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# High UV-Absorbing Films Fabricated from Low-Cost and Lightweight Materials for Bioenvironmental Application

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High-energies-absorbing materials are fabricated as shields for bioenvironmental applications to attenuate the high photons' energies with a low cost, lightweight, and high attenuation. The films are synthesized from $SiO_2$/PVP/$SnO_2$ nanosystem. The optical characteristics of films are studied. Results show that the fabricated nanomaterials have higher absorption for high-energies' radiations. The studied optical characteristics of PVP film are improved with the rise in $SnO_2$-nanoparticles' content.

Матеріяли, що вбирають високі енергії, виготовляються як щити для біоекологічних застосувань задля ослаблення високих енергій фотонів із низькою вартістю, легкістю та високим загасанням. Плівки синтезуються з наносистеми $SiO_2$/полівінілпіролідон/$SnO_2$. Вивчаються оптичні характеристики плівок. Результати показують, що виготовлені наноматеріяли мають більш високу абсорбцію для випромінень високих енергій. Досліджувані оптичні характеристики плівки полівінілпіролідону поліпшуються з підвищенням вмісту $SnO_2$-наночастинок.

**Key words:** $SnO_2$, radiations, attenuation, optical characteristics.

**Ключові слова:** $SnO_2$, випромінення, загасання, оптичні характеристики.

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## 1. INTRODUCTION

The composites based on polymer are generally employed in various industries. The polymeric-composites' using in the space technology decreases the final products' weight, fuel consumption, and operating costs [1]. These flexible, lightweight, cost-effective, and efficient materials' design, which provides radiation shielding to patients, have drew of many researchers' attention along the world. The composites consisting of elements or compounds with excellent attenuation characteristics like gadolinium, barium sulphate, molybdenum, copper, zirconium oxide, gold, iron oxide, lead, rhodium, tungsten, silver, bismuth and zinc were studied elsewhere. The polymers are flexible, lightweight and easy to process materials. Because of these characteristics, the polymer-matrix materials are perfect candidates to make lightweight and thin composites required to this field [2]. Polyvinyl pyrrolidone (PVP) is water soluble and polar solvent. It has good wetting characteristics and easily forms films. These properties make it a good material as a coating [3]. Poly-*N*-vinyl pyrrolidone takes special consideration between the polymers related to its excellent stability and environmentally friendly, appropriate electrical conductivity and easy processability. The reactive pyrrolidone group of PVP simply constitutes complexes with various inorganic salts, biomacromolecules, synthetic or natural functional polymers and biomolecules [4]. Improved characteristics of semi-conducting metal oxides create them to discovery approaches in several applications. Among the semi-conducting metal oxides, tin oxide has been generally studied due to its large band gap of 3.6 eV and its potential fields in different approaches such as liquid-crystal displays, solar cells, photovoltaic cells, and gas sensors [5]. $SnO_2$-nanostructures' multifunctionality arises related to their large band gap, high surface-to-volume ratio, high exciton binding energy of 130 meV at room temperature (300 K), variation of remarkable resistivity in gaseous environment, chemical, mechanical and thermal stabilities, *etc*. Optoelectronic characteristics of $SnO_2$ depend on the impurities' presence and its stoichiometry with respects to oxygen [6].

The present work aims to synthesize the $SiO_2$/PVP/$SnO_2$ nanosystem as high-energies-absorbing material for high photons' energies.

## 2. MATERIALS AND METHODS

Films of PVP–$SnO_2$ nanosystem on silicon oxide ($SiO_2$) slides were synthesized. The PVP solution was synthesized by dissolving 0.5 gm of PVP in the distilled water (20 ml). The tin oxide was added to PVP solution with various ratios: 1.5, 3, 4.5 wt.%. The optical characteristics were tested in a range of wavelengths from 300 to 800 nm by spectrophotometer (UV/1800/ Shimadzu).

Coefficient of absorption ($\alpha$) was measured by the relation [7–9]:

$$\alpha = 2.303(A/t), \tag{1}$$

($A$—the absorbance, $t$—the thickness of the sample).

The energy gap can be considered *via* [10, 11]:

$$\alpha h\nu = D\left(h\nu - E_q\right)^r \tag{3}$$

($D$—constant, $h\nu$—energy of light photon, $E_g$—energy gap, and $r = 2$ for the allowed indirect transition).

The extinction coefficient $k$ is given by [12, 13]:

$$k = \frac{\alpha\lambda}{4\pi}. \tag{4}$$

The optical conductivity was given by [14, 15]:

$$\sigma = \alpha nc/(4\pi). \tag{5}$$

## 3. RESULTS AND DISCUSSION

Figure 1 represents the absorbance behaviour with wavelength of photons for the films. The absorbance of PVP polymer rises with the rise in $SnO_2$ nanoparticles (NPs) ratio that is due to increase in the charge-carriers' numbers [16–20]; hence, the transmission will decrease as shown in Fig. 2.

