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RESEARCH ARTICLE

The Study of all the Optical, Electrical and the Performance Coefficients for the (Rhodamine B - Acriflavine) Laser Dyes Solar Cells Doped with Nanoparticles

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Abstract

In this study of the effect of nanomaterials on the performance of Solar cells with laser dyes. The study included visual measurements of the dye solutions with different concentrations on the optical properties such as absorption and transmittance (A, T), the absorption coefficient, refractive index, reflectivity and optical conductivity at the wavelengths (400-800) nm. Using the UV-visible spectrum device, the value of the energy gap was calculated. The changing in the values of the previous variables the focus. The electrical properties as (dielectric constant ε , the permittivity of ϵ , medium impedance Z , electrical conductivity σ_E were also calculated. the electrical response time t_E dielectric time t_{die} , and the permeability μ were also calculated, and the solar cells Parameters (Voc), (I_{sc}), (R_{sh}), (R_s), (P_{in}), (ŋ), F.F) with silver nanoparticles of higher efficiency than the cell coated with zinc oxide particles Zno is 16.9%.

Keywords: *Rhodamine B dye, Acriflavine dye, Ag,Zno nanoparticles, Solar cell, laser dyes.*

Introduction

The sun is the main source of radiation optical energy and the direct conversion from solar energy to electric energy will be an important element of the continuation of human civilization. The sun is supposed to act as a black body temperature of the surface remains at 600k. And that the temperature of this surface remains fixed by a source of energy at home and as a result of these increasing temperatures the surface glows and emits electromagnetic radiation in all directions in space.

Because traditional sources of energy are open and polluted, most researchers have sought to find alternative, new and permanent sources of energy. The best of these is green energy, which is not polluting the environment and cheap, until this energy is used by the phenomenon (Photo voltage) to generate electricity. Solar cells can be defined as a semiconductor device that converts sunlight falling directly into a constant current (DC) [1]. The work of the solar cell includes five consecutive stages [2, 3]. It is the ability of the active layer to absorb photon light, which often works to liberate the electron and go to the upper levels leaving a gap and this will generate the electronic pair (e-h) properties. As well as these areas, it can be used as a catalyst and carrier of catalysts, In the active class will spread electronic pairs and then electronic pairs separate from each other, and as a result of the movement of electronic charges will move each of them towards the appropriate pole, then will accumulate negative charges towards the positive pole, and positive charges towards the pole, but the efficiency is high to occur.

The transition that takes place between the electronic charges and the conductive electrodes, and this happens by controlling the surface formation to provide a clear relay for the transport of the charges to the electrodes [4]. Numerous studies have been conducted on Rhodamine B The study of the optical and electrical properties of the powder once and again as a liquid [5, 6]. Rhodamine

B is used in quantitative counters and has been successfully proven to be an effective medium for laser production [7, 8]. The spectral properties of both the absorption and the fluorine of the Rhodamine B dissolved in ethanol were studied theoretically and practically. The red shift (long wavelengths) of the concentration 10^{-2} M and 10^{-3} M [9] .A pilot study was conducted on the effect of the solvent on the spectral properties (absorption and fluorine) of the Rhodamine B .Three different types of rhodamine dye were mixed and mixed with different proportions and gauges, the effect of the pigment type and the mixing ratio of the spectral properties of the pigment [10, 11]. The dye of the laser (Rhodamine B) is red color and has the molecular formula $C_{28}H_{31}ClN_2O_3$ and its molecular weight is estimated at 479.02 g / mol. Emission of laser from Rhodamine B laser dye occurs at 610nm wavelength, It also possesses the efficiency of the amount of approximately (0.49 - 1.0) on the temperature reliant. Then note the full fluorescence and efficiently absolute dye rhodamine when using Argon laser and Nd: YAG laser hermetic quality at line 532 nm for pumping [12, 13].

Acriflavine laser dye which is one type of laser dyes which are manufactured in the form of an orange powder or brown color, and the label is taken from its chemical name, a (3, 6-Diamino-10-methylacridin-10-ium chloride) and its molecular formula is $C_{14}H_{14}N_3CL$, as it has a weight molecularly estimated at about 259.73 g / mol. The study of absorption spectra and fluorescence of the dye solution Acriflavine laser and dissolved in ethanol with different concentrations, as optical and spectral properties of its account. It was noted that an increase Molar concentration of the dye, the top of the emission of the dye shifted towards longer wavelengths [14]. The study also confirmed that the absorption peak of the dye was 436nm at the concentration 10^{-3} M and shifted at 457nm at concentrations of 10^{-4}M and 10^{-5}M and it has the fluorescence peak is at 493nm at 10^{-3} M concentration and is shifted to about 487nm at 10^{-4} M concentration.

The highest efficiency of fluorescence was 0.95 at 10^{-5} M concentration. The effect to satisfy the photonic fluorescence of Acriflavine laser dye and under the influence of high-intensity radiation is equipped with dual laser continuous operation with a capacity of 1mW when the laser line 407nm pump had been studied. It was found that the photonic saturation happens to the laser dye after a period of exposure to laser radiation up to about an hour [15]. In 1977 and for the first time used by researcher Goet Zberger, and other solar cell concentrators in solar cell applications by using plastic layers in aid with luminous material on the surface of solar cells [16]. In 1978, Boling and Rapp used LSC taking thin films of thickness (1mm) containing the coumarine laser dye that was deposited on the solar cells and obtained a high efficiency of (11.5 %) [17] .In 1981, the world used Lifaute and others, silicon solar cells, which include a polymeric polymer (PMMA) sheet, which is coated with fluoridated pigments, for the purpose of raising the efficiency of the solar cell to about (15%)[18].In 1982, Drake at. (PMMA) at three level layers in solar flash centers, and concluded that there was a remarkable response to this multilayered cell [19].

