Fig. 14) in the variation of voltaic efficiency with the variation of time. Initially it is changed exponentially and then after the change was almost constant with time.

It is shown (Table 2) the energy efficiency of a PKL electrochemical cell for the internal resistance, $R = 0.6 \Omega$.

Table 1 Determination of the voltaic efficiency of a PKL electrochemical cell

Time duration (min)	Potential with load (V)	Open circuit voltage (V)	Maximum potential (V)	Voltaic efficiency η_v (%)
00	5.44	5.81	5.89	92.36
20	5.31	5.89	„	90.15
40	5.07	5.79	„	86.08
50	4.60	5.72	„	78.09
60	4.20	5.72	„	71.30
70	3.99	5.54	„	67.74
110	3.40	4.82	„	57.72
123	3.26	4.58	„	55.35
313	2.65	3.15	„	45.00
383	2.63	3.13	„	44.65
423	2.60	3.02	„	44.14
1503	2.46	2.95	„	41.77

Fig. 14 Change of voltaic efficiency with time for a PKL electrochemical cell

The data was collected and the energy efficiency was also calculated and finally tabulated.

3.1 Morphological characteristics of the PKL electrochemical cell

It was considered for two half cell system (one Cu and one Zn). The area of the anode (Zn) and the area of the cathode (Cu) were tried to keep same areas (4.5 cm^2) respectively. The weight of the Cu and Zn plates were measured by a weigh meter before and after immersed into the extract. As a result, it was shown the morphological change of the plates has been occurred. According to Faraday's laws of electrolysis [115], we have,

$$m = QM/nF, \quad (4)$$

where, m is the mass of the deposits, F = Faraday constant ($96,500 \text{ C mol}^{-1}$), Q = electric charge passed, M = molar mass of the species, and n = electrical charge involved in the reaction (Fig. 15).

It is shown in Fig. 16a, b, the surface morphological change of the Cu plate was occurred for use in the PKL extract. So that before and after using the Cu plates the surface morphological change was studied using FESEM (Field Emission Scanning Electron Microscopy). As a result electron resistances were not grown there before and after using as an anode (Fig. 17a, b). Because no huge H_2 gas layer formed on the Cu-plate for a few time duration. As a result electron resistances not grow there. But for long time duration a few H_2 gas layer formed on the Cu-plate and as a result a few electron resistances were grown there. So that it is concluded that the electron resistance is inversely proportional to the time duration of the chemical reaction between Cu electrodes and the PKL extract. Moreover, the weight of the Cu Plate after use in the PKL extract became slightly greater than the weight of the Cu plate before use in the PKL extract. That is the gain of the Cu plate follows the theoretical value (Eq. 1).

It is shown in Fig. 17a, b the surface morphological change of the Zn plate was occurred for use in the PKL extract. So that before and after using the Zn plates the surface morphological change was studied using FESEM (Field Emission Scanning Electron Microscopy). As a

Table 2 The energy efficiency of a PKL electrochemical cell for the internal resistance, $R = 0.6 \Omega$

Internal Resistance, $R (\Omega)$	Average load potential, $V (V)$	Average load current, $I (A)$	Energy efficiency $\eta_E \% = \frac{VI}{VI + I^2 R} \times 100\%$
0.6	3.500	0.154	97.43

Fig. 15 Experimental set-up of a PKL Zn/Cu electrochemical cell

Fig. 16 SEM for Cu plate (1 μ scale) before and after use in PKL extract

Fig. 17 SEM for Zn plate (1 μ scale) before and after use in PKL extract

result electron resistances were not grown there before using as an anode (Fig. 17a) but some electron resistances were grown there after using as an anode (Fig. 17b). Moreover the variation of weight of the Zn plate for before and after use in the PKL extract, which was acceptable. It is shown that the weight of the Zn plate after use in the PKL extract became slightly less than the weight of the Zn plate before use in the PKL extract.

