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- RESEARCH ARTICLE-

Investigation of Optical Properties of TiO_2 Nano Powder

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Abstract

In this study, the production of TiO_2 nanoparticles was carried out nano material production device. The optical properties of the TiO_2 nanopowder produced were investigated. Nanostructures of synthesized TiO_2 were well crystallized at high concentrations and the forbidden energy range was 3.219 eV. The mean transmittance of the semiconductor metal oxide TiO_2 in the visible region was calculated as 89.72 %. The mean reflectance value in the visible region was calculated as 79.31%. As a result, it is stated that the TiO_2 nanopowder produced can be used in the production of nanooptic and electrooptical instruments.

Keywords:
Metal oxide TiO_2, Nanopowder, Optical properties.
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Introduction

Due to its excellent optical properties, titanium dioxide (TiO_2) has recently been on a rising trend (Yakuphanoglu., 2012; Yıldırım., 2018). In addition, the optical properties of the semiconductor metal oxide TiO_2 can be enhanced by adding to the structure from the outside to the desired level. TiO_2 is also used extensively in gas sensor applications (Yakuphanoglu., 2012; Hendi & Yakuphanoglu., 2016). TiO_2 nanopowder also plays an important role in heterogeneous tool application (Soylu et al., 2016). The pure TiO2 has a bandwidth of approximately 3.2 eV (Fujishima & Rao, 2000). In addition, TiO_2 thin films have unique properties. These films are mostly produced by sol-gel method in terms of being cheap and easy to apply. This method is considered to be one of the most suitable methods for producing a qualified metal oxide gel. This

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method is also often used in the production of TiO2-based thin films (Yamazoe & Shimizu1986; Medina-Valtierra et al., 2006).

Experimental Details

Nano structured TiO2 powders were synthesized using FYRTONIX nanomaterial production system, as shown in Fig. (1). Chemical precipitation method was used for the production of the powder sample. In this method, 12 ml of titanium (IV) isoproxide was taken and dissolved in 10 ml of isopropanol. Then 150 ml of de-ionized water and 5 ml of citric acid were added to this mixture and stirred at 80 °C at 1000 rpm for 4 hours. In the event of coagulation, concentrated citric acid (1:10 citric acid-water solution) was kept ready and 1 ml was added to the mixture where necessary. After 4 hours, a viscous solution was obtained, and after drying the solution at 100 ° C for 10 hours, the resulting precipitate was roasted at 450 ° C for 2 hours. The poasted precipitate pulverized by grinding in a mortar.

Figure 1. FYTRONIX nanomaterial production device

Result and Discussion

Optical Properties of TiO_2 Nano Powder

The variation of the transmittance (T) and reflectance (R) curve of pure Titanium dioxide (TiO_2) nano powder according to different wavelengths are given in Fig. 2(a) and 2(b) respectively. The mean transmittance of the semiconductor metal oxide TiO_2 in the visible region was calculated as 89.72 %. As shown in the graphic, the transmittance showed a sudden increase in wavelengths between 400 and 500 nm and then remained constant at 96% levels with an insignificant increase. Parameters such as the crystallinity, viscosity, thickness and surface roughness of the structure influences the transmittance of the synthesized TiO_2 powder (Balakrishnan et al., 2013). The reflectance curve of the TiO_2 powder sample is given in Fig. 2(b). The mean reflectance value in the visible region was calculated as 79.31%. The reflectance between 380 and 450 nm showed a linear increase up to about 77%, after this point, it showed a partial increase. The transmittance and reflectance percentages are consistent with studies on TiO_2 thin films (Sarıgul & Sorar, 2016). Visible peaks after 600 nm wavelength in reflectance curves are due to absorption intensity. To determine the optical band range of the TiO_2 nanoparticle we synthesized, diffuse reflection spectroscopy can be used. This method allows us to have knowledge of the absorption properties of thin film samples. In this study the optical band spacing of the TiO_2 sample was determined according to the diffuse reflection spectra. It is clear from Fig. 5(b) that the reflectance value decreases with decreasing wavelength after 400 nm and then remains constant. The reflectance value can be determined by the following Equation 1 with the help of the Kubelka-Munk function (Escobedo Morales et al., 2007; Yakuphanoglu, 2010).

