Linear Optical Characterization of Novel Dye Doped Poly Methyl Methacrylate with Titanium Dioxide Nanoparticale

Bashair S. Mahdi¹, Safaa A. Hasson²

Abstract
The project includes preparation of organic dyes as powder, pure dyes as thin film, pure dyes doped with Poly methyl methacrylate (PMMA) and pure dyes doped PMMA with titanium dioxide nanoparticles (TiO²) to study the linear optical properties. Organic dyes (pure and doped) are interesting materials for linear optical properties and its applications because of their high response linearity and their extended spectral transparency. In this work, preparation organic compound dyes (Schiff bases) derived from closed ring were carried out as thin films of materials have been deposited on glass substrates. The samples prepared in for concentrations (10⁻⁴ and 10⁻⁵) M and thin films were deposited via drop casting.

Key Words: Nanoparticale, Optical Characterization, Wavelength Fluorescence.

Theory
Many dyes have different important properties like strong absorption band extend from uv to the near IR, organic compounds have fluorescent light with aromatic ring, molecular which process delocalized (π)electrons that can be simple excited by photons. The photo physical characterized of these organic in different type of solid materials have been attracting a important concern in view of their long range of using such as tunable laser dye, transfer of energy experiments, biomedical test, probe and sensing tool [1,2].

Laser dyes are big organic molecules with molecular weights a few hundred. When one of these organic compounds molecules is solved in a correspondent liquid solvent (such as ethanol, methanol, or an ethanol-water mixture) it can be choice as laser medium in a laser dye. Particularly [3], laser dyes are complex molecules consist of a multi of ring structures, which lead to series of absorption and emission spectral. Famous examples are the coumarins and xanthenes [2,4]. The structure and location of the molecule have an important effect on spectr absorption and emission. However, laser dyes that can be choice to covered the emission specter from the near ultraviolet(uv) to the near infrared (IR) laser dyes[5,6], either as liquid or bulk, are the influence medium in pulsed and continuous wave (CW) dye lasers.

The linear coefficient of absorption (αₐ) with linear index refractive (nₒ) can be found belong to the below equations [7,8]:

\[ \alpha_o = \frac{1}{T} \ln \left( \frac{1}{T} \right) \]  \hspace{1cm} (1)

\[ n_o = \frac{1}{T} + \left( \frac{1}{T^2} - 1 \right)^{1/2} \]  \hspace{1cm} (2)

Corresponding author: Bashair S. Mahdi
Address: ¹Department of Human Healthy, College of Food Science, Al-Qasim Green University, Iraq; ²General Company of Electricity for Middle, Babylon, Iraq.
¹E-mail: bayeebashae75@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 20 November 2020 Accepted: 29 December 2020
Where \( \xi \) is the thickness of sample and \( T \) is the transmittance.

This significant factors can supply notice on the molecular sates. When the dipole moment of a vibration molecule is higher in excited case than in the ground cased is solved in solvent polarity. Also, the detection of a fluorescent species is of course easy when the Stokes shift is found[9,10].

We can be know the variety of frequency \( \Delta u \) from:

\[
\Delta u = u_{abc} - u_f \tag{3}
\]

Where: \( \Delta u \): Variaty of frequency, \( u_{abc} \): frequency of wavelength absorption, and \( u_f \): frequency of wavelength fluorescence.

Can be calculated the quantum efficiency from total area under the fluorescence curve, by used the relation[11]:

\[
q_{fm} = \int f(u) dV \tag{4}
\]

Where:

- \( q_{fm} \): Quantum efficiency.
- \( f(v) \): The intensity of fluorescence spectrum.
- \( dV \): Volume.

Quantum efficiency of most important parameter of dye molecular and its values between (0-1) dependence on state of concentration, temperature and state of molecular structure of solvent [12,13].

**Preparation Sample of thin Films**

Prepared the thin films of compounds (B) were done by use a clean glass substrate by choice drop method, with concentrations \( 10^{-4}\text{and}10^{-5} \) M for each of them for liquid state, this sample dried at room temperature for (3) days. These thin films have thickness about (100-140) nm. When polymer doped with dye the films were deposited on substrate by use method dropping, at concentrations \( 10^{-4}\text{and}10^{-5} \) M. The liquid of the polymer is prepared by solving in the required amount of polymer (7 g in 100 mL of DMSO solvent). Amount of dye solution was added to polymer Poly(methyl methacrylate) solution and stirred by device of a magnetic stirrer at(25) room temperature to get a homogenous mixture. Drying the films by mixed polymer dye solution on a glass block at room temperature 25°C for (three) days. Nanoparticles and Poly (methyl methacrylate) PMMA and dye films were made by dropping method. The homogenous of the polymer was prepared by mixing 7 g PMMA polymer in 100 mL of Dimethyl sulfoxide solvent. The mixture added to \( 10^{-4}\text{and}10^{-5} \) M dyes liquid. Nanoparticles weight powder (0.1) wt % were added and stirred by magnetic stirrer at room temperature to get a homogenous compounds. The dye, TiO \(_2\) and PMMA mixture was prepare on a glass substrate at room temperature. This methods was repeated for all concentration of dye.

