STUDY OF FLUORESCENCE ENERGY TRANSFER IN LASERACTIVE MEDIUM MOLECULES (ACRIDINE ORANGE+POPUP) DYES

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ABSTRACT

In this research was the study of the phenomenon of fluorescence energy transfer between two laser dyes. To get the energy transition process must equal absorption energy spectrum of the first dye (acceptor molecule) with fluorescence energy spectrum for the second dye (donor molecule). One models have been prepared in this study, the acceptor dye (acridine Orange) with the donor dye (popop).When measuring the absorption spectrum and the fluorescence spectrum of acceptor dye and donor dye check is considerable overlap between them and this confirms the check for model (acceptor + donor).Before starting mixing was studied absorption and fluorescence spectra as well as optical linear properties for two dyes used individually at concentrations (0.5 x 10^{-3}Ml).After preparation of sample (acceptor + donor) to (acridine Orange and popop) at concentration mentioned, we have noticed an increase intensity of emission spectrum (fluorescence spectrum), where the highest value (46.48) at the concentration (0.5 x 10^{-3}Ml) compared with the value (9.28) at the same concentration before mixing .It has got anti -Stokes phenomenon in the sample of (acridine Orange and popop) compared to get Stokes phenomenon for two dyes before mixing.

We note change all the linear optical properties (absorption coefficient, refraction coefficient, quantum yield, lifetime of the energy level of fluorescence) of sample (acceptor + donor) prepared compared to what it was before mixing.

Keywords: *Fluorescence Energy Transfer, Acridine Orange, acceptor + donor*

INTRODUCTION

Compared with other commercially available multi-wavelength laser sources, dye laser has its obvious advantages such as low-cost and high conversion efficiency for a variety of applications, which require tunable high-power pulsed beams [1,2]. With a specific dye, narrow line width laser output tunable in a range of tens of nanometers with high efficiency can easily be obtained [3–4]. In 1968, soon after the discovery of organic dye lasers, Peterson and Snavelly [5] demonstrated the feasibility of a dye mixture laser with flash lamp excitation.

Mechanics energy transfer between the laser dyes

The goal of energy transfer in laser dye mixture was to improve the efficiency and to broaden the tunable spectral range of dye lasers [6,7]. Even more, under a specific pump condition, the laser oscillation could be observed for some dyes by energy transfer though they did not lase previously. For decades, energy transfer dye lasers using numerous donor–acceptor pairs and the mechanisms have been demonstrated and reported[8-9].

The main mechanisms that have been proposed for energy transfer are [10,11]:

1. Radiative energy transfer, i.e., the absorption of donor emission by an acceptor molecule. This process can by represented by

   $$D^{*} \rightarrow D + h\upsilon$$

   $$A + h\upsilon \rightarrow A^{*}$$

   where the asterisk indicates an electronically excited state. In a radiative energy transfer process, the fluorescence lifetime of both the donor and the acceptor dye molecules are kept unchanged.

   2. Diffusion-controlled collision and energy transfer, this process is a nonradioactive process and is viscosity dependent.

   3. Resonance energy transfer due to long-range dipole–dipole interaction. All these processes contribute to the donor fluorescence quenching and enhance the acceptor fluorescence yield. The process of fluorescence quenching is defined as, one that competes with the spontaneous emission process and thereby reduces the lifetime of the excited state of the donor molecule The process of fluorescence quenching of the donorD, due to the interaction with the acceptor A can be represented by

$$\mathbf{D^{*} + A \xrightarrow{KET} D + A^{*}}$$

Where KET is the energy transfer rate constant. Energy transfer reduces the emission intensity from D* and sensitizes emission from A*.To study the mechanics of the transfer of energy between the laser dyes must identify the process molecular electronic energy transfer This process is denoted as a σ → σ* transition. Likewise promotion of an electron from a π-bonding orbital to an antibonding π orbital* is denoted as a π → π* transition. Auxochromes with free electron pairs denoted as n have their own transitions, as do aromatic pi bond transitions. Sections of molecules which can undergo such detectable electron transitions can be referred to as chromophores since such transitions absorb electromagnetic radiation (light), which may be hypothetically perceived as color somewhere in the electromagnetic spectrum. The following molecular electronic transitions exist:σ → σ*, π → π*, n → σ*,n → π*, aromatic π → aromatic π*.

