Extract of Green Chili—A New Source of Electricity

Chapter *in* Lecture Notes in Electrical Engineering · June 2023

DOI: 10.1007/978-981-99-0412-9_14

5 authors, including:

Md Ohiduzzaman
Jashore University of Science and Technology

Kamrul Alam Khan
Jagannath University

Shahinul Islam
Uttara University

Md. Sayed Hossain
Bangladesh Atomic Energy Commission

Extract of Green Chili—A New Source of Electricity

Md. Ohiduzzaman, K. A. Khan, Shahinul Islam, Md. Sayed Hossain, and Salman Rahman Rasel

Abstract Green chili is abundantly available for everywhere in the world. It is cultivating for cooking in curry. It can be used a green source of energy. Previously, it has been generated electricity from different vegetative and fruits. Electrochemistry is the responsible of mechanism for electricity generation from vegetative and fruits. In this paper, it has been used as a source of electricity using electrochemical cell. The Zn/Cu-based electrodes were used, and the extract of the green chili was used as an electrolyte. The green-electrochemical systems achieve the reduction reaction with a certain voltage for which electrons transfer between the cathode and anode. Here, cathode means gain of electron, and anode means loss of electrons. In this research paper, zinc is used as an anode, and copper is used as a cathode. The electrons react with Cu^{2+} and H^+. The Cu^{2+} and H^+ eventually convert into Cu and H_2 atoms. Finally, it is shown that Cu atoms were deposited onto the copper plate, and H_2 releases from the green chili electrochemical cell. The experimental results were observed with and without adding copper sulfate solution $CuSO_4 \cdot 5H_2O$ as a secondary salt. The outcome of the research work improvises a better understanding on the electricity generation technology of the system.

Keywords Green chili · Extract · Electrochemical cell · Electricity generation · Performance · Zn/Cu electrodes

---

Md. Ohiduzzaman
Department of Physics, Jashore University of Science and Technology, Jashore 7408, Bangladesh
e-mail: ohid@just.edu.bd

K. A. Khan (✉)
Department of Physics, Jagannath University, Dhaka 1100, Bangladesh
e-mail: kakhan01@yahoo.com

S. Islam
Department of Physics, Uttara University, Dhaka, Bangladesh

Md. S. Hossain
Center for Research Reactor, Bangladesh Atomic Energy Commission, Dhaka, Bangladesh

S. R. Rasel
Local Government Engineering Department (LGED), Sherpur Sadar, Sherpur, Bangladesh

A. Biswas et al. (eds.), *Microelectronics, Circuits and Systems*, Lecture Notes in Electrical Engineering 976, https://doi.org/10.1007/978-981-99-0412-9_14

1 Introduction

Renewable energy is the safeguard of our future and the Earth [1]. From the power production point of view, renewable energy sources will be the beneficiary management strategies for electricity production [2]. Renewable energy sources will be the environment-friendly and eco-friendly [3]. Renewable energy sources means that does not have a limited source; it can be generated again and again and will never run out [4]. The examples of renewable energy sources are as follows: solar energy, wind energy, biogas energy, geothermal energy, biomass energy, water energy, tidal energy, wave energy, and OTEC [5, 6]. Fruits-based energy means electricity generation from fruits [7]. The production of electricity from fruits is cost-effective, environment-friendly, and locally abundant [8, 9]. The renewable energy sources are inexhaustible and literally around us may be converted into usable power production [10, 11]. The traditional energy sources like oil, gas, and coal are exhaustible and diminishing day by day rapidly [12]. Researchers expected that nuclear power could be the alternative sources of energy [13]. But, due to the high cost and risk point of view, it is not feasible and viable for practical utilization [15]. Recently, a group of researchers have developed electricity generation mechanism from various vegetative and fruits under the leadership of Prof. Dr. Md. Kamrul Alam Khan [16]. It is found that electrochemistry is the responsible of the origin of power production. It converts chemical energy to electrical energy by immerging of electrodes into the green chili extract [17]. This electrochemical cell is called fuel cell because H_2 gas is released from this cell. This idea will create a new era and revolution for electricity production from vegetative and fruits [18]. The finding of the research suggests that the origin of the power production followed as per the rules of electrochemistry. Green chili extract as an electrolyte succeeded in producing electricity through the working principle of voltaic cell [19]. To enhance the performance of the system, copper sulfate solution ($CuSO_4 \cdot 5H_2O$) was added [20]. The performances of the parameters like open circuit voltage, load voltage, short circuit current, load current do not increase. The maximum power, load power is decreased. The internal resistance showed a higher value than the ideal value. During 27 h of conducting the experiment, the parameters varied after short intervals. But, after the addition of copper sulfate solution ($CuSO_4 \cdot 5H_2O$), the performance of the parameters did not develop like PKL electricity [21]. It will be needed more R & D work for practical utilization. This work may the guide line for further study.

