IONIC CONDUCTIVITY AND RELATED STUDIES ON CHITOSAN-BASED ELECTROLYTES WITH APPLICATION IN SOLAR CELLS

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DECLARATION

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ABSTRACT

The motivation in this work is to ensure that the chitosan biopolymer can be used as a host for ion conduction and used as an electrolyte in dye-sensitized solar cells (DSSCs). The conductivity of the chitosan-NH_4I electrolytes was optimized by varying the NH_4I concentration, blending chitosan with PVA and PEO and also by incorporating of ionic liquid (IL). The electrolytes were prepared by solution cast technique. FTIR results confirm complexation between polymer, NH_4I and IL. Hydrogen bonding between chitosan and PVA and between chitosan and PEO are observed in the respective spectrum. XRD indicates that the amorphousness of pure chitosan, chitosan-PVA and chitosan-PEO films changes with NH_4I concentration. The 55 wt.% chitosan-45 wt.% NH_4I (Ch9) sample exhibits the highest room temperature conductivity of 3.73×10^{-7} S cm^{-1}. Blending chitosan with PVA and PEO further increased conductivity. The 27.5 wt.% chitosan-27.5 wt.% PVA-45 wt.% NH_4I (CV5) sample exhibits the highest conductivity of 1.77×10^{-7} S cm^{-1} at room temperature and the highest conducting sample in (chitosan-PEO)-NH_4I system is 3.66×10^{-6} S cm^{-1} for sample containing 16.5 wt.% chitosan-38.5 wt.% PEO-45 wt.% NH_4I (CEO7) electrolyte. Incorporating 50 wt.% IL into Ch9, the electrolyte CIL5 exhibits the highest room temperature conductivity of 3.43×10^{-5} S cm^{-1}. The activation energy, E_A for the highest conducting samples follows the order Ch9 (0.45 eV) < CV5 (0.38 eV) < CEO7 (0.31 eV) < CIL5 (0.25 eV). DSSCs were fabricated using natural dyes extracted from black rice, blueberry and red cabbage. The highest conducting samples from each system have been chosen in the fabrication DSSCs. Some iodine crystals were added to the electrolytes to produce the redox-mediator. Red cabbage DSSCs using CIL5(+I_2) gel electrolyte exhibits the highest efficiency of 0.2 % compared to using CEO7(+I_2) and CV5(+I_2) gel electrolytes.

ABSTRAK

Objektif utama kajian ini adalah untuk memastikan bahawa biopolimer chitosan boleh digunakan sebagai perumah untuk mengkonduksi ion dan digunakan sebagai elektrolit di dalam "dye-sensitized solar cells" (DSSCs). Kekonduksian chitosan-NH_4I elektrolit telah dioptimumkan dengan mengubah kepekatan NH_4I, mencampurkan chitosan dengan PVA dan PEO dan dengan cecair ionik. Teknik penuangan di dalam piring Petri digunakan dalam penyediaan elektrolit. FTIR mengesahkan bahawa berlakunya interaksi diantara polimer dengan NH_4I dan cecair ionik. Ikatan hidrogen di antara chitosan dengan PVA dan chitosan dengan PEO dapat dilihat dalam spektrum FTIR. XRD menunjukkan sifat amorphous di dalam chitosan tulen, chitosan-PVA dan chitosan-PEO berubah dengan kepekatan NH_4I. Sample berkomposisi 55% chitosan-45% NH_4I (Ch9) menunjukkan kekonduksian tertinggi pada suhu bilik sebanyak 3.73×10^{-7} S cm^{-1}. Kekonduksian elektrolit meningkat dengan mencampurkan chitosan dengan PVA dan PEO. Sampel berkomposisi 27.5% chitosan-27.5% PVA-45% NH_4I (CV5) menunjukkan kekonduksian tertinggi pada suhu bilik sebanyak 1.77×10^{-7} S cm^{-1} dan 3.66×10^{-6} S cm^{-1} untuk sampel berkomposisi 16.5% chitosan-38.5% PEO-45% NH_4I (CEO7). CIL5 elektrolit memberikan kekonduksian tertinggi pada suhu bilik sebanyak 3.43×10^{-5} S cm^{-1} apabila 50% cecair ionik dimasukkan ke dalam Ch9. Tenaga pengaktifan, E_A tertinggi bagi setiap sistem adalah mengikut aturan Ch9 (0.45 eV) < CV5 (0.38 eV) < CEO7 (0.31 eV) < CIL5 (0.25 eV). Pewarna semula jadi yang diekstrak daripada pulut hitam, kubis merah dan blueberry digunakan dalam pemfabrikatan DSSCs. Iodin ditambah kepada elektrolit bagi menghasilkan pengantara redoks. DSSCs kubis merah yang menggunakan CIL5(+I_2) elektrolit gel mempamerkan kecekapan tertinggi sebanyak 0.2% berbanding dengan CEO7(+I_2) dan CV5(+I_2) elektrolit gel.

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ABBREVIATIONS

$(NCS)_2$	Diisothiocyanate
NaI	Sodium iodide
KI	Potassium iodide
I_2	Iodine
LiI	Lithium iodide
Pr_4NI	Tetrapropylammonium iodide
$AgNO_3$	Silver nitrate
TBP	4-tert-butyl pyridine
PC	propylene carbonate
$LiCF_3SO_3$	Lithium triflate
EC	Ethylene carbonate
$NaClO_4$	Sodium perchlorate
LiOAc	Lithium acetate
NH_4NO_3	Ammonium nitrate
PEG	Poly(ethylene glycol)
$LiNO_3$	Lithium nitrate
H_2SO_4	Sulfuric acid
NMP	N-methyl pyrrolidone
KOH	Potassium hydroxide
$ZnCF_3SO_3$	Zinc triflate
DOP	dioctyl phthalate
H_3PO_4	Phosphoric acid
DMPImI	1-propyl-2,3 dimethylimidazolium iodide
LiCAC	lithium complexed acetylated chitosan
DEC	Diethylene carbonate
$NaBiF_4$	Bismuth sodium fluoride
$LiClO_4$	Lithium perchlorate
MC	Methyl cellulose
PVAc	Polyvinyl acetate
PMMA	Poly(methyl methacrylate)
PA	Palmitic acid
OA	Oleic acid
J_{sc}	Short-circuit current density
V_{oc}	Open-circuit voltage
ff	Fill factor
η	Efficiency (%)

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