In addition to these assignments, electronic transitions also have so-called bands associated with them. The following bands are defined: the R-band from the German radikalartig or radical-like, the K-band from the German Konjugierte or conjugated, B-band from benzoic and the E-band from ethylenic (system devised by A. Burawoy in 1930).[3] For example, the absorption spectrum for ethane shows a σ→σ* transition at 135 nm and that of water a n → σ* transition at 167 nm with an extinction coefficient of 7,000. Benzene has three aromatic π → π* transitions; two E-bands at 180 and 200 nm and one B-band at 255 nm with extinction coefficients respectively 60,000, 8,000 and 215. These absorptions are not narrow bands but are generally broad because the electronic transitions are superimposed on the other molecular energy states[12].

PRACTICAL PART

The Materials Used

A- Two dyes laser been selected in accordance with the terms of the mechanics and energy transmission (acridine, popop).

B- Two Solvents be suitable for dyes, so check the mechanics of energy transmission(Ethanol, Chloroform).

C- Two devices are used for some measurements(Absorption Spectrophotometer, Fluorescence Spectrophotometer).

Preparation of Samples

The sample preparation methods of solution (dye + solvent) or from a mixture of two dye preparations with different concentrations and the concentrations usually attend using the equation[13]:

w=Mw.C.V/1000 ………………..(1)

When: W weight of the dissolved dye (g),M_W molecular weight of the dye (g/mol), V the volume of the solvent (ml), andC the dye concentration (mol/l)

The sample preparation of mixing dye laser(acridine orange +popop) which is have the condition of the energy transfer as shown in the figure(1) .

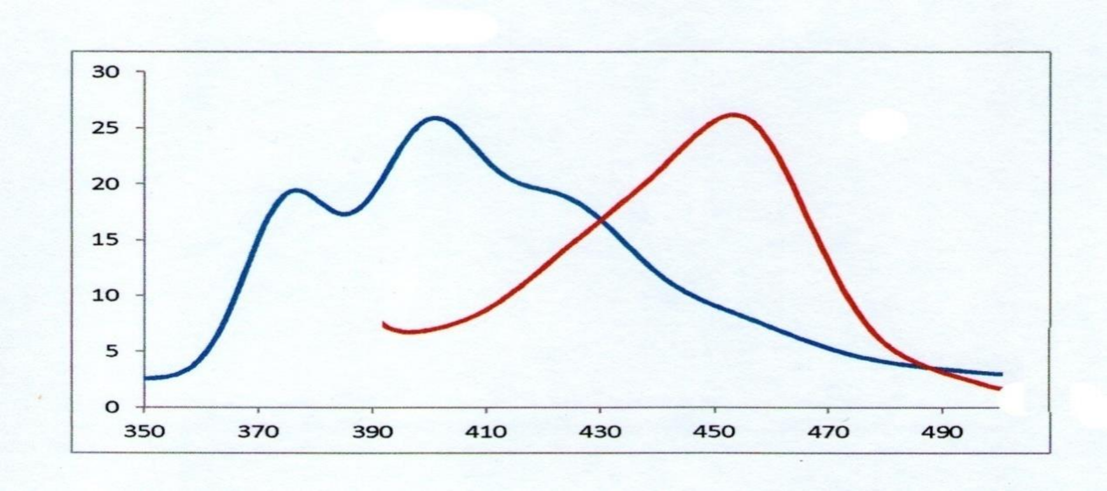

Figure 1. Absorption and fluorescence spectrum for the mixing of (Acridine Orange + popop)

Used Devices

In spectroscopic studies of this kind, and when the study of molecular electronic energy levels is used for the following devices: UV.-Vis. Spectrometer and Fluorescence spectrometer.

The Measurements

1-Nonlinear optical properties of the dyes

The study of the linear optical properties for spectrum prepared dyes (acridine Orange and Pop Pop)with different conditions through changed concentration solution, and we can also calculate the life time of fluoridation (τ_f)record compound known to his life time , as well as the area under the curve, as in the following relationship equation which is adopted in the calculations in this research [14]:

$$\tau F = \frac{ax\tau fRB}{aRB} \text{……………………(3)}$$

As τ_{fRB} represents life time record for a compound which Alrodamen B and worth(3.230) ns when the concentration (10^{-4}) M and a_RB is the area under the curve fluorescence of Alrhodamine B and its value (117.6) cm^{-1} a represents the area under the curve required for the compound in this search. It can also be account quantitative output of fluoridation (ΦF) to find the ratio of the fluorescence spectrum space to the absorption spectrum space, if any [15]:

$$\phi_F = \frac{\int F('\nu)d'\nu}{\int \varepsilon('\nu)d'\nu} \cdots\cdots\cdots\cdots\cdots\cdots (4)$$

Study the absorption and fluorescence spectra of solutions prepared

It was prepared one concentration of(10^{-5}) after dissolves Acriden Orange dye in a solvent ethanol and then measuring the absorption spectra using (UV-Visible Spectrophotometer)As shown in Figure(2) and Table (1).

