International Journal of Current Engineering and Technology

E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

Determination of Energy Gap & Efficiency in Dye Polymer Solar Cells

Enam Izeldin Ibrahim Elsayd†, Mubarak Dirar A. Allah†, Asim Ahmed Mohamed Fadol‡, Sawsan Ahmed Elhouri Ahmed‡*

†Department of Physics, Faculty of Science, Sudan University of Science & Technology, Khartoum-Sudan
‡Department of Physics, Faculty of Applied & Industrial Sciences, University of Bahri, Khartoum-Sudan

Accepted 31 July 2015, Available online 02 Aug 2015, **Vol.5, No.4 (Aug 2015)**

Abstract

In this work dye polymer thin films solar cells were used in order to find both the value of energy gap and efficiency of solar cells. Samples of polymers were dye with chemical dyes such as Chrome, DDTTC, Blue 8GX, Rohdamin and Coumarin also natural dyes such as Hibscus and Lawsonia. Then values of gap energy and efficiency under effect of these dyes were tabulated.

Keywords: *polymer, efficiency, energy gap, natural dyes, chemical dyes*

1. Introduction

A polymer solar cell is fabricated from semiconducting conjugated polymers (René Janssen-2011). Polymers are the active components in the photocurrent generation and power conversion process within thin film photovoltaic devices that convert solar light into electrical energy. Polymer solar cells are now a highly innovative research area for the last decade until today (Li, B., Wang, *et al* 2010)

Making solar cells from organic materials is possible simply by using conjugated polymers. Solar cells based on thin polymer films are particularly attractive because of their ease of processing, mechanical flexibility, and potential for low cost fabrication of large areas. Additionally, their material properties can be tailored by modifying their chemical makeup, resulting in greater customization than traditional solar cells allow. Although significant progress has been made, the efficiency of converting solar energy into electrical power obtained with plastic solar cells still does not warrant commercialization the most efficient devices have an efficiency of 4-5%. (C. J. Brabec, *et al*-2014). To improve the efficiency of plastic solar cells it is, therefore, crucial to understand what limits their performance. A polymer solar cell is a type of flexible solar cell made with polymers, large molecules with repeating structural units, that produce electricity from sunlight by the photovoltaic effect. Polymer solar cells include organic solar cells (also called "plastic solar cells") (N., Michaud, A., & Leclerc-2011). They are one type of thin film solar cell; others include the currently more stable amorphous silicon solar cell. Polymer solar cell technology is relatively new and is currently being very actively researched by universities, national laboratories, and companies around the world. This work is concerned with the effect of the types of dyes and their energy levels on the performance of polymer solar cells
(N., Michaud, A., & Leclerc-2012).

2. Experimental Work

The optical energy gap (E_g) for chemical dyes has been calculated by the relation $(\alpha h\upsilon)^2 = C(h\upsilon - E_g)$. By plotting $(\alpha h\upsilon)^2$ vs photon energy ($h\upsilon$) as shown in figure (1), (2), (3), (4) and (5)

