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Investigation the Optical Recording of Two Molecular Weights of PVA Doped with Azo Dye.

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ABSTRACT :
In this research study, thin films of pure PVA polymer with two different molecular weights, 14,000 g/ml and 72,000 g/ml were created. These films were then doped with an azo dye (4-(2-pyridilazo) resorcinol monosodium salt hydrate) in a ratio of 1:1 using the method of Rotational paint. The study focused on examining the optical properties of these films, specifically the absorption and quenching coefficient (K). In addition, the refractive properties (n), the real dielectric constant (ϵ), and the imaginary dielectric constant (i) were investigated within the wavelength range of 300–900 nm. The results of this research revealed that the light absorption of the films increased significantly after being treated with an azo dye. The maximum observed absorption was (2.59) per atom. Moreover, it was found that the behavior of the refractive index is similar to that of the absorbance. The increased light absorption and stable refractive index make these films promising candidates for various applications that require enhanced optical performance. All results illustrated there is a very few effect of the molecular weight on optical properties of PVA.
Keywords: Thin films, PVA, Polymer, Azo, Dye, Optical.

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I. INTRODUCTION

Polyvinyl alcohol has many advantages that make it eligible for use in a variety of applications and fields in medical, optical, and important electronic applications due to the high transparency of this polymer as well as other important properties. The exceptional qualities possessed by polyvinyl alcohol (PVA), namely its biodegradability, transparency, flexibility, resistance to electricity discharge, chemical resistance, film-forming ability, and wide commercial accessibility, have attracted significant interest. Previous researchers have documented the composition and creation of diverse materials using polyvinyl alcohol composites. [1-3].

In the past few years, there has been a surge of interest in studying azo-dye compounds due to their unique photochemical characteristics and significant nonlinear refraction. These properties make them particularly intriguing for various applications such as optical storage, optical limiting, and optical switching. Additionally, these compounds have also shown promise in the field of antibacterial activity, leading to numerous research endeavors. [4-6].

Approximately half of all dyes are comprised of Azo dyes, making them the dominant type in the industry. A substantial 70% of dyes used in various sectors fall under the category of Azo dyes. What sets these compounds apart is their unique functional group that brings together two radicals. Known as the paramount synthetic colorants, Azo dyes have garnered extensive usage throughout various industries. The presence of azo dyes poses a significant threat to both human health and the well-being of aquatic ecosystems. As a result, there is a growing consensus that urgent action must be taken to address the issue by either eliminating these harmful substances from liquid waste or transforming them into beneficial and non-hazardous materials.[7, 8]. Organic azo dyes were used as doping materials for some polymers to improve the optical properties of these polymers [9, 10].

The physical and chemical properties of PVA depend primarily on the hydrolysis rate, which determines the molecular weight of the polymer. The molecular weights obtained for PVA products varied from (2000-400,000) g/ml depending on the length of the PVA polymeric chains, the level of hydrolysis, and the removal of acetate groups as well as the reaction conditions greatly affect it, as the preparation medium may be acidic or alkaline. The polymer or the low polymer content results in soft materials because the chains are unrestricted in movement, while the high content of the polymer results in strong materials, so the physical properties of PVA differ according to the weight of prepared or used molecules, so a group of different molecular weights of polyvinyl alcohol was selected (14000 and 72000) g/ml and blends with azo dye to study the effect of different molecular weights on the optical properties of polyvinyl alcohol[11,13].

In this study, the effect of the molecular weight of polyvinyl alcohol on some important properties of this polymer was studied, such as the important optical properties of a mixture of polyvinyl alcohol with an organic azo dye. It is known that the molecular weight of the materials has a direct effect on both the chemical and physical properties. It was used in this research to have two molecular weights of PVA, which are (14000 & 72000) g/ml prepared by solvent casting method with a constant weight percentage of azo dye.

II. EXPERIMENTAL PART

Materials: Sigma-Aldrich (located in St. Louis, USA) was the place where the PVA M. Wt. 72,000 (g/mol) along with PVA MW 14,000 (g/mol) were purchased. The azo dye (4-(2-pyridilazo) resorcinol monosodium salt hydrate), also obtained from the same company was used in its original form.

