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Short Communication

A bioelectrolyte cell — an alternate source of energy

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Abstract

An electrochemical cell is fabricated using an extract of the leaves of *Ipomoea aquatica* from the family *Convolvulaceae* as the electrolyte. To obtain a close value to the available energy density, the cell is discharged at a current drain of 1 μA and is calculated to be 1.1 Wh/kg of electrolyte. A second cell is fabricated with a paste of the leaves as the electrolyte. The initial open-circuit voltage is 1.16 V. An observation is made regarding the variation of current under short-circuit condition with respect to time, which is unlike the variation observed for any other electrochemical cell. The curve features are discussed and interpreted. This observation opens a new field of interest for electrochemists, molecular biologists, botanists, etc. It is expected to signify the electrical activity associated with the majority of processes in plant metabolism. The promising feature lies in supporting devices with high voltage and low current requirements. With proper design, the cell can be employed on a larger scale to meet energy requirements.

Keywords: *Ipomoea aquatica*; *Calotropis gigantea*; Unit operations; Bioelectrochemical cells

1. Introduction

With continuing developments in the electronic industry, power consumption has been reduced to milli- and micro-watts. It is essential that newer and cheaper sources of energy are found to replace conventional energy sources. This study is a modest contribution towards the search for alternate energy sources.

A variety of battery systems have been developed in the past few decades. All the materials involve synthetic preparation and, hence, complicate the manufacturing process and enhance production costs. The fabrication of the cell discussed here requires only a few unit operations and offers the promise of high cost savings.

It is considered that the plant leaves used in the cell could be good protonic conductors and could be used for fabricating bio-e.m.f. cells [1]. One important advantage is that the zinc cans and graphite rods of exhausted dry cells can be re-used instead of being discarded.

2. Experimental

2.1. Case I

The bioelectrolyte cell was fabricated using an extract of the leaves of *Ipomoea aquatica* from the family *Convolvulaceae*. A paste of leaves was made and the syrup extracted was cloth-filtered to ensure uniformity. The cell is represented as: Zn | syrup | graphite.

Battery grade zinc and graphite were used as the electrodes (dimensions 1 cm × 1 cm × 0.1 cm). The pore area of the graphite was not taken into account. The electrodes were glued to the inner faces of a glass case such that the anode cathode spacing was 2 mm. The electrolyte was filled into the gap (1 cm × 1 cm × 0.2 cm) between the electrodes.

The cell was kept overnight before measuring the open-circuit voltage (OCV) and the short-circuit current (SCC) [2].

To obtain a close value to the available energy density, two cells were connected in series to power an electronic wrist watch that had an operating voltage of 1.0 V and a current of 1.0 μA.

2.2. Case II

Water-cleaned leaves of *Ipomoea aquatica* were crushed into a paste and compacted into a standard D4-size zinc shell. A standard D4-size graphite rod was inserted centrally and the cell was sealed with a tiny vent left for evolved gases to escape [3]. After the assembly, the cell was left for 48 h to ensure proper settling to give uniform electrical contact with the active material and to avoid non-uniform current distribution [2]. The initial OCV was noted. The cell was short-

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circuited using a precision ammeter; a voltmeter was connected to read the short-circuit voltage (SCV). The SCC and SCV were noted. The short-circuiting was performed to increase the cell reaction rate and was carried out in a controlled atmosphere without stirring. The weight of the electrolyte was 30 g.

3. Results and discussion

3.1. Case I

The initial OCV and SCC of the cell were 0.99 V and 0.65 mA, respectively. The functioning of the electronic wrist watch was found to be normal. The energy density of the cell was calculated to be 1.1 Wh/kg of electrolyte at a current drain of 1 μA.

3.2. Case II

The initial OCV and SCC of the cell were 1.16 V and 14.0 mA, respectively. The SCC under shorting conditions is plotted against time, *t*, in Fig. 1. The SCC on the plateau, i.e. before the ascending part, and at the peak are referred to as the plateau current and the peak current, respectively. The values of SCC and SCV are given in Table 1. The points A and B are on the slopes of the hump.

The curve obtained is unlike that obtained for any other electrochemical cell. It is observed that the variation of SCC and SCV is independent of temperature. This is concluded since the ascending part of the hump was observed during the day and continued during the night, and the decline was observed during the following day. The experiment was discontinued when the SCV and the SCC were observed to be constant for 5 h. The high variation in the SCV (7.7 to 12.8 mV) shows that it is independent of temperature. It is considered that this behaviour results from the variation in the resistivity due to the cell reaction.

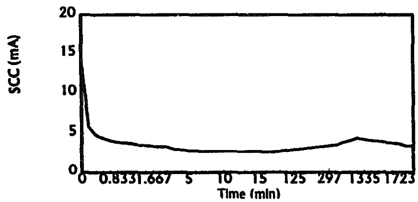

Fig. 1. Variation of short-circuit current (SCC) with time for cell made from paste of leaves of *Ipomoea aquatica*.

Table 1
Values of SCC and SCV

	At $t=0$	On plateau	At peak	At A and B
SCC (mA)	14	2.6	4.4	3.4
SCV (mV)	41	7.7	12.8	9.9

A similar observation was made with the cells made with the paste of leaves of *Calotropis gigantea* and *Pedilanthus tithymoloides*. For a single cell, the time for which the SCC remained constant, i.e., the plateau current, was found to be proportional to the number of times the cell was continuously short-circuited and also the time for which it is short-circuited. The variations are shown in Fig. 2, where the curves depicted Fig. 2(a)–(c) denote the variation of SCC with respect to time (carried out every alternate day) for the same cell made of leaves of *Calotropis gigantea*. The OCV was 1.0 V; the values of SCC are tabulated in Table 2.

Further research is required to understand the operating performance of the cell. Satisfactory exchange currents can be obtained by increasing the area of electrodes. These battery systems can be cheaply operated in the countryside where these plant materials are available. The initial OCV of 1.16 V seems to be promising and needs to be developed for various applications. Devices such as buzzers, quartz clocks and light-emitting diodes were found to function normally. The observation is expected to give vital information regard-

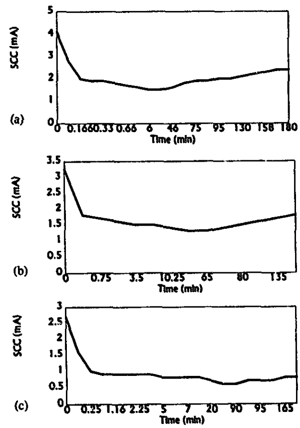

Fig. 2. Variation of short-circuit current (SCC) with time with the cell made from paste of leaves of *Calotropic gigantea* and *Pedilanthus tithymoloides*. Curves (a) to (c) for successive alternate days.

Table 2
Values of SCC

Curve	SCC (mA) at t=0 (mA)	Plateau current (mA)	Times of constant SCC (min)	SCC at 180 min (mA)
Fig. 2(a)	4.1	1.5	40	2.4
Fig. 2(b)	3.3	1.3	52	1.8
Fig. 2(c)	2.7	0.6	68	0.8

ing the electrical activity associated with the majority of processes in plant metabolism. Further systematic study is under way in our laboratories to identify and understand the phenomenon.

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References

[1] V.K. Deshpande and A.M. Joshi, *J. Power Sources, 47* (1994) 185–188.

[2] A. Salkind and E. Yeager, *Techniques of Electrochemistry*, Vol. 3, Wiley, New York.

[3] M. Ravindranath, *Electronics for You*, (Nov.) 1989.