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Enhancement Optical Characterized of Tin Oxide in Polymer Polyvinyl alcohol Colloid Prepared by Laser Ablation Method

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Abstract

Nanocomposites are appropriate materials to meet emerging demands resulting from advances in science and technology. Components with novel structures and better efficiency compared to conventionally processed components are required for technological advances. In this research, polymer-inorganic colloidal nanocomposites can be created by using pulsed laser ablation for tin oxide nanoparticles in polyvinyl alcohol as a host. The optical characteristics and absorption spectra were used to look into the optical characteristics of the nanocomposite. The optical band gap (Eg) was measured; indirect transition values for pure polymer polyvinyl alcohol were determined to be 5 eV and 3.5 eV for PVA-SnO2 nanocomposite. The samples were measured for their extinction coefficient (k), refractive index (n), and dielectric constant. Nanocomposites' dielectric constant decreased while their absorption coefficient, refractive index, and extinction coefficient all increased. The nanocomposites have a high absorbency in the UV region and may be utilized for covering materials to radiation protecting applications. Write a brief abstract about your paper's subject of study. Write a brief abstract about your paper's subject of study. Write a brief abstract about your paper's subject of study. Write a brief abstract about your paper's subject of study. Write a brief abstract about your paper's subject of study. Write a brief abstract about your paper's subject of study.

Keywords: Absorption coefficient, Energy gap, Nanocomposite, Poly(vinyl alcohol), Tin Oxide.

Introduction

New nanomaterials are being developed at a rapid pace to address the specific needs of various industries, and all these composite technologies promise a plethora of different products with better technical specifications that really are probable to significantly convert markets in a variety of major industries [1]. Composites include two substances with different physical characteristics, typically showing novel properties. Composites could provide improved characteristics that none of the original materials alone could provide and are employed in a broad range of industrial product lines. Other polymer characteristics have been targeted for enhancement by doping with different Nano-fillers including metallic materials, semi-conductor, inorganic and organic particles and natural fiber, in addition to carbon structures and ceramic materials, can alter and enhance the

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characteristics of polymers. These ingredients are included in polymers for a range of reasons, including continued to improve processing, density control, optical effects, thermal conductivity, high thermal influence, electrochemical characteristics which enable charge dispersion or electromagnetic fields shield to protect, physical properties, heat resistance, and enhanced mechanical characteristics like stiffness, suppleness, and fracture toughness [2,3]. Metal/polymer composites can be manufactured using a variety of methods. Physical blending, the polymerization, the sol-gel method, and melt blending are the most common. Tin Nano colloid was created in this study by laser ablation in PVA solution. La is a simple method for producing metallic nanoparticles and colloids [4,5]. PVA is an ideal metal host material because of its outstanding thermos ability, mechanical strength, chemical resistance, and water solubility [6]. And doping-dependent electrical conductivity, as well as it uses as a host matrix for SnO_2 nanoparticles in superior polymers [7]. The optical and electrical properties of Tin Oxide SnO_2 nanomaterial have piqued researchers' curiosity [8,9]. SnO_2 is a stable material with a high theoretical specific capacity and unusual optical transparency. Because of its unusual properties, SnO_2 has several cutting-edge applications in gas-sensing, heat mirrors, lithium-ion batteries, photo-catalysis, and glass coatings [10,11]. SnO_2 has exceptional properties at the nanoscale because of the high surface-to-volume ratio; the size and shape of a nanomaterial have a significant influence on its qualities[12]. UV-visible spectroscopy was used to characterize polymer nanocomposite colloids.

The aim of the work investigated the optical and dielectric properties of PVA-SnO_2 nanocomposites based on SnO_2 nanoparticles as an inorganic filler metal and PVA as the main matrix.

