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Research paper

Microstructure And Electrical Study Of Biopolymer Based On Methylcellulose For Solar Cells

A.M.S. Nurhaziqah1, I.Q. Afiqah2, N.A. Nik Aziz3 and S. Hasiah4

1School of Ocean Engineering, Universiti malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia Terengganu, Malaysia
ziqah32@gmail.com
2School of Ocean Engineering, Universiti malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia Terengganu, Malaysia
aqizqayyum@gmail.com
3School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia Terengganu, Malaysia
nikaziz@umt.edu.my
4Center for Foundation and Liberal Education, Universiti MalaysiaTerengganu, 21030 Kuala Nerus, Terengganu, Malaysia Terengganu, Malaysia
**Corresponding author: hasiah@umt.edu.my*

Abstract

The purpose of this research is to study effect of the addition of a various wt% of manganese chloride ($MnCl_2$) salt on the methylcellulose (MC) biopolymer electrolyte. The biopolymer electrolytes were prepared by using casting technique. It is also thoroughly characterized of microstructure and electrical properties of the samples by using Fourier transform-infrared (FTIR) spectroscopy, X-ray Diffraction (XRD), Electrical Impedance Spectroscopy (EIS) and Linear Sweep Voltammetry (LSV). Besides, the highest conductivity is sample MC:20wt%$MnCl_2$ with value 0.74X10^{-6} Scm^{-1} measured by EIS. The sample also achieved the excellent power conversion efficiency which is 0.31%. It is augmented from the microstructure properties which are proved that the enhancement of the conductivity depends on the increment of the amorphous nature region and the complexation between MC and $MnCl_2$ salt by XRD and FTIR
.

Keywords: *Biopolymer; Methylcelluloce; Efficiency; FTIR; XRD*

1. Introduction

These days world face with environmental critical crisis, attributable to the unbounded use of conventional fossil fuel products known as non-renewable energy. In this aspect, solar energy is the most powerful renewable alternative energy to fossil fuels. While solar cells are devices that convert solar energy into electrical energy through photovoltaic affect [1].
Besides, solar energy are also the top renewable energy which can usable in long-term. The solar energy have done into several generation known as 1st generarion, 2nd generation and 3rd generation. The vicinity of solar energy technology based on silicon wafers was monopoly by 1st generation while 2nd generation take a part in thin film concept [2]. However, there are several major problem which are with increasing cost of production and their low values of absorption coefficients [3].
Next, the 3rd generation of solar energy technology is involve a number of thin-film technologies often described emerging photovoltaics [4]. There are usually use biological materials, organometallic compounds as well as artificial substances. The Dye-sensitized solar cells (DSSC) are one of the third generations of solar energy technology [5]. DSSC offers an effective and easily executed technology for future energy supply drastically low cost [6]. Meanwhile, research topic of DSSC is spread rapidly include the latest designs of DSSC which is polymer electrolyte [7].
Furthermore, the mechanical properties biopolymer is ease of fabrication of thin films and ability to achieve electrode-electrolyte contact. There are several techniques approaches to perform the electrical conductivity which are blending of the polymer, doped of salt and plasticized [8]. Among these technique, doped with salt is better technique could enhance of conductivity value due to increment of addition of salts into the polymer host [9].
However, to ensure the environmental friendly and non-toxic materials use, the biopolymer is suggested in this research [10]. The aspect of physical or chemical performance and number of mobile ions of materials are also considered during this research.
From the literatures, there is no report suggesting methylcellulose (MC) doped with Manganase Chloride ($MnCl_2$) salt as biopolymer electrolyte film.

2. Methodology

A. Sample Preparation

The biopolymer electrolyte (BPE) was prepared via solution cast method. BPE were diluted by adding different weight percentages of $MnCl_2$(5-25 wt%) to solution containing 2g of MC. The solutions were stirred continuously at room atmosphere for a few hours until it is completely dissolved. The solutions were poured into petri dishes and dried at room atmosphere.

B. Fourier transform-infrared (FTIR) spectroscopy
FTIR spectroscopy was performed using Thermo Nicolet Avatar 380 FT-IR spectrometer to investigate the interactions of the functional groups present in biopolymer host and the salt. The germanium crystal and infrared light was passed through the sample at wavenumber range from 4000 to 400 cm^{-1} where the sample was placed on it. The transmittance mode was selected during the FTIR data were recorded.

C. X-ray Diffraction (XRD)
X-ray Diffraction (XRD), model of MiniFlex II diffractometer equipped with an X'celerator, using Cu Kα radiation was carried out to observe the effect of conducting elements on the amorphousness nature of BPE.

