

Dye-Sensitized Solar Cells Based on a Cross-Linked Gel Polymer Electrolyte Containing Multi-Wall Carbon Nanotubes

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Abstract – In this work we investigated a cross-linked gel polymer electrolyte based on the copolymer poly (ethylene oxide-co-2-(2-methoxyethoxy) ethyl glycidyl ether-co-allyl glycidyl ether containing γ -butyrolactone (GBL) and multi-wall carbon nanotubes (MWCNT) as additives and its application in dye-sensitized solar cells. The addition of GBL into the electrolyte allowed the dissolution of a high concentration of salt and the incorporation of the MWCNT can increase its electronic conductivity. Both additives contribute to push the overall conductivity of the electrolyte up to values close to 1 mS cm^{-1} (for the sample prepared with 1 wt.% of MWCNT). The best device's performance was achieved using the cross-linked polymer electrolyte containing 20 wt.% of Lil and 1 wt.% MWCNT (efficiency of 3.78% at 100 mW cm^{-2}).

Dye-sensitized solar cells (DSSCs) have attracted much attention since the pioneering work reported by O'Regan and Grätzel. However, the presence of a liquid electrolyte demands a perfect sealing in order to avoid solvent leakage and long-term stability. This drawback may be circumvented by using room temperature ionic liquids, organic and inorganic hole transport materials, polymer or gel electrolytes. However, the overall conversion efficiency of DSSCs assembled with gel polymer electrolytes is still lower than those using liquid electrolytes. γ -butyrolactone (GLB) and a small amount of multi-wall carbon nanotubes (MWCNT) to the cross-linked copolymer based on poly(ethylene oxide-co-2-(2-methoxyethoxy) ethyl glycidyl ether-co-allyl glycidyl ether (P(EO-EM-AGE)) were intentionally employed to increase the overall electrolyte conductivity (ionic and electronic) in order to obtain devices with improved performance.

The electrolytes were prepared by the dissolution of P(EO-EM-AGE), Lil, I_2 , GBL and functionalized MWCNT in acetone. The P(EO-EM-AGE)/GLB weight ratio was 0.1/0.9 and the amount of Lil and I_2 was fixed at 20 wt.% and 2 wt.%, respectively. The thermal cross-linking process, ionic conductivity measurements, solar cell assembly and device characterization were done according to well-established procedures developed in our laboratory. Solar cells were assembled with 0.25 cm^2 of active area and the photocurrent-voltage (J - V) curves were obtained under standard AM 1.5 conditions (100 mW cm^{-2}).

Figure 1 shows the J - V curves and electrical parameters of solar cells assembled with the gel polymer electrolytes.

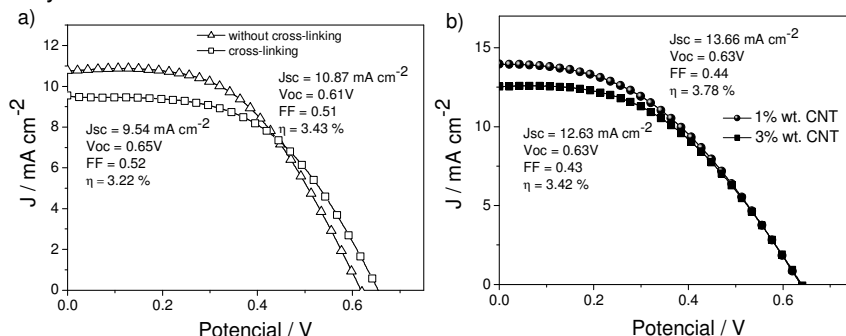


Figure 1: J - V curves and main parameters of solar cells assembled with: (a) gel polymer electrolyte with cross-linking and without (b) cross-linking gel polymer electrolytes containing different amount of MWCNT.

The thermal cross-linking process in the polymer electrolyte promoted a small increase on open-circuit potential (V_{oc}) and a slight decrease of the photocurrent (J_{sc}) of the devices, as illustrated in Figure 1 (a). These effects may be related to a more rigid polymer structure that contributes to decrease the ionic mobility. However, after the cross-linking process, the gel polymer electrolyte exhibits a more robust appearance. The addition of MWCNT to the cross-linked polymer electrolyte promoted an increase in the conductivity and as a consequence, it was observed an increase in the photocurrent values (Figure 1 (b)).

In conclusion, both MWCNT and GBL enhance the overall ionic conductivity of the cross-linked copolymer presented here, resulting in a mix conductor (ionic and electronic). This enabled a positive effect on the photocurrent values displayed by the DSSCs assembled using such electrolyte.

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