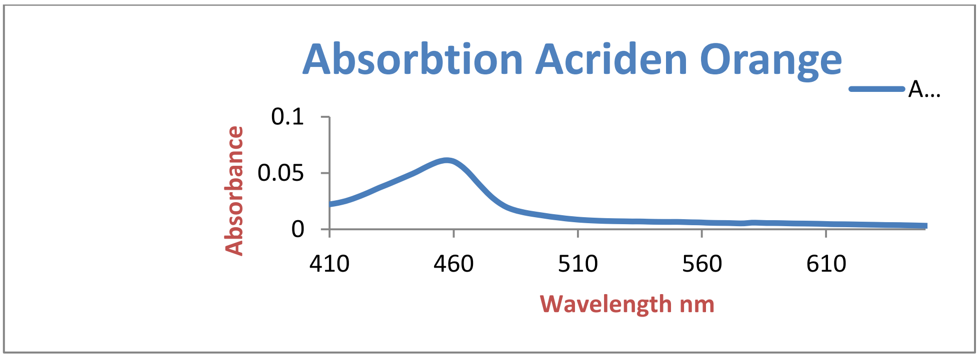

Figure 2. Absorption spectrum in the region (UV-VIS) for the solution Acridine Orange dye dissolved in Ethanol

Table1. Absorption spectrum in the region (UV-VIS) for the solution Acridine Orange dye dissolved in Ethanol

C (ML)	*λ max (nm)*	*A*
1×10^{-5}	448	0.054

And from the result of absorption spectra obtained spectra Transmission and as shown in Figure (3) and table (2).

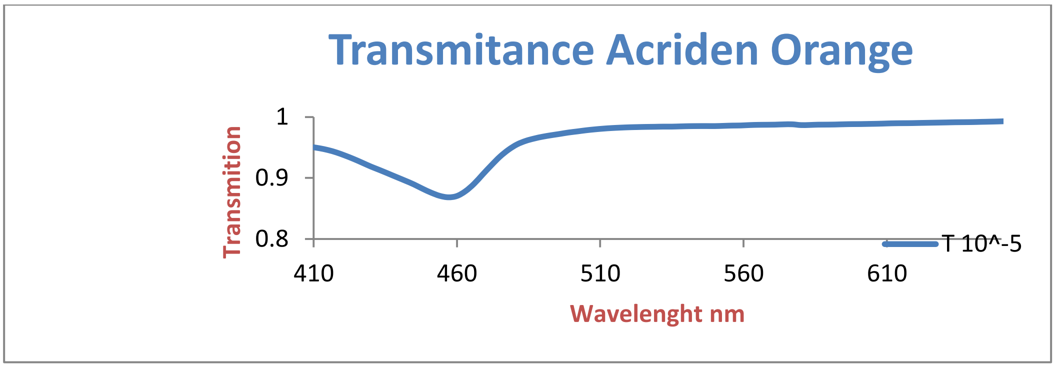

Figure 3. Spectrum Transmission in the region (UV-VIS) for the solution Acriden Orange dye dissolved in ethanol.

Table 2. Transmission spectrum in the region (UV-VIS) for the solution Acariden Orange dye dissolved in Ethanol

C (ML)	*λ max (nm)*	*T*
1×10^{-5}	448	0.88

And After obtaining the results of Transmission were measured linear absorption coefficients (α_o) and linear refractive index (n_o)for samples prepared after the introduction the result in the computer program, as shown in Figure (4) and the table (3).

