ABSTRACT

PVA/ammonium acetate (CH_3COONH_4)–based polymer electrolytes had been prepared using solution casting technique. The effect of addition of ionic liquid onto polymer electrolytes is investigated throughout this project. Three different types of ionic liquids are added into the PVA/ammonium acetate (CH_3COONH_4)–based polymer electrolytes that are 1–butyl–3–methylimidazolium chloride (BmImCl), 1–butyl–3–methylimidazolium bromide (BmImBr) and 1–butyl–3–methylimidazolium iodide (BmImI). The ionic conductivity of polymer electrolyte is increased about two orders of magnitude from $(1.94\pm0.01)\times10^{-5}$ S cm^{-1} to (8.97 ± 0.01) mS cm^{-1}, (9.29 ± 0.01) mS cm^{-1} and (9.63 ± 0.01) mS cm^{-1} upon addition of 50 wt.% of BmImCl, 60 wt.% of BmImBr and 70 wt.% of BmImI, respectively at ambient temperature. All the polymer electrolytes follow Vogel–Tamman–Fulcher (VTF) relationship which is associated with free volume theory. The complexation between PVA, CH_3COONH_4 and ionic liquids is proven in Fourier Transform Infrared (FTIR) studies. Addition of ionic liquids reduces the glass transition temperature (T_g) of polymer electrolytes as proven in differential scanning calorimetry (DSC), improves the thermal stability of polymer electrolytes as shown in thermogravimetric analysis (TGA) and widens the electrochemical potential window of polymer electrolytes as shown in linear sweep voltammetry (LSV). The crystallinity of polymer electrolytes and the coherence length of crystallites are determined in X–ray diffraction (XRD) studies. Electric double layer capacitors (EDLCs) are assembled using carbon–based electrodes. The specific capacitance of EDLC containing ionic liquid–added polymer electrolytes is much higher than the EDLC containing ionic liquid–free polymer electrolyte. The electrochemical properties of the EDLCs are analyzed using cyclic voltammetry (CV), low frequency electrochemical impedance spectroscopy (EIS) and galvanostatic charge–discharge (GCD) studies.

ABSTRAK

Elektrolit yang berasaskan PVA/ ammonium asetat (CH_3COONH_4) telah disediakan dengan menggunakan teknik pengacuan larutan. Kesan–kesan penambahan cecair ionik ke dalam elektrolit polimer telah dikaji di dalam projek ini. Tiga jenis cecair ionik yang berbeza telah ditambah ke atas polimer elektrolit yang berasaskan PVA/ ammonium asetat (CH_3COONH_4), iaitu 1–butil–3–metilimidazolium klorida (BmImCl), 1–butil–3–metilimidazolium bromida (BmImBr) dan 1–butil–3–metilimidazolium iodida (BmImI). Kekonduksian ionic elektrolit polimer telah meningkat sebanyak dua magnitud dari $(1.94\pm0.01)\times10^{-5}$ S cm^{-1} kepada (8.97 ± 0.01) mS cm^{-1}, (9.29 ± 0.01) mS cm^{-1} and (9.63 ± 0.01) mS cm^{-1} dengan penambahan 50 wt.% (peratusan berat) daripada BmImCl, 60 wt.% daripada BmImBr dan 70 wt.% daripada BmImI, masing–masing pada suhu bilik. Semua elektrolit polimer mematuhi "Vogel–Tamman–Fulcher (VTF)" konsep yang berkaitan dengan teori isipadu bebas. Pengkompleksan antara PVA, CH_3COONH_4 dan cecair ionik telah dibukti dalam kajian transformasi inframerah Fourier (FTIR). Penambahan cecair ionik menurunkan suhu transisi kaca (T_g) elektrolit polimer seperti yang dibuktikan di dalam kalorimetri pengimbasan perbezaan (DSC), meningkatkan kestabilan haba elektrolit polimer seperti yang ditunjukkan di dalam permeteran graviti haba (TGA) dan memperluaskan rangkaian potensi elektrokimia elektrolit polimer seperti yang ditunjukkan di dalam voltametri sapuan linear (LSV). Penghabluran dalam elektrolit polimer dan saiz kristal dapat dikesan dalam kajian pembelauan sinar–X (XRD). Elektrik kapasitor dua lapisan (EDLCs) telah disediakan dengan menggunakan elektrod yang berasaskan karbon. Kapasitan tertentu EDLC yang merangkumi cecair ionik–ditambah elektrolit polimer adalah lebih tinggi daripada EDLC yang merangkumi elektrolit polimer tanpa cecair ionic. Ciri–ciri elektrokimia EDLC telah dianalisis melalui kajian voltametri berkitar (CV), spektroskopi impedans elektrokimia yang mempunyai frekuensi yang rendah (EIS) dan cas–nyahcas galvanostatik (GCD).

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LIST OF SYMBOLS AND ABBREVIATIONS

Abbreviation	Description
AmImCl	1–ally–3–methylimidazolium chloride
ATR–FTIR	Attenuated total reflectance–Fourier Transform Infrared spectroscopy
BmImBr	1–butyl–3–methylimidazolium bromide
BmImCl	1–butyl–3–methylimidazolium chloride
BmImI	1–butyl–3–methylimidazolium iodide
CH_3COONH_4	Ammonium acetate
CNTs	Carbon nanotubes
CPEs	Composite polymer electrolytes
CV	Cyclic voltammetry
DSC	Differential scanning calorimetry
EDLCs	Electric double layer capacitors
EIS	Electrochemical impedance spectroscopy
GCD	Galvanostatic charge–discharge
PVA	Poly(vinyl alcohol)
TGA	Thermogravimetry analysis
XRD	X–ray diffractogram
A	Surface area of the electrodes
C_{sp}	Specific capacitance
dV	Potential change of a discharging process
E	Energy density
I_c	Area under the crystalline peak
I_t	Area under all the peaks
I	Applied current
i	Average anodic–cathodic current
l	Thickness of polymer electrolytes
m	Average mass of active materials
η	Coulombic efficiency
P	Power density
R_b	Bulk resistance
R_{ct}	Charge transfer resistance
s	Potential scan rate
T_g	Glass transition temperature
Z''	Imaginary part of the complex impedance (Z)
σ	Ionic conductivity
χ_c	Degree of crystallinity
λ	X–ray wavelength
ω	Angular frequency

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