Short Communication

Cactus (*Opuntia dillenii* Grahm) stem: a new source of energy

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Abstract

An electrochemical cell has been fabricated using cactus stem as an electrolyte. A study of the discharge characteristics reveals that, at a current drain of 100 μA, the cell gives an optimum energy density of 175 mWh kg^{-1}. The power generated by these cells is sufficient to run piezoelectric buzzer and a LCD calculator for a few hours. This work opens up a new interdisciplinary area for physicists, botanists and electrochemists.

Introduction

During the past few decades, the demand for portable electricity has increased dramatically. Portable electrical appliances are becoming increasingly popular. As a result of this activity, the development of suitable batteries has become an object of fierce competition among manufacturers, as well as a topic of intensive research. Solid-state batteries (which have the electrolyte and both electrodes in the solid-state) have distinct advantages over conventional, liquid electrolyte batteries [1]. A number of solid-electrolyte materials has been developed for solid-state batteries [2–4]. At present, crystalline materials [5], glasses [6], polymers [7] and composites [8] are being studied to evaluate their utility in solid-state batteries. Most of these materials are either lithium or silver ion conductors. In addition, certain protonic conductors have been examined and tested in batteries [9, 10]. All these materials involve synthetic preparation and this complicates the procedure for battery fabrication and enhances the production costs.

The use of natural solid-electrolyte material offers the promise of cost-savings but, to date, this possibility has been ignored. It is considered that plant leaves could be good protonic conductors and could be used for fabricating bio-e.m.f. cells. The present work is, perhaps, the first attempt to examine such a concept. Cactus stem has been used as an electrolyte to fabricate a cell and the discharge characteristics have been examined.

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Experimental

The electrochemical cells were fabricated with the following configuration:

Cu|cactus stem|Zn

The electrolyte was a stem (phylloclade) of *Opuntia dillenii* from the family *Cactaceae*. A thin slice (1×1×0.5 cm) of the stem was cut and sandwiched between copper and zinc electrodes. The constant-current discharge characteristics of the cell were recorded at 50, 100, 150 and 200 μA.

Results and discussion

The initial open-circuit voltage (OCV) of the cell was found to be 0.9 V and the short-circuit current (SCC) was found to be 1.5 mA. Figure 1 shows the constant-current discharge characteristics of the cells at four different values of current. It can be seen that as the discharge current increases, the operating voltage decreases. The cell capacity and energy density for different cells are given in Table 1. The variation of energy density as a function of current drain is displayed in Fig. 2. It is evident that for a current drain of 100 μA the cell gives an optimum energy density of 175 mWh kg^{-1}. The operating voltage for this cell is 0.35 V. The energy density in the present work is much higher than that (23.40 mWh kg^{-1}) reported for a silver solid-electrolyte battery [11].

To test the utility of this cell, a piezoelectric buzzer was connected to it and was found to work in a normal way. By connecting four such cells in series, a battery was made and shown to power continuously a calculator with an LCD for 3 h. These results warrant the investigation of more applications of this cell, where the power consumption is low, i.e., of the order of milliwatts. The batteries based on these cells could also be useful for some military purposes.

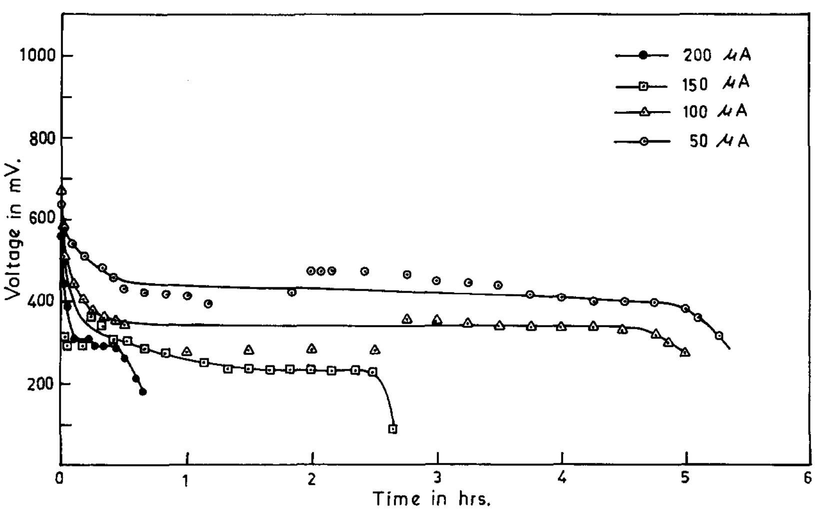

Fig. 1. Constant current discharge characteristics of prototype cell.

TABLE 1

Cell capacity and energy density for different current drains

Cell	Current drain (μA)	Cell capacity (μAh)	Energy (μWh)	Energy density (mWh kg^{-1})
1	50	250	105	110.5
2	100	475	166.25	175
3	150	375	105	110.5
4	200	100	28	29.4

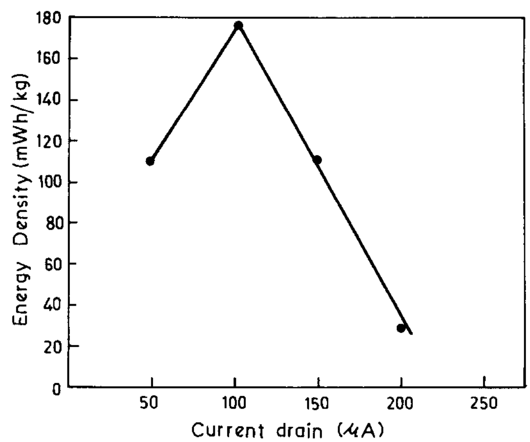

Fig. 2. Variation of energy density with current drain.

These cells are very simple to construct. The necessary electrodes and the cactus plants are both readily available. The understanding of the operating performance of these cells will require further research efforts.

The present work could open up a new interdisciplinary area where botanists, physicists, electrochemists and electronic engineers could work together to develop novel power sources.

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