3R Economy of a PKL Electrochemical Cell

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1 Introduction

The traditional sources of energy are very limited in the world which will soon run out in the near future [1–6]. Therefore, it needs alternative renewable energy sources that are environmental friendly. As a continuation of such investigation, an abandoned PKL (Pathor Kuchi Leaf) module was chosen where the basic principle of the module is a simple galvanic cell system consisting of Zinc (Zn) and Copper (Cu) electrodes, and the PKL extract is used as an electrolyte [7–12]. The age of the electrolyte was almost 8 years. It is noted that the production of electricity from PKL was invented in 2008 by Dr. Md. Kamrul Alam Khan, Ex-Dean (Faculty of science, Jagannath University), Ex-Chairman, Department of Physics, Jagannath University, Dhaka, Bangladesh [12–15]. The 3R economy is very popular nowadays [16–18]. The term 3R means reduction, recycle and reuse. To develop the economy of the country, the 3R economy is very necessary for any country. To keep it in mind, an old-aged PKL electrochemical cell has been designed and developed by the authors.

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2 Methodology

2.1 Methods for Performances of Electricity Generation Using 50% PKL Extract in the Battery Box Made by Glass

The PKL module was filled with PKL extract 50% of the box volume. When the box was filled with PKL extract, the open circuit voltage was 5.9 V and the short circuit current was almost 1A. Then with the help of this module, four types of 12 V fans and a 12 V LED lamp had been run. Here, the 12 V LED lamps were used as the load of the experimental setup (Figs. 1 and 2). After running these fans and LED lamps, the open circuit voltage of the module became 5.67 V. The experimental observations have been given in Table 1.

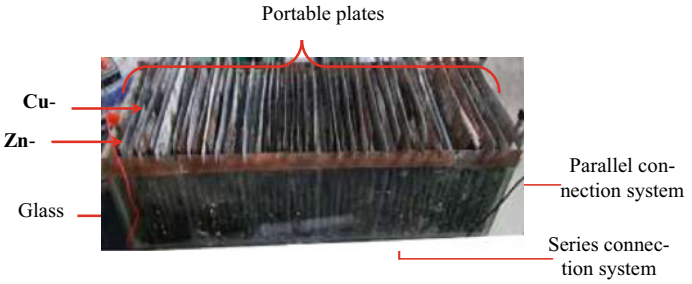

Fig. 1 An abandoned portable plate PKL module

Fig. 2 LED lamp is switching on by the abandoned portable electrode PKL module

Table 1 Experimental results of a PKL module for using 50% PKL extract of the box

No. of observations	Local time (PM)	Time duration (min)	Open circuit voltage, V_{oc} (V)	Load voltage, V_L (V)	Short circuit current, I_{sc} (A)	Load Current, I_L (mA)
1	6:54	00	5.67	5.35	0.95	60
2	7:04	10	5.65	5.33	0.90	60
3	7:14	20	5.65	5.33	0.90	60
4	7:24	30	5.64	5.33	0.85	60
5	7:34	40	5.64	5.33	0.90	50
6	7:44	50	5.65	5.33	0.90	50
7	7:54	60	5.67	5.33	0.90	50
8	8:04	70	5.68	5.33	0.85	50
9	8:14	80	5.70	5.32	0.90	50
10	8:24	90	5.71	5.32	0.85	50
11	8:34	100	5.71	5.32	0.90	50
12	8:44	110	5.70	5.32	0.90	50
13	8:54	120	5.70	5.31	0.90	50

2.2 Methods for Performances of Electricity Generation Using 100% PKL Extract in the Battery Box Made by Glass

After the experiment IIA, the Zn-plates were withdrawn but the Cu-plates were remaining in the module. After 46 h later, the Zn-plates were dipped again into the module. But this time, PKL extract was taken 100% of the box volume and similar readings were taken as like experiment IIA. The experimental observations have been given in Table 2.

2.3 Electricity Generation Performance Using a Load (LED Lamp) for 21 h

After the end of the experiment IIB, the whole experimental setup was unchanged for 21 h that means the LED lamp was switched on for 21 h. After 21 h later, similar readings were taken as like experiment IIA. The experimental observations have been given in Table 3.

