



Synthesis of zinc oxide nanofibers and Acoustic absorption coefficient of zinc oxide with polyurethane foam

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Abstract

This research studied the synthesis of zinc oxide nanofibers by electrospinning method and the acoustic absorption coefficient of zinc oxide. Zinc oxide nanofibers have attracted the attention of researchers and industrialists in various fields due to the potential applications of semiconductor, optical, piezoelectric, and pyroelectric properties. In this research, the synthesis of zinc oxide nanofibers was carried out at a temperature of 500 degrees, and according to the analysis, zinc oxide nanofibers were prepared well. This research showed that the synthesis of zinc oxide nanofibers was formed in the best state by the electrolysis method. For this purpose, zinc oxide nanofibers were first prepared using zinc acetate and polyvinyl alcohol (PVA) precursors using the electrospinning method. Then it was placed in the oven at 500 degrees Celsius and finally, the obtained nanofibers were characterized using X-ray Diffraction (XRD), Scanning Electron Microscope (SEM), Visible-Ultraviolet (UV) Spectroscopy, and Photoluminescence Spectroscopy (PL), Fourier transform infrared spectrometry (FTIR) was studied. The results obtained from the analyzes showed that the synthesis of zinc oxide nanofibers with their optical properties was well-formed.

Keywords: nanofibers, zinc oxide, electrospinning, acoustic absorption coefficient

1. Introduction

Today, zinc oxide nanofibers are used in solar cells as semiconductors [1], lasers [2], field emitters [3], sensors [4], catalysts [5], and so on. have attracted a lot of attention. According to the surveys conducted in recent years, the use of nanomaterials to increase efficiency and also eliminate common weaknesses and barriers has attracted a lot of attention in the scientific and industrial communities. Zinc oxide nanofiber (ZnO) is a unique material that exhibits semiconductor [6], optical [7], piezoelectric [8], and pyroelectric [9] properties. In the same way, with the advancement of various technologies, including the emergence of nanotechnology, the production of fibers on a nanometer scale (nanofibers) has attracted the attention of many researchers and industrialists in various fields.[10] Of course, before the discovery of nanofibers, spider webs were considered the strongest material among natural and synthetic materials, but with the success of producing nanofibers, a huge change has occurred in the field of fibers. In general, there are several methods for producing nanofibers, some of which include the stretching method, separation of multicomponent fibers, mold method, blowing, phase separation, self-assembly of macromolecules, electrospinning, etc. Among them, the fibers produced by the electrospinning method are considered due to having a high surface area to volume ratio, high porosity and flexibility, small mass and thickness, thin diameter, light, resistance, and compatible with the environment. The results of research conducted by active researchers in the area of nanofiber production have shown the superiority of the electrospinning process over other methods.[11] The electrospinning process is preferable to other methods in terms of production speed, variety, continuity, simplicity, cost, and commercialization. Electrospinning is a method to produce polymer fibers with sub-nanometer diameters. In this method, both molten solution and polymer solution can be used to produce nanofibers. [12] In the electrostatic process, polymer solution or melt in a high voltage electric field is applied and the induced charge is applied as an electrostatic force on the polymer solution or melt, which is contrary to the surface tension force of the solution or melt. When the electrostatic force is greater than the surface tension force of the solution or melt, nanofibers [13] Electrospinning is a unique, simple, low-cost, and effective method for the production of polymer and ceramic nanofibers, and it is the only method that can be used for mass and continuous production of nanofibers. In particular, in many of these applications, the sensitivity and efficiency are proportional to the specific surface area, and the nanofibers produced by this method have approximately twice the specific surface area of the thin film of continuous films. In this research, the synthesis of zinc oxide nanofibers at a temperature of 500 degrees by the electrospinning method has been investigated.

