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Battery Application of Na^+ Ion Conducting Solid Polymer Electrolyte*

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Abstract: A new Na^+ ion conducting solid state polymeric battery based on hot-pressed solid polymer electrolyte (SPE): [75 PEO : 25 $NaPO_3$], has been fabricated. The cell performances have been studied at room temperature under different load conditions. The ionic transference number (t_{ion}) measurement has also been reported by using electrochemical cell-potential and dc polarization method.

Keywords: Solid state polymeric battery, ionic transference number, electrochemical cell-potential method.

1. Introduction

Solid polymer electrolytes (SPEs), attracted widespread attention as the most appropriate choice to fabricate flexible, compact, laminated all-solid-state batteries[1-7]. Polymer electrolytes are prepared, in general, by complexing/ dissolving variety of ionic salts in different kinds of polymeric hosts adopting the usual solution-cast route. Very recently, a novel hot-press method has been developed for casting SPEs[4-8]. This technique is relatively more rapid, least expensive and solvent-free procedure as compared to the conventional solution-cast method. A new Na^+ ion conducting solid polymer electrolyte (SPE): [75 PEO: 25 $NaPO_3$], recently investigated by hot-press technique, at the present research laboratory[8]. The present paper reports the fabrication of solid state polymeric batteries by using this SPE and studies the cell potential discharge performances at room temperature under different load conditions.

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2. Experimental

A new Na^+ ion conducting solid polymer electrolyte (SPE): [75 PEO: 25 $NaPO_3$], has been synthesized by recently developed hot-press technique using the dry powder mixtures of AR grade chemicals: PEO (10^5 MW, Aldrich, USA), sodium phosphate $NaPO_3$ (> 99%, Merck), as supplied. For the details on the preparation method and materials characterization of this SPE, reference may be made to our earlier communication[8]. Solid state polymeric batteries were fabricated in the following cell configuration: **Cell:**

Na	75 PEO : 25 $NaPO_3$	$C+I_2+$ SPE
(Anode)	(Electrolyte)	(Cathode)

Na-metal was used as anode while cathode material was prepared by mixing the elemental iodine (I_2), conducting graphite (C) and SPE in 1:1 weight ratio. The cell potential discharge performances have been studied under different load conditions at room temperature. The ionic transference number (t_{ion}) in this SPE has been measured using the dc polarization and electrochemical cell potential method[9].

3. Results and Discussion

The cell potential discharge profiles for polymeric Cell under different loads viz. 100 kΩ, 50 kΩ at room temperature, is shown in Fig 1. The Open Circuit Voltage (OCV) ~ 2.75 V obtained for the Cell. It can be clearly noticed that except for the initial potential drop, OCV value remained practically stable for ~ 75 hrs. when discharged through 100 kΩ (i.e. during a low current drain state). However, the cell potential decreased relatively faster when discharge through 50 kΩ load (i.e. during higher current drain states).

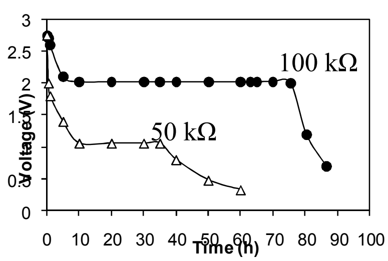

Figure 1: Cell potential discharge profiles as a function of load conditions.

Table 1 lists some important cell parameters for polymeric Cell, calculated in the plateau regions of the discharge profiles. On the basis of these studies, it can be inferred that the above cell, based on the this newly synthesized Na^+ ion conducting SPE, performed fairly satisfactorily especially during low current drains. The ionic transference number (t_{ion}) for the newly synthesized solid polymer electrolyte system was determined employing both the dc polarization and electrochemical cell potential method using following equation

Table 1: Some important cell parameters, calculated from the discharge curves at room temperature.

Load (kΩ)	Working Voltage (V)	Current Density ($\mu A.cm^{-2}$)	Discharge Capacity (μA.h)	Power Density ($mW.kg^{-1}$)	Energy Density ($mWh.kg^{-1}$)
100	2.02	1.61	141	25.34	1774.0
50	1.06	0.84	26.5	6.97	174.4

$$t_{ion} = \frac{E'}{E},$$

where E' and E are the measured and theoretical values of OCV respectively. On substituting E & E' values in the above equation, $t_{ion} \sim 0.95$ observed for the solid electrolyte system. Fig. 2 shows the ionic transference number measurement: current vs time plot and t_{ion} was also determined from the dc polarization method which is exactly similar to what was obtained using electrochemical potential method. $t_{ion} \simeq 0.95$ is indicative of the fact that Na^+ ions are the sole charge carriers in the solid electrolyte system with negligibly small electronic contribution to the total conductivity

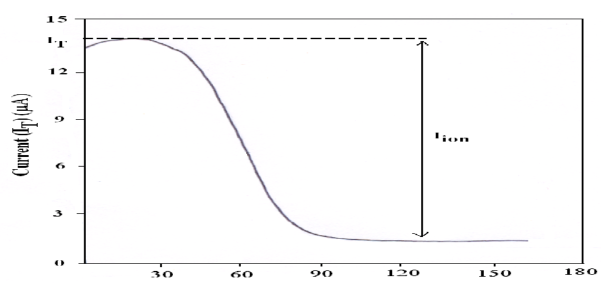

Figure 2: 'Current vs time' plot of SPE: (75 PEO: 25 $NaPO_3$).

4. Conclusion

Solid State polymeric battery was fabricated using a newly investigated fast Na^+ ion conducting SPE. The cell potential discharge performances were studied under varying load conditions. This battery performed fairly satisfactorily specially under low current drain states. Ionic transference number measurement was indicative of fact that the SPE is pure ionic systems with Na^+ ion as the sole charge carriers.

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