Figure (1) show the structure of compounds (B) which prepare from Aurintricarboxylic compound.

---

**Result and Dissuasion**

**1-Absorption Spectra of Compound (B) (Liquid and Thin Film)**

Figure (1) show spectra of Absorbance compound (B) were recorded with two concentrations as, for thin film of (pure dyes), (dye+ polymer), (dye+ polymer +nanoparticle) with two concentrations \( 10^{-4} \) and \( 10^{-5} \) M. The absorbance increasing significantly with the increasing of concentration due to the higher number of molecules per unit volume according to Beer-Lambert law, [9]. The figure (1) shows that both of two spectra have two band, in UV region which is call B-band at the rang about (260-380)nm due to transfer from \( \pi \rightarrow \pi^* \), and the other in visible region which call Q-band at the range (500-560)nm that resulted from an electronic transitions for \( \pi \rightarrow \pi^* \), the absorption happened for the( C=C) group of the aromatic system and C=N group, that resulted from an electronic transitions for \( \pi \rightarrow \pi^* \) the present results show that the absorption peaks for of two concentrations were shifted toward the short wavelengths with decrease concentrations, because.
(DMSO) solvent have high polarity; the absorbance spectra as a function of the wavelength which indicate the state of (dye+ PMMA) and(dye+ polymer +nanoparticle) as film with two concentrations show the doped of polymer and nanoparticle leads to a suitable increase in the peak intensity.

![Absorbance vs Wavelength](image1.png)

**Figure 2.** The absorption spectrum of Aurintricarboxylic acid compounds as thin films for (pure dyes, dyes +polymer, dyes+polymer+TiO2) respectively.

The transmission for compounds (B), having two concentrations prepared at room temperature, are shown in figure (3). The figure shows that the maximum transmittance value is at range (280-680) nm, the transmittance decreases strongly when concentration increases, the transmission decreases with the increasing of concentrations at the same wavelength. This behavior reported in the literatures with Beer – Lambert law that is a good agreement with [14].

![Transmission vs Wavelength](image2.png)
Figures (4) showed thin films of pure dyes, (dyes+ polymer) and (dyes+polymer+nanoparticle) respectively, most of sample the cure of fluorescent shift towered short wavelength (blue shift) with decrease concentration this behavior appeared due to formation of aggregate for dye molecules at high concentration [15]. Begin of consist dimer to form from two molecular of monomer in opposite direction this result response on the change of the spectral shift, except the fluorescence spectrum of Aurintricarboxylic acid compounds as pure thin films shows the cure of fluorescent shift towered long wavelength (red shift) with decrease concentration [16].
Fig. 4. The fluorescence spectrum of Aurintricarboxylic acid compounds as solution for two concentration.

Figures (5) represented the interference between absorbance and fluorescence spectral for four compounds for two concentrations $10^{-4}$ and $10^{-5}$, the figures showed that the energy of the fluorescence became less from the energy of the absorbance because of non-radiation processes [10].

Fig. 5. Absorption and fluorescence spectrum for Aurintricarboxylic acid compounds (B) as thin films.

Tables (1) showed pure dye, pure dye + polymer, pure dye + polymer + nanocompound compound respectively as thin films.
### Conclusion

The main conclusions that have been obtained in this research from prepared organic dyes (Schiff bases) by drop casting method on glass substrate as thin films have been successfully prepared. The results showed that when the concentrations increased the absorption increase which is considered typical characteristics of Beer-Lambert law in UV region which is call B-band at the range about (260-380) nm due to transfer from $\pi \rightarrow \pi^*$, higher concentration fluorescence intensity reaches a limiting value and then decreases with further increase in concentration several factors are responsible for this behavior due to the increasing thermal collision between the photon with increase dye concentration. This transfer of energy between molecular by collisional mechanism make the nonradioactive processes prominent and hence fluorescence decreases, as result the compounds used it in this devices made this device friendly for the environment and not pollution and as a result, it can be used as resonator cavity lasers and other optical and photonic devices.

### References


Khwala J, Furqan A. Study the Optical Properties of Fluorescein Sodium Dye Doped in Polymer Poly Polyvinyl Alcohol for Different Thickness. *Journal of University of Karbala* 2018; 16(1).


http://doi.org/10.14704/nq.2020.18.2.NQ20121


http://doi.org/10.14704/nq.2020.18.4.NQ20157