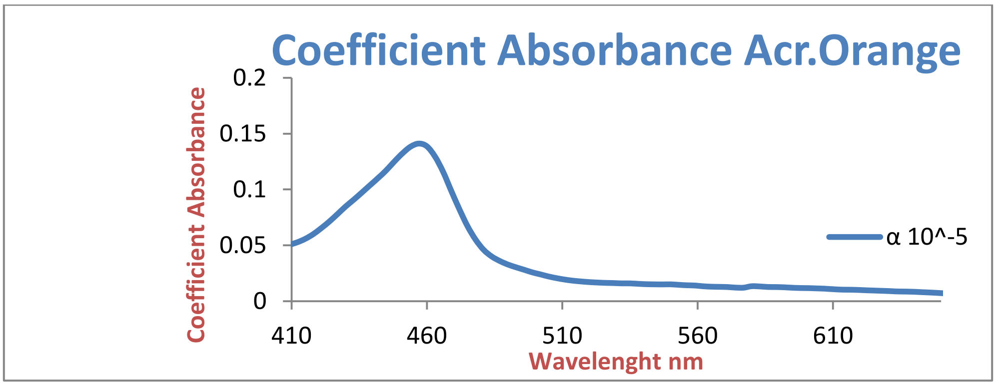

Figure 4. absorption coefficients in the region (UV-VIS) for the solution Acriden Orange dye dissolved in Ethanol

Table 3. absorption coefficients and refractive index of the dye Acriden Orange solution dissolved in Ethanol

C (ML)	*α_o (cm^{-1})*	*n_o*
1×10^{-5}	0.13	1.67

It was measured fluorescence spectra of samples prepared to dye solution (Acriden Orange + Ethanol)using a fluorescence spectrometer The results of the measurements as shown in Figure(5).

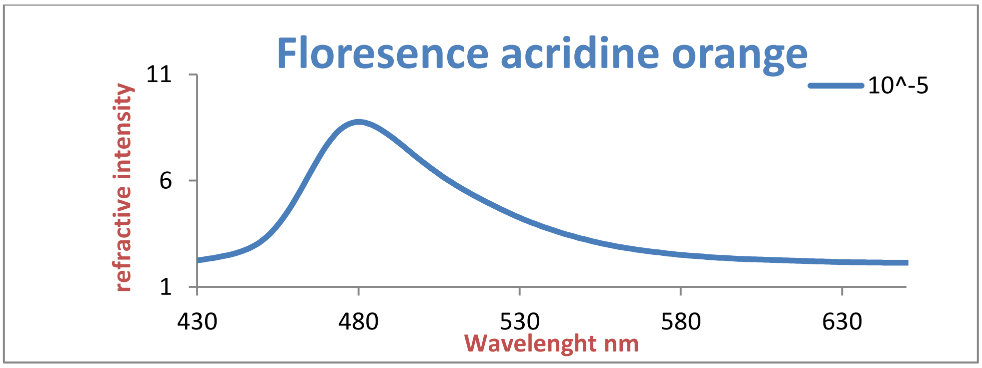

Figure 5. Spectrum fluorescence dye Acridine dissolved in Ethanol

Table 4. Florescence intensity the dye Acriden Orange solution dissolved in Ethanol

C (ML)	*λ max (nm)*	*Relative Intensity*
10^{-5}	476	8.58

Through the results of fluorescence spectraPossible account fluorescence lifetime as well as the Quantum Yield fluorescence, using the relations (3,4),After calculating the area under the curve (a) of the curved absorption and fluorescence using a computer program (GEUP 6) The results were as shown in the table 4.

Table 5. Fluorescence lifetime and the Quantum Yield fluorescence with different concentrations of the dye Acriden Orange solution dissolved in Ethanol

C (Ml)	τ_f *(ns)*	Q_f
1×10^{-5}	3.95×10^{-3}	0.87

It was prepared one concentration of(10^{-5}) after dissolves popop dye in a solvent chloroform and then measuring the absorption spectrausing (UV-Visible Spectrophotometer)As shown in Figure(5) and Table (6).

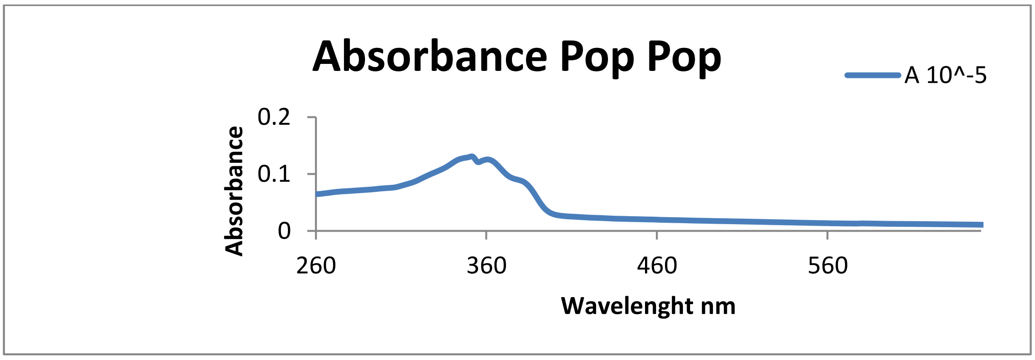

Figure 6. Absorption spectrum in the region (UV-VIS) for the solution popop dye dissolved in.