Samples Preparation: The preparation of PVA/azo dye blends were done by the magnetic stirrer technique. The powder of two molecular weights of PVA was dissolved in distilled water at 97^0C, until all PVA was dissolved and then cooled at room temperature, then the azo dye was added to PVA and stirred for 1 hr, until complete compatibility of the blend as reported in the literature. After that, the complete mixture solution is deposited by the spin coasting method in (1000 RPM) on glass bases (with a distances of 2.5cm x 2.5cm) to obtain a film with a homogeneous thickness, and then dried at room temperature.

IV. VISUAL MEASURMENTS:

Light absorption and optical constants: When light propagates through matter, it is attenuated in the direction of wave propagation. Two types of attenuation can be distinguished, absorption and scattering, as both lead to a loss in the intensity of light in the direction of propagation. All measurements were made by using the UV-visible spectroscopy at room temperature and for a range of wavelengths (300-900) nm.

V. RESULTS & DISCUSSION:

Optical Absorbance: Figure 1 illustrates the relationship between the optical absorbance and the wavelength for the measured samples, as it shows the absorption curves progressed from zero to 2 for each atom. The violet curve represents the light absorption values of the PVA polymer with a molecular weight of 72000 and is about 0.244 for the wavelength of 350 nm, and the green curve is about 0.29 for the same length. The wavelength is stable after that to the wavelength of 900 nm, while a large difference is observed in the absorbance values when doping the polymer PVA 72000, and PVA 14000 with azo dye, reaching 2.59 in the blue curve and slightly less than it for the red curve, this indicates that the dye effectively enhanced the light-absorbing capabilities of the PVA polymer films, it remained constant and showed minimal energy dissipation in the visible light region. This suggests that the doped films maintained their optical properties in terms of refraction even after the addition of the azo dye, with a very few effect of the molecular weight of PVA. Overall, this study highlights the positive impact of doping thin PVA polymer films with azo dye on their optical properties and this can be explained by the presence of the double bond in the dye composition [14].

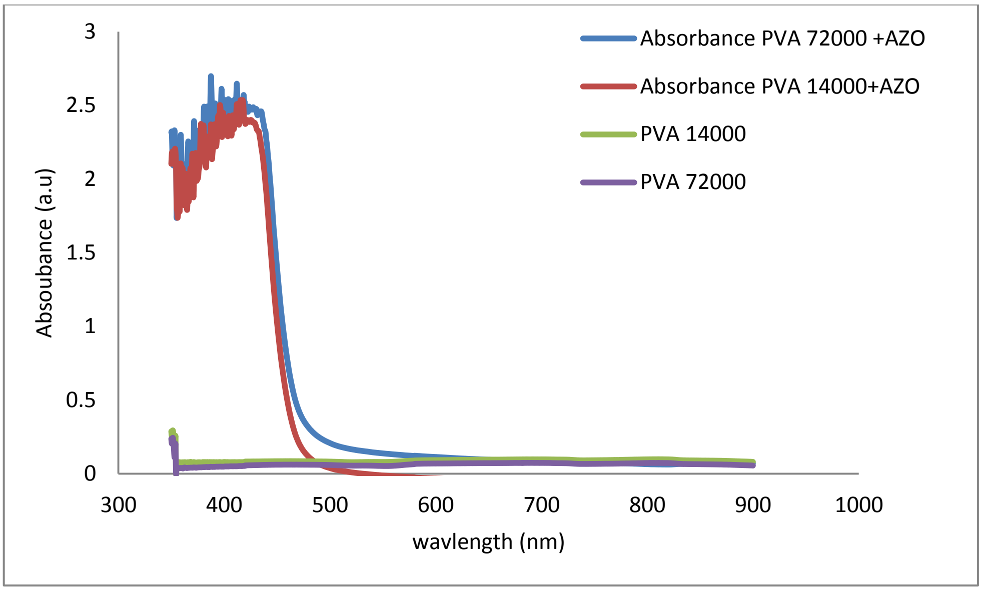

Fig.1. Relationship between absorbance and wavelength of pure and doped PVA (14000 and 72000).

