Gamma Irradiation Of PVdF Based Polymer Electrolytes

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Abstract

Solutions of PVdF containing various concentration of LiPF6 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 properties the solid polymer electrolyte were also discussed.

Keywords: conductivity, gamma irradiation, PVdF, LiPF6

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(methyImethacrylate) (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 LiCF3SO3 solution of known concentration. The conductivity of the polymer electrolyte was in the range from $10^{-5}$ to $10^{-3}$ S cm$^{-1}$ at ambient temperature. In this work, the desired amounts of PVdF and 1 M LiPF6 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 LiPF6 liquid electrolyte.

2.0 EXPERIMENTALS

2.1 Materials

PVdF with an average molecular weight greater than 500,000 (Aldrich, USA), 1 M LiPF6 in EC:DEC (v/v=1) electrolyte (E-Merck, Germany) stirred at room temperature 30 °C for 1 day. PVdF pellets were dissolved in acetone and stirred continuously for 12 hours before irradiating with Co-60 gamma rays at 50, 100, 150 and 300 Gy. The solution was poured into different petri dishes and dried at 45 °C in an oven for 48 h to remove any further traces of DMF. The prepared polymer films were peeled from the petri dish and rinsed with ethanol. Finally, these films were dried in an oven for 48 hours. The thickness of films obtained were in the range of 70 μm as measured with a micrometer.
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

\[ \sigma = \frac{t}{R_b A} \]  

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 \( 7.48 \times 10^{-6} \) S cm\(^{-1} \). At 50 Gy irradiation, the conductivity increases to \( \sim 1.0 \times 10^{-5} \) 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 \( \sim 2.0 \times 10^{-5} \) S cm\(^{-1} \) at 200 Gy is quite unexpected. At 300 Gy, the conductivity obtained is \( 2.06 \times 10^{-5} \) S cm\(^{-1} \). From the results obtained, it can be inferred that the gamma irradiation process has produced more conducting ions.

![Fig. 1](attachment:image1.png)

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

The plot of dielectric constant, \( \varepsilon_r \) 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 \( \varepsilon_r \) increases with \( \gamma \)-ray doses except for sample irradiated with 250 Gy \( \gamma \)-ray. This again supports the inference that the \( \gamma \)-irradiation produces more ions that contribute to the conductivity.

![Fig. 2](attachment:image2.png)

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 \( 2.06 \times 10^{-5} \) S cm\(^{-1} \) was obtained when the electrolyte was irradiated with 300 Gy \( \gamma \)-ray.
REFERENCES
