Journal of Engineering and Applied Sciences

MEDWELL PUBLICATIONS SINCE 2000

# Effect of Thin Films of Rhodamine C Dye with Different Weights of ZnO Nanoparticles on the Performance of Si-Solar Cell

S.I. Ibrahim, K.S. Rida and Bashar Al-Ogaidi
*Energy and Renewable Energies Technology Center, University of Technology, Baghdad, Iraq*

**Key words:** Nanoparticles, films, concentration, efficiency, increment

**Corresponding Author:**
S.I. Ibrahim
*Energy and Renewable Energies Technology Center, University of Technology, Baghdad, Iraq*

Page No.: 2718-2722
Volume: 15, Issue 13, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences


**Abstract:** Thin films of Rhodamine C dye in fixed concentration ($5\times10^{-5}$ mol $L^{-1}$) and different weights of zinc oxide nanoparticles (50 nm) have been prepared by doping in epoxy resin. The optical properties of thin films were measured and the results obtained from the measurements of electric conversion efficiencies of all thin films indicate that the best conversion efficiency $(\eta\%)_{LSC}$ of Si solar cell was with (0.1 g) of Nano ZnO ($\eta$ = 2.589%), compared with the thin film without ZnO nanoparticles ($\eta$ = 2.322%) efficiency increment ($\Delta\eta$ = 28.23%) and solar cell without LSC ($\eta$ = 2.019%) efficiency increment ($\Delta\eta$ = 15%).

## INTRODUCTION

One of the goals of renewable energy technology is to reduce the use of fossil energy and its pollution caused to the environment in addition to reducing the use of energy[1, 2]. However, the cost is still high compared to fossil fuels of five to ten times[3, 4].

Luminescent Solar Concentrators (LSCs) give an attractive way of concentrating sunlight frugally and without tracking[5, 6]. LSCs generally consisting of polymer sheets wrapped with luminescent species.

Falling sunlight is absorbed by luminescent species and then emits it with boost quantum efficiency.The sheet will trap the light emitted into the edges where they are collected by solar cells[7].

Thin films are a so, cost-efficacious solution and utilize inexpensive support over it which the energetic component is utilized as a thin coating[8].

There is presently a modern concern in this technology because the availability of some advanced materials and models to emulation the photon transport. Main thing to be overcome are: finite stability of the luminescent species, rise self-absorption and little knowledge of the measurable factors dominant the efficiency. A constraint in the development of LSC is the lack of standard methods for calculating these data.The ability of a LSC to concentrate light relied on the geometry of the dye doped film and the "edge surface area". Many researchers are probing new materials for use in solar energy diversion. Mounting interest in the expansion of new types of doped colloidal nano-crystals is stimulated by essential science and possible applications. Successful doping process of nano-materials requires an understanding and development of the strategies used in the doping process[9].

Organic dyes present the modest means of blending in a LSC, it can easily dissolved in many organic polymers and then it was casting into sheet form. Inceptive LSC research utilize dyes originally improved for employ in dye lasers, like Xanthene dyes, many laser dyes are ideal suited to use in LSC due to its yields of "near-unity quantum", although, its limiting photo-stability. In addition to the possibility of increasing the stability of dyes by using host material[10].

Zinc oxide nanoparticles are a numerous use material with several functional properties like rise (chemical stability, photo stability); low dielectric constant, in addition to good ultraviolet absorption material[11].

ZnO have some appropriate piezoelectric properties due to the "hexagonal wurtzite" structure and its belongs to semiconductors family. It is a stellar semiconductor material due to its wide band gap (3.37 eV) at room temperature. Thus, ZnO is used in optoelectronic devices[12-14].

Further, to take advantage of more properties of ZnO, it is requisite to adjust its structure according to the field of the devices and utility of the research[15].

The aim of this research is to study the effect of Rhoda mine C dye doped epoxy resin with different weights of Nano ZnO on the performance of Si-Solar cell.

## EXPERIMENTAL PART

**Preparation of LSC:** (A) Thin film at concentration ($5\times10^{-5}$ mol $L^{-1}$) Rhodamine C (R C) from (HIMEDIA) India company were prepared by dissolving it in epoxy resin from CLEVER EPOXY TP (A), Polyurethane systems clever polymers and construction chemicals INC. (Istanbul, Turkey) and then mixed with type (B) in the ratio mixture (3A:1B) with softly stirring to avoid air bubbles. The mixture is then poured into molds and allowed to dry at room temperature, the thickness of prepared sheet is equal to (1 mm).

