Gamma Irradiation Of PVdF Based Polymer Electrolytes

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Abstract

Solutions of PVdF containing various concentration of $LiPF_6$ were gamma irradiated. solutions were then cast to form films. The conductivity of the solid polymer electrolyte then determined by electrochemical impedance spectroscopy (EIS). Dielectric propertie the solid polymer electrolyte were also discussed.

Keywords: conductivity, gamma irradiation, PVdF, $LiPF_6$

1. INTRODUCTION

Research and development on polymer electrolyte have become active for application in solid-state batteries and other electronic devices. Numerous investigations on polymer electrolytes focused on systems related to poly(ethylene oxide) (PEO) [1], poly(acrylonitrile) (PAN), poly(vinylidene-fluoride) (PVdF) [3], poly(methylmetha-crylate) (PMMA) and chitosan [2].

Nasef and Saidi [4] prepared a PVdF based electrolyte by γ-irradiating the PVdF membrane that has been soaked in a $LiCF_3SO_3$ solution of known concentration. The conductivity of the polymer electrolyte was in the range from10^{-5} to 10^{-3} S cm^{-1} at ambient temperature. In this work, the desired amounts of PVdF and 1 M $LiPF_6$ in EC:DEC (v/v=1) was irradiated with different doses of γ-rays before being cast to form films. PVdF was procured from Magna Value (Malaysia) Sdn. Bhd. in the form of pellets. The PVdF pellets were initially dissolved in acetone at 60 °C before adding with the $LiPF_6$ liquid electrolyte.

2.0 EXPERIMENTALS

2.1 *Materials*

PVdF with an average molecular weig greater than 500,000 (Aldrich, USA), a M $LiPF_6$ in EC:DEC (v/v=1) li electrolyte (E-Merck, Germany) stirred at room temperature 30 °C for 4 PVdF pellets were dissolved in aceton °C before adding into the commercia liquid electrolyte.

2.2 *Sample Preparation*

PVdF (4 g)-$LiPF_6$ liquid electrolyte (4 was dissolved in acetone at 60 °C. PVdF: liquid electrolyte solution was s with dimethylformamide (DMF) and st continuously for 12 hours before irradi with Co-60 gamma rays at 50, 100, 150, and 300 Gy. The solution was poured different petri dish and dried at 45 °C i oven for 48 h to remove any further t of DMF. The prepared polymer films peeled from the petri dish and rinsed ethanol. Finally these films were dried in an oven for 48 hours. The thickness o films obtained were in the range of 70 μm as measured with a micrometer gau

2.3 *Ionic Conductivity*

Ionic conductivity of the polymer electrolyte membranes was measured at room temperature by complex AC impedance spectroscopy [5]. Measurements were carried out using the HIOKI 3525 LCR meter over a frequency range of 10 Hz to 100 kHz. The ionic conductivity of the polymer electrolyte membranes was calculated from the equation below

$$\sigma = \frac{t}{R_b A} \qquad (1)$$

where t and A represent the thickness and the area of the sample, respectively. R_b (bulk resistance) was obtained from the intercept on the real axis at the high frequency end of the complex impedance plot.

3.0 RESULTS AND DISCUSSION

Fig. 1 shows the conductivity of the PVdF based polymer electrolyte at different doses of gamma. From the graph, the conductivity of the non-irradiated PVdF based polymer electrolyte is 7.48 x 10^{-6} S cm^{-1}. At 50 Gy irradiaton, the conductivity increases to ~1.0 x 10^{-5} S cm^{-1} and can be considered to remain constant even when the radiation dose has increased to 100 Gy. Further increase in radiation dose at 150 Gy results in an increase in conductivity. Considering the nature of the rise in conductivity at low radiation doses, the drastic increase in conductivity to ~ 2.0 x 10^{-5} S cm^{-1} at 200 Gy is quite unexpected. At 300 Gy, the conductivity obtained is 2.06 x 10^{-5} S cm^{-1}. From the results obtained, it can be inferred that the gamma irradiation process has produced more conducting ions.

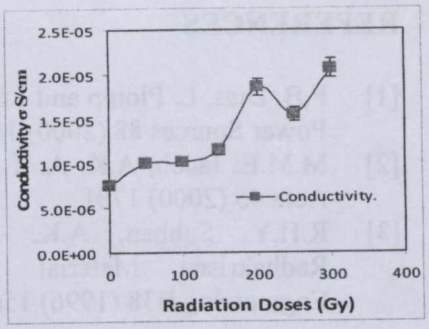

Fig. 1 The conductivity of PVdF based polymer electrolyte versus the radiation doses

The plot of dielectric constant, ε_r versus frequency for PVdF films containing salt is shown in Fig. 2. The dielectric constant decreases with frequency. It can also be observed that for a fixed frequency ε_r increases with γ-ray doses except for sample irradiated with 250 Gy γ-ray. This again supports the inference that the γ-irradiation produces more ions that contribute to the conductivity.

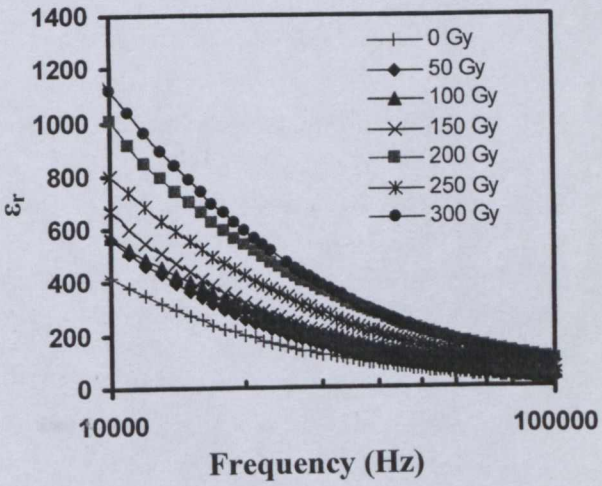

Fig. 2 Dielectric constant versus log frequency for PVdF based polymer electrolyte

4. CONCLUSIONS

From the present investigation, conductivity of the PVdF based electrolyte increases with radiation dose. The highest conductivity 2.06 x 10-5 S cm^{-1} was obtained when the electrolyte was irradiated with 300 Gy γ-ray.

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