D. Electrical Impedance Spectroscopy (EIS)
The conducting capability of the BPE films were measured using a Hioki 3532-50 LCR Hi-Tester interfaced to a computer with used a frequency range between 50Hz to 1MHz. The samples were sandwiched between the stainless steel electrodes holder with a surface area of 2 cm^2. The conductivity of biopolymer electrolyte with using the bulk resistance (R_b) value can be calculated from the equation below:

$$\sigma = \frac{t}{R_b A} \quad (1)$$

Here, t is thickness of the samples while A is area of the samples.

E. Linear Sweep Voltammetry (LSV)
The power conversion efficiency (PCE) was determined with LSV using Autolab Potentiostat PGSTAT 302. The starting potential was applied at -2.0 V and ending potential at 4.0 V. Meanwhile, from the J-V curve, short circuit current (J_{sc}), open circuit voltage (V_{oc}), fill factot (FF) and power conversion efficiency (PCE) were measured by following equations:

$$FF = \frac{J_{opt} V_{opt}}{J_{sc} V_{oc}} \quad (2)$$

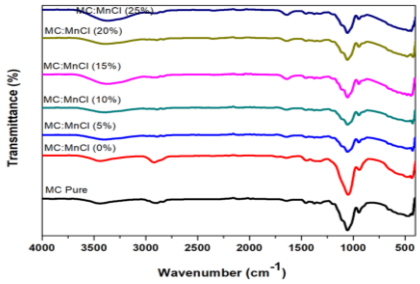
Where, J_{opt} is optimum current density while V_{opt} is optimum voltage.

$$\eta(\%) = \frac{J_{sc} V_{oc} FF}{P_{in}} \times 100 \quad (3)$$

Where, P_{in} is the total intensity of light.

3. Result And Discussion

F. Fourier transform-infrared (FTIR) Analysis
The characteristic complexation and the existence of functional groups were confirmed through FTIR spectra. Fig. 1, depicts the FTIR spectra of MC doped with different weight per cent of $MnCl_2$ salt. The ether band was discovered at 1056 cm^{-1} for the MC pure[11]. While in the MC: $MnCl_2$, occurance a smeager shifted of the peak due to complexation of the C-O-C bonding with the solvent [12]. Dissimilar vibration mode of assorted functional groups of MC and $MnCl_2$ approach to the observed IR characteristics peaks of biopolymer-salt system.
The complexation between MC and $MnCl_2$ salt was observed in band range 1700 to 1040 cm^{-1}. The band at 1641 cm^{-1} was assigned to asymmetrical C=O stretching of the $MnCl_2$ anion in the MC [13, 14]. Commonly, the O-H bonding appear in the range 3500 to 3000 cm^{-1} [15]. The changes of intensity are not apparent other than shifting of the bands. It is imply the amorphous phase of the samples was amplified with increment wt% of the $MnCl_2$ salt. The shifts of O-H stretching vibration from 3442 to 3367 cm^{-1}, C=O stretch from 1641 to 1638 cm^{-1} and out of plane rings C-H bonding mode from 1056 to 1053 cm^{-1} were observed at MC:20wt%$MnCl_2$. This occurance from the analysis indicates the chemical interactions of $MnCl_2$ with the host polymer.



G. X-ray Diffraction (XRD) Analysis
The amorphous nature of the polymer film regard to pure MC and $MnCl_2$ complex have been examined by X-ray Diffraction (XRD). Fig. 2 shows the amorphous nature patterns of biopolymer electrolyte with 5 to 25 wt% of $MnCl_2$ salt. The pattern shows width diffused band at 2θ=21° and the initial peak at 2θ=8°. The disturbance of MC structure by $MnCl_2$ salt is great indication of increment of the wt% of $MnCl_2$ salt affected the broad of the peak. It is proved by the higher broad peak at 2θ=21° are 20wt% of $MnCl_2$ salt. Meanwhile, the reduction of intensity is effect from increment in amorphous nature of the biopolymer-salt common [16]. From these clarification affirm that doping salt enhance the amorphous phase known supportive action for conductivity enhancement [17].

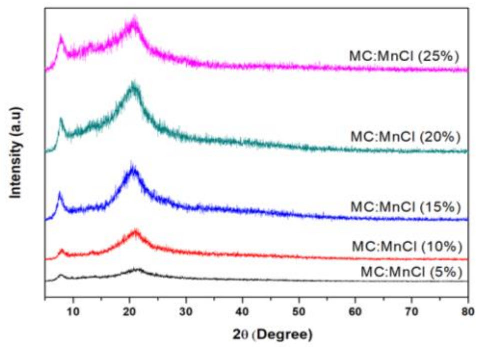


Fig. 2. XRD analysis.

