Improve solar cell energy conversion efficiency by using illuminescent dyes concentrators

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Abstract

AuramineO is fluorined organic and sensitive for light,has been chosen in this workdissolved in ethanol liquid. The Ethanol did not effected onAuramineO absorption because the absorption of Ethanol drop and approaches to zero in the visible spectrum region .After studying the spectroscopic properties of AuramineO dye ,it showed that it have wide range of absorptionspectra and high fluoridation.So the relative intensity of both absorption and fluorescespectra were increasedbyincreasing concentrationto a certain extent andthus compatible with Beer- Lambert law. Accordingly we could determine the highest absorption and fluorescence of each concentration and calculated molar absorptioncoefficientes ,quantum efficiency , radiated lifetime, fluorescence lifetime and stokes shift . These panelsofAuramineO dye were used as concentrators for solar cell and all their panels are infallible improving and raies the efficiency of solar cell at ratio spotty.Measuresof the thickness for the panelsshowed they effect on the efficiency solar cell that the thicknessof panels if increase thesolar cell efficiency decrease, therefore it is preferred using little thickness.

Keyword: Solar cell,Dye concentrator, Conversion efficieny**.**

تحسين كفاءة تحويل الطاقة للخلية الشمسية باستخدام مركزات الاصباغ الأضائية

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الخلاصة

الاورامين(O) هي صبغة عضويةمتفلورة وحساسة للضوء تم اختيارها في عملنا واذابتها في كحول الايثانول . ان سائل الايثانول لم يؤثرعلى امتصاصية الصبغة لان امتصاصيةالايثانول تهبط وتقترب من الصفر في منطقة الطيف المرئي . بعد دراسة الخصائص الطيفية للصبغة تبين ان لها طيف امتصاص واسع المدى وفلورة عالية وان الشدة النسبية لطيفي الامتصاص والفلورة يزداد مع زيادة التركيز لحد معين وهذا يتفق مع قانون بيرلامبرت , وفقالذلك تم تحديد اعلى امتصاصية وفلورة لكل تركيز مستخدم لصبغة الاورامين وكذلك حساب معامل الامتصاص المولاري والكفاءة الكمية و زمن عمر الاشعاعي و زمن عمر الفلورة وازاحة ستوكس. ان الواح صبغة الاورامين استخدمت كمركزات للخلايا الشمسية وكل هذه الالواح ساهمت في تحسين ورفعكفاءةالخليةالشمسية وبنسب متفاوتة.اما قياسات السمك للالواح اظهرت تاثيرها على كفاءة الخلية الشمسية ذلكان سمك الالواح اذا زاد كفاءة الخلية الشمسية تقل لذا يفضل استخدام السمك القليل.

كلمات مفتاحية: الخلية الشمسية , مركزات الصبغية , كفاءة التحويل.

1- Introduction:

Solar energy is the most available renewable energy on Earth and it is becoming more widely used to generate electrical power all around the world due to its environmental , economical and strategic benefits. Photovoltaics(PV) is the main technologies used to convert solar energy into electricity. Most of solar energy studies aim to increase the conversion efficiency of solar cell by using the luminescent concentratots of panels or films of the epoxy which are created from organic dye materials.(1)

Luminescent solar concentrators: are interesting devices for use in combination with photovoltaic (PV)cells. A luminescent solar concentrator (LSC) is a glass or plastic plate containing or coated with luminescent materials phosphors or dyes that absorb sunlight and emit light at longer wavelengths. (2)

Organic dyes pigments are organic chemicals capable of absorbing and reverse light wavelengths transition within the visible spectrum of the electromagnetic spectrum, and often these dyes in the form of powder would need to be fluid in order to melt it and become a solution.The source of organic pigments from either plants or animals ormetallic materials .Thesemust be abundant and inexpensive, and most havehigh fluoridation.For thesereasons we used in our research organic pigments instead of inorganic pigments that are expensive and do not exist in abundance, and most of them are low-lying with fluoridation (4) . In this present work wasAuramine O dyewere used and it has a large overlap between absorption and emission spectra. It is used in LSC as Luminescent materials .