Table 6. Absorption spectrum in the region (UV-VIS) for the solution popop dye dissolved in chloroform.

C (ML)	*λ max (nm)*	*A*
1×10^{-5}	340	0.07

And from the result of absorption spectra obtained spectra Transmittance and as shown in Figure (7) and Table (7).

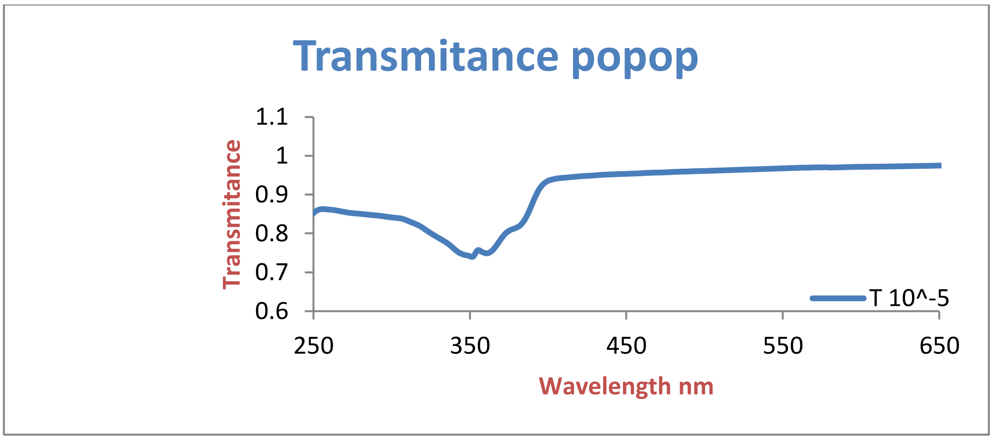

Figure 7. Spectrum Transmission in the region (UV-VIS) for the solution popop dye dissolved in chloroform.

Table 7. Transmission spectrum in the region (UV-VIS) for the solution popop dye dissolved in chloroform

C (ML)	*λ max (nm)*	*T*
1×10^{-5}	346	0.74

And After obtaining the results of Transmission were measured linear absorption coefficients (α_o) and linear refractive index (n_o)for samples prepared after the introduction the result in the computer program, as shown in Figure (8) and the table (8).

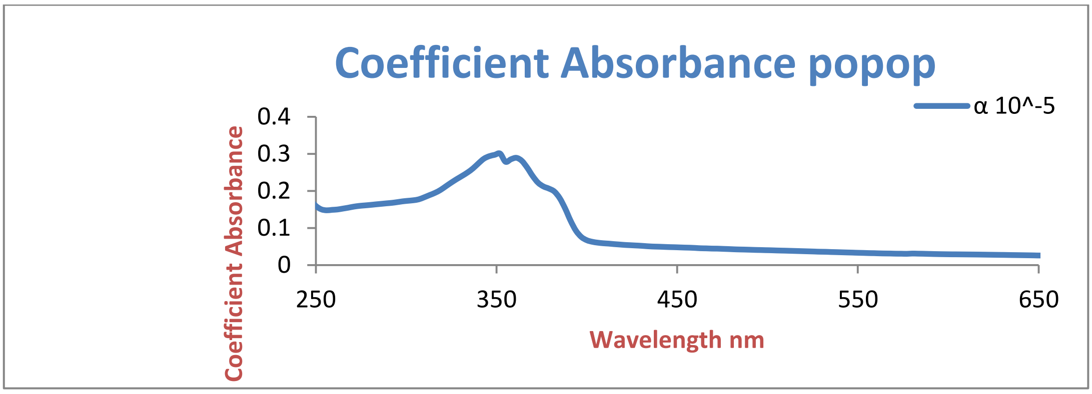

Figure 8. Absorption coefficients in the region (UV-VIS) for the solution popop dye dissolved in chloroform.

Table 8. absorption coefficients and refractive index with different concentrations of popop dye dissolved in chloroform

C (ML)	*α_o (cm^{-1})*	*n_o*
1×10^{-5}	0.29	2.20

It Was measured fluorescence spectra of samples prepared to dye solution (popop + chloroform)using a fluorescence spectrometer. The results of themeasurements as shown in Figure(9)and table (9).