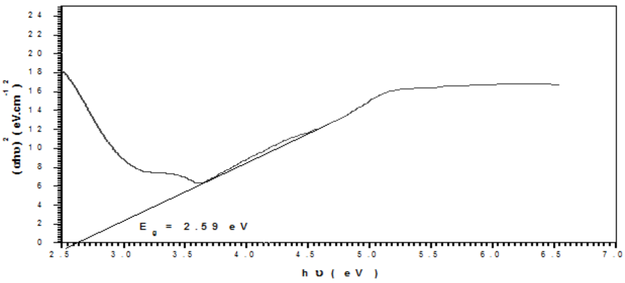

Fig (1): The optical energy gap (E_g) value of Ero-Chrom black

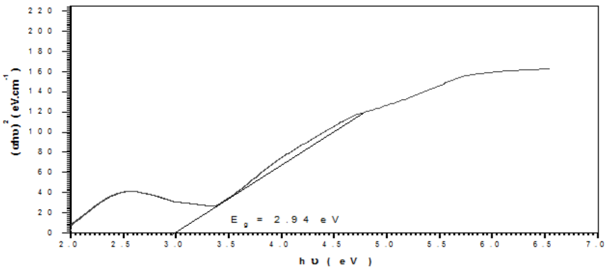

Fig (2): the optical energy gap (E_g) value of DDTTC

*Corresponding author: **Sawsan Ahmed Elhouri Ahmed**

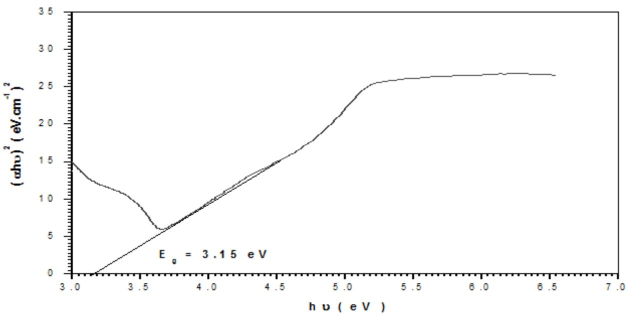

Fig (3): The optical energy gap (E_g) value of Blue 8GX

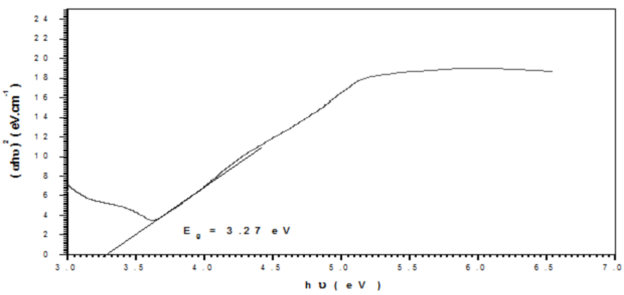

Fig (4): The optical energy gap (E_g) value of Rohdamin B

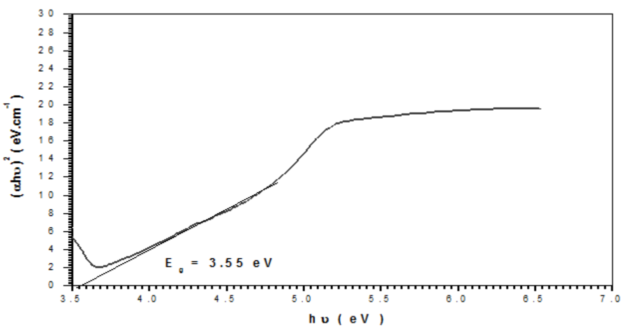

Fig (5): The optical energy gap (E_g) value of Coumarin

3-a. Results

Table (1): The energy gap (E_g) of chemical dyes
$\eta = effeciency$

Chemical Dyes	$E_g(in\ ev)$	η
Blow conduction band		
Chrome	2.59	0.046
DDTTC	2.94	0.065
Above conduction band		
Blue 8GX	3.15	0.051
Rohdamin	3.27	0.063
Coumarin	3.55	0.070

The optical energy gap (E_g) for natural dyes has been calculated by the relation $(\alpha h\upsilon)^2 = C(h\upsilon - E_g)$. By plotting $(\alpha h\upsilon)^2$ Vs photon energy ($h\upsilon$) as shown in figure (6) and (7).

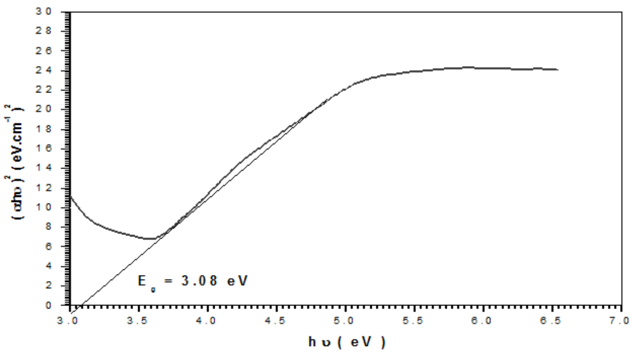

Fig (6): The optical energy gap (E_g) value of Hibiscus

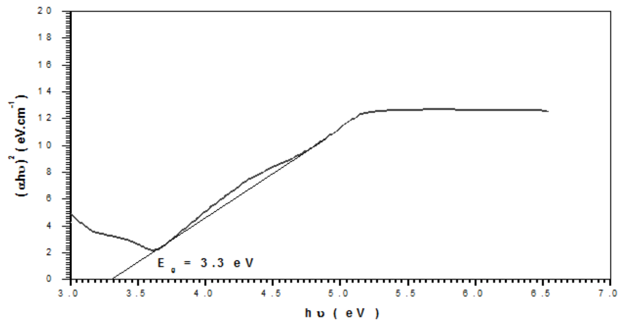

Fig (7): The optical energy gap (E_g) value of Lawsonia

3-b. Results

Table (2): The energy gap (E_g) of natural dyes
$\eta = effeciency$

Natural dyes	$E_g(in\ ev)$	η
Hibscus	3.08	0.054
Lawsonia	3.30	0.040

Discussion

The dependence of the efficiency of the polymer on the energy gap of dyes is classified in to three categories. The first two ones are related to chemical dyes and polymer band gap 3 eV. For those dyes having energy levels 2.59 eV (chrome) and 2.94 eV (DDTTC), efficiencies are respectively 0.46 and 0.065 which increases. This may be due to the fact that the two levels are in band gap. The first one (2.59 eV) is relatively for from conduction band, thus their electrons need enough higher energies to be in the conduction band. Thus they have low efficiency compared to that (2.94 eV) which is very near to conduction band thus electrons easily become free and thus have higher efficiency.

In the second category the increase of energy levels of chemical dyes which are in the conduction band have values (3.15, 3.27 and 3.55 eV) increases the efficiency. This may be related to the fact that the kinetic energy gained by electrons are (3.15, 3.27 and 3.55 eV) respectively. The increase in the kinetic energy increases velocity thus increases current which in turn increase efficiency.

In the third category which is concerned with natural dyes the situation is different. Increasing the energy gap from 3.08 eV to 3.3 eV decreases the efficiency from 0.054eV to 0.040 eV this may be indicate no over labing between polymer bands with that of natural dyes. The lower band gap 3.08 eV allows electrons to be free easily thus one expects high efficiency as shown by table (2).

Conclusion

The efficiency of dyes depends on energy gap whether they are natural or chemical. It is also strongly related to the polymer and dyes energy gaps levels.

References

René Janssen (2011), Introduction to polymer solar cells, Eindhoven University of Technology, The Netherlands.

Li, B., Wang, L., Kang, B., and Qiu, Y. (2010), Solar Energy and Solar Cells, Wiley-VCH.

A. Mayer, S. Scully, B. Hardin, M. Rowell, M. McGhee (2012), Polymer-based solar cells, Materials.

C. J. Brabec, *et al*. (2013), "Polymer-Fullerene Bulk-Heterojunction Solar Cells," Advanced, Materials.

Li, G. *et al*. High-efficiency solution process able polymer photovoltaic cells by Self-organization of polymer blends. Nature Mater. 2014.

N., Michaud, A., & Leclerc (2011), M. A low-band gap poly (2, 7-carbazole) derivative for use in high-performance solar cells. Advanced Materials, ISSN.

N., Michaud, A., & Leclerc. (2012) Efficiency enhancement in low-band gap polymer solar cells . Nature Mater.