In 1997, Kohl and others developed a solar cell sensor for pigments, compared to traditional silicon solar cells by taking advantage of the large and low energy of fallen photons(UV-IR) Which is not received by silicon solar cells and for efficiency of 10% [20].In 2003 he used D. Chirvase and another polymer ($PCBM$, p_3HT) and considered that (p_3HT) Is an effective layer in solar cells to study optical and electrical properties, and proved to be the difference between the highest molecular level (HOMO) The lowest partial level is incomplete(LUMO) he is(2.1 eV)And be efficient cell (0.2%) [21].In 2007, the researcher described G. Mclntire manufactured green pigment chlorophyll-like green Found in the plants and concluded that these cells became more sensitive when adding this dye industrial [22]. In this research we will study the effect of nanoparticles as (Ag, ZnO) in the performance of solar cell with laser dye (Rhodamine B- Acriflavine).

Theory

Optical Properties

The absorbance (A) describes the amount of absorbed photons by molecules, can be written as [23, 25]:

$$A = 1 - \log\left(\frac{1}{T}\right) \text{ .... (1)}$$

Where T : is the transmittance of medium which is related with refractive index n as [23-26]:

$$T = \frac{2n}{n^2+1} \text{ .... (2)}$$

The absorption coefficient α of an optical medium can be related to the A absorbance according to eq. (3) [25-28]:

$$\alpha = \frac{1}{2.302\, A} \text{ .... (3)}$$

The reflectivity (R) explains the reflected photons from a material can be given as a function of (n) as [26-28]:

$$R = \left[\frac{n-1}{n+1}\right]^2 \text{ .... (4)}$$

The optical conductivity can be formulated as [24, 28]:

$$\sigma_{Opt} = \frac{\alpha\, n\, C}{4\,\pi} \text{ .... (5)}$$

The energy gap for the dyes can be calculated as organic materials using the following equation [29]:

$$Eg = \frac{1240}{\lambda(nm)} \text{ .... (6)}$$

Electrical Properties

Km = 1 for rear media so that dielectric constant [30, 32]:

$$\varepsilon = n^2 \text{ .... (7)}$$

Material permittivity (Є) can also be given as [30-32]:

$$\epsilon = \varepsilon\ \epsilon_o \text{ .... (8)}$$

Where ($Є_o$) is the permittivity of free space of ($8.854x10^{-12}$ F/m) and (µ) can also be calculated according to the following equation [30-32]:

$$\mu = \frac{n^2}{\epsilon c^2} \text{ .... (9)}$$

Electromagnetic field of laser had been suffered from resistivity (Z) within across media. (Z) may be given as below [30-32]:

$$Z = \sqrt{\frac{\mu}{\epsilon}} \text{ .... (10)}$$

Electrical conductivity (σ) is a property of a material that quantifies the ease with which charges flow inside the material along an applied electric field. (σ_E) can be calculated using following equation [30-32]:

$$\sigma_E = \frac{1}{Z\,.\,\ell} \text{ .... (11)}$$

Where (ℓ) is the material thickness.

Both of electrical conductivity (σ_E) and permittivity (Є) of any media, have been continued for specific time which known as electrical response time t_E [30-32]:

$$t_E = \frac{\epsilon}{\sigma_E} \ldots\ldots\ldots\ldots\ldots (12)$$

In the beginning of laser (or any electromagnetic wave) applying on any material, nothing happened for its electrical properties for period called as (dielectric time τ_{die}) [30-32]:

$$\tau_{die} = \frac{\ell\sqrt{\varepsilon}}{c} \ldots\ldots\ldots\ldots \ldots (13)$$

Solar Cell Parameters

The short circuit current (I_{sc}) is influenced by several factors that are illustrated by the following relationship [33]:

$$I_{ph} = I_{sc} = gR_0\, l_n\, (q\alpha) \ldots\ldots. (14)$$

Open Circuit Voltages (V_{oc})

The solar cell is defined by the voltage measured under the light [34].

Fill Factor (F.F)

Known as the ratio between the current and voltages at the maximum power point of the cell to the short circuit current and the open circuit voltages calculated using following equation:

$$F.F = \frac{I_{Max} * V_{Max}}{I_{sc} * V_{oc}} \ldots\ldots. (15)$$

Solar Cell Efficiency (ŋ)

Efficiency of the solar cell the efficiency of the solar cell can be defined as the percentage between the power outputs from the cell at the maximum power point, to the incoming power .The efficiency of conversion of power in the solar cell is given by the following relationship [35]:

$$ŋ = \frac{P_m}{P_{in}} \times 100\% \ldots\ldots. (16)$$

Respectively

Sequential and parallel resistance are highly influential in solar cell efficiency, where any high efficiency requires ($1/R_{sh}$) and (R_s) very low.

