UNIVERSITI TEKNOLOGI MARA

ELECTRICAL, STRUCTURAL AND ELECTROCHEMICAL STUDIES OF POLYMER GEL ELECTROLYTE BASED ON AGAROSE–LITHIUM BIS(OXALATO)BORATE AND POLY (1-VINYLPYRROLIDONE-CO-VINYL ACETATE)–LITHIUM BIS(OXALATO) BORATE

MUHAMMAD SYAHIR BIN SAK ARI

MSc

September 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Muhammad Syahir bin Sak Ari
Student I.D. No.	:	2017771701
Programme	:	Master of Science (Applied Physics) – AS760
Faculty	:	Applied Science
Thesis Tittle	:	Electrical, Structural and Electrochemical Studies of Polymer Gel Electrolyte based on Agarose–Lithium bis(oxalato)borate and Poly(1-vinylpyrrolidone-co-vinyl acetate)–Lithium bis (oxalato)borate
Signature of Student	:	…….....
Date	:	September 2020

ABSTRACT

Energy material has become a current topic in almost every nation around the world wide. Dependency to the conventional fossil fuels as the sources of energy, researcher nowadays are focusing more on how to replace this non-renewable sources to more reliable renewable resources. One of the vital requirement for future energy application is the fabrication of high quality electrolyte. This thesis focuses on the preparation and characterization of liquid electrolytes (LEs) and polymer gel electrolytes (PGEs). Electrochemical impedance spectroscopy (EIS) is a technique for characterizing a wide variety of electrochemical systems and to determining the contribution of electrode and electrolyte processes in these system. In this work, lithium bis(oxalato)borate (LiBOB) salt was incorporated as the source of charge carriers. LEs was first prepared by dissolving LiBOB salt into solvent, dimethyl sulfoxide (DMSO) by using different molar concentrations of LiBOB (0.2 – 1.2 M). The optimum for the highest conducting (0.8 M LiBOB) of the liquid electrolytes was then gelled with various concentrations of agarose and poly(1-vinylpyrrolidone-co-vinyl acetate) [P(VP-co-VAc)] (1 – 8 wt.%) to making PGEs formed. The ionic conductivity of all electrolyte samples were calculated using the bulk resistance value obtained from the complex impedance plot in the frequency range of 100 Hz to 1 MHz. The conductivity behavior of PGEs decreases as composition of agarose and P(VP-co-VAc) increases until 8 wt.%. EIS studies shows the optimum conductivity of 6.91 x 10^{-3} S.cm^{-1} and 7.83 x 10^{-3} S.cm^{-1} for the electrolyte containing 1 wt.% agarose and P(VP-co-VAc) at room temperature respectively. Ionic conductivity for all electrolyte system was also studied in the studied range of temperature or known as temperature dependence from 298 K to 373 K. Each samples are plotted in log σ versus 1000/T to prove the Arrhenius rule are obeyed and implying that the ionic conductivity is thermally assisted. The activation energy, E_A observed to decrease as the temperature increase hence increase the ionic conductivity. The conduction mechanism in PGEs in both systems, agarose–LiBOB–DMSO and P(VP-co-VAc)–LiBOB–DMSO can be explained by using small polaron hopping (SPH) model. Transference number characterizations supports the ionic conductivity results. The lithium ion transference number, t_{Li^+} of 1 wt.% agarose and P(VP-co-VAc) composition is to be 0.03 and 0.12. The voltammogram of highest conducting PGEs with anodic decomposition of the electrolyte was stable up to 4.50 V vs Li. Fourier transform infrared (FTIR) spectroscopy confirmed the complexation between polymer and salt. The complexations between host polymer and salt used in an electrolyte systems are divulged based on shifting of the bands, O-H stretching in agarose, C=O stretching in P(VP-co-VAc), and change in intensity of the bands in BOB^- ion and existence of some new peaks in FTIR spectra. The result of the study confirms the PGE of P(VP-co-VAc) exhibit favourable performance compared with PGE of agarose.

ACKNOWLEDGEMENT

In the name of Allah, the most gracious and the most merciful. All praise and thanks to Allah S.W.T for the blessing, wisdom and guidance his bestow upon me, the strength and the opportunity for me to be able to completing my research work together with this thesis successfully. I would like to convey my earnest gratitude to all who has contributed in this research either directly or indirectly.

First, I would like to take this opportunity to express my profound gratitude and appreciation to Dr. Siti Zafirah binti Zainal Abidin, Professor Dr. Muhd Zu Azhan Yahya and Dr. Mohamad Fariz bin Mohamad Taib for their invaluable advice, constant encouragement, imparting their knowledge and the expertise toward the research.

I extend my heartfelt appreciation to my seniors and members of Ionic Material and Devices Research Laboratory (iMADE) who have helped me throughout the whole MSc program. I cherish the moments where we coped with the challenges and difficulties. Sincere thanks to laboratory officer, Puan Cik Masni for sharing their knowledge and ideas during my study. Their assistance and understanding make it easier for me to finish the research work on time.

I warmly thanks and appreciate to Universiti Teknologi MARA (UiTM) as it provides the instruments, equipment, facilities, apparatus and materials for me to complete my thesis work. Thank you for the financial support from Initiative Research Grants (GIP) 600-IRMI 5/3/GIP (054/2018) of UiTM.

Finally, this thesis is dedicated to my father and mother for the vision and determination to educate me. My endless appreciation to my beloved family and my siblings who always support and give their fully trust to me during my MSc journey.

TABLE OF CONTENTS