2. Experimental method

1-2. Synthesis of zinc oxide nanofibers

Polyvinyl alcohol with molecular weight $M_w=145000$ g/mol, ethanol, and zinc acetate were prepared as raw materials. An aqueous solution of 6% by weight of PVA was prepared by



dissolving PVA powder in distilled water with vigorous stirring for 24 hours, and a zinc acetate solution was prepared by dissolving 1.5 grams of zinc acetate powder in the smallest possible amount of ethanol. These materials were kept for 48 hours. Put on a mixer to combine. After preparing the zinc acetate/polyvinyl alcohol polymer composite solution, it was time for the electrospinning process.

2-2. Electrolysis

After preparation, the intended solution was poured into a syringe (10 ml) with a steel needle whose head was smoothed using sandpaper (with an inner diameter of 1 mm). Finally, this syringe was installed on the syringe pump of the spinning machine so that the pump can remove the desired solution from the needle head of the syringe with a feeding rate of 0.04 ml/hour. The distance between the needle head and the collector was 10 cm for all experiments. To spin the solution and form the nanofiber, the tip of the needle was connected to the potential difference source. This power source for spinning gives a potential difference of 10 kV to the desired solution. After the electrospinning process, the spun sample is collected from the collector and placed in the furnace for 24 hours. After that, it was analyzed using XRD, SEM, UV, PL, and FTIR processes.

3. Discussion and conclusion

1-3. XRD spectrum analysis

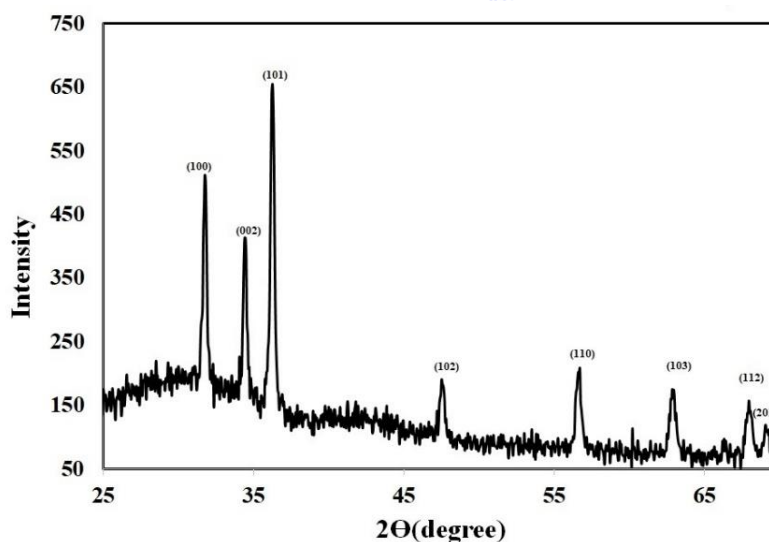


Figure 2. X-ray diffraction (XRD) pattern

The XRD diffraction spectrum of zinc oxide nanofibers is shown in Figure 2. The intensity, size, and position are determined by analyzing the XRD results. About 8 diffraction peaks at angles of 27, 33, 35, 47, 56, 63, 67, and 68 degrees are observed. Crystal plates (100), (200), (101), (102), (110), (103), (112), (201) were formed. The broadest diffraction and the most intense peak are observed in the peak (101). The only material obtained is related to ZnO and no other impurities have been observed. Of course, this does not mean that all the obtained samples contain only pure ZnO, but there may be There are amorphous anomalies that cannot be detected by XRD analysis.