Materials and Methods

The steps for preparing a colloidal nanocomposite polymer are:

1. Polyvinyl alcohol has the chemical formula $(C_2H_4O)_n$ and a purity of 99.6 %. It is manufactured by Central Drug House (P) Ltd in India. Inside the glass cylinder placed an aqueous solution of polymer PVA in which an amount 0.5 g has been dissolved in 10 ml volume of deionized water and stirred for half an hour at 80°C then when the homogeneous solution is obtained.
2. On the underside, a thin metal target has been placed. Metallica Enterprise, India processed the material, which is a thin Tin Oxide disc with a diameter of 31 mm and a purity of 99 %. To avoid large holes inside the target and also to maintain the same surface conditions with each laser pulse, throughout the ablation process, the entire structure rotates smoothly around its vertical axis.
3. The laser used is a polarized Nd:YAG laser (Quantel, Brilliant B). The radiation source was generated by generating 8 nm pulses at a frequency of 10 Hz in the third harmonic (THG = 335 nm). The laser effect was 17 joules/cm^2 per pulse, with a 0.5 mm diameter beam spot on the target surface. An energy detector (Gentec, model ED-200) was used to measure the laser energy, which can be changed by delaying the Q-Switch mechanism of the laser's optical cavity. For metallic targets, the ablation time (t) ranged from 10 to 15 minutes, depending on the concentration of metal particles, as the basic experimental setup was shown in Fig 1 [13].

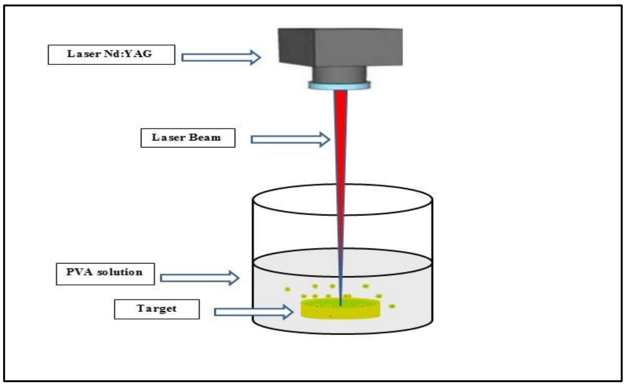

Figure 1. Experimental setup.

Results and discussion

Fig 2 shows the transmittances for PVA and its nanocomposites were increased with wavelength. After the addition SnO_2 nonmetals, The transmittance spectra actually reduced in the UV-Vis spectrum, which caused the nanoparticles to cumulate and much more incident light to really be absorbed and reflected [14].

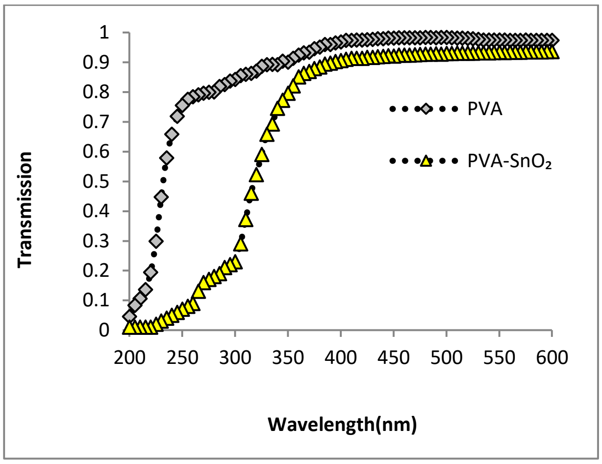

Figure 2. Transmittance spectra of polyvinyl alcohol and nanocomposite.

Fig 3 depicts UV-Vis optical absorption spectra of pure PVA and nanocomposites of PVA-SnO_2, which clearly show that each sample has a separate area of strong absorption. The absorption edge of PVA doped Nano-oxide metal nanocomposites moves to lower energies (redshift). This might be attributable to the interaction of PVA bonds with nanomaterials and an increase in the Nano size of the nanocomposite, which then rapidly decreases as the wavelength increases [15]. After doping the sample with nanometal SnO_2, the absorption was enhanced; incoming light is absorbed by free electrons[16].