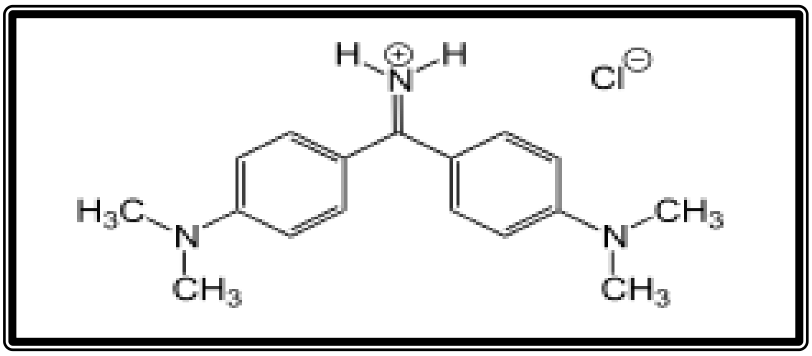
2- Aim of the work :

1) To improve the performance efficiency of solar cells by using luminescence solar concentrators panels of organic dyes, to get a high efficiency of solar cell.

2)Determining of the best concentration and thickness for (LSC) panels .

2) Auramine (O) dye:

Auramine O is a diaeylmethane dye used as a fluorescent stain. In its pure form, Auramine O appears as yellow needle crystals. It is very soluble in water and soluble in ethanol and can be used to stain acid – fast bacteria. Also it can be used as an antiseptic agent(5).Only AuramineO displays an amplification of the fluoresecence signal with increasing concentration ,while the fluoresecence of the other dyes is quenched by interaction with the polymer – stabilized metal nanoparticles(6). AuramineO is strong brilliant yellow dyes stuff, deconlourizes immediately on contact with strong alkali(7).Figure belowis shows the structure of AuramineO dye .



Figure(2) The structure ofAuramineO dye[8]

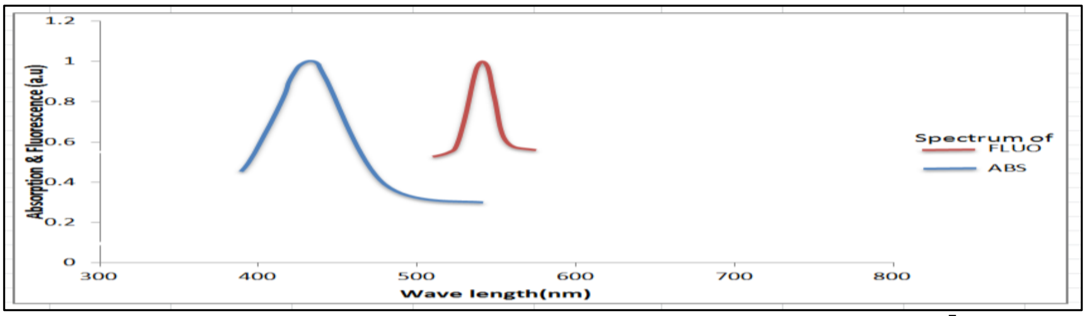
Table(1)The properties of AuramineOdye[9]

Properties	
Mulcarole formula	$C_{17}H_{22}ClN_3$
Molar mass	303.83 gm.mol^{-1}
Form	Powder
Melting point	267 C^o
Fluorescence	λ_{max} 542 nm
Absorption	λ_{max} 370 nm
Composition	Dye content85%

2) The Absorption and fluorescence spectrum of AuramineO in Ethanol:

TheAbsorption and fluorescence spectra has been studied for four concentrations (1×10^{-5}, 3×10^{-5}, 5×10^{-5} , 3×10^{-4}) mol/L as shown in figures (3),(4),(5,),(6) from these figures the Auramine O dye has large absorption spectrum from (430-470)nm .At the lowest concentration (1×10^{-5}) mol/L the peak of absorption spectrum was at (434)nm , and at the high concentration (3×10^{-4}) mol/L the peak of the absorption spectrumat (466)nm. Also the fluorescence spectrum from (535-545nm.While at the lowest concentration(1×10^{-5})mol/L the peak of fluorescence spectra was at (542)nm and for a high concentration (3×10^{-4}) mol/L the peak of fluorescence spectrum at (540)nm .

