Studying the Optical Properties of Epoxy Panel doped with Al-Anthedin Dye

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Abstract:

In this work the luminescent solar concentrators (LSC) plates doped with Al-Anthedin dye was prepared by at the solid state laboratory at room temperature with different thicknesses and concentrations .The Anthedin dye concentrations were (1×10^{-4}, $2\times10^{-4}$and 3×10^{-4}) mol/L. The optical characteristics have been studied such as absorption and energy gap also the optical constants such as the absorption coefficient and extinction coefficient were calculated for all panels.

Increasing the concentration of the Al-Anthedin dye led to increase the values of absorbance, absorption and extinction coefficient. The results also demonstrate that the value of the energy gap was decreased with increasing the concentrations from (2.2eV) for the lowest concentration to (2.1eV)for the highest one.

Keywords: Polyemer, Epoxy resin, Al-Anthedin dye, Optical properties.

دراسة الخصائص البصرية لألواح الإيبوكسي المطعمة بالصبغة المركبة الإنثايدين

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الخلاصة:

في هذا العمل حضرت ألواح الإيبوكسي المطعمة بالصبغة المركبة الإنثايدين(LSC)في مختبر الحالة الصلبة وبدرجة حرارة الغرفة ذوات أسماك و تراكيز مختلفة . وكانت تراكيز صبغة الإنثايدين هي ^{4} (3×10^{-4},$2\times10^{-}$,1×10^{-4})) مول/لتر .درست الخصائص البصرية مثل (الإمتصاصية وفجوة الطاقة) وكذلك حسبت الثوابت البصرية مثل معامل الإمتصاص و معامل الخمود لجميع الألواح. فوجد أن تأثير زيادة تركيز صبغة الإنثايدين أدى إلى زيادة قيم الإمتصاصية ومعامل الإمتصاص ومعامل الخمود. اظهرت النتائج إن قيمة فجوة الطاقة تقل بزيادة التركيز من (٢.٢) الكترون فولت عند أقل تركيز الى (٢.١) الكترون فولت لأعلى تركيز.

الكلمات المفتاحية: البيوليمر، راتنج الإيبوكسي، صبغة الإنثايدين، الخصائص البصرية.

1. Introduction

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 sun light and emit light at longer wavelength [1].(LSC) in our work was made by dissolving Anthedin complex dye in Acetone before solving them in epoxy resin. In 2008,Suma made (LSC) plates by dissolving Rohdamine 6G dye in epoxy resin. She studied the optical properties and optical constants for all pure and doped epoxy plates at many thicknesses and concentrations. She found that the effect of plates thickness confront the effect of dye concentration[2]. Faiz S. Abbas and Nibras F. Ali fabricated (LSC) by doping the fluorescence dye in epoxy resin and studied the effect of the floursine-sodium dye concentrations on the optical characteristics of the epoxy panel and compared them with pure ones. They found that the energy gap value decreased from (3.6eV) for epoxy resin to (2.3,2.25) eV for the both concentrated panels [3]. The structure of Polymers can be divided into two types, namely thermoplastic and thermoset polymers. Thermoset polymers are characterized by having a distinct structure called 'cross-linked networks' between the polymer chains. Epoxy resin is one of the thermoset polymers [4].The epoxy resin was first produced in Europe and in United States in the late 1930_s and an early 1940_s[5].Then they were first sold in 1946 and were widely used for industrial purposes such as protective coating and for structural applications such as laminates and composites, tooling ,molding ,casting, bonding, adhesives [6] ,aerospace[7]and spacecraft industries[8].

The versatility of epoxy resin comes from its ability to react with different substrates[6].The epoxy resins offer unique combination of properties that are unattainable with other thermoset resins[9].The epoxy resins are almost characterized by following: high chemical and corrosion resistance ,good mechanical (strength and stiffness),good thermal properties[10],excellent weather resistance, excellent performance at elevated temperature[11], low toxicity, low cost [9] and versatility in processing.[11].The simplest epoxy resin is prepared by the reaction of bisphenol A with epichlorohydrine as shown in fig.(1)[8] .

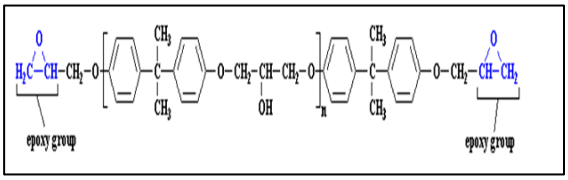

Fig.1. The structure of epoxy groups [10].