2-3. SEM image analysis

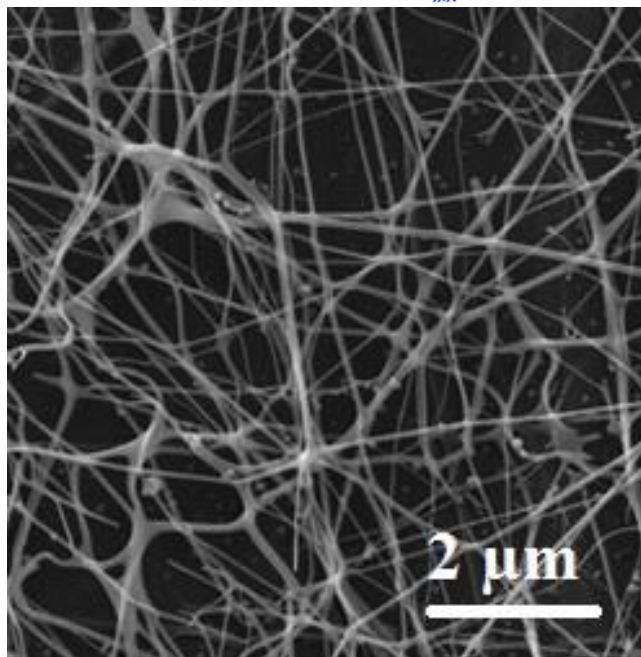


Figure 3. SEM image of zinc oxide nanofiber composite

Figure 3 shows the nanofibers synthesized at a temperature of 500°C. The morphology of the homogeneous particles is well shown. It seems that after calcining the fiber at a temperature of 500°C, the fibers have a rougher surface due to the crystallization of zinc oxide at this temperature, and they are more uneven. This figure shows that zinc oxide nanofibers using zinc acetate material can be of the nanosize scale.

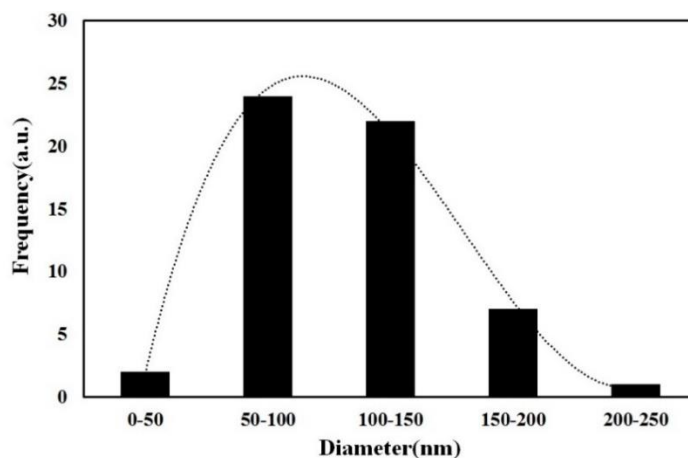


Figure 4. Diameter distribution diagram of zinc oxide nanofiber composite

3-3. UV-vis spectrum analysis

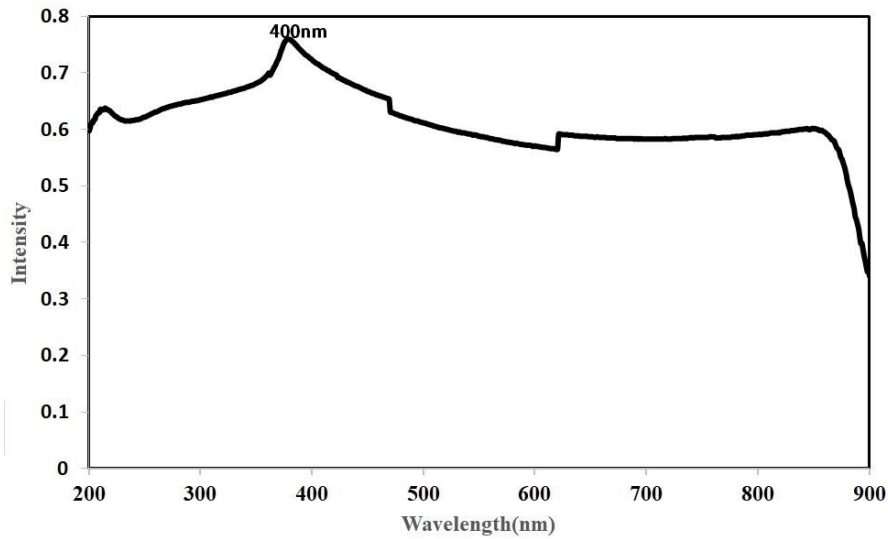


Figure 5. UV-vis spectrum of zinc oxide composite nanofibers

The UV-vis absorption spectrum of zinc oxide nanofibers produced at 500°C is shown in Figure 5. Here, the peak was observed in the range of 400 nm. This shows that there is a high ability to absorb ultraviolet rays. Therefore, the synthesized nanofiber has a high absorption ability in the region of 300 to 400. UV-vis absorption technique is usually very widely used to investigate the optical properties of nano-sized particles. ZnO nanofibers are significantly below the bandgap frequency of 376nm ($E_g = 3.29\text{eV}$), the bandgap energy of the synthesized sample. By using relationships you get.

