



FABRICATION OF THIN FILM LITHIUM-ION BATTERIES USING CONDUCTING POLYMER ELECTROLYTES

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ABSTRACT

The polymer electrolytes are promising materials for the ever-growing need for high energy density power sources for power and traction applications. In present study we have prepared solid state battery using polymer electrolyte. Three electrochemical cells were prepared by varying the polymer electrolyte. Electrochemical cells have been fabricated with the configuration Li |polymer electrolyte|(C+I₂) and their discharge characteristics were studied. The open circuit voltage (OCV) was observed between 2.54 V and 3.4 V and short circuit current (SCC) 19.8 μ A and 120 μ A. Other cell parameters were also measured at room temperature such as current density, energy density etc., by using load of 1M Ω .

Key words: Polyaniline (PANI), Li₂SO₄.H₂O, LiClO₄.3H₂O, LiCl, Li metal.

INTRODUCTION

A battery is a transducer that converts chemical energy into electrical energy and vice versa. It contains an anode, a cathode, and an electrolyte. Anode, in case of a lithium battery, is the source of lithium ions. The electrolyte provides for the separation of ionic and electronic transport and in a perfect battery the lithium ion transport number will be unity in the electrolyte. The cell potential is determined by the difference between the chemical potential of the lithium in the anode and cathode, $\Delta G = -E_F$. The lithium ions flow through the electrolyte whereas the electrons generated from the reaction, $\text{Li} = \text{Li}^+ + \text{e}^-$, go through the external circuit to do work. Thus, the electrode system must allow for the flow of both lithium ions and electrons. That is, it must be both a good ionic conductor and an electronic conductor. Many electrochemically active materials are not good electronic conductors, so it is necessary to add an electronically conductive material such as carbon example, in cell phones, laptop computers, and MP3 players such as the iPod¹. Although much work has continued sporadically on the carbon fluorides, by Exxon and others, the major challenge has been to make this reaction reversible even when lower fluoride levels were used. Sanyo, the largest manufacturer today of both lithium rechargeable and nickel metal hydride batteries, developed^{2,3} one of the earliest lithium batteries with the Li/MnO₂ system that they initially sold in solar rechargeable calculators⁴.

Some early work on ambient systems was also underway in the United States by 1970, for example, by Dey et al.⁵ on the lithium reactivity with a range of metals, such as aluminum. The increasing energy needs of modern society have spurred extensive research and development in the areas of energy production, storage and distribution. Devices incorporating solvent-free polymer electrolytes, in particular the 'lithium polymer battery' (LPB), are highly desirable due to characteristics such as inherent low safety risks and their ability to be formed into thin film structures of large surface area, yielding high energy density cells that are lightweight and flexible⁶. However, to realize these performance advantages, several challenges related to materials design must be overcome, including the ability to make LPBs mechanically robust and operable at high current rates while still retaining their lightweight construction. This is particularly important in applications where batteries are designed to serve a secondary function as a structural or insulating element that might commonly encounter significant stress or deformation. Poly (ethylene oxide) (PEO) doped with alkali metal salts has long been favored a candidate for use as an electrolyte in solid-state rechargeable lithium batteries⁷. Q. Li et al.⁸ Polyethylene oxide (PEO)-based polymer electrolytes with BaTiO₃ as a filler have been examined as electrolytes in 4 V class lithium polymer secondary batteries. A mixture of 90 wt.% LiN(CF₃SO₂)₂. 10 wt.% LiPF₆ was found to be the best candidate as the salt in PEO, and showed high electrical conductivity, good corrosion resistance to the aluminum current collector and low interfacial resistance between the lithium metal anode and the polymer electrolyte. The possibility of practical solid rechargeable lithium battery using polymer electrolytes was proposed by Armand et al.⁹ in 1978. A lithium ion cell has three main components: positive electrode (cathode), negative electrode (anode) and separator. This has both advantages and disadvantages.

