Enhancing Performance of Photovoltaic Solar Cell by P3HT:PCBM Doped Graphene Flakes as Photoactive Layer

Adnan Ali*1, Brahim Aïssa1

1Qatar Environment and Energy Research Institute, Hamad Bin Khalifa University, Qatar Foundation, PO Box 5825, Doha, Qatar

Abstract

Photoactive materials based on conjugated polymers are very promising candidates for Hybrid organic photovoltaic (OPV) cells. Conjugated polymers are inexpensive materials and therefore, their processing is very cost-effective and the ease of fabrication by solution processing make them more attractive. So far, OPV with modest efficiency are obtained. The low power conversion efficiency (PCE) of OPV is one of the main reason which has impeded large scale deployment. The low PCE of OPV solar cells is attributed to the low carrier mobility, which is closely correlated to the transport diffusion length of the charge carriers within the photoactive layers. 2D material like graphene which has huge carrier mobility, thermal and chemical stability and its compatibility of fabrication by solution processing techniques making it an excellent candidate for assisting charge transport improvement in the active layer of OPV cells. In this work, we report on the improvement of the optoelectronic properties and photovoltaic performance of photoactive blended layers i.e. P3HT:PCBM doped graphene flakes which was then integrated into a bulk heterojunction (BHJ) organic-photovoltaic-based device, using PEDOT:PSS on an ITO/glass substrate. Firstly, effect of graphene flakes content was studied in terms of the light absorption capacity which has shown increase with increasing concentration of graphene flakes. Besides this, quenching was observed through photoluminescence which is a clear indication of electron transfer between the graphene flakes and the polymeric matrix. P3HT:PCBM doped graphene flakes layer is incorporated into the BHJ as active layer. An increase in PVperformance with respect to the reference cell was observed. The best PV performance was obtained for 3 wt.% loading of graphene flakes. The solar cell showed an open-circuit voltage (Voc) of 1.24 V, a short-circuit current density (Jsc) value of 6.18 mA cm−2 , a fill factor of 47.12%, and a power conversion efficiency of about 3.61%. It is obvious from the organic photovoltaic solar cell efficiency that sp2-bonded carbon doping of photoactive conjugated polymer has strong role in its enhanced performance.

Keywords: P3HT: PCBM, graphene, optical absorbance, photoluminescence, photovoltaic

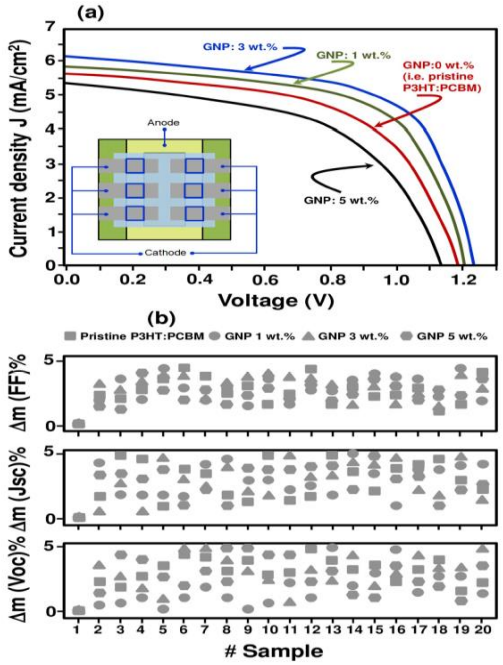


Figure 1. (a) Typical J–V characteristics of polymer P3HT:PCBM: GNP solar cells with 0, 1, 3 and 5 wt.% graphene loading, and (b) device-to-device variation for each measured performance (Voc, Jsc and FF) for a set of 20 samples. The first measurement is taken as a reference.

Recent Publications

[1] Mei Q S, Zhang K, Guan G J, Liu B H, Wang S H and Zhang Z P 2010 Highly efficient photoluminescent graphene oxide with tunable surface properties Chem. Commun. 46 7319–21

[2] Ye L, Zhang S, Qian D, Wang Q and Hou J 2013 Application of Bis-PCBM in polymer solar cells with improved voltage
J. Phys. Chem. C 2013 117 25360–6

[3] Khlyabich P P, Burkhart B, Rudenko A E and Thompson B C2013 Optimization and simplification of polymer-fullerene solar cells through polymer and active layer design Polymer 2013 54 5267–98

[4] Mihailetchi V D, Xie H X, de Boer B, Koster L J A and Blom P W M 2006 Charge transport and photocurrent generation in poly(3-hexylthiophene):methanofullerene bulk-heterojunction solar cell Adv. Funct. Mater. 16 699–708

[5] Liu Y, Liu C Y and Liu Y 2011 Investigation on fluorescence quenching of dyes by graphite oxide and graphene Appl. Surf. Sci. 257 5513–8

[6] Mallajosyula A T, Iyer S S K and Mazhari B 2010 Role of single walled carbon nanotubes in improving the efficiency of P3HT:PCBM solar cells—impedance spectroscopy and morphology studies Proc. of the 35th IEEE Photovoltaics Specialists Conf. pp 95–101



Biography

Dr. Adnan Ali is PhD in Mechatronics Engineering and has been working on Printed Electronics, since 2008. He has developed printing techniques for printing thin films and patterns using solutions containing nanoparticles and dissolved precursors. He has been working on multidisciplinary projects:
Nanomaterials Synthesis & Hybrid Membrane Fabrication by Electrospinning, Nanomaterials Synthesis for Energy Applications like batteries, Electronic Transport Layer (ETM), Pervoskites/ CZTS/CIGS Absorbing Thin Films, Novel Transparent & Conductive Thin Films for solar cell.

Email: adnanaligohar@gmail.com