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Development of counter electrodes based on graphene and quantum dots for dye-sensitized solar cells

<u>Diogo M. G. Neto</u>[1] (IC), Helton P. Nogueira[1] (PQ), Mubiayi P. Kalenga[2] (PG), Nosipho Moloto[2] (PQ), Jilian N. Freitas[1,]*(PQ)

[1] *Center for Information Technology Renato Archer (CTI), Rod. D. Pedro I, km 143.6, Campinas, SP, Brazil*
[2] *University of the Witwatersrand, P. Bag 03, Wits, 2050, Johannesburg, South Africa*
** jilian.freitas@cti.gov.br*

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Introduction

Dye-sensitized solar cells (DSSCs) have drawn a lot of attention because of their low manufacturing cost, simple fabrication process and reasonable power conversion efficiency (PCE). A typical DSSC consists of a dye-sensitized TiO_2 photoanode, a liquid electrolyte typically containing the I_3^-/I^- redox couple, and a counter electrode (CE).[1-2] Amongst the components of the DSSC, the CE plays a critical role for the device performance, because it helps in the regeneration of the dye by the catalytic reaction with the redox electrolyte . A sluggish kinetics could cause increased charge recombination at the photoelectrode, resulting in a low PCE.[2-3] Although a thin platinum film is normally used as CE on DSSCs, there is a recent attraction to graphene as a replacement of platinum, because it has high transparency and electrical conductivity, chemical and mechanical robustness.[1] Quantum dots (QD) are also used as CEs and are particularly advantageous when combined with alternative electrolytes, containing other redox couples in substitution to the corrosive I^-/I_3^-. In this study we focus on the investigation of a series of CEs for DSSCs: platinum (Pt), graphene oxide (GO), reduced graphene oxide (RGO), graphene oxide with quantum dots (GOQD) and reduced graphene oxide with quantum dots (RGOQD).

Results and Discussions

Graphene-based CEs were prepared by spray deposition from an aqueous solution containing graphene oxide or reduced graphene oxide, with or without $CuInGaSe_2$ quantum dots (Figure 1). Figure 2 shows images made with optical microscopy for the as-deposited electrodes, revealing that homogenous and compact films were obtained with this method.

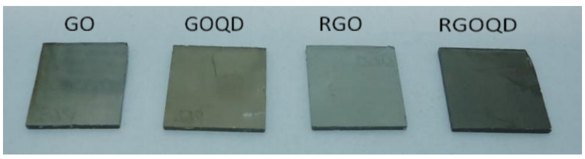

Figure 1. Images of the graphene-based CEs manufactured by spray.

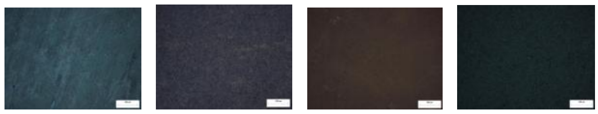

Figure 2. Optical microscopy of as-deposited CEs.

Figure 3 presents the cyclic voltammetry tests that were performed to analyze the reactions on the surface of the CE and the electrolyte containing I^-/I_3^- or a thiolate/disulphide (T^-/T_2) redox couple. The characteristics of the CE/electrolyte interfaces were also investigated with electrochemical impedance spectroscopy. Then, all CEs were applied in DSSCs and reasonable PCEs were obtained.

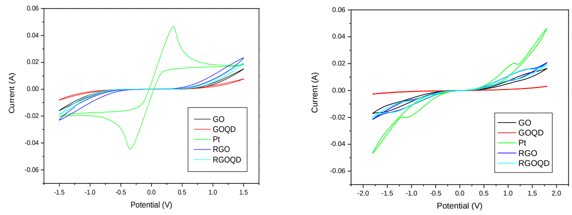

Figure 3. Cyclic voltammetry analyzes of the CEs with electrolytes containing: (a) I^-/I_3^- or (b) T^-/T_2.

Conclusions

This preliminary study presents a method to prepare CEs based on graphene and quantum dots by a spray technique, their characterization and application in DSSCs. Despite of the poorer performance than the platinum CE, the investigated electrodes offer opportunity to produce a less expensive DSSC, with reasonable performances if used with alternative electrolytes. However, a deeply study is needed to develop more efficient solar cell with the graphene and quantum dots-based CEs.

Aknowledgemnents

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