Experimental Part

Preparation Liquid Solutions for Dyes and with Different Concentrations

To prepare a solution of a specific substance at a certain concentration, an appropriate amount of material has been dissolved in a certain volume of the solvent (Rhodamine B, Acriflavine) with concentration(1×10^{-3} M) was dissolved (0.0030, 0.0040) g respectively of powder dye in size (10 cm^3) of solvents (ethanol and chloroform), according to the following relationship. Those rhodamine B dyes used in this research are of the type (R 6626 – 25G) from producer company (Sigma-Aldrich, USA) and the purity is estimated at about 99.59. Acriflavine laser dye used in this research are type (417025 – 1G), and processed from the company (Sigma – Aldrich – USA) and purity is estimated at about 98.00.

$$W_m = \frac{C \times V \times M.W}{1000} \ldots\ldots\ldots\ldots\ldots (17)$$

And for diluted solutions ($1X10^{-5}$, $2X10^{-5}$, $3X10^{-5}$, $4X10^{-5}$) of the concentration that has been prepared is done using the following relationship called the mitigation relationship:

$$C_1V_1 = C_2V_2 \quad \ldots\ldots\ldots\ldots \quad (18)$$

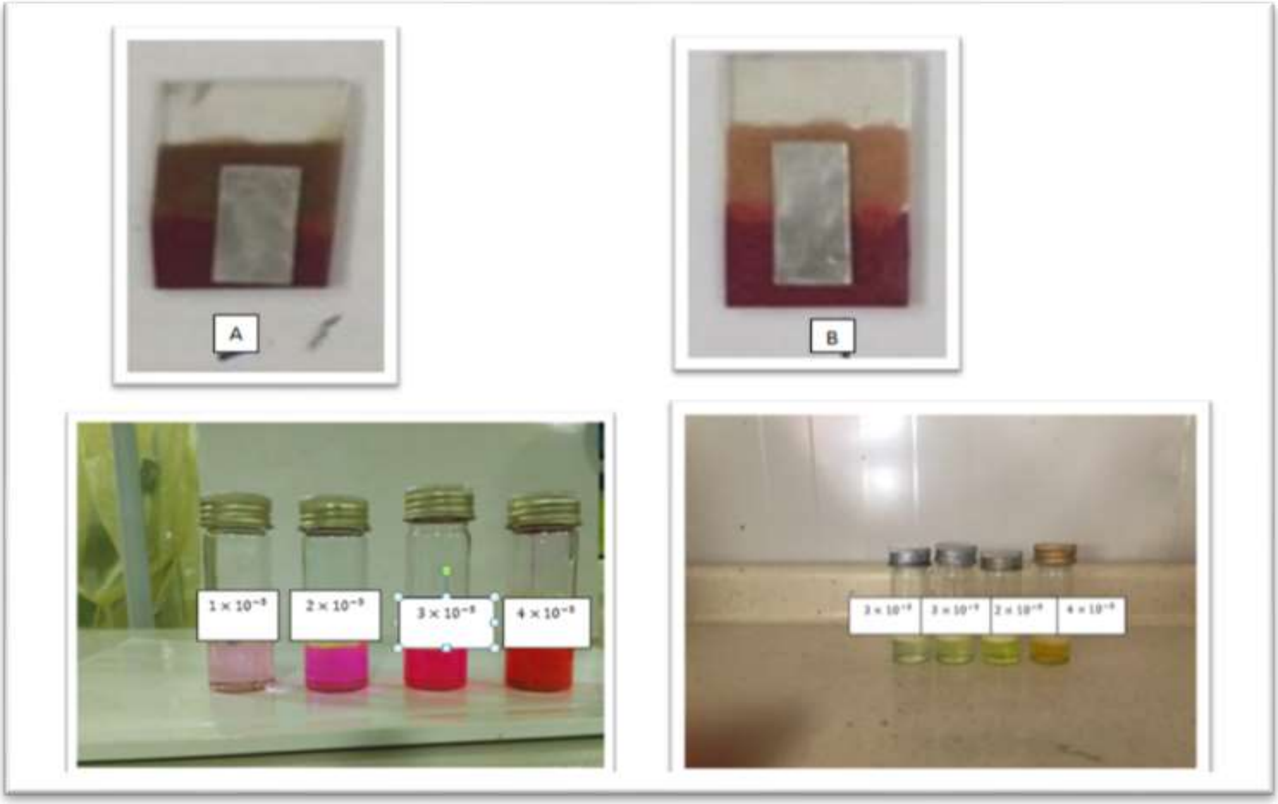

Fig. 1: Demonstrates the preparation of liquid samples and prepared solar cells

Operation Solar Cell

Glass chips covered with ITO were used for the manufacture of pigmented solar cells:-

- The ITO-coated glass slides shall be placed in distilled water for a quarter of an hour and then lifted and placed in acetone and then in distilled water until the impurities are removed in the slides and left to dry afterwards.
- Place an adhesive tape of equal size on the (ITO)coated glass slides from the edge of the slide, leaving an equal dimensional distance between the bars and then cleaning the covered material (ITO) between adhesive tapes.
- Place the slides in the ultrasonic device for a quarter of an hour and then leave to dry.

