OPENING MINDS: RESEARCH FOR SUSTAINABLE DEVELOPMENT

Investigation of Applicability of Banana Pith as Electrolytic Media for Bio-Batteries

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1 INTRODUCTION

To face e global challenges in energy, new technologies are essential for the future which should be aligned with sustainable development. There has been quite a number of impressive research and developments over the past years with the intention of harvesting sustainable electrical energy via various methods. The usage of sustainable energy for the production of electricity mainly requires the availability of a relevant technology for production and storage of energy using batteries. However, there are many challenges facing the development of batteries that can address environmental concerns and stability with a prolonged life cycle to meet current demands. The technology of batteries has evolved over the years. One promising technology has been the use of biological tissues. Galvani [1] was one of the earliest researchers to explore the electrical properties of biological tissues. Since then, the usage of either biological tissues or fluids for power generation has attracted a number of researchers throughout the world who have conducted further research towards developing organic fuel cells [2, 3]. This has been accompanied by rapid advances for power sources for devices where portability is important.

The problems associated with bio-batteries are primarily related to the materials used to fabricate the battery electrodes as well as the electrolytes. In the recent past, bio- battery technology has been widely optimized by the usage of new alternative materials such as tubers, yams, fruits etc. to address energy and power demands by the introduction of different structural modifications [4, 5]. A local study has conducted extensive research to explore the applicability of plantain pith as an electrolytic material for Galvanic cells [6]. The chopped plantain pith after boiling showed the best battery performance. The battery fabricated using this particular material had excellent stability and was able to light up an LED light for more than 500 hours if the electrolyte was prevented from drying. Even the inedible banana peels which serve little economic purpose are now being used as a constituent in super capacitors [7] and rechargeable batteries [8].

The current study was aimed at exploring the initial bio-battery design specification using the pith of ambun banana variety which has not been previously tested as an electrolytic media.

2 METHODOLOGY

The trunk of the ambun banana plant was mashed using a blender to form the pith. The mashed pith was kept on a hot plate set at 120 0C for 30 minutes to boil and concentrate its liquid content for usage as an electrolytic medium in Galvanic Cells.

The galvanic cell was fabricated by sandwiching plantain pith between Zn and Cu plates of area 2 × 6 cm2. Initially the separation between the Zn and Cu plates was fixed at 2 cm and plantain pith was filled in between the two plates to a height of 5 cm. Electrical properties of the cells was characterized by discharging through a 300 Ω resistor. Thereafter the Zn and Cu electrode combination was checked to find the optimum cell arrangement. Different parameters of bio-battery performance were investigated to obtain a basic idea of its functionality. In this regard, separation of the two plates was varied from 1 cm to 5 cm with different heights of the electrolyte media: 1 cm, 2 cm, 3 cm, 4 cm and 5 cm which was obtained by inserting different amounts of plantain pith at each configuration. At each setting of the cell, charge transfer resistance was measured by taking Nyquist plots using AutoLab FRA 32.

3 RESULTS AND DISCUSSION

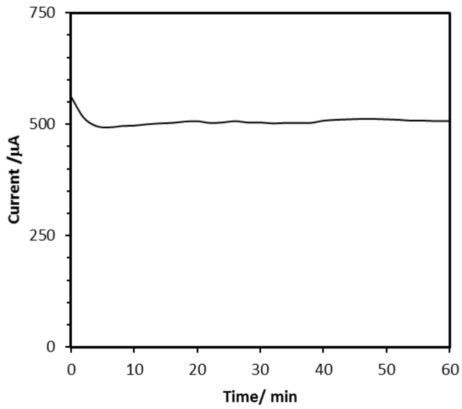
The chemical reaction responsible for the operation of the Galvanic cell to produce net electric potential is given below.

2H+ + Zn → Zn2+ + H2 (gas)

E0 = 0.76 V

A battery in general is used to store energy and release it at the desired time in a controlled manner to satisfy the energy demand. Particularly, a discharge curve which shows the variations in cell voltage and current with time can be regarded as an important indicator of battery performance. Therefore, discharge curve of the cell through a 300 Ω resistor initially for Zn and Cu plates fixed at 2 cm apart filling the electrolytic media to a height of 5 cm was investigated. Since the width of the plates is 2 cm the active area of this configuration was restricted to 10 cm^2. Figure 1 shows the discharge curve of the cell for a period of one hour.

Figure 1: Discharge curve of the



Galvanic cell when plantain pith was used as electrolytic media.

The cell was capable of delivering a 500 µA current throughout the observed period across the load resistor. Electrical power of the galvanic cell of this configuration was ~ 350 µW.

The current and voltage of the cells varying the active area of the Galvanic cell was studied again using plantain pith as the electrolytic media. Figure 2(a) depicts this information when the area was varied as 2 cm^2, 4 cm^2, 6 cm^2 and 8 cm^2. It could be noticed that the short circuit current of the cell increased when the area of the cell increased while the open circuit voltage of the cell decreased. But the increase of the short circuit current of the cell was not proportional to the increment of the active area of the Zn and Cu plates. Figure 2(b) shows the variation of the short circuit current and open circuit voltage of the Galvanic cell when the separation between the Zn and Cu plates were varied while keeping the active area of the cell constant at 4 x 2 cm^2.