Refractive Index: The measurement of the refractive index is based on the comparison of the speed of light in a vacuum, denoted as C, and its speed in a specific medium v, which is the real part of the complex refractive index N, the refractive index can be determined from the following relationship [15]: -

$$n = \frac{1+R}{1-R} + \sqrt{\frac{4R}{(1-R)^2} - K^2} \dots\dots\dots *$$

Figure 2 represents the refractive index as a function of the wavelength, where the refractive index of the PVA polymer with a different molecular weights (14000, 72000) is stable at the value of 1, and this is what is expected from the color of the polymer with a transparent color, and this is indicated by the green and purple curves, while the blue and red curves represent the polymer doped with an azo dye and have a value of 2 at wavelengths from 350 to 500 nanometers, after which the value stabilizes to 1.3, without any effect of the molecular weight of PVA .

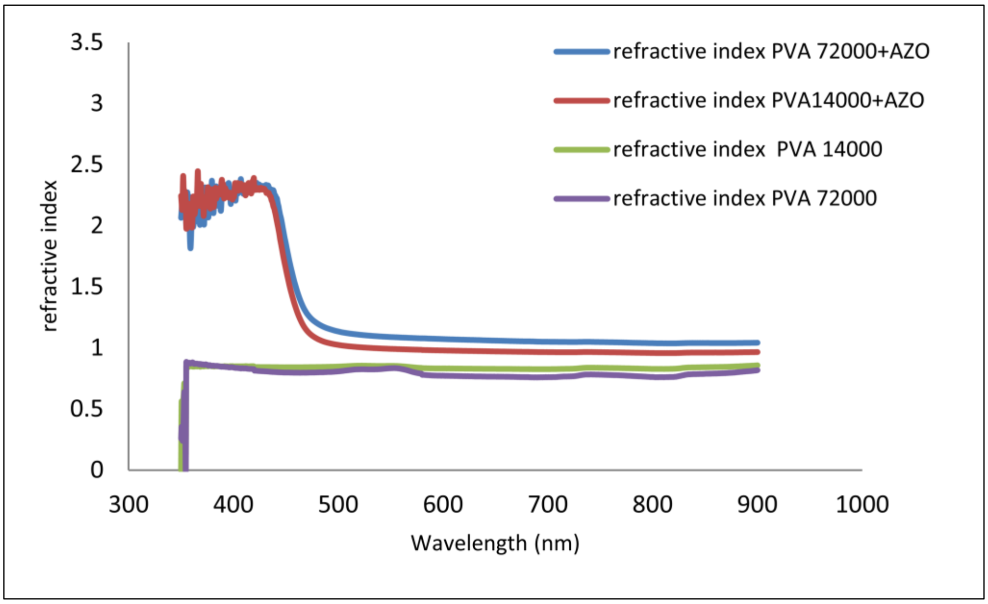

Fig.2. Refractive index by wavelength of pure PVA and doped PVA (14000 and 72000).

Attenuation damping coefficient (K). Extinction Coefficient K: Estimating the portion of lost light due to scattering and absorption from the medium's penetration distance, the fading coefficient can be determined by considering the values of absorption coefficient α and wavelength λ, as per the subsequent equation. [16]: -

$k = (\alpha \lambda / 4\pi)$ ………**

Figure 3 represents the relationship between the attenuation coefficient and the wavelength, with a tiny effect of the molecular weight of PVA, where the attenuation values are low and this is expected because the absorption values for the same regions and for the same wavelengths are high and do not exceed the correct one.