After the slides have been cleaned, the dye solution mixture (solvent + dye + polymer + nanoparticle) is poured and left for 24 hours to dry afterwards. The other dye solution is poured with the same ingredients and left to dry for the same period of time.

Absorption Spectrum UV

Absorption spectrometry was measured using a two-band spectrometer (UV-Visible-Spectrophotometer). This spectrometer covers a wide area of the electromagnetic spectrum from the ultraviolet region to the nearby infrared region. The device includes a mono wave analyzer (Mono chromater) To select the wavelengths that the model is irritating by containing a diffraction booster (Grating) As well as filters Depending on the wavelength required, and a photovoltaic tube type detector (PMT) side the device also includes a large range of power supplies because of the multiplicity of parts. The idea of measurement depends on the separation of the falling beam into two packets, one of which passes through the model sample To be studied, While the second beam is in the solvent that represents the reference packet The device then subtracts the reference beam and records the absorption spectrum of the model purely.

The Circuit of I-V Characteristics for Laser Dye Solar Cell

The electrical properties measurement circuit consists of a measuring device of digital current and voltage that is connected to both ends of the sample as well as a light source of the type of tungsten halogen lamp with a capacity of (10W), It has an emission spectrum similar to the solar emission spectrum. The sample to be measured is installed at a distance (10cm), The light source has been connected to the computer circuit.

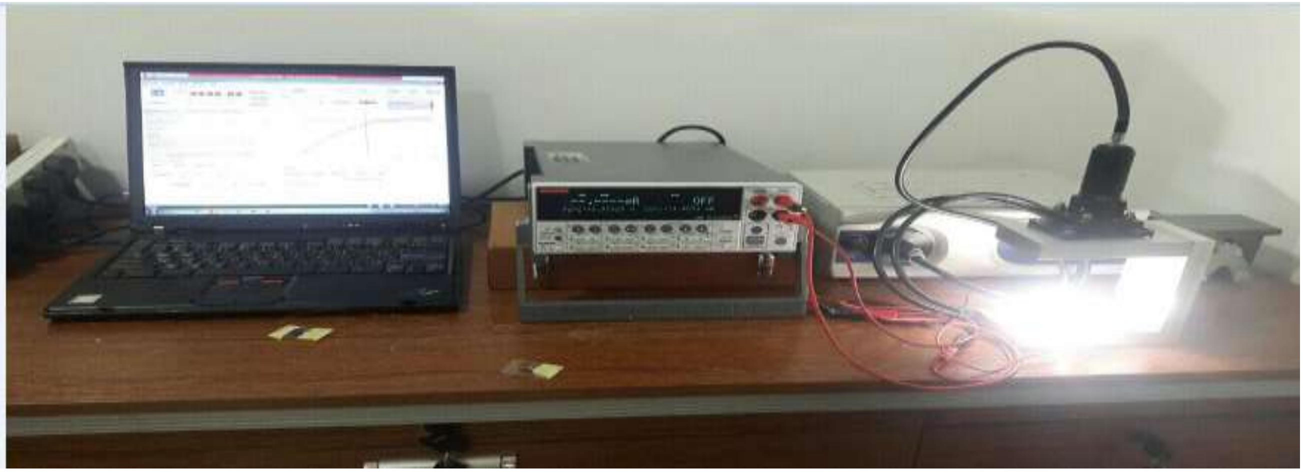

Fig. 2: A device for measuring the electrical properties of solar cells

Results

Absorption Spectra

The linear visual properties of the prepared models were calculated based on the absorption spectra and using the equations (1), (2), (3), (4), (5).

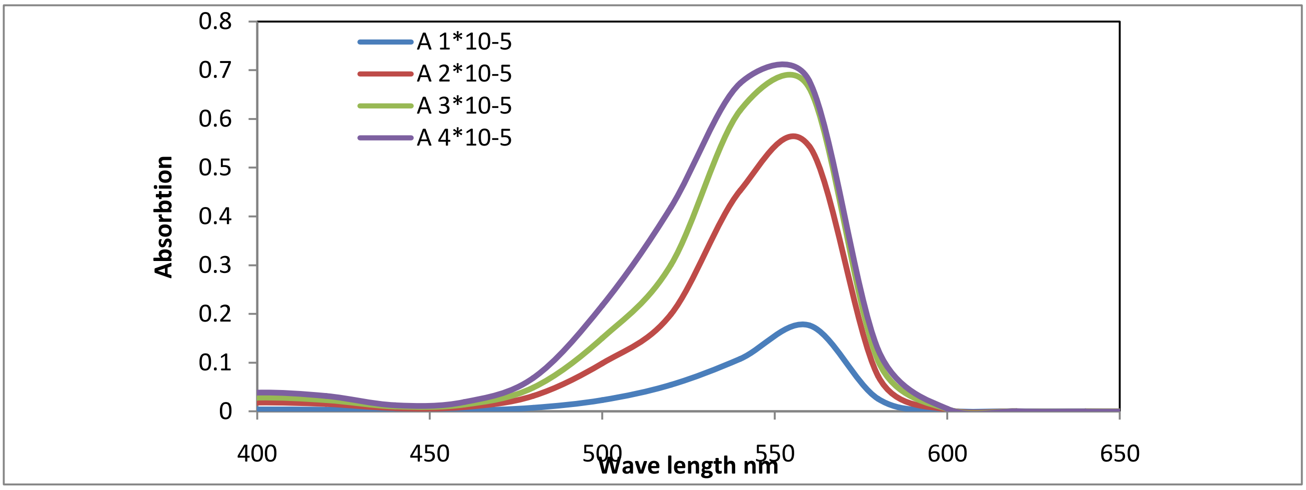

Fig.3: Absorption spectrum of the Rhodamine B with different concentrations.