Table 2 Experimental results of a PKL module for using 100% PKL extract of the box

No. of observations	Local time (PM)	Time duration (min)	Open circuit voltage, V_{oc} (V)	Load voltage, V_L (V)	Short circuit current, I_{sc} (A)	Load current, I_L (mA)
1	6:50	2756	5.69	5.31	0.90	45
2	7:00	2766	5.71	5.31	0.90	40
3	7:10	2776	5.71	5.31	0.95	40
4	7:20	2786	5.71	5.31	0.90	40
5	7:30	2796	5.70	5.31	0.95	40
6	7:40	2806	5.69	5.31	0.95	40
7	7:50	2816	5.68	5.31	0.90	40
8	8:00	2826	5.67	5.30	0.90	40
9	8:10	2836	5.67	5.30	0.90	40
10	8:20	2846	5.66	5.30	0.85	40
11	8:30	2856	5.66	5.30	0.85	40
12	8:40	2866	5.67	5.30	0.90	35
13	8:50	2876	5.66	5.30	0.85	35

Table 3 Experimental results of a PKL module for switching on the load for 21 h

No. of observations	Local time (PM)	Time duration (min)	Open circuit voltage, V_{oc} (V)	Load voltage, V_L (V)	Short circuit current, I_{sc} (A)	Load current, I_L (mA)
1	5:50	4136	5.48	5.17	0.60	17
2	6:00	4146	5.48	5.17	0.60	17
3	6:10	4156	5.48	5.17	0.60	17
4	6:20	4166	5.49	5.17	0.60	15
5	6:30	4176	5.49	5.17	0.62	15
6	6:40	4186	5.49	5.17	0.60	17
7	6:50	4196	5.48	5.17	0.60	17
8	7:00	4206	5.47	5.17	0.60	17
9	7:10	4216	5.49	5.17	0.60	17
10	7:20	4226	5.49	5.17	0.60	17
11	7:30	4236	5.49	5.17	0.60	17
12	7:40	4246	5.49	5.17	0.63	17
13	7:50	4256	5.48	5.17	0.63	17

Table 4 Experimental results of a PKL module for withdrawing the load for 22 h

No. of observations	Local time (PM)	Time Duration (min)	Open circuit voltage, V_{oc} (V)	Load voltage, V_L (V)	Short circuit current, I_{sc} (A)	Load current, I_L (mA)
1	5:50	5576	5.46	5.17	0.55	15
2	6:00	5586	5.45	5.17	0.60	14
3	6:10	5596	5.44	5.17	0.55	14
4	6:20	5606	5.44	5.17	0.60	15
5	6:30	5616	5.44	5.16	0.55	15
6	6:40	5626	5.44	5.16	0.50	14
7	6:50	5636	5.44	5.16	0.50	15
8	7:00	5646	5.44	5.16	0.50	15
9	7:10	5656	5.44	5.16	0.55	14
10	7:20	5666	5.44	5.16	0.55	14
11	7:30	5676	5.45	5.16	0.55	14
12	7:40	5686	5.44	5.16	0.55	14
13	7:50	5696	5.44	5.16	0.55	14

2.4 Electricity Performance Withdrawing the Load (LED Lamp) for 22 h

After the end of the experiment IIC, the whole experimental setup was unchanged except for the load. The load (LED lamp) was withdrawn and 21 h later, the load (LED lamp) was switched on again and similar readings were taken as like experiment IIA. The experimental observations have been given in Table 4.

3 Results and Discussion

Figure 3 shows the variation of open circuit voltage, V_{oc} (V), with the variation of time duration (min) for four types of experiments. It was found that for the experiment 2A (PKL extract 50% of the box volume), V_{oc} was changing very slightly (5.67–5.71 V) with the increase of time duration. The change of V_{oc} was almost periodic. But it was interesting that for the experiment IIB (PKL extract 100% of the box volume), the change of V_{oc} was almost like experiment 2A. That means the change of V_{oc} is independent of the amount of PKL extract. Although V_{oc} is more flat (stable) for experiment IIB.

It was also found that after switching on the LED lamp for 21 h (experiment 2C), the open circuit voltage, V_{oc}, was dropped for about 0.2 V. But in this case, V_{oc} was almost constant with the increase of time duration. V_{oc} was changed from 5.47 to 5.49 V. It was interesting that for the experiment 2D (Withdrawing the load for 22 h),

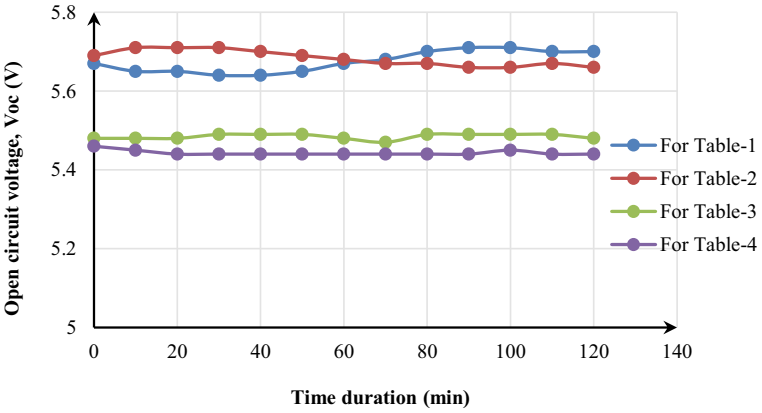

Fig. 3 Variation of open circuit voltage, V_{oc} (V), with the variation of time duration (min)

V_{oc} was almost constant too with the increase of time duration. In this case, V_{oc} was changed from 5.44 to 5.46 V.