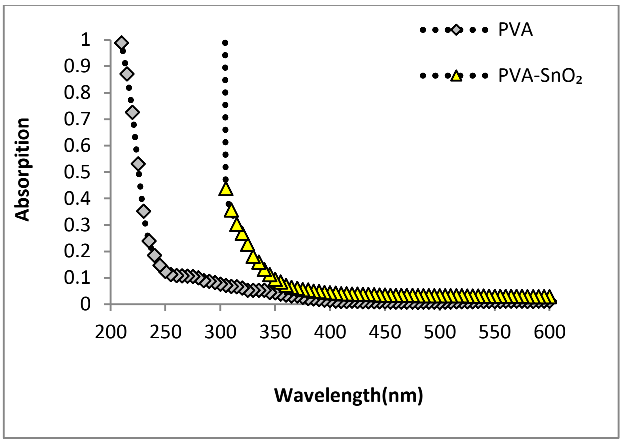

Figure 3. Absorption spectra of polyvinyl alcohol and nanocomposite

Lambert's rule, which stipulates that the level of intensity of energy propagation falls off exponentially with distance, is used to describe the intensity of energy propagation throughout an absorbing identical midst [17].

$$I = I_o e^{-\alpha x} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

(α) to signify the absorption coefficient and (x) to the thickness of sample.

$$\alpha x = 2.303 \log \frac{I}{I_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

The phrase is (log I / I0) has been placed equalize to the quantity absorbance (A):

$$\alpha = 2.303 \log \frac{A}{x} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 3$$

In Fig 4, an increase in the absorption coefficient was discovered for the sample as the wavelength increased. This could well be attributed to the electronic change from bonding to a nonbonding molecular orbit [18].

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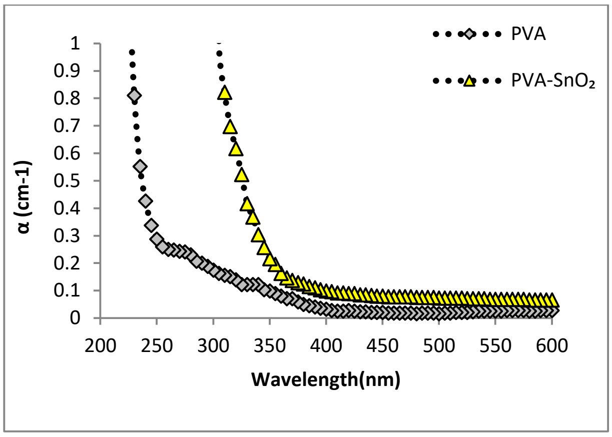

Figure 4. Absorption coefficient of polyvinyl alcohol and nanocomposite.

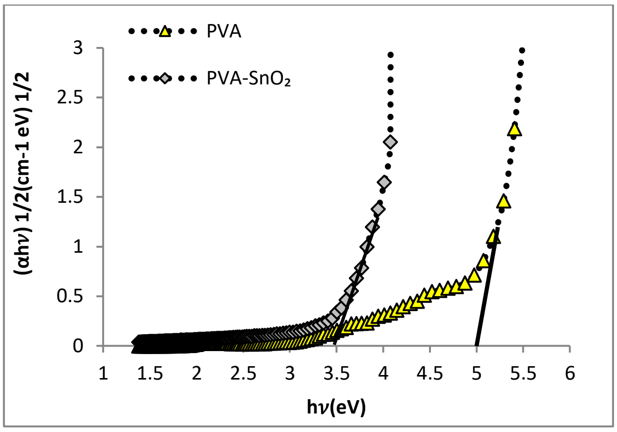

Figure 5. Photon energy against (αhν)1/r of polyvinyl alcohol and nanocomposite.