2 Methods and Materials

The necessary materials for electricity production using green chili are given: green chili (*Capsicum annuum*) extract, $CuSO_4$ solution, 4 falcon tubes, 8 Zn plates, 8 Cu plates, LED bulb, copper wires, crocodile clips, ammeter, voltmeter.

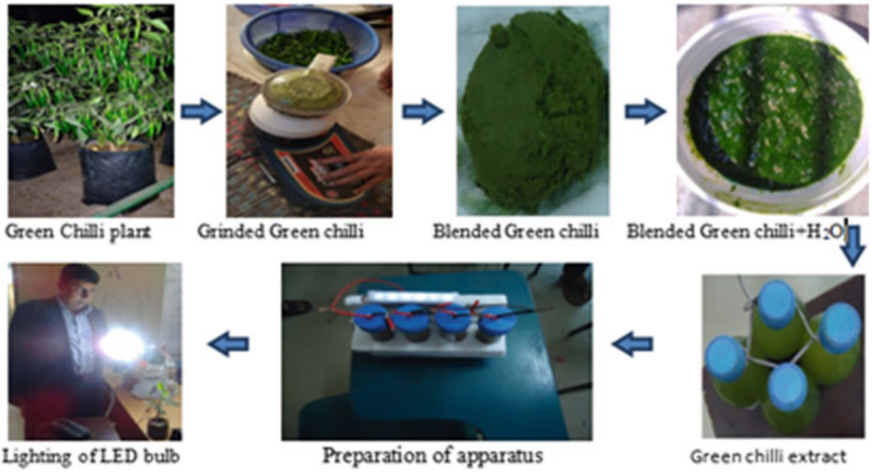

Fig. 1 Steps diagram of LED bulb lighting system using *Capsicum annuum extract*

Figure 1 shows the electricity production using green chili. It is shown that the outcomes of the findings of the research work from the starting. It acts as a graphical abstract.

Figure 2 shows an experimental setup of an LED bulb lighting system using green chili extract. It is shown that there are 4 unit cells. Each cell has one copper plate and one zinc plate. There are 4 unit cells where 4 copper and 4 zinc plates. The unit cells are connected by copper wire in series combination. As a result, electrons can flow easily through the circuit. It was bought newly Zn and Cu plates those were used as electrodes. Calibrated digital multimeter was used for accurate measurement. It was ensured the same amount of filtered extract among the 4 falcon tubes. The quantity of the equipments is given below:

(a) 500 g of fresh green chili were collected from the garden and then washed thoroughly with clean water, and a fine extract was made using a grinding stone.
(b) The extract was kept in a bottle for about a week being sealed.
(c) A Zn/Cu bio-electrochemical cell is designed where Zn and Cu plates were used as electrodes, green chili (*Capsicum annuum*) extract as electrolyte.
(d) An LED bulb was attached to ensure that the bio-electrochemical cell is functional.
(e) Each of the four falcon tubes was filled with green chili extract of 30 ml
(f) Readings of different parameters such as open circuit voltage, load voltage, short circuit current, and load current were taken at an interval of 3 h using an ammeter and voltmeter.
(g) Again after adding 1 ml $CuSO_4 \cdot 5H_2O$ in the tubes, readings of the same parameters were taken at an interval of 3 h using an ammeter and voltmeter.