Figure 4 shows the variation of load voltage, V_L (V), with the variation of time duration (min) for four types of experiments. It was found that for the experiment IIA (PKL extract 50% of the box volume), the initial value of V_L was 5.35 V. But with the increase of time duration, V_L was changing very slightly and the minimum value of V_L was 5.31 V. But in the experiment IIB (PKL extract 100% of the box volume), V_L was almost constant and it was confined between 5.30 and 5.31 V.

It was also found that after switching on the LED lamp for 21 h (experiment 2C), the load voltage, V_L, was dropped by about 0.16 V. But in this case, V_L was just constant with the increase of time duration. This constant voltage was 5.17 V.

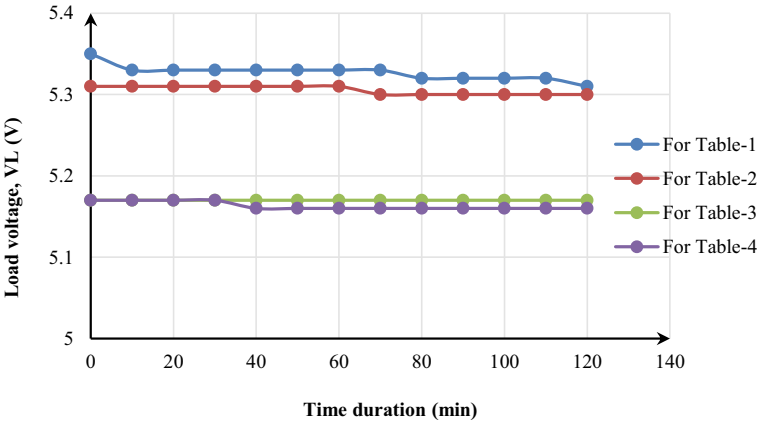

Fig. 4 Variation of load voltage, V_L (V), with the variation of time duration (min)

It was interesting that for the experiment 2D (Withdrawing the load for 22 h), V_L was almost constant too with the increase of time duration. But sometimes it deviated from 5.16 to 5.17 V.

Figure 5 shows that the variation of short circuit current with the variation of time duration for four different conditions. It is shown that the short circuit current decreases for different conditions of the different tables. It is also shown that the short circuit current was almost constant for Table 3.

Figure 6 shows the variation of load current with the variation of time duration for four different conditions. It is shown that the load current decreases for different conditions of the different tables. It is also shown that the load currents were almost constant for Tables 3 and 4.

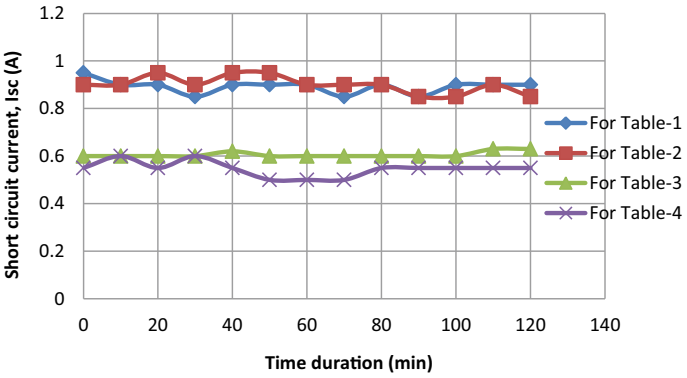

Fig. 5 Variation of short circuit current, I_{sc} (A), with the variation of time duration (min)

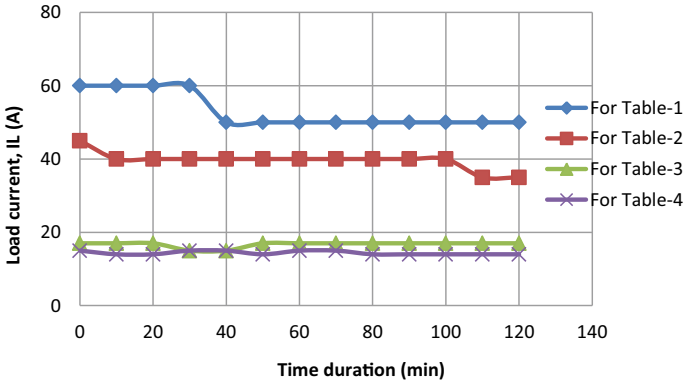

Fig. 6 Variation of load current, I_L (A), with the variation of time duration (min)

4 Conclusions

From this research work, it can be concluded that the 3R economy is feasible and viable for PKL electrochemical cells. In this research work, it is shown that both the Zn/Cu-based electrodes and PKL electrolyte can be used as a 3R economy.

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