AuramineO dye has ahigh fluorescence and absorption and it has big disunion between fluorescence and absorption curves.



Figure(3) Absorption and Fluorescencespectra for AuraminO of (1×10^{-5})mol/L

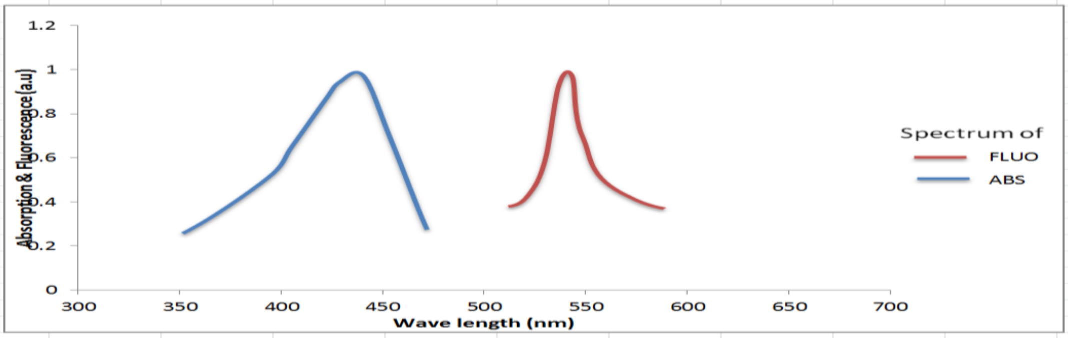
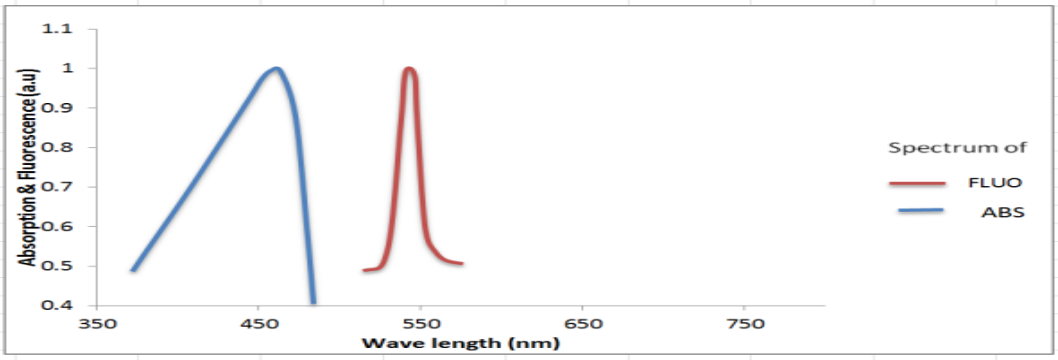
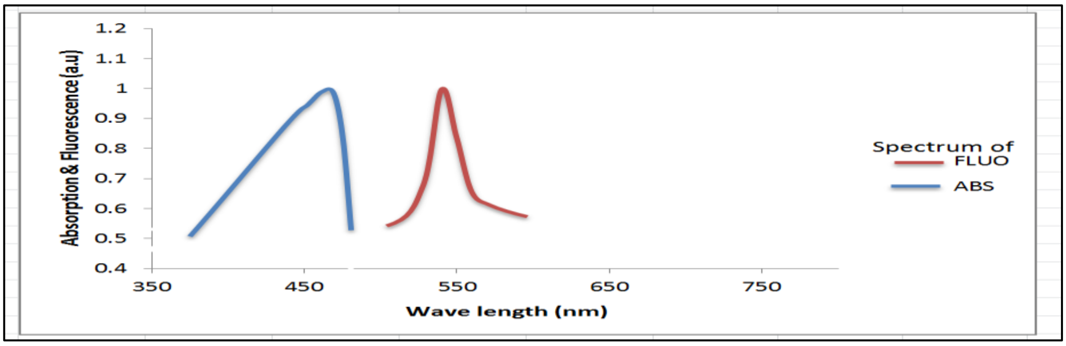