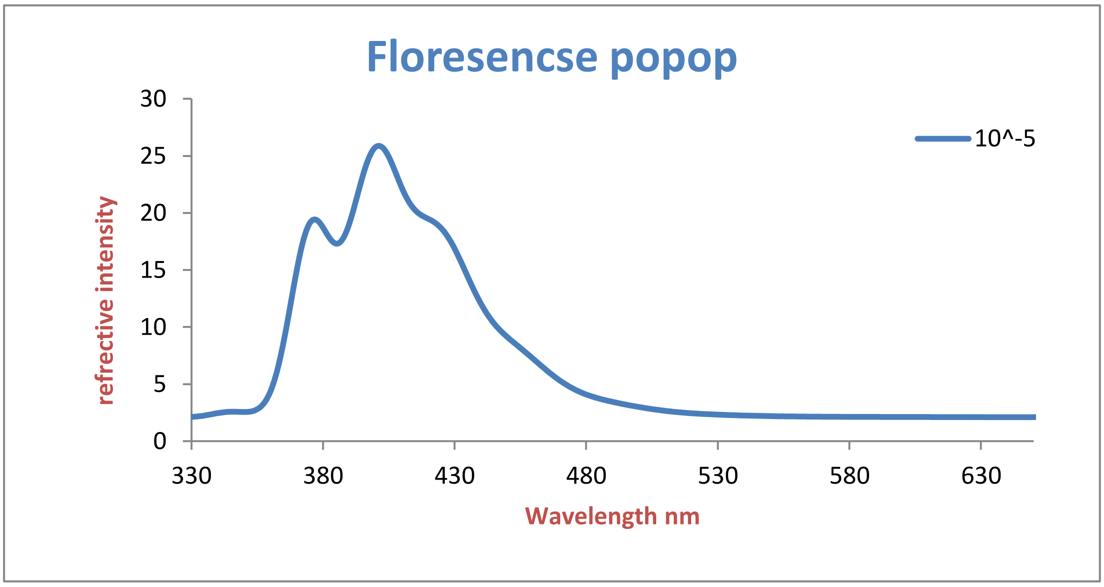

Figure 9. the fluorescence intensity popup dye dissolved in chloroform

Table 9. Fluorescence intensity popop dye dissolved in chloroform

C (ML)	*λ max (nm)*	*Relative Intensity*
10^{-5}	399	25.11

Through the results of fluorescence spectra possible account fluorescence lifetime as well as the Quantum Yield fluorescence, using the relations (3,4),respectively. After calculating the area under the curve (a) of the curved absorption and fluorescence using a computer program (GEUP 6) The results were as shown in the table (10):

Table 10. Fluorescence lifetime and the Quantum Yield fluorescence of the dye popop solution dissolved in chloroform

C (Ml)	τ_f *(ns)*	Q_f
1×10^{-5}	$3.04x10^{-3}$	0.97

It was prepared oneconcentration of(10^{-5})mixing two dyeAcridineOrange and thepopop the absorption spectra using (UV-Visible Spectrophotometer)As shown in Figure(10) and Table (11).

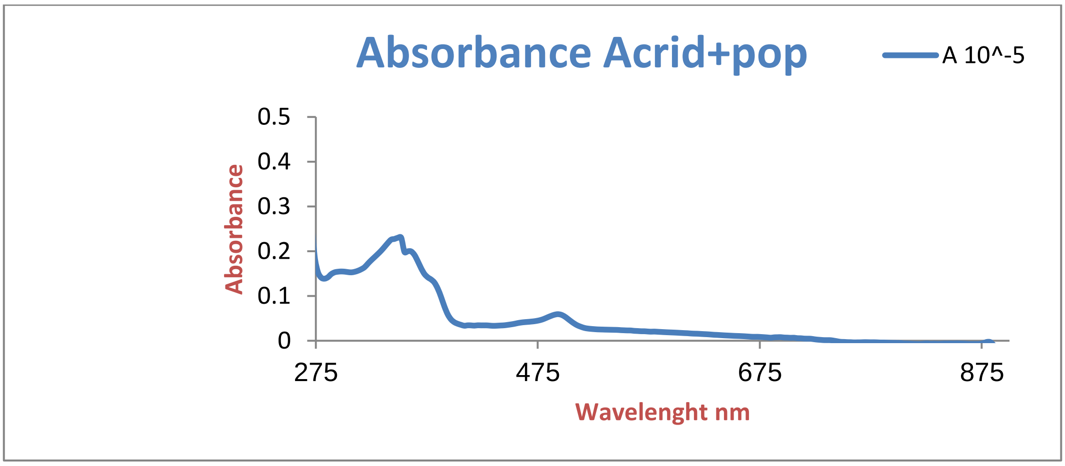

Figure 10. Absorbency mixing two dyes,Acridine Orange and the pop pop.