Two things are needed for making epoxy resins systems ,first, epoxy resins second curing agent (hardener or catalyst). Additives such as organic solvents, fillers(e.g. fiber glass or sand) and pigments are contained within products of many epoxy.[7]. The choice of curing agents depends on the required physical and chemical properties ,processing methods and curing conditions[12].When epoxy resin systems are in use a combination at single molecules(monomers) of the epoxy resin chemical and the curing agent were achieved to form long chains of molecules (polymers).As the mixture "cures", it becomes a hard polymer .Some epoxies curves in a few minutes at room temperature other need additional time or heat to harden[6]. 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 or metallic materials .These must be abundant and inexpensive, and most have high fluoridation. For these reasons 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[13].

The purpose of the present work is to fabricate (LSC) by doping organic dye Al-Anthedin complex dye(APADMP)in epoxy resin and study the effect of this dye concentrations on the optical characteristics of the epoxy panel.

2. Experiment

2.1. Preparation of the samples

The chemical epoxy name is bisphenol -A- (epichlorhydrin)epoxy resin average molecular weight 700 g/mol ,and it is of limpid color. The molecular formula of Anthedindye is$C_{19}H_{20}N_4O$,it's molecular weight 149 gm/mol , This compound dye, is called the detector by the chemists.Organic detector (APADMP) whose solution color is bright red. Al-Anthedin complex dye had been solved in acetone before solving it in Epoxy.

Our study showed that solvent which are used (Acetone) did not affect the absorption of the dyes because the solvent become absorption drops in the visible spectrum. From study the absorption spectrum , no absorption for Aceton within the spectral range of dyes about (450-800)nm was noticed[14].

All fluorescence panels are prepared in the Laboratory with different thickness and different concentrations, where the thickness of panels were increased with increasing concentrations of the dye ,as shown in table (1).The process of preparing panels is as follow:

1-Prepare the desired concentration of the dye by weighting the right amount of dye by the equation[15] :

$$W = \frac{M_w \times V \times C}{1000} - - - - - - (1)$$

Where W weight of the dissolved dye (g) ,M_w Molecular weight of the dye (g/ mol) ,V the volume of the solvent (ml), and C the dye concentration (mol / L).

2- Dissolving the amount of the dye that was weighting in the specified size of an epoxy resin solvent A and mix well for ten minutes to ensure dissolving well and the high concentration increases the time required for melting .

3-Add hardener (B) to resin (A) which doped by dye at the requirement concentration, with constant stirring for a specified period depends on the type of epoxy used, (to the epoxy for this study 6 min).

4- Processing casting molds according to the desired measurement fitting the solar cell is $(10 \times 10)cm^2$.

5- The mixture is placed in the mold to create fluorescence panels and is left for 48 hours at room temperature in order to be fully polymerization process and could raise the panels from the mold.

Table (1): The value of thickness for each concentration.

concentration mol/L	1×10^{-4}	2×10^{-4}	3×10^{-4}	4×10^{-4}
Thickness (mm)	0.34	0.52	0.55	0.67

2.2. Measurements

Spectrophotometer F96 PRO from SHANGHAI KINGDAK company was used to measure the absorption spectra in the wave length range (200-1100)nm for all panel samples**.**

Optical Characterization:

The absorption spectra of the doped epoxy panel with different concentration of Al-Anthedin dye are shown in fig.(2).It is gradually decreasing as the wavelength increases. From the figure it can be seen that the absorbance increases by doping effect i.e. as the Al-Anthedin concentration increase, the absorbance will increase

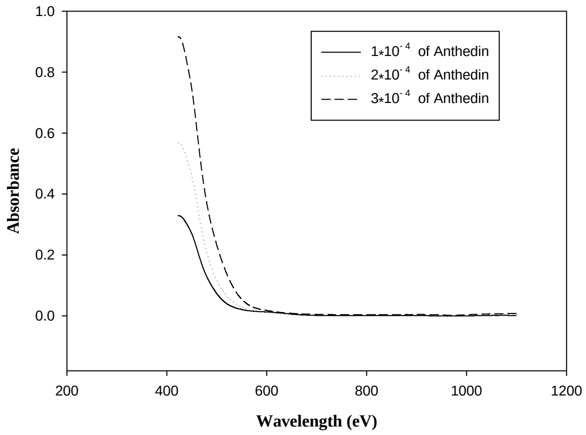

Fig.(2): Optical absorbance spectra of concentrated epoxy with Al-Anthidendye.