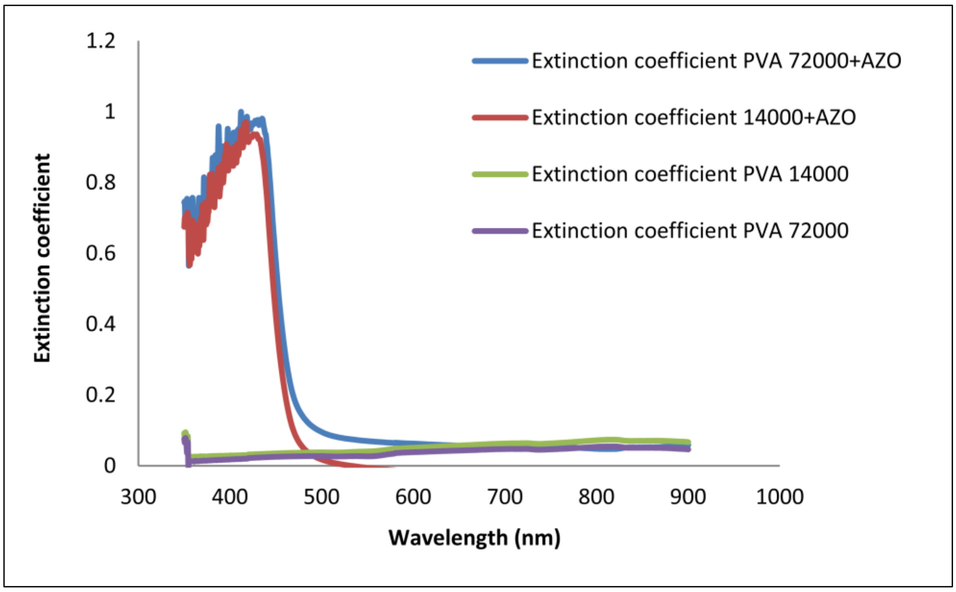

Fig.3. Extinction coefficient by wavelength of pure PVA and doped PVA (14000 and 72000).

Calculating the Dielectric Constant: The complex dielectric constant of the medium (ϵ) can be calculated using the following relationship [17]: -

$\epsilon = \epsilon_r + i\,\epsilon_i$ ……..***

Since:- ϵ_r: The dielectric constant consists of two components: the real part, ϵ_i, and the imaginary part. The real part of the dielectric constant reveals the amount by which the speed of light is reduced in the medium. On the other hand, the imaginary part signifies the ability of the dielectric material (i.e., the medium) to absorb energy from the electric field due to the influence of dipoles The dielectric constant can be expressed as a combination of its real and imaginary components, which can be represented as follows [18]: -

$\epsilon_r = n^2 - k^2$ … … … ****

$\epsilon_i = 2nk$ … … … *****

Figures 4 and 5 represent the real and imaginary dielectric constant and its relationship to the wavelength. Figure 4 represents the real dielectric constant, which is clear from the figure that the values range from one to 5 for each atom in the curves of the polymer doped with azo dye, which are the blue and red curves. For the polymer PVA 14000, PVA 72000, its value is stable at the correct one, with a very few effect of the molecular weight of PVA. As for Figure 5, it shows the values of the imaginary dielectric constant, and its value is low compared to the imaginary dielectric constant.