To make it a bigger electronic band structure of film material, the energy gap is required. It may be determined from a straight line, which can be derived from plotting $(hv)^{1/r}$ as a function of photon energy as shown in Fig 5. Tacue is a member of the equation where [18]:

$$\alpha h\nu = B(h\nu - E_g)^r \quad .... \quad 4$$

The index (r) is concerned with the distribution of the density of states. It's also an index that assumes the characteristics 1/2, 3/2, 2, and 3 counts on the kind of electronic transition in Eq.4. the absorption coefficient values for PVA and PVA-SnO_2. Nanocomposite solutions in this investigation are indirect electronic transitions, as in the prior study. The energy bandgap of the pure PVA polymer is 5 eV, for PVA- SnO_2, the extracted energy gap is 3.5 eV. The bandgap of the concerned polymer structure is affected by the doping of nano-oxide metals. The concerned energy bandgap polymer structure is affected by the doping of nano-oxide metals. This also confirms that inorganic fillers are present within the host. The effect of nano-oxide metal placement in changing the electrical configuration of the PVA matrix is demonstrated by the change in estimated optical energy band gap values. Additional levels inside this bandgap have been developed at the beginning of this. The movement of electrons from the valence band to these conduction band-specific levels is facilitated, leading to a lower bandgap and a rise in conductivity [19].

The film's reflectance (R) could be calculated by the following formula [19,20]:

$$R + A + T = 1 \quad .... \quad 5$$

After the adding of nano-oxide metal, the values of reflectance reduction due to the procedure of bonding between molecules, resulting in a reduction in the quantity of radiation reflected by polymer particles because nano-oxide metal in the PVA solution with augmented concentration of nano-oxide metal this is due to a decrease of polymer particles in the solution and thus a decrease in solution density as reflectance is dependent entirely on density as show reflectance spectra in Fig 6.

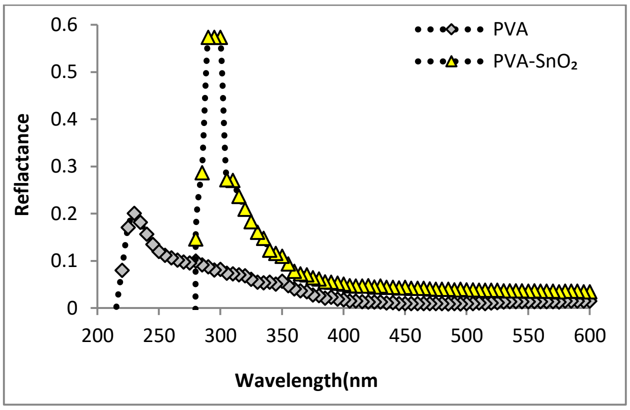

Figure 6. Optical Reflectance as wavelength of polyvinyl alcohol and nanocomposite.

The index of refraction (n) affects both the electronic polarization of ions and the magnetic

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field of interior materials, which is one of the most important properties of an optical material. The following Eq 6 has been used to calculate the required samples' complicated continuous refractive index (n) from the (R) [20]:

$$n = \sqrt{\frac{4R}{(R-1)^2} - R^2} - \frac{(R+1)}{(R-1)} \quad \ldots\ldots\ldots\ldots \quad 6$$

Fig 7 depicts the sample's refractive index (n) as a function of wavelength. The refraction index for nanocomposite solutions of PVA-SnO_2 is higher than the standard PVA polymer. This rise in the n-value of polymer nanocomposite colloid might be attributed to the insertion of NPs, which causes the condensation of smaller nanoparticles into larger clusters. Furthermore, as shown by Eq 6, refractive index is closely related to reflectance [20].