Table 11. Absorbency mixing two dyes Acridine Orange and the pop pop.

C (ML)	*λ max (nm)*	*A*
1×10^{-5}	493	0.01

And from the result of absorption spectra obtained spectra Transmittance and as shown in Figure (11) and Table (12).

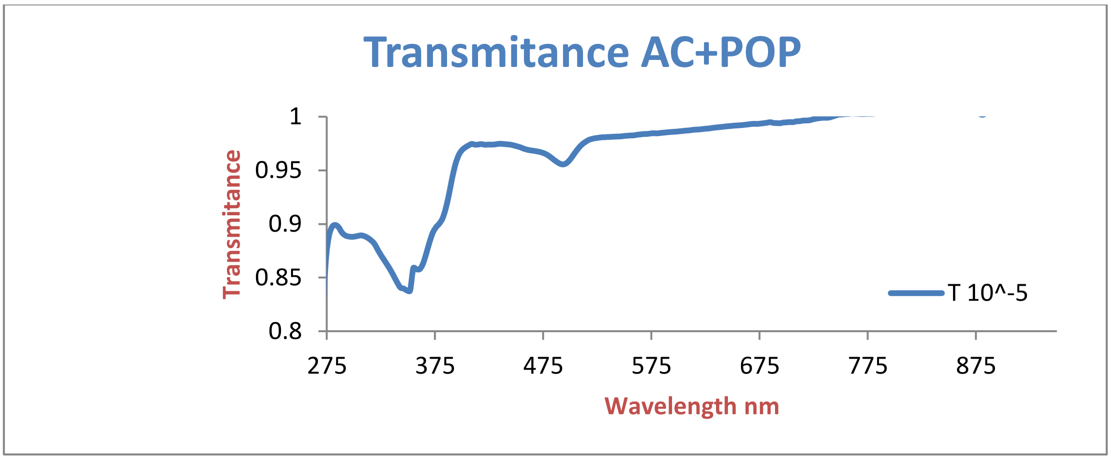

Figure 11. spectrum Transmission in the region (UV-VIS) for the solution(Acridine+ popop).

Table 12. Transmission spectrum in the region (UV-VIS) for the solution (Acridine+ popop) dye and different concentrations

C (ML)	*λ max (nm)*	*T*
1×10^{-5}	340	0.98

And after obtaining the results of Transmission were measured linear absorption coefficients (α_o) and linear refractive index (n_o)for samples**.**

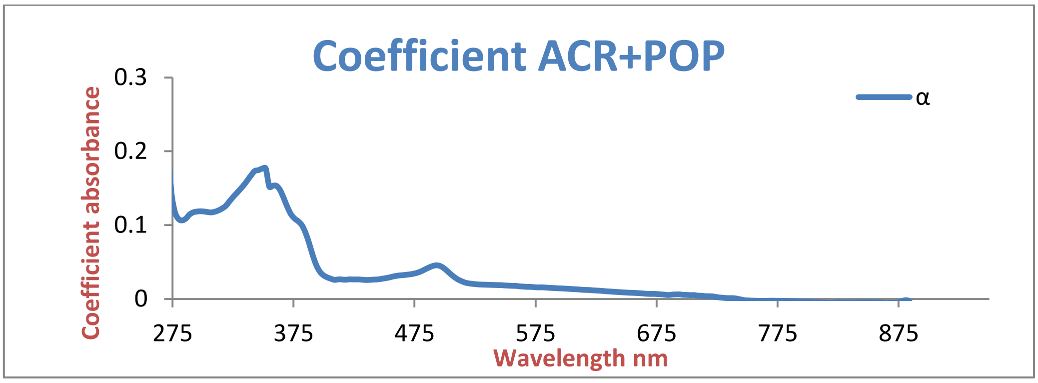

Figure 12. Absorption coefficients in the region (UV-VIS) for the solution (Acridine+ popop) dye

Table 13. Absorption coefficients and refractive index with different concentrations of(Acridine+ popop) dye

C (ML)	α_o *(cm^{-1})*	n_o
1×10^{-5}	0.17	1.1

It was measured fluorescence spectra of samples prepared to mixture dye solution (AcridineOrande + popop)using a fluorescence spectrometer The result of the measurements as shown in figure (13).