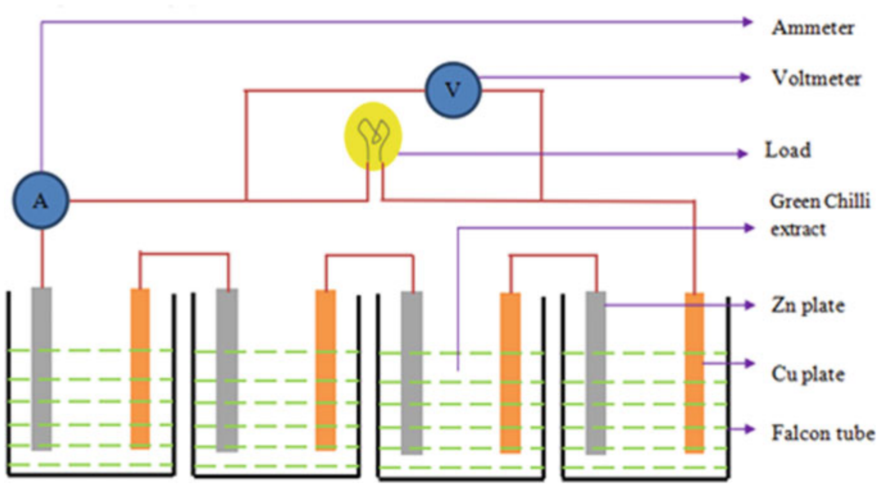

Fig. 2 An experimental setup of an LED bulb lighting system using green chili extract

In this experiment, $CuSO_4$, $5H_2O$ was used as a secondary salt. Figure 3 shows the methods of the measurement of the current and voltage collection for both use of with and without $CuSO_4$, $5H_2O$. A digital multimeter has been used to take the reading.

Chemical reactions: According to electrochemistry, a few typical standard electrode potentials are given below:

Fig. 3 Experimental setup of a unit cell for both with and without $CuSO_4$ solution

Metal/Metal ion combination	$E°$(V)
Mg^{2+}/Mg	2.37
Zn^{2+}/Zn	− 0.76
Cu^{2+}/Cu	+ 0.34
Ag^{+}/Ag	+ 0.80

The potential at Zn, $E_{\text{Zn}} = -0\ .76$ V and the potential at Cu, $E_{\text{Cu}} = +\ 0.34$ V. So that the cell potential, $E_{\text{cell}} = E_{\text{Cu}} - E_{\text{Zn}} = +\ 0.34-(-\ 0.76) = 1.10$ V, which is considered as an ideal value. But practically, it is fluctuated due to various reasons like due to impurity of the Zn and Cu materials, distance between two electrodes, concentration of the extract, temperature of the extract, pH of the extract, area of the electrodes, density of the electrodes, etc.

3 Results and Discussion

III. A Graphical analysis of LED bulb lighting system using Green Chili (*Capsicum annuum*) extract without $CuSO_4$.

Table 1 shows the collected data for LED bulb lighting system using green chili (*Capsicum annuum*) extract without $CuSO_4$. It has been collected different parameters like open circuit voltage, load voltage, short circuit current, load current, maximum power, load power, and internal resistance using a calibrated multimeter.

Figure 4 shows the open circuit voltage versus time duration curve. It is shown that the maximum open circuit voltage was 3.60 V, and the minimum open circuit

Table 1 Data for LED bulb lighting system using green chili (*Capsicum annuum*) extract without $CuSO_4$

Time duration (hr)	V_{oc}(Open circuit voltage) (V)	V_L(Load voltage) (V)	I_{sc}(Short circuit current) (mA)	I_L(Load current) (mA)	Maximum power $P_{max} = V_{oc} I_{sc}$(mW)	Load power $P_L = V_L I_L$(mW)	Internal resistance, $r_{in} = \frac{V_{oc}}{I_{sc}}$ (Ω)
0	3.27	2.5	0.7	0.6	2.3	1.5	4.67
3	3.14	2.4	0.8	0.6	2.5	1.44	3.93
6	3.22	2.5	0.7	0.5	2.2	1.25	4.60
9	3.30	2.2	0.8	0.5	2.6	1.1	4.12
12	3.40	2.3	0.7	0.6	2.4	1.38	4.85
15	3.50	2.4	0.8	0.4	2.8	0.96	4.38
18	3.40	2.4	0.9	0.6	3.0	1.44	3.70
21	3.40	1.9	0.8	0.5	2.7	0.95	4.25
24	3.60	1.9	0.7	0.6	2.5	1.14	5.14
27	3.40	2.1	0.8	0.4	2.7	0.84	4.25

