International Journal of Scientific & Engineering Research, Volume 4, Issue 3, March-2013
ISSN 2229-5518

Characterization of a Battery cell fueled by Bryophyllum Pinnatum sap

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Abstract- Demand for energy is growing fast worldwide amid depletion in conventional non-renewable resources. Bangladesh being hugely dependent on expensive imported fuel is forced to search for alternative renewable resources such as solar and biomass etc. This paper investigates the potential of the sap of a widely available plant called Bryophyllum pinnatum (life plant) as an electrolyte for use in a battery to generate electricity. The objective is to analyze the cell and optimize its design parameters which will help develop a cost-effective battery. A manually operable mechanical device has been designed and built to squeeze juice from the leaves. The results of the experiment and major parameters affecting the performance of the cell have been discussed in this paper. We identified the major parameters affecting the development of potential difference in a cell between copper and zinc electrodes and short circuit current by varying some parameters of electrodes immersed into the Bryophyllum sap acting as the electrolyte. We observed that the potential difference between the electrodes remains fairly constant but the short circuit current increases proportionally with the increase in the surface area of the electrodes in contact with the sap. The current also increases with the decrease in the gap between the electrodes. Finally a mathematical relationship between the short circuit current and the surface area of the electrodes in contact with the sap has been derived using curve fitting tool of Matlab.

Index Terms- Bangladesh, Battery, Biomass, Bryophyllum, Curve fitting, Electrolyte, Matlab, Renewable Energy

1 Introduction

Currently only 53 percent of the total population of Bangladesh has access to electricity and per capita generation being 265 kWh, leaving vast majority being deprived of a power supply [1]. Generation and supply of electrical power in the country is lagging much behind the growing demand and hence prohibiting sustainable growth of the economy. Bangladesh has limited proven natural gas reserve, so for its energy need it heavily depends on imported fossil fuel. With the increase in the fuel price in the international market and reduction of gas reserve in the country, Bangladesh is forced to look for alternative sources of energy i.e., renewable energy resources. Renewable Energy Policy of Bangladesh sets targets for developing renewable energy resources to meet 5 percent of the total power demand by 2015 and 10 percent by 2020 [2].

Vast area of the country is likely to remain off-grid due to the constraint in building transmission lines from the point of view of economic feasibility. Stand alone generating units from solar and biomass could be viable options for these areas. The high price of solar PV system prohibits its use among many rural people. A power generating device fuelled by Bryophyllum Pinnatum plants would be a cheaper solution.

Lund and Bush carried out a series of experiments which showed that a complex system of measurable, inherent, and continuously maintained electric potentials existed in the leaf of Bryophyllum [3]. They noted that "It has long been known that some forms of living tissues have the peculiar property of producing a continuous output of electrical energy under normal conditions of growth and development" [3]. "In Bangladesh, a new method of electricity generation based on Pathor kuchi (Bryophyllum pinnatum) leaf has been developed at SERC (Solar Energy Research Center), Department of Physics, Jagannath University, Dhaka-1100" [4]. However, there is a need to design and build a compact battery like device that could be easily operated, repaired and maintained by rural people in their households. Detailed investigations are required to identify the factors affecting the generation of potential difference and amount of current produced.

2 Outlines of Methodology/Experimental Design

In order to find the characteristics of the Bryophyllum pinnatum sap fuelled battery like device a small prototype of an individual cell has been designed and constructed. A plastic container of size length 280 mm, width 155 mm and depth 184 mm was used to house the solution. The container has three chambers of different sizes. Sizes are 155 mm x 45 mm x 184 mm, 155 mm x 90 mm x 184 mm and 155 mm x 140 mm x 184 mm. Experiments were carried out in the largest chamber (155 mm x 140 mm x 184 mm) to allow a wider range of separations between the electrodes. A copper plate was used as the anode and a zinc plate as the cathode. The sizes of both the two electrodes were 140 mm x 140 mm x 0.5 mm. Clearance at the bottom was 53 mm between the chamber and the electrodes. A digital multimeter was used to take the open circuit voltage and short circuit current readings. Setup diagram for generating electricity from the sap is shown in Fig. 1.

A mechanical device as shown in Fig. 2 was designed and built to extract the sap by squeezing the leaves. All components of this device are made of stainless steel except for the two bushes made of brass. Stainless steel is used to protect the device from corrosion because the sap is an acidic in nature. As the handle is rotated by hand the leaves pass through the

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two rollers and are squeezed to produce sap. The sap falls on a tray placed at the bottom. The sap is collected in a beaker. Fig. 3 shows the experimental setup.