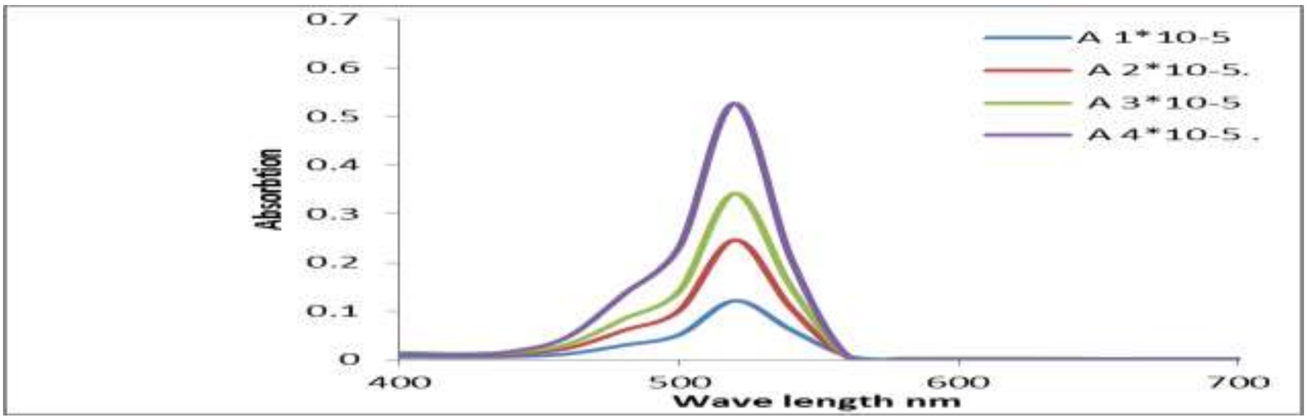

Fig. 4: Absorption spectrum of the Acriflavine with different concentrations

Table 1: The optical properties of the studied dyes

Dyes	C M	A	T	α m^{-1}	R	σ_{op}	n
Rhodamin B	10^{-5}	0.178	0.666	0.405	0.157	0.176×10^{8}	1.816
	2×10^{-5}	0.544	0.285	1.252	0.170	0.569×10^{8}	1.904
	3×10^{-5}	0.662	0.217	1.527	0.119	0.576×10^{8}	1.580
	4×10^{-5}	0.678	0.209	1.561	0.112	0.573×10^{8}	1.536
Acriflavine	10^{-5}	0.121	0.755	0.279	1.225	0.067×10^{8}	1.596
	2×10^{-5}	0.246	0.566	0.568	0.187	0.136×10^{8}	2.023
	3×10^{-5}	0.342	0.454	0.788	0.203	0.404×10^{8}	2.148
	4×10^{-5}	0.527	0.296	1.214	0.175	0.563×10^{8}	1.943

Calculate the Energy Gap of the Studied Dyes

To calculate the energy gap for prepared dyes solutions, the equation was used (6), the relationship between $(\alpha hv)^2$ versus photon energy (*hv*), showing the results obtained.