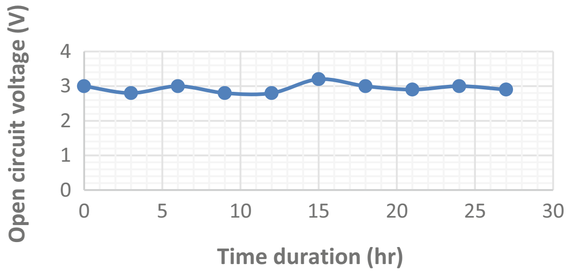

Fig. 4 Open circuit voltage versus time duration curve

voltage was 3.14 V. The difference between two cases was 0.46 V. It was also shown that the open circuit voltage change was in almost sinusoidal up to 27 h.

Figure 5 shows the load voltage versus time duration curve. It is shown that the maximum load voltage was 2.50 V, and the minimum load voltage was 1.90 V. The difference between two cases was 1.60 V. It was also shown that the load voltage change was in almost sinusoidal up to 27 h.

Figure 6 shows the short circuit current versus time duration curve. It is shown that the maximum short circuit current was 0.9 mA, and the minimum short circuit current was 0.7 mA. The difference between two cases was 0.2 mA. It was also shown that the short circuit current change was in almost sinusoidal up to 27 h.

Figure 7 shows the load current versus time duration curve. It is shown that the maximum load current was 0.60 mA, and the minimum load current was 0.40 mA. The difference between two cases was 0.2 mA. It was also shown that the load current change was in almost sinusoidal up to 27 h.

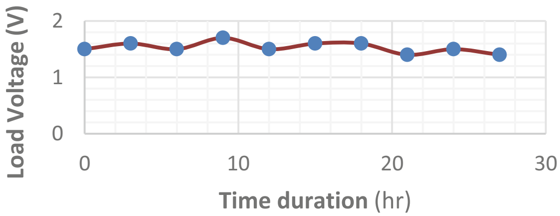

Fig. 5 Load circuit voltage versus time duration curve

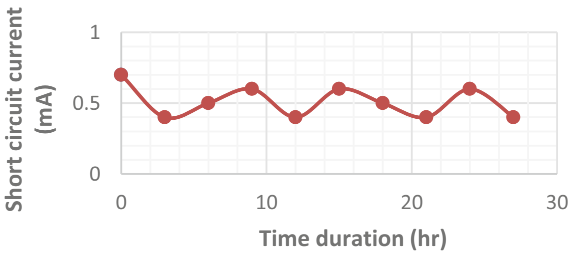

Fig. 6 Short circuit current versus time duration curve

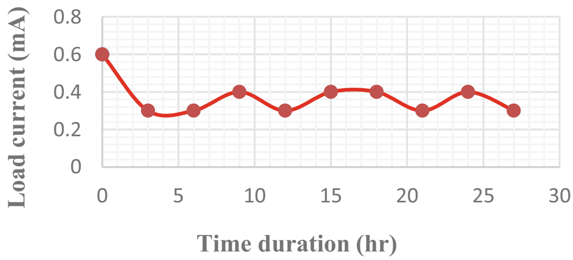

Fig. 7 Load current versus time duration curve

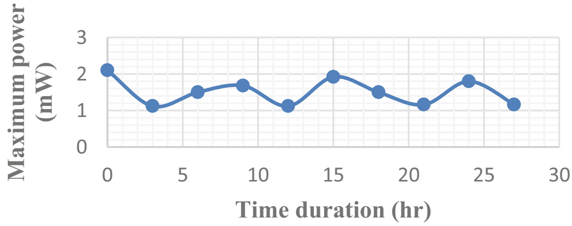

Fig. 8 Maximum power versus time duration curve

Figure 8 shows the maximum power versus time duration curve. It is shown that the maximum power was 3.00 mW and the minimum maximum power was 2.30 mW. The difference between two cases was 0.70 mW. It was also shown that the maximum power change was in almost sinusoidal up to 27 h.