Epoxy was used as a good solvent for Rhodamine C dye in addition to easy drying in ambient temperature, cheap price and simplicity of work for forming of LSC sheets.

(B) different weight of Zinc oxide (50 nm) molecular weight (81.83 g $mol.^{-1}$) assay 99.5%, from US Research Nanomaterials, Inc. (USA) were dissolved in Ethanol (absolute) from (GCC) Gainland Chemical Company at 78°C and then mixed with a certain volume of pre-prepared mixture. The mixture is then poured into molds and allowed to dry at room temperature, the sheets were prepared with a thickness of (1 mm).

### Thin films (LSC) characterization

**Absorption and transmittance spectrum:** AUV-visible spectrophotometer-T60 PG instruments limited was used to record absorption and transmittance spectrumof Rhodamine C doped in epoxy resin at concentration ($5\times10^{-5}$ mol $L^{-1}$) without/with Nano ZnO as shown in Fig. 1-3, calibration curves of Nano ZnO weight versus absorption intensitywere illustrated in Fig. 2. Maximum absorption peak appear sat wavelength (550~552 nm) and at (377 nm) for Rhodamine C and Nano ZnO, respectively where the absorption intensity increases with the

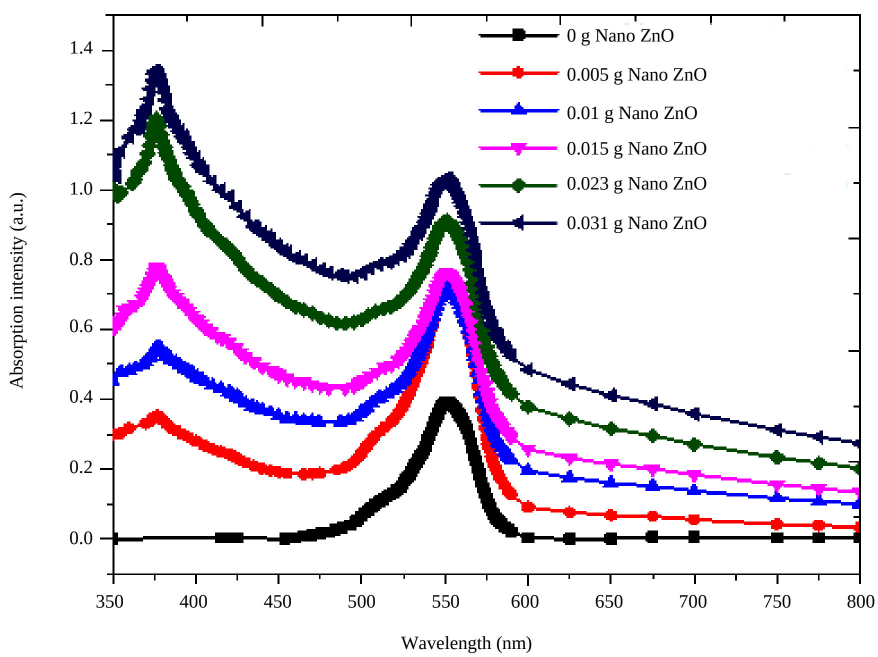


Fig. 1: Absorption spectrum of (Rh C) at concentration ($5\times10^{-5}$ mol $L^{-1}$) with different weight of ZnO nanoparticle

concentration of Nano ZnO and the transmittance of the LSC decrease with the increasing of Nano ZnO due to the slight turbidity which appears in the sheet.

**The effect of LSC on solar cell:** Si-Solar cell dimensions are equal to (10×10 cm) was used to study the effect of LSC on current-voltage by using a device "Solar Module Analyzer" (60V, 6A), "PROVA 200 Co".

