ELECTRICAL AND DIELECTRIC PROPERTIES OF SOLID AND NANOCOMPOSITE POLYMER ELECTROLYTES BASED ON CHITOSAN

SHUJAHADEEN BAKR AZIZ

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Designation: Senior lecturer

DR. ZUL HAZRIN ZAINAL ABIDIN
PENSYARAH
JABATAN FIZIK, FAKULTI SAINS
UNIVERSITI MALAYA
50603 KUALA LUMPUR

ABSTRACT

In solid polymer electrolytes (SPEs) and nano-composite polymer electrolytes (NCPEs) the ion conduction mechanism is still not well understood. This motivates us to study the electrical and dielectric properties of solid polymer electrolytes (CS:AgTf, CS:LiTf and CS:NaTf) and nano-composite polymer electrolytes ((1-x)(0.9CS:0.1AgTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$), (1-x)(0.9CS:0.1NaTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$) and (1-x)(0.9CS:0.1LiTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$)) based on chitosan. In the present work the SPEs and NCPEs were prepared by the solution cast technique. The XRD results reveal the increase of amorphous fraction in chitosan upon the addition of salts. The UV-vis, TEM, SEM and EDX analysis confirms the formation of metallic silver nanoparticle in CS:AgTf system. The dependence of DC conductivity and dielectric constant on salt concentration is almost the same. In CS:AgTf, CS:NaTf and CS:LiTf systems the DC conductivity follows the Arrhenius equation. The DC conductivity and dielectric constant for these SPEs have been correlated at different temperatures. The pre-exponential factor is independent on dielectric constant and temperature for these SPEs. The broadness of loss tangent peaks and incomplete semicircles of Argand plots reveals the non-Debye relaxation. The impedance plots and AC conductivity spectra at different temperatures were used to confirm the effect of electrode polarization on AC conductivity dispersion. The calculated frequency exponent (s) at different temperatures was used to characterize ion conduction model for each system.

To produce NCPEs the Al_2O_3 nanoparticle (size < 50 nm) were added to SPEs (CSA6, CSB6 and CSC6). The XRD results revealed the increase of amorphous regions (small crystallite size) in NCPEs up to 4 wt.% of Al_2O_3. At high alumina concentration the crystallinity of these NCPEs are increased. The SEM analysis shows a well dispersed Al_2O_3 nanoparticle at low concentration and a cluster formation at high alumina concentrations. The EDX analysis reveals that the white clusters are mostly alumina nanoparticles. The DC conductivity and bulk dielectric enhancement of these NCPEs reveal the role played by alumina nanoparticles. The curvature of DC conductivity versus 1000/T at higher temperatures were observed for these NCPEs. The drop in DC conductivity at a particular temperature for these three NCPEs can be ascribed to the phase transition of alumina ceramic from ferroelectric to paraelectric. The DC conductivity and dielectric constant study performed at different temperatures are well correlated for these NCPEs. However, the pre-exponential factor and dielectric constant cannot be correlated. The pattern of Arrhenius and compensated Arrhenius are almost the same. The broad loss tangent peaks and electric modulus (Argand plots) reveal the distribution of relaxation times. The electrode polarization effect was clearly observed in the study of impedance plots and AC conductivity spectra at different temperatures. The temperature dependences of frequency exponent were used to specify the ion conduction model for each NCPE system.