Figure 9 shows the load power versus time duration curve. It is shown that the maximum load power was 1.50 mW, and the minimum load power was 0.84 mW. The difference between two cases was 0.66 mW. It was also shown that the load power change was in almost sinusoidal up to 27 h.

Figure 10 shows the internal resistance versus time duration curve. It is shown that the maximum internal resistance was 5.14 Ω, and the minimum internal resistance was 3.70 Ω. The difference between two cases was 1.44 Ω. It was also shown that the internal resistance change was in almost sinusoidal up to 27 h. But, this sinusoidal behavior is in opposite phase to open circuit voltage, short circuit current, load current, maximum power, load power. But also, this sinusoidal behavior is in same phase to load voltage.

Table 2 shows the collected data for LED bulb lighting system using green chili (*Capsicum annuum*) extract with $CuSO_4$. It has been collected different parameters

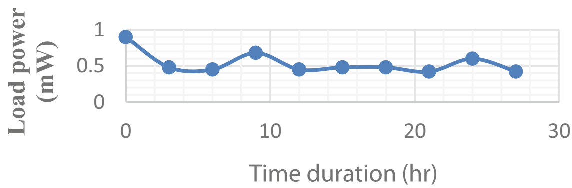

Fig. 9 Load power versus time duration curve

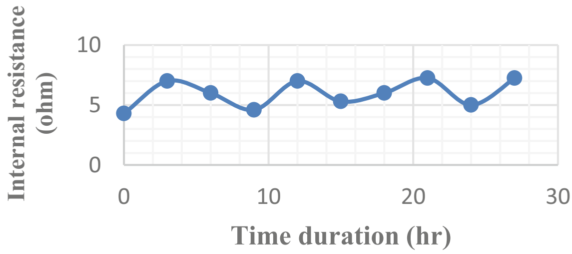

Fig. 10 Internal resistance versus time duration curve

Table 2: Data for LED bulb lighting system using green chili (*Capsicum annuum*) extract with $CuSO_4$

Time duration (h)	V_{oc}(Open circuit voltage) (V)	V_L(Load voltage) (V)	I_{sc}(Short circuit current)(mA)	I_L(Load current) (mA)	Maximum power $P_{max} = V_{oc}I_{sc}$ (mW)	Load power $P_L = V_L I_L$ (mW)	Internal resistance, $r_{in} = \frac{V_{oc}}{I_{sc}}$ (Ω)
0	3.0	1.5	0.7	0.6	2.10	0.90	4.29
3	2.8	1.6	0.4	0.3	1.12	0.48	7.0
6	3.0	1.5	0.5	0.3	1.50	0.45	6.0
9	2.8	1.7	0.6	0.4	1.68	0.68	4.6
12	2.8	1.5	0.4	0.3	1.12	0.45	7.0
15	3.2	1.6	0.6	0.4	1.92	0.48	5.3
18	3.0	1.6	0.5	0.4	1.50	0.48	6.0
21	2.9	1.4	0.4	0.3	1.16	0.42	7.25
24	3.0	1.5	0.6	0.4	1.80	0.60	5.0
27	2.9	1.4	0.4	0.3	1.16	0.42	7.25

like open circuit voltage, load voltage, short circuit current, load current, maximum power, load power, and internal resistance using a calibrated multimeter.

Figure 11 shows the open circuit voltage versus time duration curve. It is shown that the maximum open circuit voltage was 3.00 V, and the minimum open circuit voltage was 2.80 V. The difference between two cases was 0.20 V. It was also shown that the open circuit voltage change was in almost sinusoidal up to 27 h.