Figure (4) Absorption and Fluoescencespectra for AuramineO of (3×10^{-5})mol/L

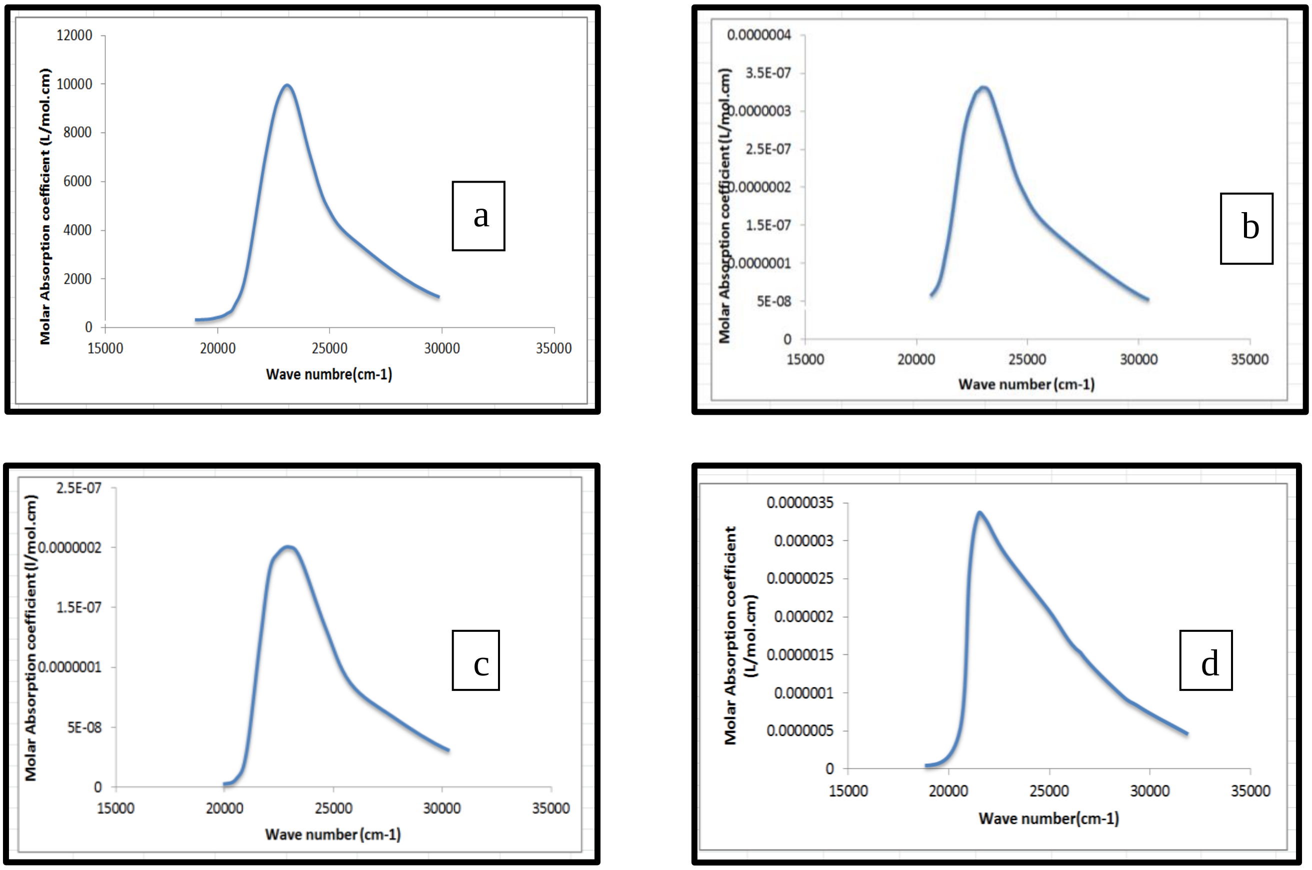


Figure(5)Absorption and Fluorescencespectra for AuramineOof(5×10^{-5}) mol/L



Figure(6) Absorption and Fluorescencespectra for AuramineO of (3×10^{-4})mol/L

The relationship between Molar absorptioncoefficient $(L/mol^{-1}.cm^{-1})$ and wave number (cm^{-1}) has been illustrated also, in figure (7) , these are to calculate the area under the curve as well as non radiative life time (τ_{fm}) and fluorescence life time (τ_f) .



Figure(7) Spectrum of Molar coefficient (L/mol.cm) and Wave number(cm^{-1}) of AuramineO for(a)1×10^{-5},(b)3×10^{-5},(c)5×10^{-5}(d)3×10^{-4}mol/L.

And the radiative lifetime is calculated By equation as follows:

$$\tau_{fm} = \frac{1}{K_{fm}} \dots\dots\dots\dots\dots\dots (2)$$

τ_{fm} : is the radiative lifetime and its unit (s)

K_{fm} : is the rate of disappearance of the the unit (s^{-1}) .

$$\tau_f = Q_{fm\times}\tau_{fm} \dots\dots\dots\dots\dots\dots (3)$$

τ_f : fluorescence lifetimeand its unit (s)

The values of the stock shift betweenabsorption and fluorescence spectra intable (2) ,were calculated by take thedifferent between maximumfluorescence and absorption which are measures by UV-Visible spectrophotometer, and the valuesquantum efficiencymeasures by equation:

$$Q_{fm} = \frac{\int F(v^{-})dv^{-}}{\int \varepsilon\,(v^{-})dv^{-}} \dots\dots\dots\dots\dots\dots (1)$$

$\int F(v^{-})dv^{-}$:The total area under the curve of the fluorescence

$\int \varepsilon\,(v^{-})dv^{-}$:The area under the curve of the molar absorption coefficientwhich is a function for the wave number (v^{-})

Table (2) the stock shift between the Abs. and fluor. Spectra ,the radiated lifetime, fluorescence lifetime and quantum efficiency of fluoresecence forAuramineO.

Concentration Mol/L	A_{max} nm	F_{max} nm	**Δλ=λflo-λabo**	τ_{fm}**n sec**	τ_f**n sec**	Q_{fm}**%**
1×10^{-5}	434	542	108	1.1E+06	9.1E+07	o.83
3×10^{-5}	436	540	104	3.2E+ 02	3.2E+02	0.99
5×10^{-5}	438	542	104	5.1E+02	4.8E+02	0.94
3×10^{-4}	466	540	74	2.9E+01	2.2E+01	0.93

4- (LSC) panels of Auramine O dye:

When theLuminescent Solar Concentrator panels of Auramine O dyeputting on the solar cell, the module analyzer appearance measures the efficiency (η), fill factor (FF) and current – voltage relationship curves.The values of these are shown in table (3), as followswith increasing efficiency ratio .