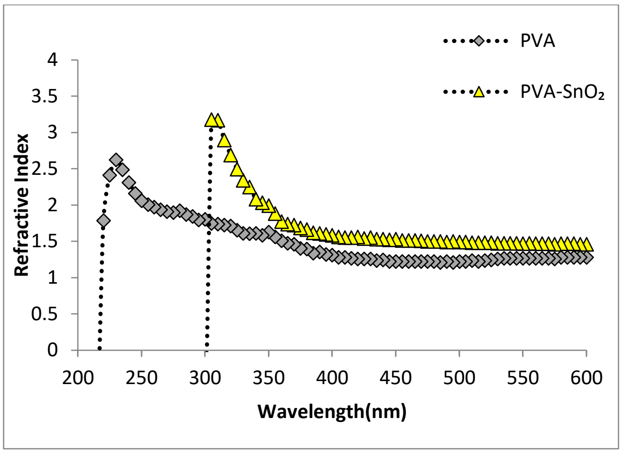

Figure 7. Dispersal of refractive index of polyvinyl alcohol and nanocomposite.

The extinction coefficient (k) shows how well the material reacts to light of a given wavelength and shows absorption variations as the electromagnetic waves move through all of it. The absorption coefficient is associated with the extinction coefficient (k) by the following Eq [21]:

$$K = \frac{\alpha\lambda}{4\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 7$$

The wavelength (λ) is shown in Fig 8 illustrates the relationship between the extinction coefficient (k) and wavelength for entire samples. The doped PVA-SnO_2 nanocomposite solutions samples have an extinction coefficient peak at 340 and 380 nm, which decline with increasing wavelength. Surface Plasmon absorption raises the extinction coefficient (k) in doped samples [21].

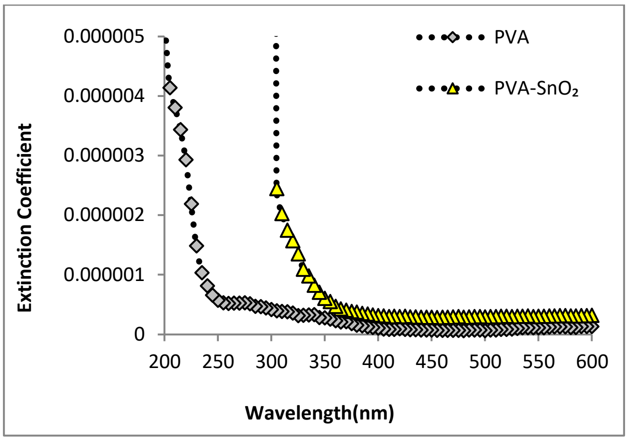

Figure 8. Dispersal of extinction coefficient of polyvinyl alcohol and nanocomposite.

The fluctuation of the real (r) and imaginary (i) components of the dielectric constants is concluded. Fig 9 illustrates that the dielectric real part is dependent on the refractive index since the extinction coefficient result is very little and may be ignored in accordance with Eq 8 [22]:

$$\varepsilon_r = n^2 - K^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 8$$

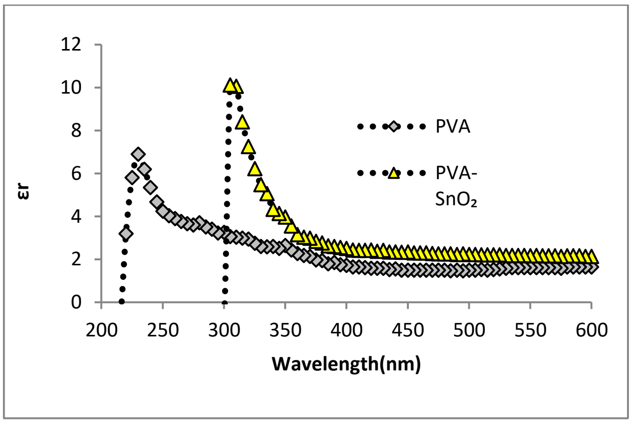

Figure 9. dielectric constant real part with wavelength of polyvinyl alcohol and nanocomposite.

Because of the relationship between the real part of dielectric constant and refractive index,

$PVA\text{-}SnO_2$ had a higher real part of dielectric constant after than PVA. The following Eq 9 can be used to compute the dielectric imaginary component:

$$\varepsilon_i = 2\,nK \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 9$$

Fig 10 exemplifies that $PVA\text{-}SnO_2$ had a higher imaginary portion of dielectric constant (i) than PVA, indicating that the samples do not have the same structure. As a result, changing the doping resulted in a change in the chemical composition of the polymer [22].