H. Electrical Impedance Spectroscopy (EIS) Analysis
Fig. 3 shows the several different of wt% of $MnCl_2$ salt doped to MC biopolymer with 303 K conductivity. Based on that figure also can be seen that the pattern of the enhancement of the conductivity due to increment of the wt% of $MnCl_2$ salt. The conductivities were measured and calculated values are listed in Table I.
From the conductivity values of the MC increased correspond on increment of wt% of $MnCl_2$ salt. The highest conductivity was achieved to be 0.74X10^{-6} Scm^{-1} at MC:20wt% $MnCl_2$. It was affirmed due to highest amorphous nature region characterized by XRD. The increment of conductivity are also effect from the electrolyte systems which contains the higher free charge carriers. Meanwhile, the conductivity was reduced at MC:25wt%$MnCl_2$ because of the mobility of the charge carriers were decreased [18]. Therefore, the optimized composition of MC doped $MnCl_2$ salt was indicated at MC:20wt%$MnCl_2$ [19]. From analysing the

result it can be augmented with MC:20wt%$MnCl_2$ performed an increase of only one order of magnitude of conductivity [20].

Table I. Conductivity for Different (wt%) of sample

Sample (wt%)	Conductivity, σ(μScm^{-1})
0	0.000035
5	0.00032
10	0.0056
15	0.026
20	0.74
25	0.017

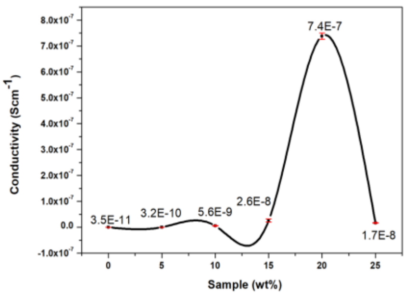


Fig. 3. EIS analysis.

I. Linear Sweep Voltammetry (LSV) Analysis

The photovoltaic performance (I-V curve) of the highest conducting MC:20wt% $MnCl_2$ was measured with 1000mW of light intensity shown on Linear Sweep Voltammetry in Fig. 4. There is not apparent of the current flow in the electrolyte up to ~0.3V. Meanwhile, the electrode potential increase continuously after 0.3V was related to the increment on decomposition of the biopolymer electrolyte. It is indicate that MC:$MnCl_2$ can perform in electrochemical device due to its electrochemically stable. The various cell parameters are listed in Table II. It is including the photocurrent density (Jsc), open circuit voltage (Voc), fill factor (FF) and power conversion efficiency (Ƞ). The performance shows efficiency of 0.31% with Jsc of 0.8 μA cm^{-2}, Voc of 0.3V and FF of 0.24.

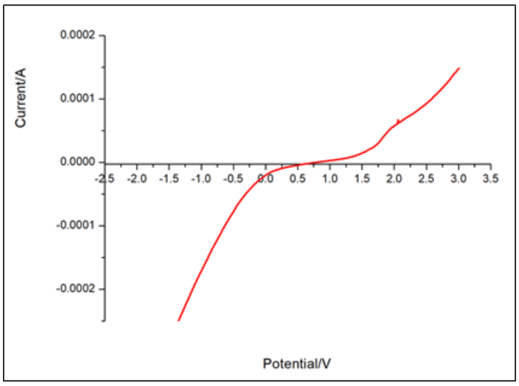


Fig. 4. LSV analysis

Table II. Different Photovoltaics Parameters for Different (wt%) of sample

Sample (wt%)	Different PhotovoltaicsParameters			
	J_{sc} (μA/cm^2)	V_{oc} (mV)	ff	Ƞ (%)
0	0.007	225	0.30	0.003
5	0.005	395	0.25	0.004
10	0.173	504	0.21	0.12
15	0.450	202	0.22	0.13
20	0.763	313	0.24	0.31
25	0.183	504	0.22	0.14

4. Conclusion

This is important for obtained excellent biopolymer electrolyte because of the enhancement electron recombination due to addition of wt% of $MnCl_2$ salt. The conductivity measurement affirms the increment of the amorphous phase increase the conductivity with approaches 0.74X10^{-6} Scm^{-1}. While the composite nature are confirms by FTIR characteristic. Corresponding maximum conductivity MC:20wt% $MnCl_2$ biopolymer electrolyte, indicate the power conversion efficiency of 0.31% at one sun condition.

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