Pure sap was used in these experiments. The pH of the sap was found to be 4.6 using microprocessor pH meter pH-211 (Hanna Instruments).

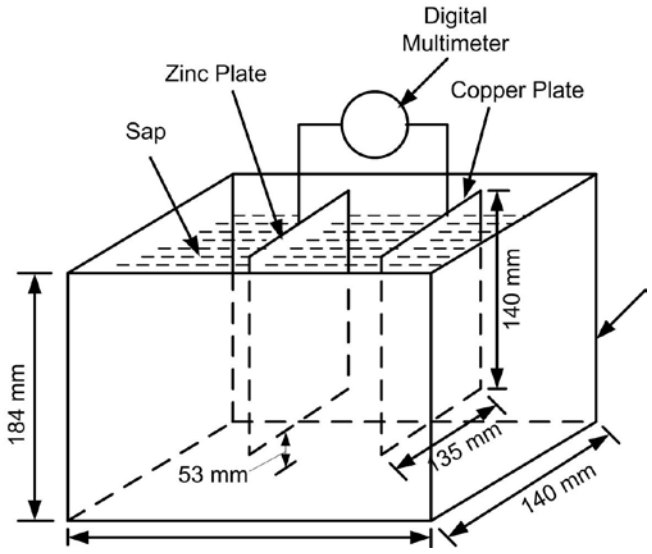

Fig. 1 Diagram of experimental setup

Fig. 2 Juice being squeezed from leaves

Fig. 3 Experimental setup

3 Results and Discussions

As soon as the electrodes were immersed into the sap, voltage was generated immediately and gradually it rose to around 900 mV. When the electrodes were short-circuited, current shot up quickly then gradually settled down to a lower value.

3.1 Determination of the relation between short circuit current and the distance between the electrodes

The electrodes were immersed 100 mm deep in the sap. This depth was kept fixed throughout this experiment. The two leads of the multi-meter were connected to the two electrodes. The space (gap) between the electrodes was varied and corresponding open circuit voltage and short circuit current readings were taken. We took reading eight times for eight different spaces. Spaces between the electrodes were 1 mm, 5 mm, 15 mm, 35 mm, 75 mm, 100 mm, 120 mm and 140 mm respectively. The readings are shown in Table 1.

TABLE 1. DATA OBTAINED BY VARYING SPACE BETWEEN THE ELECTRODES

Sl.	Electrodes inside the sap (mm)	Space between the electrodes (mm)	Open circuit voltage (mV)	Short circuit current (mA)
1	100	1	904	60
2		5	900	50
3		15	901	36
4		35	902	28
5		75	905	24
6		100	901	20.5
7		120	900	19.25
8		140	902	17.8

We observed that the open circuit voltage remained fairly constant at around 900 mV throughout these experiments (Fig. 4).

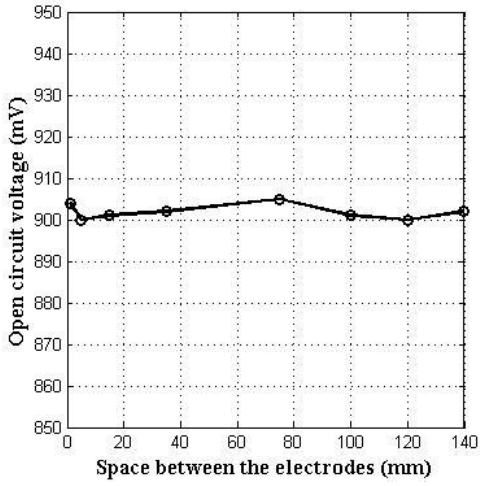

Fig. 4 Dependence of voltage on Space between the electrodes

However short circuit current decreased as the gap between the electrodes increased (Fig. 5). With the increase in gap, the

charged ions faced higher resistance from the liquid substance.