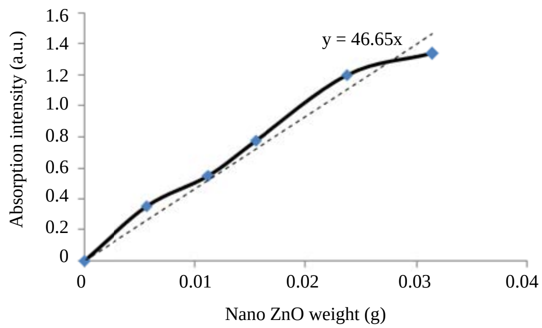


Fig. 2: Calibration curves of Nano ZnO weight versus absorption intensity

The results obtained from the measurements of the solar cell (without/with) the presence of LSC plates in door are shown in Table 1 which indicates that there is a raise in the conversion efficiency $(\eta\%)_{LSC}$ of Si solar cell when it is covered with LSC consists of (0.1 g) Nano ZnO which is equal to (2.589%), it means that the efficiency is improved by (28.231%) which is calculated from the following equation:

$$\Delta = \frac{(\%)_{LSC} - (\%)_{SC}}{(\%)_{SC}} \times 100\% \qquad (1)$$

Where:

$(\Delta\eta\%)_{LSC}$ = Efficiency by using (LSC) sheet
$(\eta\ \%)_{SC}$ = Efficiency of solar cell

Improvement of LSC performance is usually attributed to the enhanced of dye adsorption because of its morphology or layer thickness and fast electron transport.

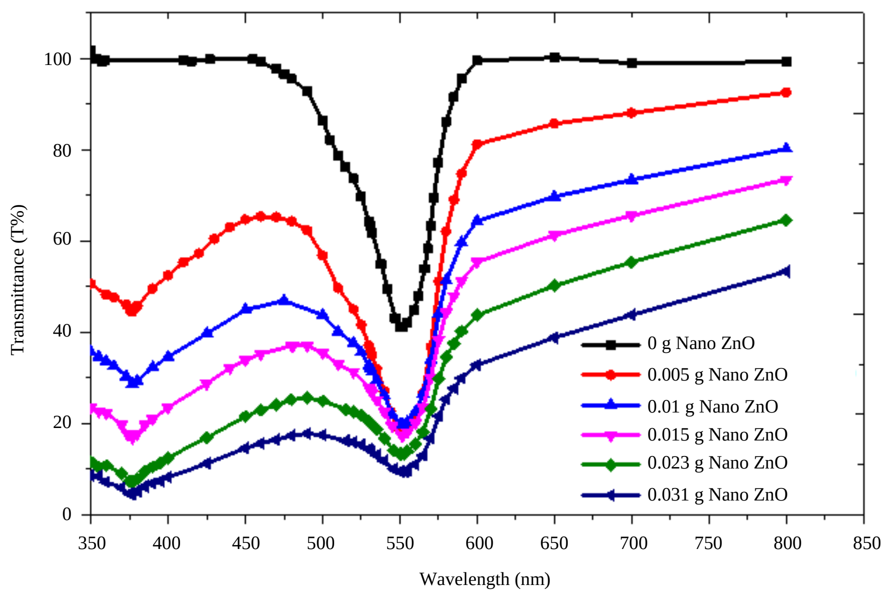


Fig. 3: Transmittance spectrum of (Rh C) at concentration ($5\times10^{-5}$ mol $L^{-1}$) with different weight of ZnO nanoparticle

Table 1: Si-solar cell parameters covered with (Rh C) thin film at concentration ($5\times10^{-5}$ mol $L^{-1}$) using different weight of ZnO nanoparticle

| Weight of Nano ZnO (g) | Conc. of ZnO Nano (mol $L^{-1}$) | $P_{max}$.(mW) | $V_{max}$.(V) | $I_{max}$.(mA) | EFF (%) | FF | Δη |
|---|---|---|---|---|---|---|---|
| Solar cell | - | 70.68 | 8.726 | 8.100 | 2.019 | 0.902 | - |
| 0 | 0 | 77.04 | 8.513 | 8.400 | 2.322 | 0.854 | 15.007 |
| 0.005 | 0.0061 | 103.10 | 8.859 | 10.900 | 2.418 | 0.851 | 19.762 |
| 0.01 | 0.0122 | 119.60 | 9.008 | 12.500 | 2.589 | 0.905 | 28.231 |
| 0.015 | 0.0183 | 112.20 | 8.840 | 11.700 | 2.407 | 0.872 | 19.217 |
| 0.023 | 0.0281 | 103.80 | 8.722 | 11.200 | 2.338 | 0.859 | 15.799 |
| 0.031 | 0.0378 | 95.40 | 8.952 | 9.900 | 2.199 | 0.830 | 8.915 |