ABSTRAK

Didalam elektrolit polimer pepejal (EPP) dan elektrolit polimer nano-komposit (EPNK), mekanisma konduksian ion masih belum difahami sepenuhnya. Ini mendorong kami untuk mengkaji tentang sifat elektrik dan dielektrik elektrolit polimer pepejal (CS:AgTf, CS:LiTf dan CS:NaTf) dan elektrolit polimer nano-komposit ((1-x)(0.9CS:0.1AgTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$), (1-x)(0.9CS:0.1NaTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$) dan (1-x)(0.9CS:0.1LiTf)-xAl_2O_3 ($0.02 \leq x \leq 0.1$)) berdasarkan kitosan. Dalam kajian ini, EPP dan EPNK disediakan menggunakan teknik pembekasan larutan. Keputusan XRD menunjukkan bahawa pecahan amorfus meningkat apabila garam ditambahkan. Analisis Uv-vis, TEM, SEM dan EDX mengesahkan adanya pembentukan zarah nano logam perak dalam system CS:AgTf. Kebergantungan konduktiviti AT dan dielektrik malar terhadap kepekatan garam adalah hampir sama. Dalam sistem CS:AgTf, CS:LiTf dan CS:NaTf, konduktiviti AT mematuhi persamaan Arrhenius. Konduktiviti AT dan dielektrik malar bagi semua EPP ini telah di hubungkait pada suhu yang berbeza. Faktor pra-eksponen adalah tidak bergantung dengan dielektrik malar dan suhu bagi semua EPP. Kelebaran puncak tangen kehilangan dan ketidaksempurnaan semibulatan plot Argand membuktikan kelonggaran bukan-Debye. Plot impedans dan konduktiviti AU graf pada suhu yang berbeza telah digunakan untuk membuktikan kesan pengutuban elektrod ke atas penyerakan konduktiviti AU. Eksponen frekuensi yang telah dikira pada suhu yang berbeza telah digunakan untuk mencirikan model kekonduksian ion bagi setiap sistem.

Untuk menghasilkan EPNK, zarah nano Al_2O_3 (saiz < 50 nm) telah dicampurkan ke dalam EPP (CS:AgTf, CS:LiTf dan CS:NaTf). Analisa XRD menunjukkan peningkatan bahagian amorfus (saiz kristal yang kecil) dalam EPNK sehingga 4 wt.%

Al_2O_3. Pada kepekatan alumina yang tinggi, pengkristalan sampel EPNK meningkat. Analisa SEM menunjukkan taburan Al_2O_3 yang sekata pada kepekatan yang rendah manakala pembentukan kelompok pada kepekatan alumina yang tinggi. Analisa EDX membuktikan bahawa kelompok putih adalah kebanyakkannya merupakan zarah nano alumina. Peningkatan konduktiviti AT dan dielektrik EPNK menunjukkan peranan yang dimainkan oleh nano-partikel alumina. Kelengkungan konduktiviti AT melawan 1000/T pada suhu tinggi telah diperhatikan bagi EPNK ini. Kejatuhan dalam konduktiviti AT pada suhu tertentu bagi tiga EPNK ini boleh digambarkan sebagai peralihan fasa bagi seramik alumina dari feroelektrik kepada paraelektrik. Kajian konduktiviti AT dan dielektrik malar yang telah dijalankan pada suhu yang berbeza. Walaubagaimanapun, faktor pra-eksponen dan dielektrik malar tidak dapat dikaitkan. Bentuk graf Arrhenius dan imbangan Arrhenius adalah seakan sama. Kelebaran puncak pada tangen kehilangan dan modulus elektrik (plot Argand) menunjukan taburan masa kelonggaran. Kesan elektrod pengutuban dapat dilihat dengan jelas dalam kajian ini melalui plot impedan graf konduktiviti AU pada suhu berbeza. Kebrgantungan suhu terbadap gelombang telah digunakan untuk menyatakan model kekonduksian ion untuk setiap sistem EPNK.

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List of Published Article in Journals:

1. Shujahadeen B. Aziz, Z. H. Z. Abidin, A. K. Arof, Effect of silver nanoparticles on the DC conductivity in chitosan-silver triflate polymer electrolyte, Physica B: Condensed Matter 405 (2010) 4429-4433.

2. Shujahadeen B. Aziz, Z. H. Z. Abidin, A. K. Arof, Influence of silver ion reduction on electrical modulus parameters of solid polymer electrolyte based on chitosan-silver triflate electrolyte membrane, eXPRESS Polymer Letters 4 (2010) 300-310.

List of Papers presented at Conferences

1. Shujahadeen B. Aziz, Z. H. Z. Abidin, A. K. Arof " AC conductivity analysis of solid polymer electrolyte based on chitosan:$AgCF_3SO_3$" presented at the National Workshop on Functional Material (NWFM), 20-21 June 2009, University of Malaya, Kuala Lumpur.

2. Shujahadeen B. Aziz, Z. H. Z. Abidin, A. K. Arof " DC conductivity analaysis of solid polymer electrolyte based on chitosan:$NaCF_3SO_3$", presented at the 3rd International Conference on Functional Materials and Devices (ICFMD), 14-17 June 2010, Terengganu, Malaysia.

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