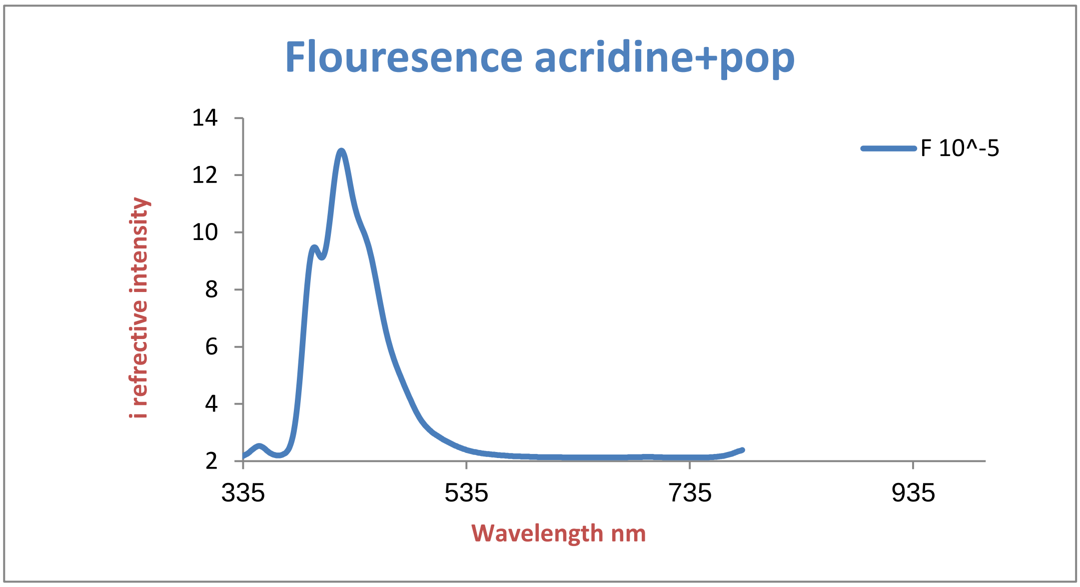

Figure 13. The intensity fluorescence Acridi ne+ popup)

Table 14. Intensity fluorescence of the dye Acridine Orange and popop solution

C (ML)	*λ max (nm)*	*Relative Intensity*
10^{-5}	429	9.67

Through the results of fluorescence spectraPossible account fluorescence lifetime as well as the Quantum Yield fluorescence, using the relations (3,4),respectively. After calculating the area under the curve (a) of the curved absorption and fluorescence using a computer program (GEUP 6) The results were as shown in the table (15):

Table 15. Fluorescence lifetime and the Quantum Yield fluorescence of the dye Acridine Orangeand popop solution

C (Ml)	τ_f *(ns)*	Q_f
1×10^{-5}	$1.37\text{x}10^{-3}$	0.66

Note from the mixing process to dyesAcridine Orange and popop for transmission of energy fluorescence of dye popop (the donor) to dye Acridine (the accepter) where we note changes in the value of energy increases with increase the value of wavelengths from 448 to 490 were we note indentation towards the wavelength biggest(green).

DISCUSSION

From the results of the florescence transmission energy is large increase relatively in the intensity emission spectrum of the model of mixing two dyes and in one concentration. If we discussed the effect of the transmission energy fluorescence process on the wavelength we will see for the phenomenon (anti-stocks) mean emission spectrum fluorescence wavelength shorter than the absorption spectrum , and this is different from the spectrum fluorescence of both two dyes individually where I got the phenomenon (stocks) mean emission spectrum fluorescence wavelength higher than the wavelength length the absorption spectrum.

As well as we note from mixing model the change in all optical nonlinear properties (absorption coefficients and refractive index , the time of life the level of fluorescence , quantitative output) than it was before mixing the dyes individually.

CONCLUSION

1. The increase large relatively in the emission spectrum intensity of the samples prepared from mixing dyes (acridine Orange + popop) .
2. The effect increasing concentration on the intensity increasing of the emission spectrum of the sample mixing effect.
3. The effect of fluorescence transmission energy of on wavelength model prepared.
4. Get Stokes and anti- Stokes phenomenon
5. The effect of the fluorescence transition energy process on the optical properties of the models prepared by the change on the spectral absorption and fluorescence.

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