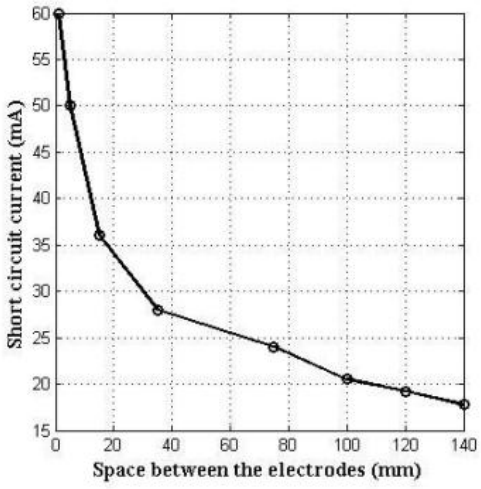

Fig. 5 Dependence of Short circuit current on Space between the electrodes

3.2 Determination of the relation between Short circuit current and surface area in contact

The space between the electrodes was kept constant at 1 mm by placing a separator (1 mm thick separators used in car batteries) in between them. Small pieces of insulated sticky plastic tape were used at eight positions to hold them tight together. Each electrode was marked beforehand for 10 mm, 20 mm, 40 mm, 70 mm and 100 mm distance mark from the bottom end of the electrode. A 50 cc plastic syringe was used to pour the sap into the chamber initially for 10 mm mark. Corresponding readings of open circuit voltage and short circuit current were taken. More sap was poured gradually to reach the 20 mm mark and corresponding readings were taken. This process was repeated for 40 mm, 70 mm and 100 mm marks. The readings are shown in Table 2.

TABLE 2. DATA OBTAINED BY VARYING DEPTH OF EACH ELECTRODE IN THE SAP

Sl.	Depth of Electrodes inside the sap (mm)	Space between the electrodes (mm)	Open circuit voltage (mV)	Short circuit current (mA)
1	10		901	24
2	20		901	28
3	40	1	903	36
4	70		902	50
5	100		905	60

The curve in Fig. 6 shows that short circuit current increases proportionally with the increase in surface area of electrodes in contact with the sap.

The equation for relationship between the current and surface area of each electrode in contact with the sap has been derived using curve fitting tool of Matlab.

$$y = 0.09\,x + 8.1$$

where x represents the area in contact and y represents the corresponding short circuit current.

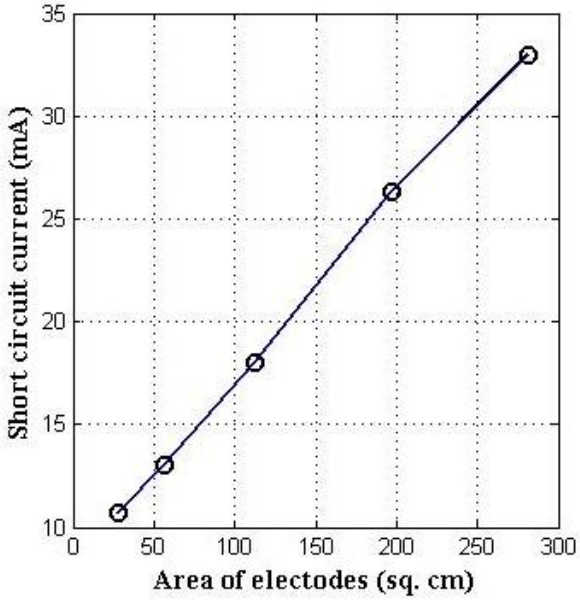

Fig. 6 Dependence of Short circuit current on area of the electrodes

From the two experiments mentioned above, it is found that a battery like device can be built by using copper and zinc plates as electrodes and Bryophyllum Pinnatum sap as electrolyte. Voltage in each cell is found to be around 0.9 V and it can be scaled up by connecting a number of cells in series as required. The capacity of such a battery to deliver more current can be achieved by increasing the number of electrodes in each cell joined in parallel.

4 CONCLUSION

The results from these experiments help us to understand the role of the size of the electrodes in delivering output current. Voltage did not depend much on the size of the electrodes; rather it remained almost fixed for the sap. The results also confirm that it is possible to design a battery like device to generate electricity for running small household dc appliances. Further investigations are required to make a battery by adding cells and using several electrodes connected in parallel in a cell. These types of batteries could be cheap alternative sources of renewable energy for the rural community in Bangladesh. If widely disseminated, this will release some pressure on the foreign currency reserve of the country as well.

ACKNOWLEDGMENT

The author wishes to thank Md. Shariful Islam, Assistant Professor, Ahsanullah University of Science and Technology for his support in carrying out the experiments.

REFERENCES

[1] "Power and Energy Sector Roadmap: Second Update", Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh, Jun 2012 (Report)

[2] "Renewable Energy Policy of Bangladesh", Power Division, Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh, 6 Nov 2008 (Policy Document)

[3] E.J. Lund and M. Bush, "Electric correlation potentials in the leaf of Bryophyllum", Plant Physiology, The American Society of Plant Physiologists, vol. 5, no. 4, pp. 491-508. Oct 1930. (article)

[4] Md. Kamrul Alam Khan, "Studies on electricity generation from stone chips plant (Bryophyllum pinnatum), International J. Eng. Tech 5(4); pp. 393-397, Dec 2008