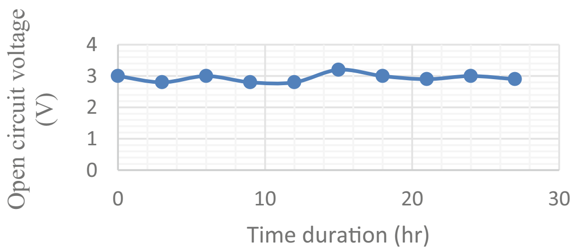

Fig. 11 Open circuit voltage versus time duration curve

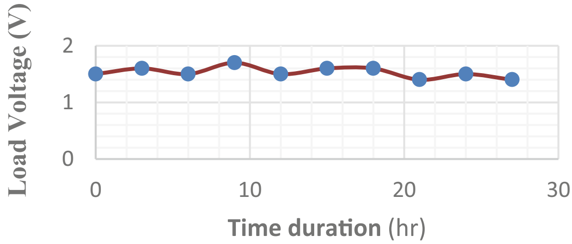

Fig. 12 Load voltage versus time duration curve

Figure 12 shows the load voltage versus time duration curve. It is shown that the maximum load voltage was 1.60 V, and the minimum load voltage was 1.40 V. The difference between two cases was 0.20 V. It was also shown that the load voltage change was in almost sinusoidal up to 27 h. But, the phase is opposite to the open circuit voltage.

Figure 13 shows the short circuit current versus time duration curve. It is shown that the maximum short circuit current was 0.7 mA, and the minimum short circuit current was 0.4 mA. The difference between two cases was 0.5 mA. It was also shown that the short circuit current change was in almost sinusoidal up to 27 h. It is same phase to open circuit voltage but opposite to load voltage.

Figure 14 shows the load current versus time duration curve. It is shown that the maximum load current was 0.60 mA, and the minimum load current was 0.30 mA. The difference between two cases was 0.3 mA. It was also shown that the load current change was in almost sinusoidal up to 27 h. It is same phase to open circuit voltage but opposite to load voltage.

Figure 15 shows the maximum power versus time duration curve. It is shown that the maximum maximum power was 2.10 mW, and the minimum maximum power was 1.20 mW. The difference between two cases was 0.90 mW. It was also shown

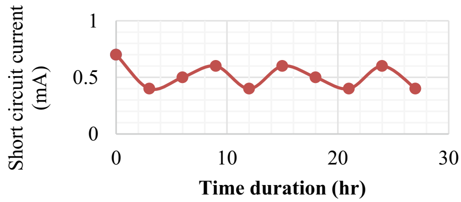

Fig. 13 Short circuit current versus time duration curve

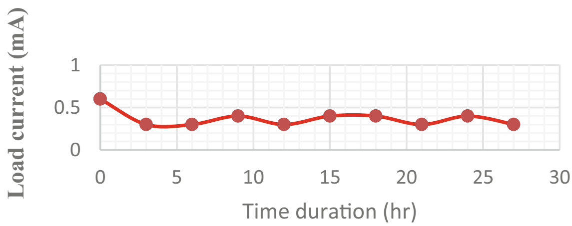

Fig. 14 Load current versus time duration curve

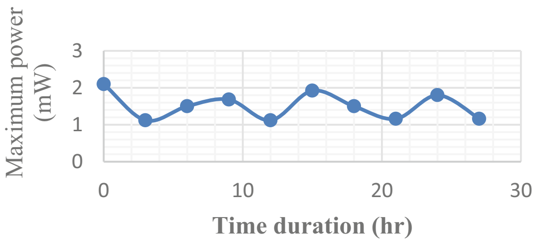

Fig. 15 Maximum power versus time duration curve

that the maximum power change was in almost sinusoidal up to 27 h. It is same phase to open circuit voltage but opposite to load voltage.

Figure 16 shows the load power versus time duration curve. It is shown that the maximum load power was 0.90 mW, and the minimum load power was 0.42 mW. The difference between two cases was 0.48 mW. It was also shown that the load power change was in almost sinusoidal up to 27 h. It is same phase to open circuit voltage but opposite to load voltage.