Table (3) efficiency solar cell using (LSC) panels of AuramineO dye

Samples	**concentration** mol/L	I_{max} **(mA)**	V_{max} **(volt)**	**FF**	**Thickness (mm)**	η%	$\Delta\eta$%
(LSC) pnels AuramineO dye	1×10^{-5}	62.10	3.916	o.751	0.21	8,843	0.503
	2×10^{-5}	55.60	3.989	0.87	0.32	8.065	0.371
	3×10^{-5}	52.90	4.020	0.841	0.38	7.733	0.314

From table(3) we observed that the maximum increase in efficiency is ($\Delta\eta = 0.503\%$) for the concentration (1×10^{-5}) mol/L and the thickness (0.21) mm,the minimum ($\Delta\eta = 0.314$) for the concentration (3×10^{-5})mol/L and the thickness (0.38) mm .

Figures(9,10 and 11)showsof the current – Voltage curves for solar cell by using (LSC) panels for AuramineOdye.

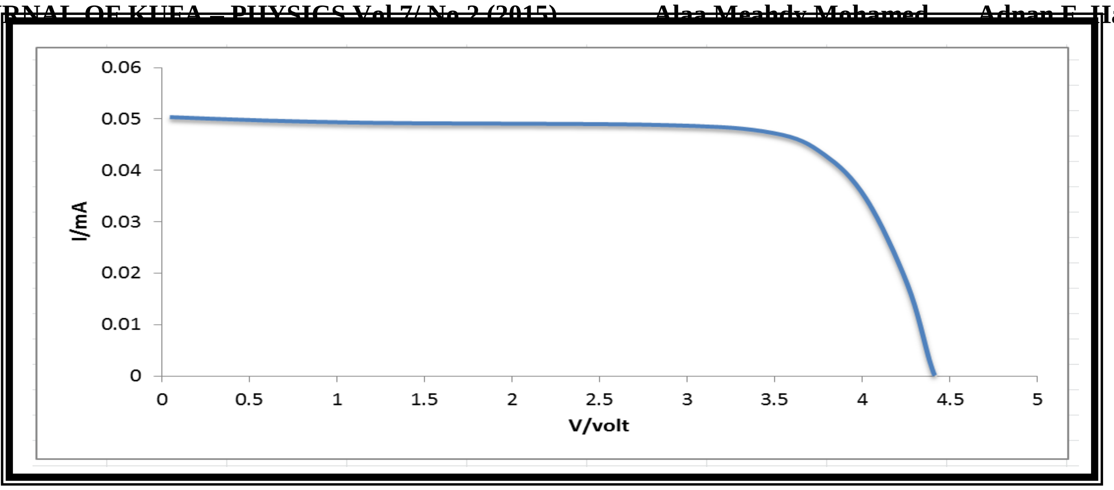
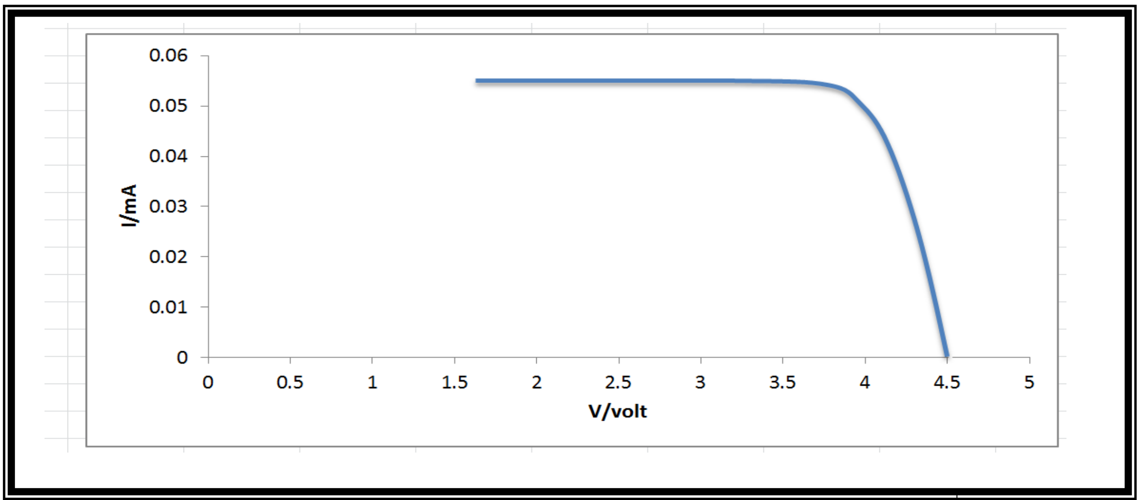


Figure (9) current – voltage curve solar cell using Auramine O dye$(1 \times 10^{-5})\ mol/L$of (0.21)mm thickness.



