E1-14: Charge/discharge characteristics of solid state batteries based on solid polymer electrolyte $(PEO)_9$ $LiCF_3SO_3$

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The main development thrust in solid polymeric batteries has been towards lithium systems with intercalation cathode materials, because they have high energy densities and are relatively cheap to manufacture. To minimize the interfacial resistance at electrode/electrolyte interfaces, during charge/discharge cycling, there should be no products of electrolysis formed at the interfaces. This is solved by using insertion cathode materials such as LiV_3O_8 and V_6O_{13}.

In order to understand the charge / discharge characteristics of polymeric batteries, the batteries based on the following configurations were studied:

1. Li/(PEO)9 $LiCF_3SO_3/Li_{1+x}V_3O_8$
   Anode Electrolyte Cathode

2. Li/$(PEO)_9$ $LiCF_3SO_3$/ V_6O_{13}
   Anode Electrolyte Cathode

Solid polymer electrolyte was prepared with starting materials poly(ethylene oxide) of molecular weight $4x10^6$ (BDH) and $LiCF_3SO_3$. These materials were dried well for 4 h under vacuum at 60°C and dissolved in a solution of anhydrous acetonitrile. The ratio of the molecular weight of $LiCF_3SO_3$ to that of PEO was chosen to be 1:9 and $(PEO)_9LiCF_3SO_3$ solid electrolyte films were obtained by the solvent casting method.

A pellet of LiV_3O_8 cathode was prepared by the following method:

LiV_3O_8 compound was ground well for a few hours to get very fine particles. This was mixed together with Kajan-black, PEO and $LiCF_3SO_3$. The mass percentages of each material taken to prepare the pellets were: 60% LiV_3O_8 : 10% Kajan-black : 20% PEO : 10% $LiCF_3SO_3$.

The V_6O_{13} based cathode which was cast on a nickel foil and had a thickness of the order of 50-100 μm, was used as received from Denmark Technical University. A thin Li foil was used as the anode and cells were assembled in an argon filled glove box.

A special kind of sample holder was used to sandwich the cell in argon atmosphere. After assembling, the cell was subjected to charge / discharge cycling using an automated galvanostat and a chart recorder.

The electrical conductivity of $(PEO)_9LiCF_3SO_3$ solid polymer electrolyte film, measured using the complex impedance technique was 4.56×10^{-7} at 32°C and 3.69×10^{-4} at 120°C. They are comparable with reported values.

Following values were obtained by galvanostatic charge / discharge cycling of 2 batteries kept at 90°C and cycled between the 2 voltage limits of 3.5 V and 1.5 V.

Cell

$Li/(PEO)_9\ LiCF_3SO_3\ /V_6O_{13}$ (Cathode film on Nif oil)

Initial open circuit voltage	= 3.23 V
Discharge current	= 0.1 mA
Discharge time	= 15 h
Cell capacity	= 1.5 mAh

Complete charge / discharge curves have been recorded for the first few cylces.

Cell

$Li/(PEO)_9/LiCF_3SO_3/LiV_3O_8$ (Cathode pellet)

Initial open circuit voltage	= 3.62 V
Discharge current	= 0.2 mA
Discharge time	= 27h
Cell capacity	= 5.3 mAh

Theoretical capacity, calculated for the amount of active material (LiV_3O_8) in the cathode pellet is 16 mAh.

Complete charge / discharge characteristics have been recorded for the first few cycles. Polarization curve (I vs V) for the cells exhibited the behaviour expected for a typical cell.

The solid polymer electrolyte $(PEO)_9LiCF_3SO_3$ was synthesized and its conductivity measured as a function of temperature. Solid state batteries of configurations:

Li /$(PEO)_9LiCF_3SO_3$ / V_6O_{13}
Anode Cathode (film)

and

Li /$(PEO)_9LiCF_3SO_3$/$Li_{1+x}V_3O_8$
Anode Cathode (Pellet)

have been fabricated successfully and their charge/discharge characteristics and polarization characteristics have been studied. Cell capacities and cathode utilization have been estimated. The first cell has a capacity 1.5 mAh and the second 5.3 mAh.