Finally, it is also shown that both the theoretical (using Eq. 4) and practical (measuring the weight by a weigh meter) weight loss were also coincide with each other.

3.2 Effect of the concentration of Cu^{2+} and Zn^{2+} ion during PKL electricity generation

Cu^{2+} ion presence in PKL juice solution as a secondary salt acts as a reactant ion. Thus the presence of Cu^{2+} ion increases both potential and current flow with time Cu^{2+}

reduces to Cu and so the concentration of Cu^{2+} ion decreases (Khan et al. 2018j, k, l).

Reactions:

Again the anode undergoes corrosion to give the product ion Zn^{2+} by the following the reaction:

So the variation of concentration of Zn^{2+} ion will be helpful to this study. But Zn^{2+} cannot be determined by UV–Vis spectrophotometer (Khan et al. 2018l). For this reason AAS has been used to determine this.

The variation of concentration of Cu^{2+} and Zn^{2+} ion during Electricity Generation with the variation of time is shown in Table 3 and Fig. 18. It is also shown (Table 3 and Fig. 19), the variation of pH with the variation of time duration.

4 Results

It is shown in Fig. 18, for a particular specification, the PKL extract was 60% and the water was 40%. From Fig. 18, it is shown that the $[\text{Zn}^{2+}]$ increased as a product ion with the variation of time and the $[\text{Cu}^{2+}]$ was const as reactant ion with the variation of time during electricity generation. It is shown (Fig. 18) that the variation of the concentration of $[\text{Zn}^{2+}]$ increases almost exponentially with time whereas the variation of the concentration of $[\text{Cu}^{2+}]$ decreases almost constant with time duration during electricity generation. It is also shown that the variation of pH with time duration (specification is the PKL extract was 60% and the water was 40%). It is shown that pH increases firstly linearly and then almost exponentially.

5 Conclusion

It has been found the energy efficiency, voltaic efficiency and columbic of the PKL electrochemical cell. It has been also found the pH variation of the PKL extract during electricity generation period. The morphological change of the electrodes has been studied by SEM analysis. It has been found the concentration of product and reactant ions by AAS technique and their variations with time during electricity generation. Furthermore some electrical parameters have been studied in this work. Electricity from Pathor Kuchi Leaf (PKL) is the new innovation. It is the innovated in Bangladesh. Bangladesh. In Bangladesh perspectives it has a great impact in our society. Now a days, electricity is becoming an essential part of the life. We cannot keep running even a mobile telephone without

Table 3 Table for effect of the concentration of Cu^{2+} and Zn^{2+} ion during electricity generation

Date	Time duration (h)	PKL (conc.)	H_2O	Cu^{2+} (mg L^{-1})	Zn^{2+} (mg L^{-1})	pH
18.09.17	0	60%	40%	0.15	1.19	4.92
18.09.17	2			0.2	3.61	4.98
18.09.17	7			0.11	54.43	5.12
19.09.17	16			0.1	118.12	5.39
19.09.17	25			0.09	125.56	5.21
24.09.17	170			0.08	330.03	5.53
10.10.17	552			0.05	386.20	5.76

Fig. 18 Variation of concentration of Cu^{2+} and Zn^{2+} with time duration for a particular specification, the PKL extract was 60% and the water was 40% **Fig. 19** Variation of pH with time duration specification, the PKL extract was 60% and the water was 40%

electricity, although it needs a very low amount of electricity to charge it. In our country a few people are getting electricity. There are a large number of people in large part of the country like coastal areas, small islands; remote areas are not getting electricity yet. The production of electricity from PKL is so easy. So that it can be produced by any one even a handicapped and an illiterate people of the country. It is simple and affordable technology by all users among the society. Its need no advance knowledge on production of electricity. They can use it instead of Karocin lantern especially at the off-grid areas across the world.

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Compliance with ethical standards

Conflict of interest On behalf of all the authors, the corresponding author declares that we don't have any conflict of interest.

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