Figure 17 shows the internal resistance versus time duration curve. It is shown that the maximum internal resistance was 7.25 Ω, and the minimum internal resistance was 4.29 Ω. The difference between two cases was 2.96 Ω. It was also shown that the internal resistance change was in almost sinusoidal up to 27 h. But, this sinusoidal behavior is in opposite phase to open circuit voltage, short circuit current, load current, maximum power, load power. But also, this sinusoidal behavior is in same phase to load voltage.

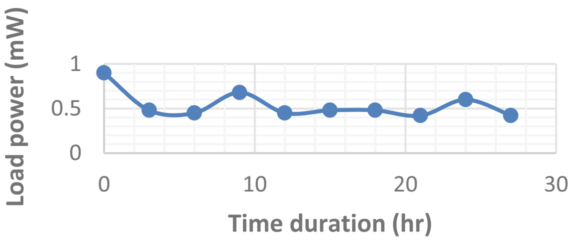

Fig. 16 Load power versus time duration curve

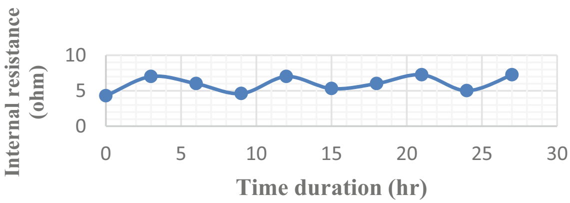

Fig. 17 Internal resistance versus time duration curve

4 Conclusions

In this research work, electricity is produced on the principle of mechanism of electrochemistry. So that the electrochemistry is the responsible of the production of electricity green chili extract. Two electrodes have been immerged into the green chili extract and then connected it to the load by copper wire to flow the electrons in the circuit. Based on the obtained results, it is found that performances have been decreased after applying the copper sulfate as a secondary salt. When the load voltage is kept half of the source voltage, then the more conductive electrons can flow through the external load for making a non-saturated effect. It is found that oxidation has been occurred successfully.

Acknowledgements The authors are grateful to the GARE (Grant of Advanced Research in Education) project, Ministry of Education, GoB for providing the financial support during the research work (Project/User ID: PS2019949).

References

1. M. Ratna, R. Sarker , R. Ara , M.M. Hossain, M.M. Kamruzzaman, Performance of chilli (Capsicum annuum L.) lines with different plantation time during rainy season. Archiv. Agric. Environ. Sci. **3**(3), 240–244(2018). https://doi.org/10.26832/24566632.2018.030305
2. Y.Y. Choo, J. Dayou, A method to harvest electrical energy from living plants. J. Sci. Technol. **5**(1), 79–90 (2013)
3. Y.Y. Choo, J. Dayou, N. Surugau, Origin of weak electrical energy production from living-plants. Int. J. Renew. Energy Res. **4**(1), 198–203 (2014)
4. Y.Y. Choo, J. Dayou, Increasing the energy output from living-plants fuel cells with natural photosynthesis. Adv. Environ. Biol. **8**(14), 20–23 (2014)
5. S. Lower, Electrochemistry. chemical reactions at an electrode, Galvanic and electrolytic cells (2004). http://www.chem1.com/acad/webtext/elchem/
6. R.A. Hinrich, M.H. Kleinbach, Energy – its use and the environment. 4th ed. Thomson/Brooks Cole (2006)
7. R.P. Varun, I.K. Bhat, Energy, economics and environmental impacts of renewable energy systems. Renew. Sustain. Energy Rev. **13**(9), 2716–2721 (2009)
8. A. Elgammal, A.M. Sharaf, Dynamic self adjusting FACTS-switched filter compensation schemes for wind-smart grid interface systems. Int. J. Renew. Energy Res. **2**(1), 103–111 (2012)
9. W.Y. Toong, K. Sulaiman, Fabrication and morphological characterization of hybrid polymeric solar cells based on P3HT and inorganic nanocrystal blends. Sains Malaysiana. **40**(1), 43–47 (2011)
10. H.N. Afrouzia, S.V. Mashaka, Z.A. Maleka, K. Mehranzamira, B. Salimia, Solar array and battery sizing for a photovoltaic building in Malaysia. J. Teknol. **64**(4), 79–84 (2013)
11. M. Hasan, K.A. Khan, Dynamic model of Bryophyllum pinnatum leaf fueled BPL cell: a possible alternate source of electricity at the off-grid region in Bangladesh, Microsystem Technologies Micro - and Nanosystems Information Storage and Processing Systems, Springer, ISSN 0946–7076. Microsyst Technol (2018). https://doi.org/10.1007/s00542-018-4149-y
12. K.A. Khan, M. Hazrat Ali, A.K.M. Obaydullah, M.A. Wadud, Production of candle using solar thermal technology, microsystem technologies Micro- and nanosystems information storage