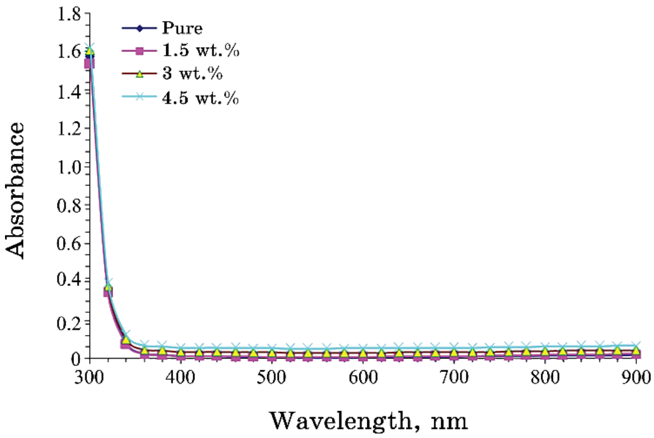


**Fig. 1.** Absorbance behaviour with wavelength of photons for the films.

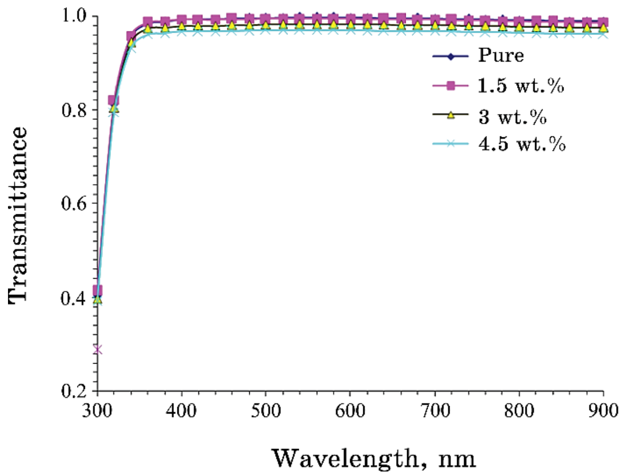


**Fig. 2.** Transmittance behaviour with wavelength of photons for the PVP/$SnO_2$ films.

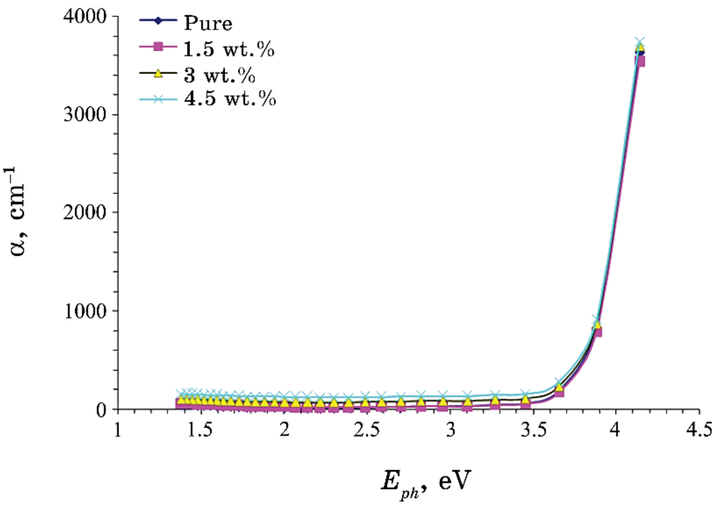


**Fig. 3.** Absorption coefficient with energy of photon for $SiO_2$/PVP/$SnO_2$ nanosystem.

Figure 3 shows the absorption coefficient with energy of photon for $SiO_2$/PVP/$SnO_2$ nanosystem. The absorption coefficient of PVP polymer is rising with the rise of $SnO_2$ NPs' content that is related to rise of the charge-carriers' numbers [21].

Figure 4 shows the energy-gap values for $SiO_2$/PVP/$SnO_2$ nanosystem. From this figure, the energy gap of PVP is reduced with rise in $SnO_2$ NPs' content that is due to the certain imperfec-