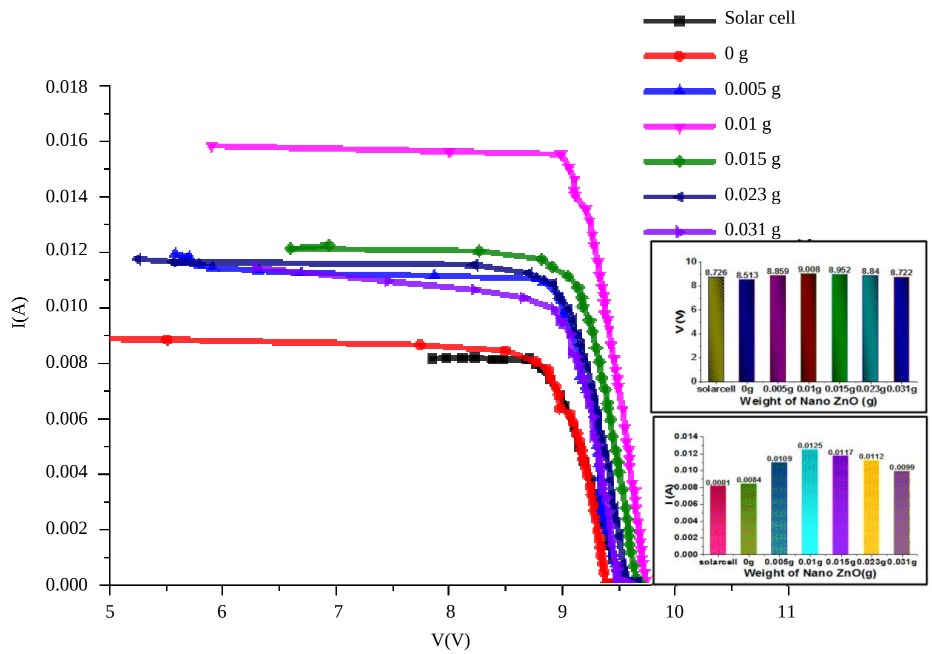


Fig. 4: Characteristic curve (I vs. V) of (Rh C) thin film at concentration ($5\times10^{-5}$ mol $L^{-1}$) using different weight of ZnO nanoparticle

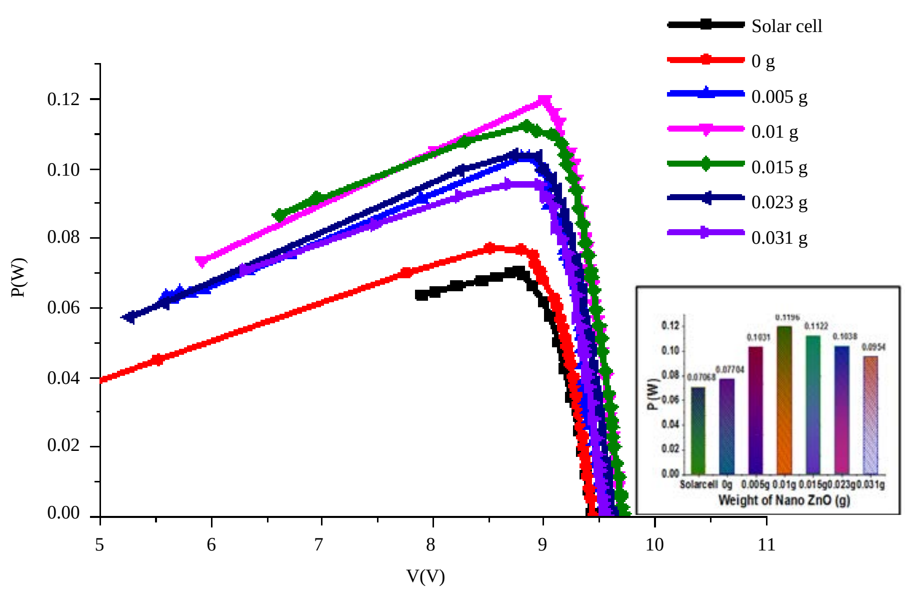


Fig. 5: Characteristic curve (P vs. V) of (Rh C) thin film at concentration ($5\times10^{-5}$ mol $L^{-1}$) using different weight of ZnO nanoparticle

The (I−V/ P-V) curves of the LSC prepared with different weights of ZnO nanoparticle are shown in Fig. 4, 5 and the internal shapes illustrate the relationship between Nano ZnO weight vs. (current, voltages and power).