Absorption Coefficient:

Absorption coefficient refer to the attenuation that can occur in incident photon energy on the material for unit thickness, This attenuation is caused by the absorption processes [16].

From the absorbance data, the absorption coefficient (α) was calculated in the fundamental absorption region using Lambert law[17] :

$$Ln(I_0/I) = 2.303A = \alpha d -----(2)$$

$$\alpha = 2.303A/d -----(3)$$

Where I_o and I are the intensity of incident and transmitted light respectively,(A)the optical absorbance and (d) the film thickness . Variation of absorption coefficient with photon energy for the doped epoxy panel can be seen in fig.(3) , where their values increase rapidly beyond absorption edge regions for all concentrations.

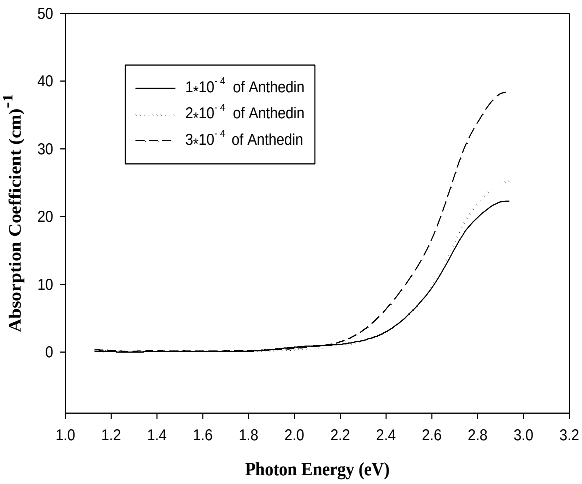

Fig.(3): Optical absorption coefficient vs. photon energy of concentrated epoxy with Al-Anthidendye.

Extinction Coefficient:

Extinction coefficient (k) for all samples was calculated by using the relation [17]:

$$K = \frac{\alpha\lambda}{4\pi}. -----(4)$$

Variations of extinction coefficient as a function of energy of photon are shown in fig.(4). Extinction coefficient behavior is closely similar to that of the corresponding absorption coefficient ,as shown in fig.(4).For all concentrated panels, we can observe that the extinction coefficient increases with increasing the concentrations.

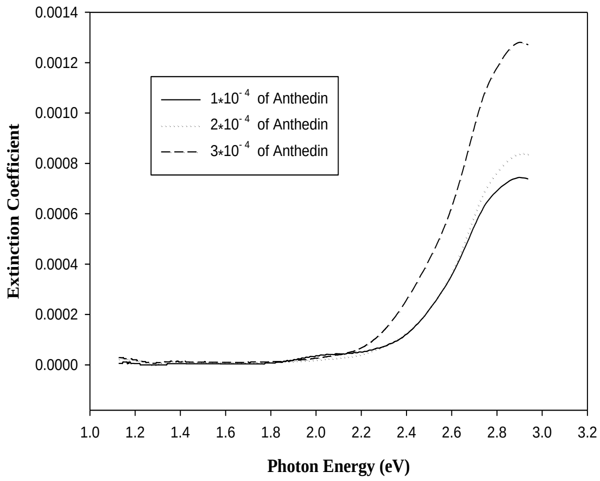

Fig.(4):Extinction coefficient vs. wavelength of concentrated epoxy with Al-Anthidendye

Energy Gap:

Study of material by means of optical absorption provides a simple method for explaining some features concerning the band structure of material. For determination of optical band gap energy, the method based on the following relation [18]:

$$\alpha h\nu = A(h\nu - E_g)^r \text{------} (5)$$

Where hυ is the photon energy, E_g the band gap energy, A and r are constants. The value of r depends on the nature of the transition. In this case it's value was found to be 2 (which corresponds to indirect band to band transition)[19]. Figures(5, 6,7) show the plot of $(\alpha h\upsilon)^{1/2}$ vs. hυ for pure and doped epoxy . The electronic transition is indirect because of the absorption coefficient value was less than 10^{4} cm^{-1}.In following figures, from the straight line obtained at high photon energy the indirect allowed energy gap could be determined. The value of the optical energy gap decreased with increasing the concentrations of the Al-Anthedin dye. This may be attribute to the formation of a localized states inside the band gap upper the valance and lower the conduction bands edges which refer to the dopant atoms. These results were in good agreement with the results in reference [3].