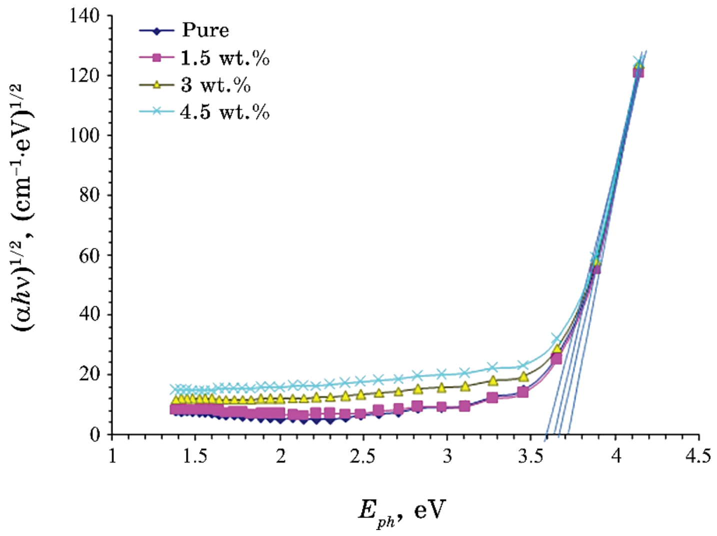


**Fig. 4.** Energy-gap values for allowed indirect transition.

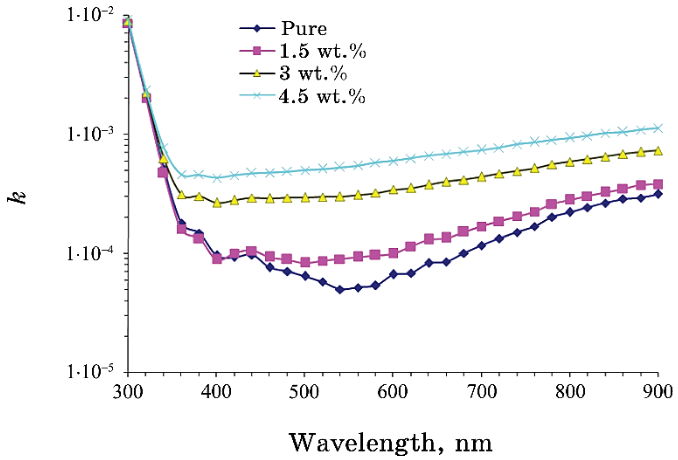


**Fig. 5.** Extinction coefficient variation with wavelength for $SiO_2$/PVP/$SnO_2$ nanosystem.

tions' formation in the nanosystem. These imperfections create the localized levels in the band gap [22–24].

Figure 5 represents the extinction coefficient variation with wavelength for $SiO_2$/PVP/$SnO_2$ nanosystem. From this figure, the extinction coefficient of PVP film rises with the rise in $SnO_2$ NPs' ratio and wavelength of photon. The increase in $k$ is attributed to the rise of the absorption coefficient [25–28].

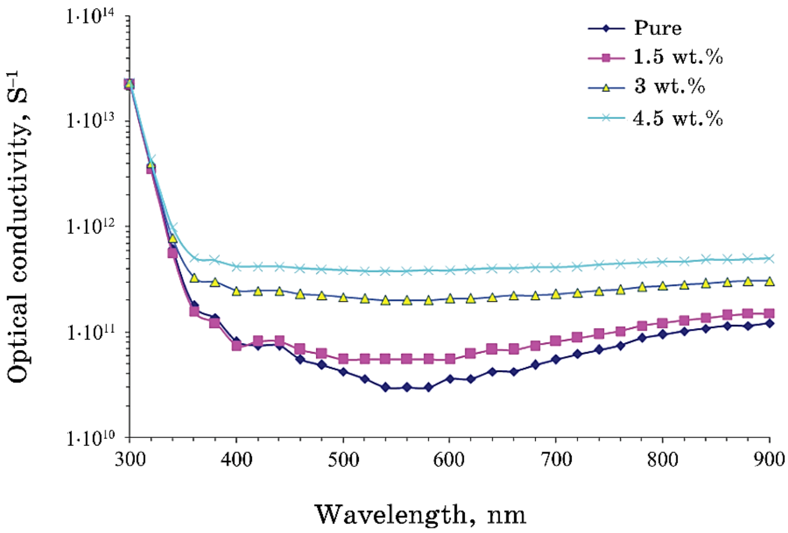


**Fig. 6.** Optical conductivity of $SiO_2$/PVP/$SnO_2$ nanosystem.

Figure 6 demonstrates the optical conductivity of $SiO_2$/PVP/$SnO_2$ nanosystem. The optical conductivity of PVP increases with rising $SnO_2$ NPs' content that is related to increase of the localized-states' density in the band structure; therefore, the coefficient of absorption increases, and, hence, the conductivity of optical will increase with rise in the nanoparticles' content and photon energy [29, 30].

## 4. CONCLUSIONS

In this work, shields of high-energies-absorbing materials were fabricated to attenuate the high photons' energies for bioenvironmental applications with high attenuation, low cost and lightweight. These shields are fabricated from $SiO_2$/PVP/$SnO_2$ nanosystem. Results indicate that the fabricated nanomaterials have higher absorption for high-energies' radiations. The optical characteristics of PVP polymer were enhanced with the rise in $SnO_2$ NPs' ratio.

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