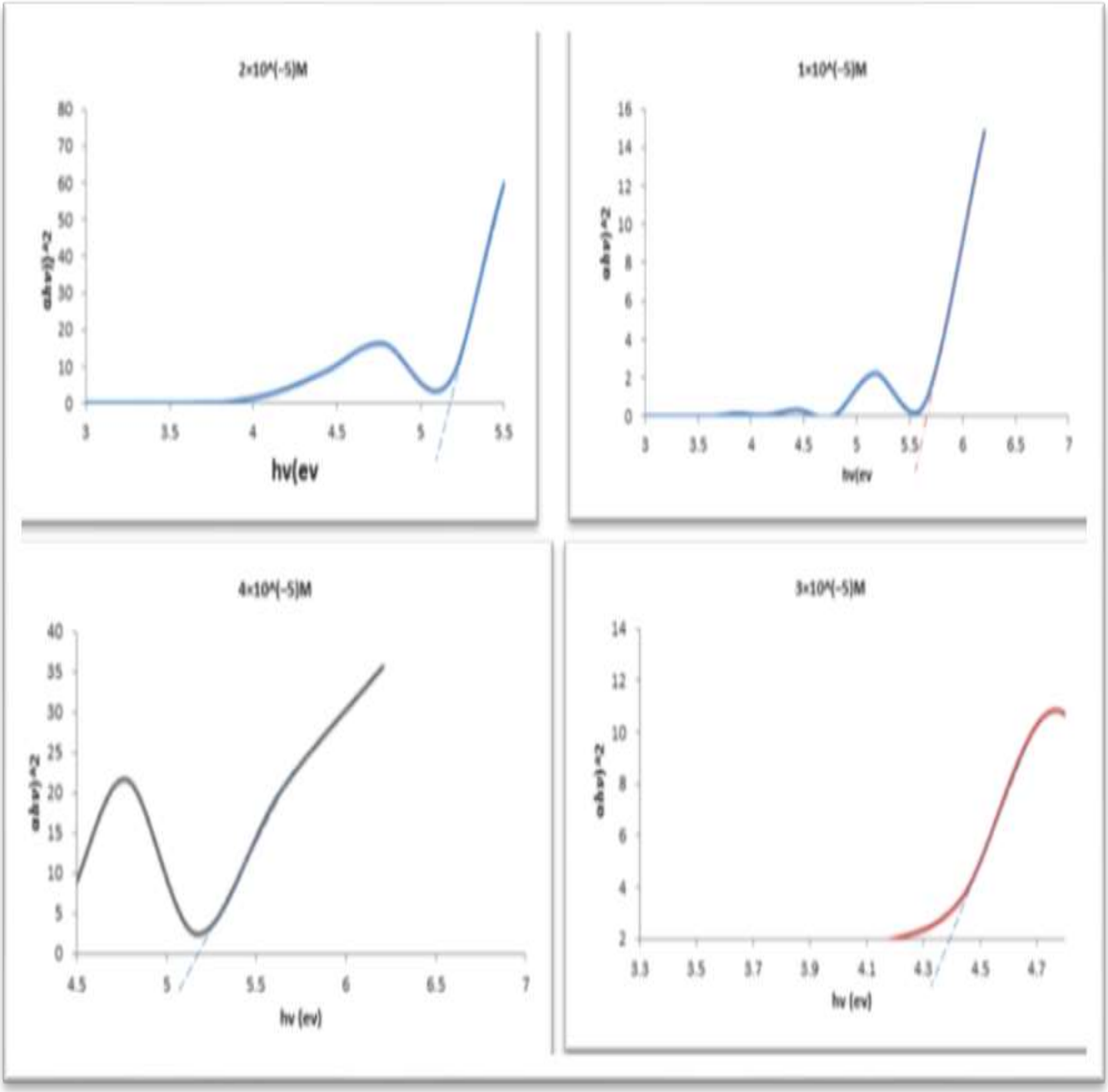

Fig. 5: The energy gap for the solution of the Rhodamine B dye is different in different concentrations

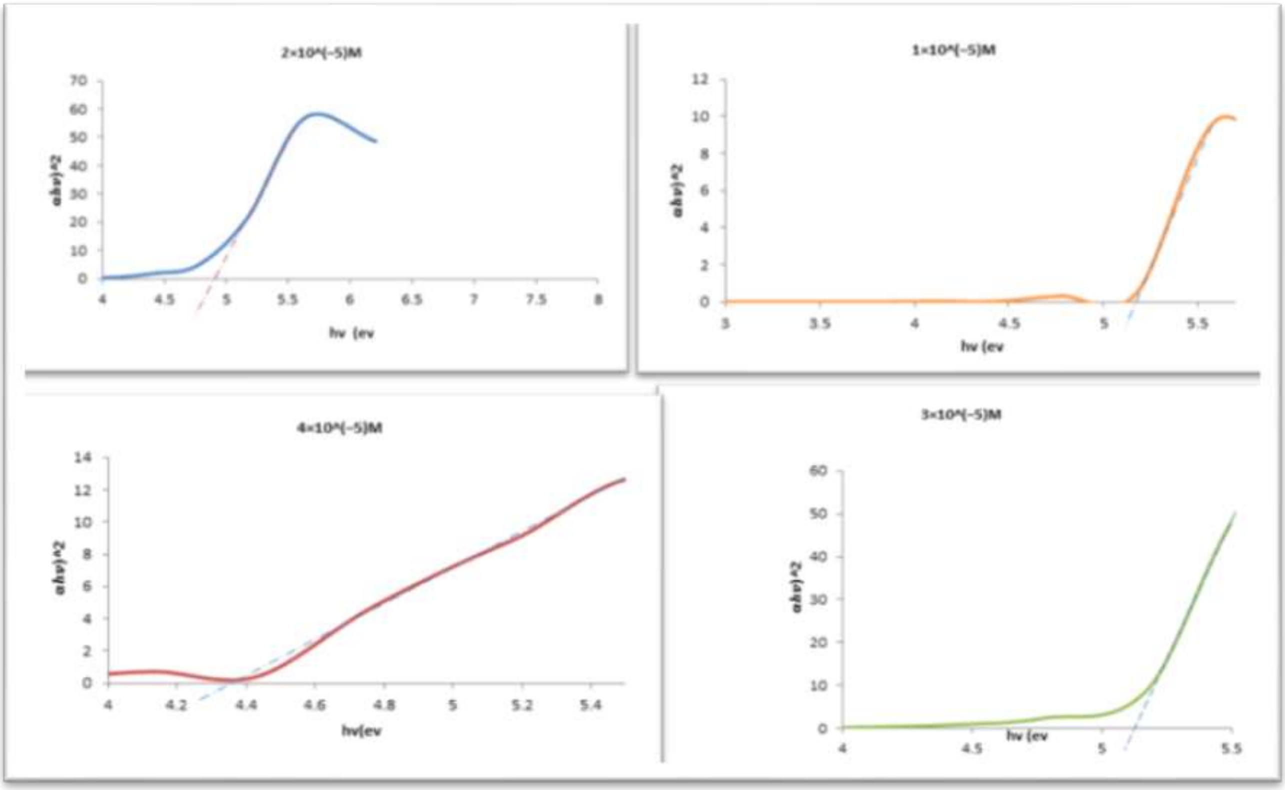

Fig. 6: The energy gap for the solution of the Acriflavine dye in different concentrations

