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Research Article

Multifunctional graphene oxide implanted polyurethane ionomer gel electrolyte for quantum dots sensitized solar cell

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ABSTRACT

Electrolyte active group (EAG) embedded structured hard segments have been developed via graphene oxide coupled with polyurethane chain. The polysulfide redox couples (S^{2-}/S_n^{2-}) free functionalized polyurethane electrolyte possesses electron donating pendant anions (carboxylate and sulfonate segments) with sufficient oxygenic functional groups on polyurethane backbone. Polyelectrolyte activity is due to elevation of number density of pendant anions (electrolyte active group) into polyurethane chain. Electrochemical impedance spectroscopy (EIS) reveals higher electrical conductivity (4.48×10^{-3} S/cm) for optimized PUI-GO (0.5 wt%) electrolyte. The electrolyte active groups are prone to facilitate photovoltaic reaction due to synergistic interaction and function with MPA capped CdS. The QDSSC (FTO-RGO/TiO_2/MPA-CdS/PUI-GO/FTO-Pt) exhibits maximum power conversion efficiency (1.63 %) and open circuit potential (V_{OC} = 0.594 V) under 1 sun (100 mW/cm^2) photo illumination. V_{OC} is found to be improved with PUI-GO electrolyte due to its multi-functional activities such as expanded electrocatalytic area, conducting nanochannel and interfacial passivation effect of carboxylate ion on photoanode.

1. Introduction

Global energy demand is growing exponentially, the society needs abundant, green renewable and efficient resource to transform energy crisis and climate change [1]. Among the various possible renewable energy sources, solar energy is zero carbon emissive and non pollutant in nature [2,3]. Quantum dot (QD) sensitized solar cell is an efficient solar energy conversion device based on photo electrochemical reaction in third generation solar cell technology. Surface engineered photovoltaic dyes have been utilized to enhance efficiency and conversion activity of dye sensitized solar cells. Organic dyes having proper donor and acceptor functionalities cause enhancement of photo absorption and charge separation efficiency [4]. Cherifi et al. developed triphenylamine (TPA) based organic dye with ethylenedioxythiophene linkage which extends the binding affinity (bidentate capacity) of –COOH moiety towards semiconducting perovskite materials result in enhancement of absorption energy (5.82 eV) and injection efficiency[5]. Cheknane et al. reported composite photovoltaic material consisting of poly (2-methoxy-5-(20-ethylhexyloxy)-1,4-phenylenevinylene) (MEH-PPV) with [6,6]-phenyl C_{60} butyric acid methyl ester (PCBM) result in the formation of donor-acceptor (p-n) heterojunction for photoexcitonic diffusion [6]. Likewise dyes, the size quantization property of QDs allow one to tailor the visible absorption spectrum by changing their size and morphology. It has been reported that the high electron mobility of nanostructured carbons (e.g., graphene oxide, graphene and carbon nanotubes) intensifies the separation of the photogenerated charge carriers upon delocalization in the π electron density (C═C) of the carbon matrix (acting as sinks of electrons) [7,8]. Quantum dots possess a high absorption coefficient and an appropriate band gap to harvest solar light [1,9]. In QDSS cells, an electrolyte active redox couple performs the function of energy barrier for efficient charge transport between the photoanode and the counter electrode [10–12]. Liquid polysulfide electrolytes are the most widely used redox active couples for scavenging oxidized sensitizer (hole) in QDSSC owing to their rapid photo-induced hole scavenging capability and stabilizing nature towards frequently utilized chalcogenide QD sensitizers [13]. However, there are some drawbacks to polysulfide redox couples including the over redox potential for QD regeneration and high surface tension which limits the contact between mesoporous TiO_2 and redox couples, subsequently lowering the performance of QDSSCs. Moreover, these liquid electrolytes are volatile and flammable. The extensive studies on synthesis and application of polysulfide gel polyelectrolyte (GPE) in

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