

**THE IMPACT OF UV-MODIFIED EPOXIDISED NATURAL  
RUBBER ON PMMA/ENR 50 BLENDS ELECTROLYTE  
FOR LITHIUM ION BATTERY**

**DISEDIAKAN OLEH :  
DR FAMIZA ABDUL LATIF**

**APRIL 2011**

## **PENGHARGAAN**

Setinggi-tinggi penghargaan dan jutaan terima kasih di ucapkan buat semua pihak yang telah terlibat secara langsung atau tidak langsung dalam menjayakan penyelidikan ini dengan sempurna.

Diantaranya :

Prof Dr Abu Bakar Abdul Majeed  
Penolong Naib Canselor (Penyelidikan)  
Research Management Institute (RMI)

En. Mustafar Kamal Hamzah  
Ketua penyelidikan S & T  
Research Management Institute (RMI)

Dan

Semua kakitangan Research Management Institute (RMI), Pn. Ruhaida Sabron, Pn Intan Syarinaz Mohd Nazhar, Pn Hanipah Mohd Yatim serta semua kakitangan makmal di Fakulti Sains Gunaan yang membantu dalam menjayakan penyelidikan ini.

## ABSTRACT

This research focused on the development of a new thin film electrolyte based on Poly (methyl methacrylate) / Irradiated- 50% epoxidized natural rubber (iENR 50). Before the blending was carried out by solvent casting technique, the rubber was irradiated under UV light for 30 seconds (30iENR 50), 120 seconds (120iENR 50) and 600 seconds (600iENR 50) to reduce the number of inter-chain cross-linking of ENR 50. From the DSC analysis, it was found that the  $T_g$  of un-irradiated ENR 50 was reduced from  $-25^\circ\text{C}$  to  $-26^\circ\text{C}$  when it was irradiated for 30 seconds indicating that it has the highest chain flexibility as a result of breaking of the inter-chain cross-linking. Therefore, it can be concluded that it requires only 30 seconds of UV irradiation to heal the inter-chain cross-linking in the ENR 50 system. The reduction of the number of inter-chain cross-linking has been confirmed by the reduction of the intensity of the OH band at  $3440\text{-}3424\text{ cm}^{-1}$  followed by the increased in the intensity of the epoxy ring at  $1255\text{ cm}^{-1}$ . When this 30iENR 50 was blended with PMMA, it produced the most flexible freestanding film as compared to un-irradiated and other irradiated ENR 50 systems. Furthermore, this PMMA / 30iENR 50 exhibited the highest conductivity of  $1.03 \times 10^{-4}\text{ S/cm}$  due to the flexibility of the polymer chain and the formation of a less viscous phase that favor the migration of lithium ion in the blend matrix. The addition of PC plasticizer further enhanced the conductivity of the PMMA / 30iENR 50 /  $\text{LiCF}_3\text{SO}_3$  electrolyte to  $1.16 \times 10^{-3}\text{ S/cm}$ . The ionic conduction of the doped PMMA / 30iENR 50 system was found to obey the Arrhenius behaviour in which the migration of ions was thermally assisted. Interestingly, there were two activation energies ( $E_a$ ) were observed from the doped PMMA / 30iENR 50 electrolytes in which the  $E_{a2}$  at higher temperature was less than  $E_{a1}$  observed at lower temperature due to the change of the phase from crystalline to an amorphous phase at  $70^\circ\text{C}$ . This was confirmed from the DSC thermogram of the blend system. However, for the plasticized PMMA / 30iENR 50/  $\text{LiCF}_3\text{SO}_3$  electrolyte, the ionic conduction was due to the segmental motion of the polymer indicating that the presence of PC enhanced the mobility of the polymer.

## TABLE OF CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	viii
LIST OF FIGURES	x
LIST OF PHOTOGRAPH	xvi
LIST OF ABBREVIATIONS	xvii
LIST OF SYMPOLS	xix
LIST OF PUBLICATION	xx
<b>CHAPTER 1 : INTRODUCTION</b>	<b>1</b>
1.1 Polymer Electrolyte Background	3
1.2 Classification of polymer electrolytes	6
1.3 Preparation of polymer electrolytes	7
1.4 Surface Modification and Adhesion Improvement	8
1.5 Polymer Electrolyte Applications	12
1.6 Problem statements	12
1.7 Objectives	13
1.8 Research Scope	13

1.8.1	Selection of materials	13
1.8.2	Selection of material characterization	15
1.9	Expectations	15
1.10	Technical Challenge and Limitations	16
<b>CHAPTER 2 : LITERATURE REVIEW</b>		17
2.1	Poly (methyl methacrylate), ( PMMA)	17
2.2	Epoxidised Natural Rubber ( ENR )	22
2.3	The effect of UV irradiation on polymers	25
2.4	Material Characterization	26
2.4.1	Physical and chemical properties	27
2.4.1.1	Optical Microscopy	27
2.4.1.2	Fourier Transform Infrared Spectroscopy (FTIR)	28
2.4.1.3	Thermal Analysis	32
a)	Defferential Scanning Calorimetry (DSC)	32
b)	Thermogravimetric Analysis (TGA) and Deferential Thermogravimetric Analysis (DTG)	36
2.4.2	Electrical properties	38
2.4.2.1	Conductivity Study	38
2.5	Mechanisms of Ionic Conduction	42
2.5.1	Arrhenius behaviour	42
2.5.2	Vogel – Tammam – Fulcher Equation: A Free Volume – Based Theory	46