Table 2: Energy gap values for studied dyes

Dyes	C (M)	Eg(eV)
Rhodamin B	10^{-5}	5. 6
	2×10^{-5}	5.3
	3×10^{-5}	4.4
	4×10^{-5}	4.8
Acriflavine	10^{-5}	5.2
	2×10^{-5}	5.1
	3×10^{-5}	4.9
	4×10^{-5}	4.4

Electrical Properties

The electrical properties of the dyes prepared were calculated using the studied optical Using equations(7) ,(8),(9),(10),(11),(12),(13), The tables illustrate the results obtained.

Table 3: The Electrical properties for different solutions Rhodamine B dye indifferent concentrations

Dyes	Cm M	ε	ϵ	μ	Z	σ_E	t_E	τ_{die}
R.B	10^{-5}	27.31	2.42×10^{-9}	1.23	7.13×10^{-10}	1.40×10^{-11}	1.73×10^{-2}	9.10×10^{-8}
	2×10^{-5}	12.722	1.13×10^{-10}	0.03	1.63×10^{-11}	6.13×10^{-12}	1.843×10^{-2}	4.241×10^{-8}
	3×10^{-5}	129.458	1.146×10^{-9}	0.03	1.62×10^{-8}	6.173×10^{-9}	0.186	$43.153.\times10^{-8}$
	4×10^{-5}	139.535	1.235×10^{-9}	3.24	1.62×10^{-9}	6.173×10^{-10}	2.001	46.512×10^{-8}

Table 4: The Electrical properties for different solutions Acriflavine dye in different concentrations

Dyes	Cm M	ε	ϵ	μ	Z	σ_E	t_E	τ_{die}
A	10^{-5}	14.166	1.25×10^{-10}	0.18	3.79×10^{-11}	2.64×10^{-12}	4.73×10^{9}	4.722×10^{-8}
	2×10^{-5}	4. 317	3.82×10^{-11}	0.02	7.23×10^{-13}	1.38×10^{-14}	2.7710^{-4}	1.439×10^{-8}
	3×10^{-5}	17. 006	1.505×10^{-10}	7.71×10^{-3}	2.26×10^{-12}	4.42×10^{-13}	340.5	5.669×10^{-8}
	4×10^{-5}	34.091	3.02×10^{-10}	0.013	6.561×10^{-12}	1.52×10^{-13}	1.986	11.364×10^{-8}

Properties of Curves (I - V)

To determine the mechanical conductivity in the membranes prepared, consisting of polymer Pmma with Weight of (0.6 g) and nanomaterials (Ag, Zno) with Weight (0.004) g and the studied dyes (Rhodamine B, Acriflavine) With concentration 4×10^{-5}M with Using Keithiely Series and The results are in Fig (7, 8) The relationship between the voltages and the current of the prepared membranes is shown within the current and voltage range measured and the samples prepared: It consists of a glass base covered with a material ITO Followed by a layer of nano materials (Ag) Followed by a layer made up of two dyes (Acriflavine, Rhodamine B) Followed by an aluminium layer.

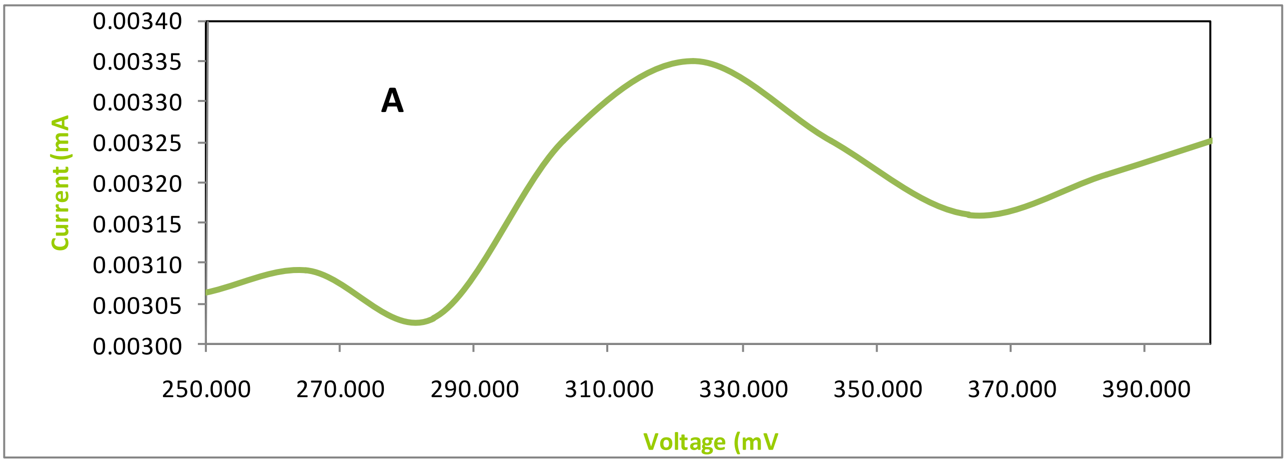

Fig. 7: The relationship between voltage and current of the first sample

It consists of a glass base covered with a material ITO Followed by a layer of nano materils (Zno) Followed by a layer made up of two dyes(Acriflavine, Rhodamine B) Followed by an aluminium layer.