Figure(10) Current -Voltage curve solar cell using AuramineOdye(3×10^{-5})mol/L of thickness(0.38)mm.

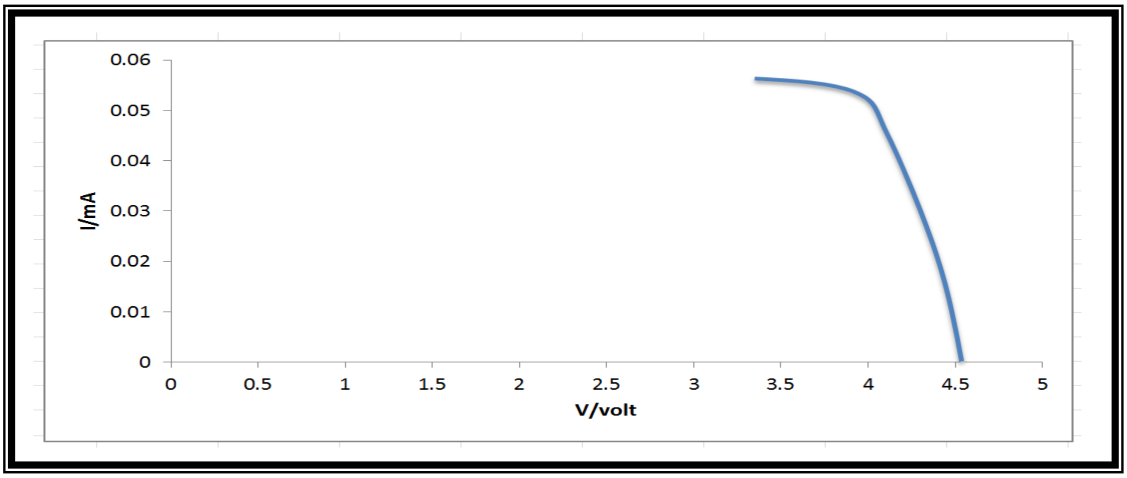


Figure (11) Current-Voltage curve solar cell using AuramineOdye(2×10^{-5})mol/L of(0.32)mm thickness.

Table (2), it shows dislodgmentin Stokes shift, highest efficiency accrued atconcentration($3x10^{-5}$) mol/L while it decreases when the concentration increases, and the results were not true at high concentration because Beer-

Lambert law doesn't work at these concentrations. Current-Voltage curves of the AuramineO dye which used as concentrator panels concentrations shows that the increasing of the concentration led to increase thecircuit current at the same values of the voltage. The overlaping between the absorption and fluorescence spectra of AuramineO dye in table(2) decreased while we notice the values of the stock shift increase this is in agreement with Beer-Lambert law.

5-Conclusion:

AuramineO dye withconcentration($3x10^{-5}$) mol/L,gave the highest quantum efficiency (0.99%), and it has a large extent for absorption and a high fluorescence. All (LSC) panels for AuramineO infallible to raise the efficiency of the solar cell of certain degrees and depend on concentration and for thickness also affect the panels.TheAuramineO dye when increased the concentration,radiated lifetime and fluorescence lifetime decreased. Best results were obtained for Luminescent Solar Concentrator panels with AuramineO dye of$(1 \times 10^{-5})mol/L$ and thickness (0.21)mm at which sthe efficiency reached ($\eta = 8.84\%$) and the raito of increase in efficiency was($\Delta\eta = 0.503\%$) .

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