In contrast, to the increment of active area of the cell, short circuit current of the cell decreased and open circuit voltage of the cell increased when the separation of the two electrodes was increased.

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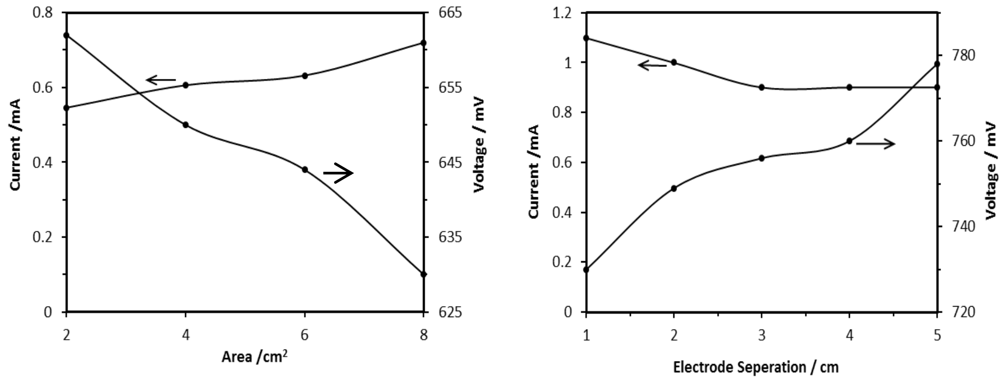

Figure 2: Variation of short circuit current and open circuit voltage of Galvanic cell with (a) the active area of the cell (b) electrode separation (cell area 4 x 2 cm^2)

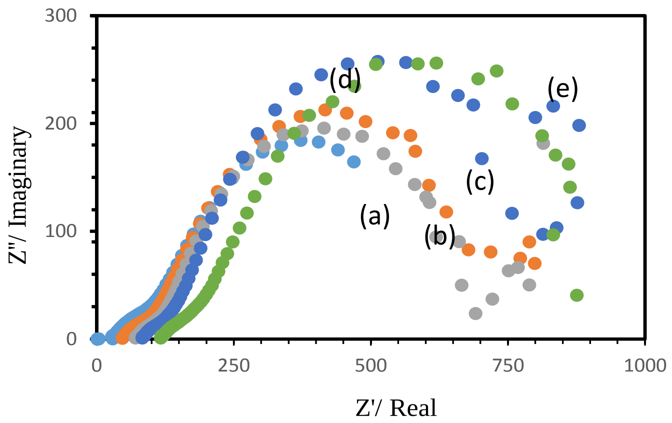

Figure 3: Variation of Nyquist plot of the cells with electrode separation for a constant active cell area of 2 x 2 cm^2 (a) 1 cm (b) 2 cm (c) 3 cm (d) 4 cm (e) 5 cm

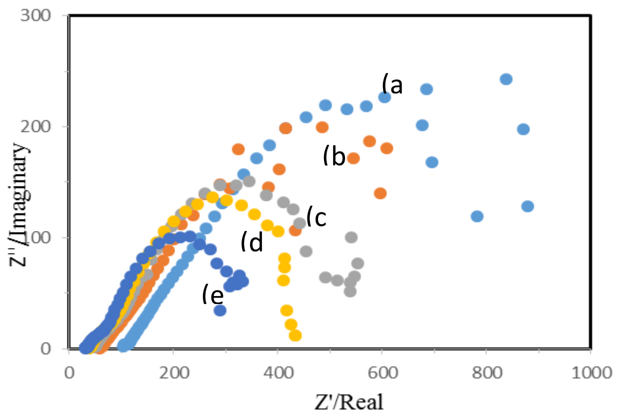

Figure 4: Variation of Nyquist plot of the cells with the area for a constant electrode separation of 2 cm (a) 2x2 cm^2 (b) 2x3 cm^2 (c) 2x4 cm^2 (d) 2x5 cm^2

The impedance of different cell configurations was analyzed with Impedance Spectroscopy (IS). With the IS data it is possible to find out the charge transfer resistance at each electrode and the series resistance of the Galvanic cells. With this data, an equivalent circuit for the cell can be simulated which will give important information on each configuration of the cells.

Figure 3 shows the Nyquist plots of the cells when the distance of separation of the Zn and Cu electrodes was varied. It can be observed that two semicircles are appearing in these plots. The semicircle at lower frequency end of the plot corresponds to the charge transfer resistance at the Cu electrode and electrolyte interface which happens at a low reaction rate and produces hydrogen gas. The semicircle at the high frequency end is for the charge transfer resistance at the Zn electrode and electrolyte interface where the electron transfer rate is quite high. It can be observed that the series resistance of the cells as well as the parallel resistances increases when the separation was increased.

Figure 4 shows the Nyquist plots of the cells when the area of the electrodes was varied at constant electrode separation. It can be noticed that the series resistance of the cells as well as the parallel resistance of the cells decrease when the area of the cell is increased.

4 CONCLUSIONS AND RECOMMENDATIONS

Short circuit current delivered by a Galvanic cell that uses plantain pith electrolytic media increased while open circuit voltage decreased when the active area of the cell is increased. With the increment of the separation of electrodes, open circuit voltage increased while short circuit current decreased. The Nyquist plots of the cells were also helpful to identify the charge transfer characteristics of the cell. Further investigations are necessary to improve the cell performance of bio-batteries.

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