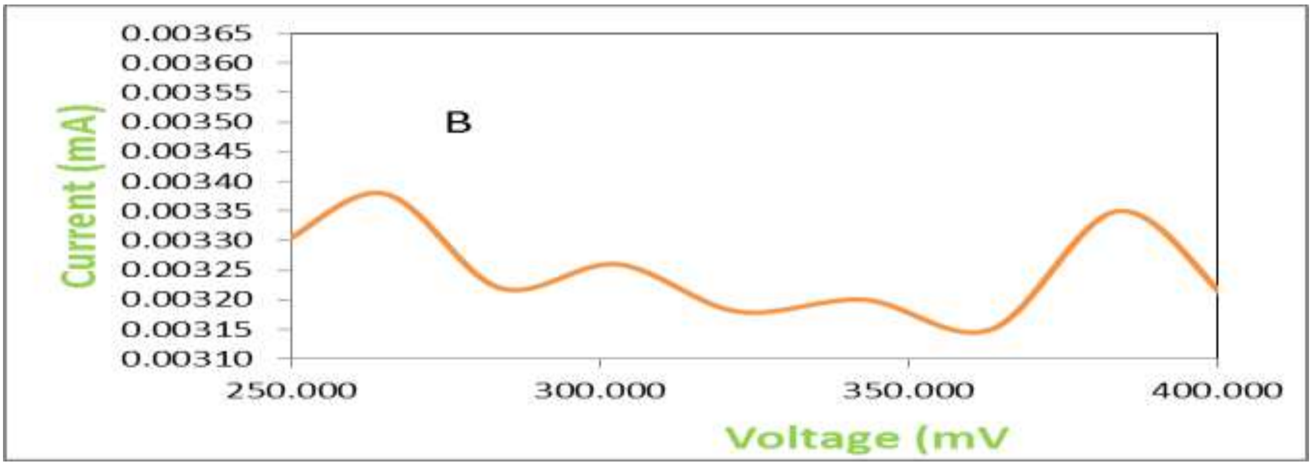

Fig.8: The relationship between voltage and current of the second sample

Table 5: The performance coefficients for the (Rhodamine B- Acriflavine) laser dyes Solar cells doped with nanoparticles

Sample	V_{oc} (mV)	I_{sc} (mA)	$F.F$	ŋ %	P_{in} mW/cm^2	R_{sh} Ω	R_s Ω
A	283.8	0.332	1.399	16.9	78.019	0.946	97109.524
B	126.4	0.331	1.049	16.2	78.835	0.421	156646.154

Discussion

It has explained from the fig (3) and the table (1) that the increase of the laser dye molar concentration leads to maximum absorption wavelength of (620) nm, with relatively little creep with increased focus towards less wavelength) Blue Shift). The effect of increasing concentration on molecular electronic energy levels, and The reason for the increase in the number of molecules as is known with the increased concentration is observed increase in absorbability. Explain from the Fig(4) and the table(1) increases the wavelength of absorbance irregularly with relatively little creep with increased concentration towards the upper wavelength (Red Shift), the effect of increased concentration on molecular electronic energy levels, and the reason for the increase in the number of molecules as is known with increased concentration, we note the increased absorption. And note from the Fig (5), (6) and the table (2) the energy gap values for dye solutions are reduced by increasing the molars concentration.

All the electrical properties as (dielectric constant ε , the permittivity of film ϵ, electrical conductivity σ_E , the electrical response time t_E , and dielectric time t_{die}), and the magnetic properties as (the magnetic permeability μ), had been increased as shown in Table (3, 4). In Table (5), the short circuit current of sample (A) is higher than that of (B). For cell efficiency, the best efficiency obtained for cell (A) is close to a certain extent due to the increase in the number of secondary levels between the valence and conduction Increase the movement of electrons and gaps by driving the anode and cathode poles respectively, thus increasing the short circuit current.

Conclusions

Through the preparation of solutions of dyes studied and study the spectra of absorption and optical and electrical properties and applications as a solar cell dye, The following was concluded: The spectral results of the dyes showed that the absorption spectrum increased with increasing concentration ,this increases the number of molecules and thus increases the absorption intensity with them, Increase the absorption intensity with increasing concentration and thus increase the absorption and refractive factors of the treated pigments (Rhodamine B and Acriflavine),

The solvent type has a significant and clear effect on spectral and optical properties, The results show that the energy gap increases with a molar concentration increase, an unstable increase of pure tincture solution, and the greatest value of the energy gap obtained is(4.9eV) For prepared dyes solutions, The difference in dyes used in this study has an effective effect on the advantage of the solar cell, The use of a glass of conductive glass (ITO), which has a high absorption of visible light, is effective in the manufacture of solar cells, The use of dyes and nanomaterials has a positive effect on the efficiency of solar cells, That the best efficiency of the dyed solar cells obtained are limits 16.9%.

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