## CONCLUSION

Epoxy resin was used as a good solvent for Rhodamine C dye at a concentration of ($5\times10^{-5}$ mol $L^{-1}$) to prepare LSC sheet first without Nano ZnO and then with different weight of Nano ZnO to improve the performance of solar cell. The LSC sheet with (0.1 g) Nano ZnO gives the best conversion efficiency of Si-solar cell.

## REFERENCES


01. Aklalouch, M., A. Calleja, X. Granados, S. Ricart *et al*., 2014. Hybrid sol-gel layers containing $CeO_2$ nanoparticles as UV-protection of plastic lenses for concentrated photovoltaics. Solar Energy Mater. Solar Cells, 120: 175-182.
02. Al-Ghamdi, A.A., E M. Mahrous, A.M. Al-Enizi and A. Azam, 2015. Preparation and characterization of pyrromethene-567 dye-doped polymer samples using Gamma Irradiation Polymerization Method (GIPM). J. Lumin., 157: 310-314.
03. Chandra, S., J. Doran, S.J. McCormack, M. Kennedy and A.J. Chatten, 2012. Enhanced quantum dot emission for luminescent solar concentrators using plasmonic interaction. Solar Energy Mater. Solar Cells, 98: 385-390.
04. Chemisana, D., 2011. Building integrated concentrating photovoltaics: A review. Renewable Sustainable Energy Rev., 15: 603-611.
05. Zhang, Y., S. Sun, R. Kang, J. Zhang *et al*., 2015. Polymethylmethacrylate-based luminescent solar concentrators with bottom-mounted solar cells. Energy Convers. Manage., 95: 187-192.
06. Albers, P.T.M., C.W.M. Bastiaansen and M.G. Debije, 2013. Dual waveguide patterned luminescent solar concentrators. Solar Energy, 95: 216-223.
07. Van Sark, W.G., K.W. Barnham, L.H. Slooff, A.J. Chatten and A. Buchtemann *et al*., 2008. Luminescent solar concentrators-A review of recent results. Opt. Exp., 16: 21773-21792.
08. Sethi, V.K., M. Pandey and M.P. Shukla, 2011. Use of nanotechnology in solar PV cell. Int. J. Chem. Eng. Appl., 2: 77-80.
09. Dienel, T., C. Bauer, I. Dolamic and D. Bruhwiler, 2010. Spectral-based analysis of thin film luminescent solar concentrators. Solar Energy, 84: 1366-1369.
10. Al-Hamdani, A.H., S.I. Ibrahim and S.A. Alrda, 2015. Effects of luminous solar concentrator parameters (dyes mixture, host type and LSC thickness) on the SI solar cell performance efficiency. Int J. Curr. Eng. Technol., 5: 2439-2443.
11. Preethi, S., A. Anitha and M. Arulmozhi, 2016. A comparative analysis of the properties of zinc oxide (ZnO) nanoparticles synthesized by Hydrothermal and Sol-Gel methods. Indian J. Sci. Technol., Vol. 9, 10.17485/ijst/2016/v9i40/92696
12. Klingshirn, C.F., A. Waag, A. Hoffmann, J. Geurts, 2010. Zinc Oxide: From Fundamental Properties Towards Novel Applications. Springer, Berlin, Germany, ISBN: 978-3-642-10577-7, Pages: 300.
13. Djurisic, A.B., A.M.C. Ng and X.Y. Chen, 2010. ZnO nanostructures for optoelectronics: Material properties and device applications. Prog. Quantum Electr., 34: 191-259.
14. Nunes, V.F., A.P.S. Souza, F. Lima, G. Oliveira, F.N. Freire and A.F. Almeida, 2018. Effects of potential deposition on the parameters of ZnO dye-sensitized solar cells. Mater. Res., Vol. 21, No. 4. 10.1590/1980-5373-mr-2017-0990
15. Sajjad, M., I. Ullah, M.I. Khan, J. Khan, M.Y. Khan and M.T. Qureshi, 2018. Structural and optical properties of pure and copper doped zinc oxide nanoparticles. Results Phys., 9: 1301-1309.