$$F(R)=\frac{(1-R)^2}{2R} \tag{1}$$

Here *R* is diffused reflection, *F(R)* is the Kubelka-Munk function corresponding to the absorbance. The specified *F(R)* values are converted to linear absorption coefficient (Yakuphanoglu, 2010; Yakuphanoglu, 2012). Optical transitions of semiconductor materials are characterized as direct and indirect transition. The absorption coefficient (α) of the produced semiconductor materials is used to determine the band structure and the forbidden energy range. The relationship between the absorption coefficient (α) and the photon energy ($h\upsilon$) can be determined using the following equation 2 (Karthik et al., 2010):

$$(\alpha h\upsilon)=\left(\frac{F(R)h\upsilon}{t}\right)=B\left(h\upsilon-E_g\right)^n \tag{2}$$

Here *B* is a constant, E_g band range energy, *n* is an index that characterizes the optical absorption process. The *n* parameter has 1/2 for direct transitions and 2 for indirect transitions. In Fig. 3(b), the optical band range can be determined directly from the ($h\upsilon$) versus $(\alpha h\upsilon)^2$ curves. In this study, the optical band range of the pure TiO_2 powder sample was found to be 3,219 eV. In a study by Yakuphanoglu (Yamazoe et al., 1986), the optical band spacing of TiO_2 powder synthesized by sol-gel calcination method was found to be 3.17, and the reported forbidden energy range value coincides with the value we found. Also It is clear from the absorbance graph of the TiO_2 nanoparticle shown in Fig. 3(a) that there is little scattering at sub-band-range wavelengths of 400 nm and that absorption after 360 nm decreases.

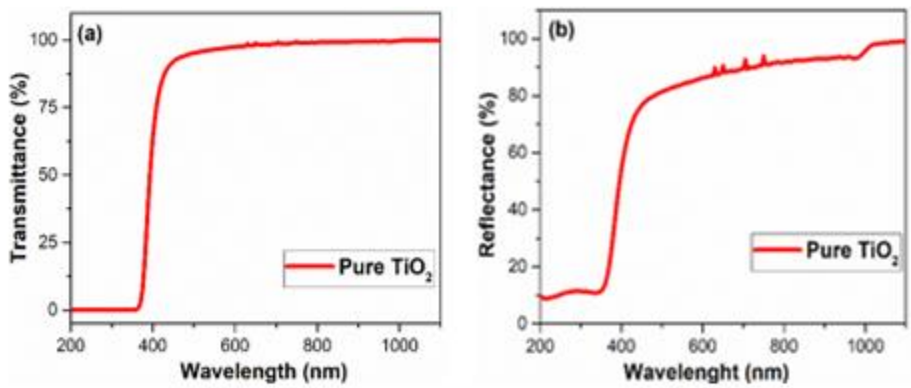

Figure 2. a) Optical transmittance spectrum of pure TiO_2 nanostructures as a function of wavelength b) Diffuse reflectance spectra of pure TiO_2.

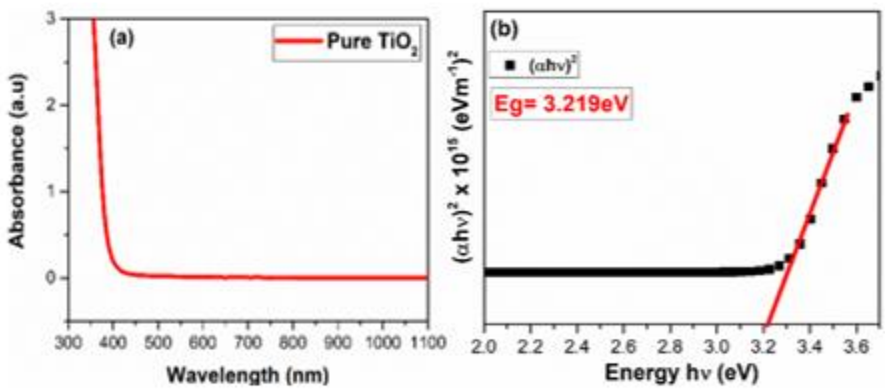

Figure 3. Produced pure of TiO_2 powder a) UV-Vis absorption spectra b) Energy band range graph.

Conclusions

In the first part of this study, the optical properties of the produced TiO_2 nanoparticle such as transmittance, reflectance and absorbance were investigated between 200 nm and 1200 nm wavelength. The mean transmittance and reflectance percentages of TiO_2 powder in the visible region were found as 89.72% and 79.31%, respectively. In addition, as a result of the measurements made, the forbidden energy range of the produced TiO_2 powder was calculated 3,219 eV. It was concluded that the produced TiO_2 nano powder can be used in the production of nanooptic and optoelectronic instruments.

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Conflict of Interest: The author declares that he has no conflict of interest.

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