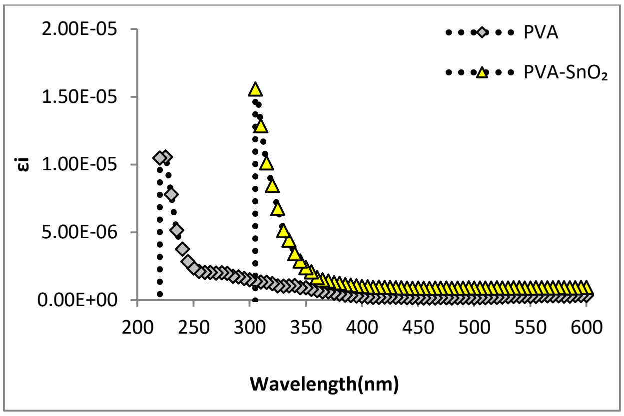

Figure 10. dielectric constant imaginary part with wavelength of polyvinyl alcohol and nanocomposite.

Conclusion

The nanocomposites were created to test the influence of metal oxide nanoparticles SnO2 on the optical characteristics of the PVA host. The addition of nanomaterials improves UV-Vis absorption of the polyvinyl alcohol host and decreases the rate of the energy gap for the poly (vinyl alcohol) by adding it to get a better energy gap. The energy gap values were found to be 5 eV for pure PVA, 3.5 eV for nanocomposite $PVA\text{-}SnO_2$. The dielectric constant of nanocomposites decreased. With additional metal oxide nanoparticles, the absorption coefficient, refractive index, and extinction coefficient were all raised. The nanocomposite displays a high retention in the UV region and may be utilized for covering materials in radiation protecting applications.

Author's Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Mustansiriyah University.

Author's Contribution

Nadeer JM and Zahraa SR contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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تحسين الخصائص البصرية لأوكسيد القصدير النانوي في بوليمر بولي فينيل الكحول الغروي المحضر بطريقة الاستئصال بالليزر

نظير جاسم محمد، زهراء صباح رشيد

قسم الفيزياء ,كلية العلوم ,الجامعة المستنصرية ,بغداد ,العراق.

الخلاصة

المركبات النانوية هي مواد مناسبة لتلبية الطلبات الناشئة الناتجة عن التقدم في العلوم والتكنولوجيا. المكونات ذات الهياكل الجديدة و الكفاءة الافضل مقارنة بالمكونات المعالجة تقليديًا مطلوبة للتقدم التكنولوجي. في هذا البحث , يمكن إنشاء مركبات نانوية غروية غير عضوية من البوليمر باستخدام الاستئصال بالليزر النبضي لجسيمات أكسيد القصدير النانوية في بوليمر البولي فينيل الكحول كمضيف. تم استخدام الخصائص البصرية وأطياف الامتصاص للنظر في الخصائص البصرية للمركب النانوي. تم قياس فجوة الطاقة (Eg) ، وتم تحديد الانتقال غير المباشر لقيم بوليمر بولي فينيل الكحول النقي لتكون 5 الكترون . فولت و 3.5 الكترون . فولت للمركب النانوي PVA-SnO2. تم قياس العينات لمعامل الانقراض (k) ، معامل الانكسار (n)، وثابت العزل الكهربائي. انخفض ثابت العزل الكهربائي للمركبات النانوية مع زيادة معامل الامتصاص ، معامل الانكسار ، ومعامل الخمود. تتمتع المركبات النانوية بقدرة امتصاص عالية في منطقة الأشعة فوق البنفسجية ويمكن استخدامها لتغطية المواد لتطبيقات الحماية من الإشعاع.

الكلمات المفتاحية: معامل الامتصاص، فجوة الطاقة، المركب النانوي، البولي (فينيل الكحول) ، أوكسيد القصدير.