Charge transport and electron recombination suppression in dye-sensitized solar cells using graphene quantum dots

ABSTRACT

In this study, TiO2 photoelectrodes were sensitized in different concentration of Graphene Quantum Dots (GQDs) solution to enhance photovoltaic performance and charge transport of DSSC. The performance of pristine TiO2 and TiO2-GQDs photoelectrodes were compared to investigate the effect of GQDs incorporation in DSSC. It was found GQDs increased light absorption of TiO2 photoelectrode at visible spectrum in the range of $\lambda = 375$ nm to $\lambda = 600$ nm, resulting highest current–density, Jsc and photon-to-current conversion efficiency, Ηc. Solar cell sensitized in 7.5 mg/ml concentration of GQDs known as (PG 7.5) cell shown the highest reading by 15.49 mA cm−2 and 6.97%, which indicated an improvement by 28.07% and 70.83% for Jsc and Η compare to pristine TiO2 DSSC at 12.10 mA cm−2 and 4.08%. Photoluminescence property own by GQDs may enhance photon emission to visible region when uv-ray excited on solar cell. Thus, generate more electron-hole pairs in the photoelectrode and enhance the photovoltaic parameters of DSSC. PG 7.5 cell also exhibited lowest series resistance (Rs) of 36.60 Ω, highest charge transfer resistance (Rct2) of 41.98 Ω and electron lifetime of 6.33 ms among other DSSC. These possibly due to suppression of recombination between TiO2/dye/electrolyte interfaces. Hence, resulting highest charge collection efficiency (CCE) of 53.42%. The EIS analysis confirmed the PV performance of the best cell of PG 7.5 since the same cell also generated the best photon-current conversion efficiency (PCE). This study revealed GQDs can enhanced photovoltaic parameter and charge collection efficiency of DSSC.

Keyword: TiO2-GQDs; Charge transport; Charge collection efficiency; GQDs-DSSC