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Novel development towards preparation of highly efficient ionic liquid based co-polymer electrolytes and its application in dye-sensitized solar cells

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ABSTRACT

Ionic liquid polymer electrolytes (ILPE) were prepared with poly(1-vinylpyrrolidone-co-vinylacetate) P(VP-co-VAc) copolymer, tetrahexylammonium iodide (THAI) salt and 1-butyl-3-methylimidazolium iodide (BMII), a room temperature ionic liquid (RTIL). The ILPEs were characterized using electrochemical impedance spectroscopy (EIS) analysis, X-ray diffraction (XRD) studies, Fourier transform infrared spectroscopy (FTIR) and Thermogravimetric analysis (TGA). The highest ionic conductivity obtained was 1.05×10^{-3} S cm^{-1} at room temperature in ILPE3 which is the sample incorporated with 80 wt% of BMII. FTIR analysis proved the formation of complexes in between the copolymer, salt and ionic liquid. XRD studies have shown that ILPE3 has the optimum amorphous nature. The ILPE based dye sensitized solar cell (DSSC) was assembled by sandwiching the ILPE in between the nanoporous TiO_2 working electrode and Pt-coated counter electrode and thus subjected to device photovoltaic characterization. The DSSC with ILPE3 as its electrolyte has shown the highest power conversion efficiency (η) with a value of 4.93% with short circuit current density (J_{sc}), open circuit voltage (V_{oc}) and fill factor (FF) of 12.37 mA cm^{-2}, 0.69 V and 0.58, respectively. Temperature dependence studies has been done on the DSSCs to understand effect of the cell temperature on the performances of the DSSCs. EIS studies of the DSSCs shows that the ILPE is having higher diffusion coefficient compared to the GPE.

1. Introduction

Solar energy is considered as one of the inexhaustible energy sources as our earth receives vast supply of this energy. In order to fully utilize this energy, there is a need for a technology that can harvest this solar energy into usable power reservoir source. Great effort has been put onto this blue-sky research and one of the discoveries is the invention of solar cells. Solar cells or also known as photovoltaic cells are the devices that convert the solar energy to electrical energy [1–3].

Dye sensitized solar cells (DSSC), an alternative version of the conventional solar cells with low production cost were introduced by Michael Grätzel and Brian O'Regan in 1991 [4,5]. Dye sensitized solar cells are made up of three layers. The upper layer is known as working electrode and it is made up of nanoporous titanium dioxide (TiO_2) sensitized with dye and coated on a FTO glass. The second layer is the electrolyte layer. There are a few types of electrolyte used in the DSSC such as solid type electrolyte, liquid type electrolyte and gel type electrolyte. The third layer is the counter electrode which is commonly made up of platinum conducting layer [6].

Dye sensitized solar cells (DSSCs) has many advantages compared to the conventional silicon solar cells as it is easy to be made, inexpensive raw materials, low consumption of energy during the DSSC production, and DSSC is also green replacement to the environment [7,8]. It is proven that DSSC can provide a photovoltaic efficiency up to 12% when the electrolyte used in the dye sensitized solar cell is in liquid form [9]. However, liquid electrolyte has its own drawbacks, as liquid electrolyte is sensitive to temperature. It evaporates at high temperature and freezes at low temperature thus impeding the working of DSSC. Liquid electrolyte also has leakage problem making it hard to be sealed causing the cells to fall back in terms of long stability. Sometimes

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