and processing systems, Springer, ISSN 0946–7076, Microsyst Technol, 25(12). DOI (2019). https://doi.org/10.1007/s00542-019-04390-7
13. K.A. Khan, S.R. Rasel, M. Ohiduzzaman, Homemade PKL electricity generation for use in DC fan at remote areas, Microsystem Technologies Micro- and Nanosystems Information Storage and Processing Systems, ISSN 0946–7076, Microsyst. Technology, 25(12). DOI (2019). https://doi.org/10.1007/s00542-019-04422-2
14. M. Hasan, K.A. Khan, Experimental characterization and identification of cell parameters in a BPL electrochemical device. Springer, SN Appl. Sci. **1**, 1008(2019). https://doi.org/10.1007/s42452-019-1045-8
15. L. Hassan, K.A. Khan, A study on harvesting of PKL electricity. Springer J. Microsyst. Technol. **2020**(26), 1031–1041 (2019). https://doi.org/10.1007/s00542-019-04625-7,26(3),PP:1032-1041
16. K.A. Khan, M.A. Mamun, M. Ibrahim, M. Hasan, M. Ohiduzzaman, A.K.M. Obaydullah, M.A. Wadud, M. Shajahan, PKL electrochemical cell: physics and chemistry. Springer J. SN Appl. Sci. **1**, 1335(2019). https://doi.org/10.1007/s42452-019-1363-x
17. M. Hazrat Ali, U. Chakma, D. Howlader, M. Tawhidul Islam, K.A. Khan, Studies on performance parameters of a practical transformer for various utilizations, microsystem technologies (Springer, 2019), https://doi.org/10.1007/s00542-019-04711-w. Accepted 03 Dec 2019
18. K.A. Khan, L. Hassan, A.K.M. Obaydullah et al., Bioelectricity: a new approach to provide the electrical power from vegetative and fruits at off-grid region. Microsyst. Technol. (2018). https://doi.org/10.1007/s00542-018-3808-3
19. K.A. Khan, M.S. Bhuyan, M.A. Mamun, M. Ibrahim, L. Hasan, M.A. Wadud, Organic electricity from Zn/Cu-PKL electrochemical cell, in *Contemporary Advances in Innovative and Applicable Information Technology, Advances in Intelligent Systems and Computing*, vol. 812, eds. by J.K. Mandal et al. (Springer Nature Singapore Pvt. Ltd., 2018), Chapter 9, p. 75–90
20. A.K.M.A. Ullah, M.M. Haque, M. Akter, A. Hossain, A.N. Tamanna, M.M. Hosen, A.K.M.F. Kibria, M.N.I. Khan, M.K.A. Khan, Green synthesis of Bryophyllum pinnatum aqueous leaf extract mediated biomolecule capped dilute ferromagnetic α-MnO2 nanoparticles. Mater. Res. Express **7**(1), 015088 (2020), IOP publishing Ltd.
21. K.A. Khan, M. Hazrat Ali, M.A. Mamun, M. Mahbubul Haque, A.K.M. Atique Ullah, M.N. Islam Khan, A.K.M. Lovelu Hassan, M.A.W. Obaydullah, Bioelectrical characterization and production of nanoparticles (NPs) using PKL extract for electricity generation, received: 31 July 2018/Accepted: 4 February 2020. Microsyst. Technol. Springer J. (2020). https://doi.org/10.1007/s00542-020-04774-0