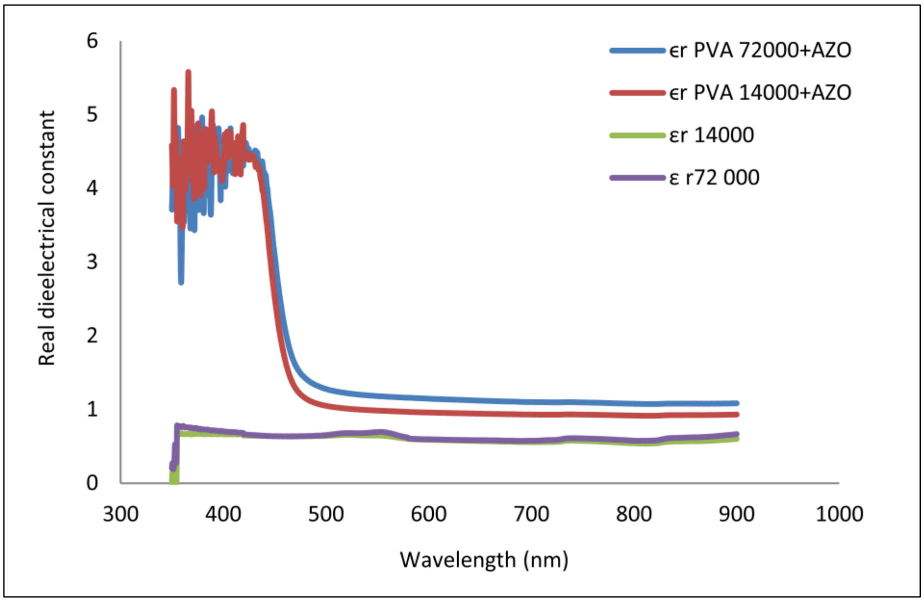

Fig.4. Show real part dielectric constant by wavelength of pure and doped PVA (14000 and 72000).

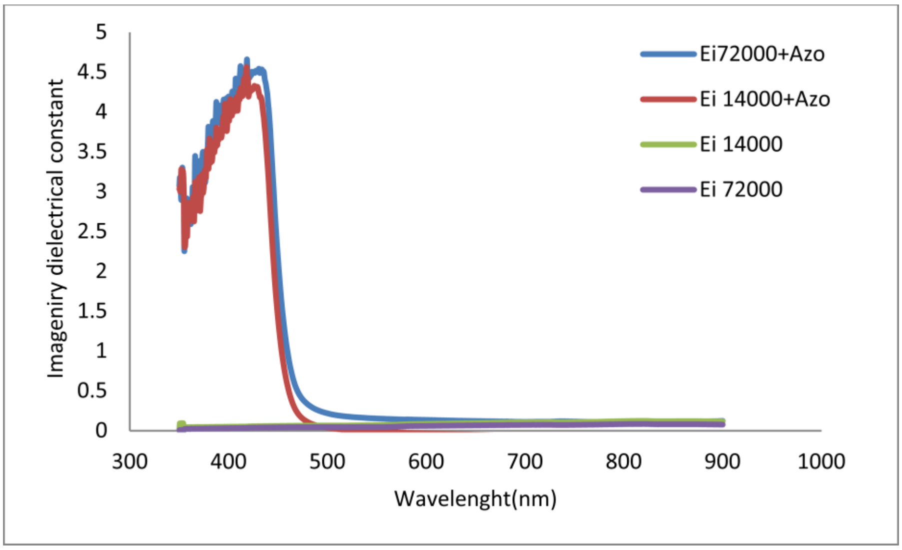

Fig.5. Imaginary part of dielectric constant by wavelength of pure and doped PVA (14000 and 72000).

VI. CONCLUSION

Based on the results of our research, generally its illustrated there is a very few effects of weight molecular of PVA on its optical properties, and we show that the inclusion of an azo dye in solar cells enhances their optical properties. These improvements include a combination of important parameters such as absorbance, dielectric constant, refractive index, extinction coefficient, dielectric real part constant, reflectivity, and absorption coefficient. By incorporating an azo dye, the resulting solar cell shows increased light absorption efficiency. Moreover, the inclusion of azo dye also helps reduce the energy gap of the cell, which is important for improving its performance. This improvement makes polyvinyl alcohol an excellent choice as a liquid electrolyte medium in solar cells. With an azo dye, the optical properties of polyvinyl alcohol can be greatly improved. This, in turn, leads to enhanced light absorption capabilities and the overall performance of the solar cell. In conclusion, our research highlights the beneficial effects of azo dye incorporation into solar cells. By doing so, we observed improvements in various optical properties that are essential for an efficient solar cell. In addition, we showed that an azo dye can be used to improve the optical properties of polyvinyl alcohol, making it a promising material for use as a liquid electrolyte intermediate. These findings open new avenues for developing more efficient and cost-effective solar cell technologies.

Understanding how organic azo dyes interact with PVA is crucial for optimizing material performance, ensuring color stability. Future research directions in this field should focus on investigating alternative methods for incorporating organic azo dyes into PVA matrices to enhance dye dispersion and minimize agglomeration. The findings from this research have important implications for various applications of PVA-based materials, particularly those involving colorants or dyes.

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