The values of the above optical parameters at energy gap of all doped samples are expressed in table (2)

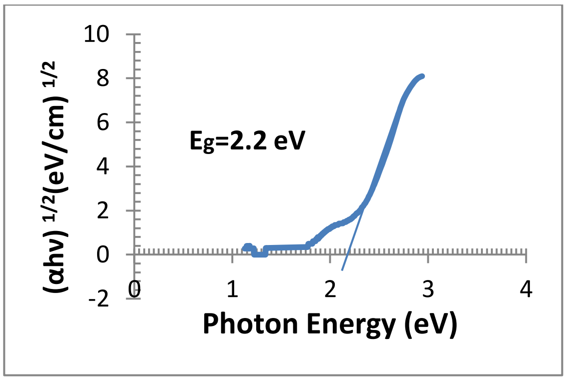

Fig.(5): Variation of $(\alpha h\upsilon)^{1/2}$ with photon energy for the Al-Anthedin concentration (1×10^{-4})of doped epoxy sample.

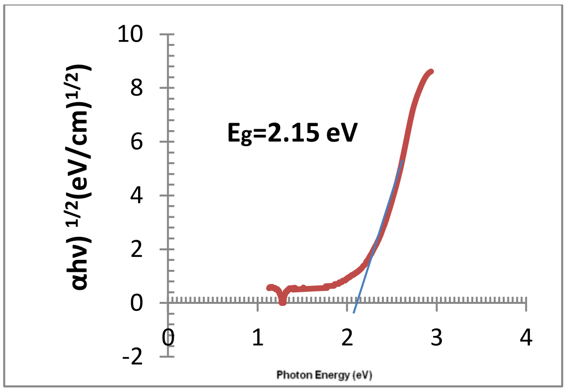

Fig.(6): Variation of $(\alpha h\upsilon)^{1/2}$ with photon energy for the Al-Anthedin concentration (2×10^{-4})of doped epoxy sample.

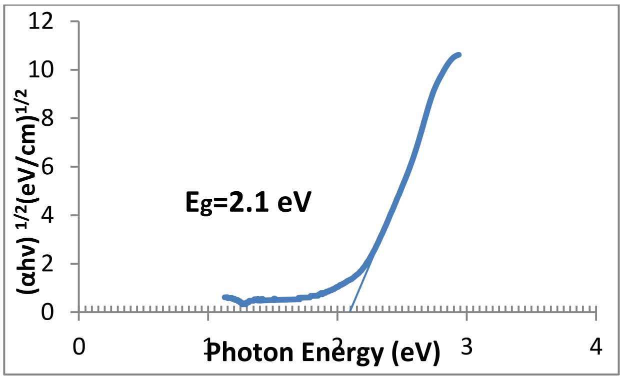

Fig.(7) :Variation of $(\alpha h\upsilon)^{1/2}$ with photon energy fortheAl-Anthedin concentration (3×10^{-4})of doped epoxy sample.

Table (2): The values of the above optical parameters at energy gap of all doped samples.

Al-Anthedin concentration	E_g(eV)	λ_c (nm)	A	α $(cm)^{-1}$	K
1×10^{-4}	2.2	563.64	0.017	1.152	5.1×10^{-4}
2×10^{-4}	2.15	576.744	0.017	0.753	3.404×10^{-4}
3×10^{-4}	2.1	590.48	0.021	0.879	4.07×10^{-4}

3. Conclusion:

1) Al-Anthedin is a good dye and have a large extent for absorption in the visible region i.e.it is suitable as concentrators of solar cell .
2) Acetone succeeded to solve Al-Anthedindye. But the epoxy resin not succeeded to solve it in completed form. Therefore Acetone used as a solvent for Al – Anthedin dye.
3) The optical band gap value was decreased with the increase of the concentrations of the Al-Anthedin dye.(2.2,2.15,2.1)eV.

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