UNIVERSITI PUTRA MALAYSIA

RADIATION AND TEMPERATURE EFFECTS ON CONDUCTIVITY AND DIELECTRIC PROPERTIES OF POLY (VINYL ALCOHOL)-POTASSIUM HYDROXIDE-PROPYLENE CARBONATE

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By

MOHD ASRI BIN MAT TERIDI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Dedication

To my Mom and Dad.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman: **Associate Professor Elias Bin Saion, PhD**

Faculty: **Science**

The physical and chemical properties of polymeric materials can be modified by treatment with ionizing radiation. This radiation processing technique has been used to modify the structural and electrical properties of polymer composites for use as electrical devices. Alkaline composite polymer electrolytes (ACPEs) are materials that have attracted great attention for their vast application in the development of solid-state ionic devices. The materials have their chemical and electrical properties change with radiation dose allowing modification of the electrolytes in the solid state form. One serious problem of the ACPEs is low ionic conductivity at room temperature because they have a tendency to crystallize. In this study radiation-processing technique was chosen to increase the ionic conductivity at room temperature. The ACPE consists of poly(vinyl alcohol) (PVA) as the host polymer, potassium hydroxide (KOH) as an ionic blend and propylene carbonate (PC) as a plastisizer. The compositions of KOH and PC were varied from 40 to 70%. The electrolytes were prepared by chemical method and the finished films were obtained by solvent-casting technique. The films were irradiated with 1.25 MeV gamma rays with dose from 0 to 200 kGy at room temperature. The sample of irradiated and unirradiated films of different compositions was placed

between two parallel-plate metal electrodes and the conductivity and dielectric properties were measured using an impedance analyzer at different frequencies ranging from 20 Hz to 1 MHz. For the unirradiated samples, the conductivity and dielectric properties were also measured at different temperatures of narrow range from room temperature to 343 K. The X-ray diffraction (XRD) measurements were performed to characterize the change of molecular structure of the electrolytes with radiation dose and compositions of the blend and plastisizer.

The results show that the ACPE sample of PVA-KOH (40 wt.%)- PC (60 wt.%) irradiated with dose 200 kGy exhibits the highest ionic conductivity of 2.7 x 10^{-3} Scm^{-1} at room temperature. For ACPE sample with PVA-KOH (40 wt.%)-PC (60 wt.%) the highest ionic conductivity value is 7.8 x 10^{-3} Scm^{-1} at 343 K. The results show that the frequency dependent conductivity and dielectric constant of the ACPEs depend on radiation dose, temperature and composition of the blends and plastisizer. From the XRD analysis, the molecular structure of the electrolytes change from semi-crystalline to amorphous when the composition of PC increased to 60% and the radiation dose increased to 200 kGy. Finally, we have demonstrated that radiation processing can be used to modify ACPEs to increase their ionic conductivity for the development of solid-state ionic devices.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN RADIASI DAN SUHU KE ATAS KEKONDUKSIAN DAN SIFAT DIELEKTRIK KE ATAS POLI (VINIL ALCOHOL)-KALIUM HIDROKSIDA-PROPILENA KARBONAT

Oleh

MOHD ASRI BIN MAT TERIDI

Mac 2005

Pengerusi: **Profesor Madya Elias Bin Saion, PhD**

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Ciri-ciri fizik dan kimia bahan polimer boleh diubah sifatnya dengan menggunakan rawatan sinaran mengion. Teknik pemprosesan dengan sinaran ini telah digunakan untuk mengubah cirri-ciri struktur dan elektrik komposit polimer untuk digunakan dalam rekabentuk elektrik. Komposit beralkali polimer elektrolit (ACPEs), merupakan bahan menarik yang diberi keutamaan kerana mempunyai aplikasi yang meluas dalam memajukan rekabentuk ionik keadaan pepejal. Bahan ini mempunyai cirri-ciri kimia dan elektrik yang berubah terhadap dos sinaran yang memudahkan pengubahsuaian sifat elektrolit dalam keadaan pepejal. Satu masalah besar dihadapi ialah kekonduksian ion ACPEs yang rendah pada suhu bilik kerana ia berkecenderungan untuk menghablur. Dalam kajian ini, teknik pemprosesan sinaran telah dipilih untuk meningkatkan kekonduksian ionnya pada suhu bilik. ACPEs mengandungi poli(vinil) alcohol (PVA) digunakan sebagai polimer asas, kalium hidroksida (KOH) sebagai pencampur ion dan propilena karbonat (PC) sebagai agen pemplastik. Komposisi KOH dan PC diubah daripada 40 hingga 70%. Elektrolit ini disediakan dengan kaedah kimia dan hasilnya dalam bentuk filem didapati dengan kaedah acuan-pelarut. Filem-filem disinarkan dengan sinar gama dengan tenaga 1.25 MeV pada dos 0 hingga 200 kGy dalam suhu

bilik. Setiap sampel yang telah dan belum dirawat dengan sinaran diletakkan diantara dua elektrod logam plat selari dan ciri-ciri kekonduksian dan dielektrik diukur dengan menggunakan kaedah analisis impedans pada frekuensi daripada 20 Hz kepada 1 MHz. Untuk sampel yang tidak dirawat dengan sinaran, dan ciri-ciri kekondusian dan dielektrik juga diukur terhadap suhu berbeza daripada suhu bilik hingga 343K. Pengukuran XRD juga dilakukan untuk pencirian perubahan struktur elektrolit terhadap dos dan komposisi pencampur ion dan agen pemplastik.

Hasil kajian menunjukkan bahawa sampel ACPE PVA-KOH (40 wt.%)-PC (60 wt.%) yang dirawat dengan sinaran sehingga 200 kGy mempamirkan kekonduksian ion tertinggi pada suhu bilik 2.7 x 10^{-3} Scm^{-1}. Bagi sampel ACPE PVA-KOH (40 wt.%)-PC (60 wt.%) pada 343K kekonduksian ion tertinggi ialah 7.8 x 10^{-3} Scm^{-1}. Hasil kajian mendapati bahawa kebergantungan frekuensi bagi kekonduksian ion dan pemalar dielektrik ACPEs adalah bergantung kepada dos sinaran, suhu dan komposisi pencampur ion dan agen pemplastik. Analisis XRD menunjukkan bahawa struktur elektrolit berubah daripada semi-hablur kepada amorfus apabila komposisi PC bertambah kepada 60% dan dos sinaran bertambah kepada 200 kGy. Akhir sekali, kami telah menunjukkan bahawa pemprosesan sinaran boleh digunakan untuk mengubah sifat ACPEs dalam menambahkan kekonduksian ionnya untuk pembangunan rekabentuk ionic keadaan pepejal.

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