EXPERIMENTAL

Preparation of electrolyte

PANI, PEO and Li₂SO₄.H₂O were added to NMP (1-methyl 2-pyrrolidone) which was stirred for 30 min¹⁰. Films containing PANI, PEO and Li₂SO₄.H₂O (Lithium sulphate) were obtained by drying the mixtures at 75 °C for 24 h. The films are deposited on plain Teflon sheet so that it should not stick to it and can be easily removed without damage. Same procedure repeats for PANI-LiClO₄.3H₂O-PEO, PANI-LiCl-PEO composite polymer electrolyte films.

Anode and cathode

Lithium metal is used as anode. The lithium ions flow through the electrolyte whereas the electrons generated from the reaction, $\text{Li} = \text{Li}^+ + \text{e}^-$. The composite cathode material was prepared in the 5 : 5 ratio carbon and iodine (C + I₂).

RESULTS AND DISCUSSION

The Li-ion batteries are considered to be one of the most promising power sources because of the main advantages such as light weight and very high energy density. Because there's no liquid, the solid polymer cell does not require the heavy protective cases of conventional batteries, the absence of free liquid makes Lithium-ion polymer batteries more stable and less vulnerable to problems caused by damage or abuse. Discharge characteristics of the cells are studied under constant load 1 K ohms. The common cell configuration Li|Electrolyte|I₂+C was used for three kinds of cells. Copper plates were used as a current collector on both side of the cell. The composite cathode material was prepared in the 5 : 5 ratios of carbon and iodine. The cell studied measured at the room temperature that results are tabulated in table 1 and discharge curves for these cells are represented in Fig 1. The power density as well as discharge time is found to be more for Li| LiCl/ PANI/ PEO| C+I₂ cell configuration.

Table 1: Various cell parameters for three systems

Cell Parameters at 30°C	Cell configuration Li Electrolyte C+I ₂		
	Li LiCl/ PANI/ PEO C+I ₂	Li LiClO ₄ .3H ₂ O /PANI/ PEO C+I ₂	Li Li ₂ SO ₄ .H ₂ O /PANI/ PEO C+I ₂
Area of cell (cm ²)	0.8	0.8	0.8
Load	1MΩ	1MΩ	1MΩ
Weight of the pellet (g)	0.180	0.165	0.3
OCV(V)	2.56	3.4	3.1
SCC(μA)	120	19.8	104
Current density μA/cm ²	150	24.75	130
Discharge time(h)	37	31	8
Discharge capacity μA/h	3.243	0.6387	13
Power density W/Kg	1.707	0.408	1.074
Energy density	63.159	12.648	8.592

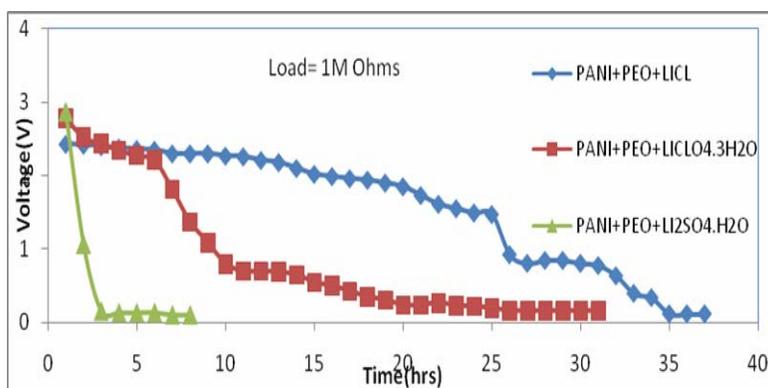


Fig. 1: Discharge characteristic curve for a) Li |PANI PEO LiCl|(C+I₂) b) Li |PANI PEO LiClO₄.H₂O|(C+I₂) c) Li |PANI PEO Li₂SO₄. H₂O|(C+I₂)

CONCLUSION

Open circuit voltage of Li/LiClO₄.H₂O /PANI/ PEO| C+I₂ cell is higher (3.4V) than Li|LiCl/ PANI/ PEO| C+I₂ and Li|Li₂SO₄.H₂O /PANI/ PEO| C+I₂. Cutoff voltage for these the cell is around 0.15V.

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