EFFECT OF DOPING FILLERS TOWARDS CORN STARCH BASED GREEN POLYMER ELECTROLYTES

TEOH KOK HAU

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UNIVERSITY OF MALAYA
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ABSTRACT

Corn starch based polymer electrolytes with lithium perchlorate, ($LiClO_4$), as dopand salt, silica (SiO_2) and barium titanate ($BaTiO_3$) as fillers were prepared using solution-casting technique. The prepared corn starch based polymer electrolytes were subjected to scanning electron microscopy (SEM), A.C. impedance spectroscopy, differential scanning calorimetry (DSC), thermal gravimetry analysis (TGA), water solubility test, linear sweep voltammetry (LSV), cyclic voltammetry (CV), galvanostatic charge discharge and low frequency impedance spectroscopy. The addition of fillers alters the ionic conduction mechanism and structural properties of the polymer electrolytes. Ionic conductivity studies were carried out and it was found that the polymer electrolyte systems of corn starch:$LiClO_4$ (60:40), corn starch-$LiClO_4$:SiO_2 (96:4) and corn starch-$LiClO_4$:$BaTiO_3$ (90:10) reaches the maximum ionic conductivity of 1.55×10^{-6} S cm^{-1}, 1.23×10^{-4} S cm^{-1} and 1.84×10^{-4} S cm^{-1}, respectively. The addition of filler resulted in better heat resistivity, thermal stability and structural properties. The highest conducting polymer films from each system were used to fabricate electrical double layer capacitor (EDLC) cells. The fabricated cells show wide electrochemical stability windows ~2.7 V. Charge discharge profiles show the EDLCs fabricated have stable performance up to 500 cycles with 90 % efficiency. The highest specific capacitance obtained from the fabricated EDLC cells is 16.22 F g^{-1}. Corn starch polymer electrolytes have shown promising results in EDLC application.

ABSTRAK

Polimer elektrolit yang terdiri daripada kanji jagung dengan lithium perchlorate ($LiClO_4$), sebagai garam tambahan, silica (SiO_2) dan barium titanate ($BaTiO_3$) sebagai pengisi telah dihasilkan dengan menggunakan kaedah teknik pengacuan larutan. Polimer elektrolit sampel disiapkan dengan jumlah kadungan pengisi yang berbeza dan kemudian, ia dikaji dengan mikroskop elektron pengimbasan (SEM), spektroskopi impedans (A.C. *Impedance*), calorimeter pengimbasan pembezaan (DSC), Analisis gravimetri termal (TGA), ujian keterlarutan air, voltammetri pengimbasan linear (LSV), voltammetry berkitar (CV), galvanostatik caj dan pelepasan caj dan spektroskopi impedans frekuensi rendah. Penambahan suapan dalam polimer elektrolit telah mengubahsuai mekanisme konduksi ionik dan sifat struktur. Kajian ionik konduktiviti telah dijalankan dan mendapati polimer elektrolit mengandungi $LiClO_4$, SiO_2, and $BaTiO_3$ masing-masing mencapai konduktiviti ionik maksimum 1.55×10^{-6} S cm^{-1} (40 wt.%), 1.23×10^{-4} S cm^{-1} (4 wt.%) and 1.84×10^{-4} S cm^{-1} (10 wt.%). Penambahan pengisi mengakibatkan peningkatan kestabilan haba dan rintangan haba serta modifikasi struktur. Polimer elektrolit yang menunjukkan ionik konduktiviti maksimum telah dipilih untuk menjalani ujian pembuatan kapasitor lapisan ganda listrik, EDLC. Sel yang telah dipasang telah menunjuk kestabilan elektrik yang luas, ~2.7 V. Ujian caj dan pelepasan caj telah menunjukkan keputusan yang amat memuaskan sehingga 500 kitaran dengan kecekapan sel 90%. Kapasitan maksimum yang terdapat daripada EDLC sel ialah 16.22 F g^{-1}.

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LIST OF PUBLICATIONS

- International Journal
  - K.H. Teoh, S. Ramesh, A.K. Arof, (2012) Investigation on the Effect of Nano Silica Towards Corn Starch Lithium Perchlorate Based Polymer Electrolytes, *Journal of Solid State Electrochemistry*, in press. DOI: 10.1007/s10008- 012-1741-4. [Impact factor : 2.131] (*ISI/SCOPUS Cited Publication*)
- International Conferences
  - Kok-Hau Teoh, S.Ramesh, A.K. Arof , Investigation on the Effect of Nano Silica Towards Corn Starch Lithium Perchlorate Based Polymer Electrolytes, International Conference on Materials for Advanced Technologies, Suntec, Singapore, 26th June- 1st July 2011. (Poster)
  - Kok-Hau Teoh, S.Ramesh, A.K. Arof, Effect of Barium Titanate Incorporated in Corn Starch-Lithium Perchlorate Based Polymer Electrolytes, International Conference on Materials for Advanced Technologies, Suntec, Singapore, 26th June- 1st July 2011. (Poster)
  - S.Ramesh, K.H.Teoh, A.K.Arof, Lithium ion conduction in corn starch based gel polymer electrolytes, 18th International Conference on Solid State Ionics, Warsaw, Poland, 3rd-8th July 2011. (Poster)
  - K.H. Teoh, S.Ramesh, A.K.Arof, The effect of incorporation of silica toward corn starch based polymer electrolytes, The Seventh Mathematics and Physical Sciences Graduate Congress 2012, National University of Singapore, 12-14th Nov 2011. (Oral)
- National Conference
  - K.H. Teoh, S.Ramesh, A.K.Arof, The effect of addition of fillers toward corn starch based polymer electrolytes, Physics Research Colloquium 2012, University of Malaya, 28-29th May 2012. (Oral)

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LIST OF ABBREVIATION

σ	Conductivity in S cm^{-1}
l	Thickness of the film sample in cm
R_b	Bulk resistance, Ω
A	Surface area of the stainless steel blocking electrodes in cm^2
σ_0	The pre-exponential factor
E_a	Activation energy
k	Boltzmann constant
T	Absolute temperature
ε'	Real parts of dielectric
ε''	Imaginary part of dielectric
M'	Real part of modulus
M''	Imaginary part of modulus
tan σ	Dissipation factor
T_g	Glass transition temperature in ℃
T_m	Melting point in ℃
W_s	Water solubilities in %
W_0	Weight of dried samples
W_1	Weight of dried samples after water soaking
ESR	Equivalent series resistance
η	Coulombic efficiency
C_c	Charge capacitance
C_d	Discharge capacitance

C	Specific capacitance in F g^{-1}
ΔI	Discharge current in A
ΔV	Voltage scan
m	Mass of electrode in g
j	Average current in A
v	Scan rate in V s^{-1}
C_m	Specific capacitance in F g^{-1}
IR_{drop}	Voltage drop in V
i	Discharge current
P	Power
E	Energy stored
R_{ct}	Charge transfer resistance
W	Warburg element
R_p	Pore resistance
C_{ct}	Charge transfer capacitance
C_{dl}	Double layer capacitance
R_t	Overall resistance
f	Frequency in Hz