$$E_g = h\nu_g = \frac{hc}{\lambda_g}$$

Here $h = 4.14 \times 10^{-12}\text{eVs}$ and $c = 2.99 \times 10^8\text{ms}^{-1}$

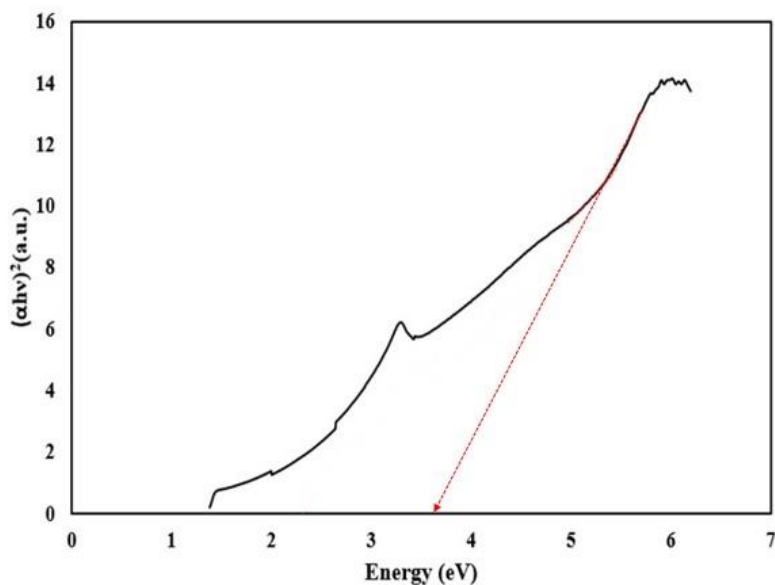


Figure 6. Band gap diagram of zinc oxide nanofiber composite

3-4. PL spectrum analysis

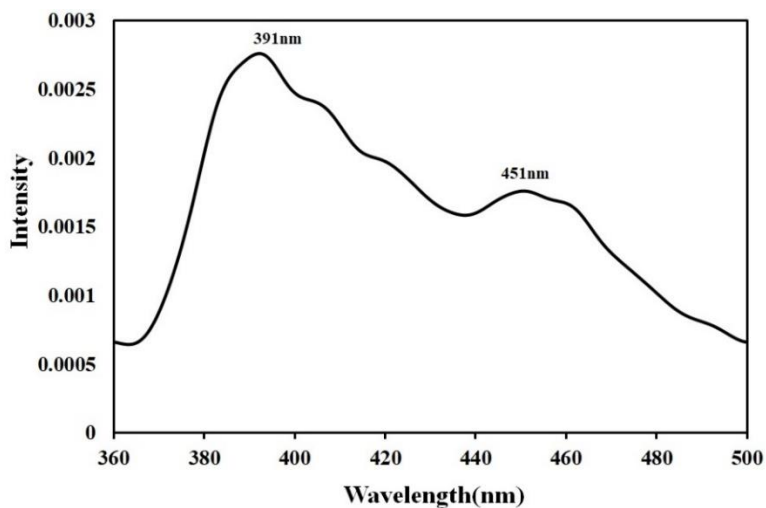


Figure 7. PL

To check the optical properties and identify the emission region, the synthesized sample of the photoluminescence spectrum was taken. For this purpose, the electrons were excited with a wavelength of 380 nm. As can be seen in the photoluminescence spectrum of Figure 7, the absorption peak is in the regions of 391 and 451 nm.

5-3. FTIR spectrum analysis

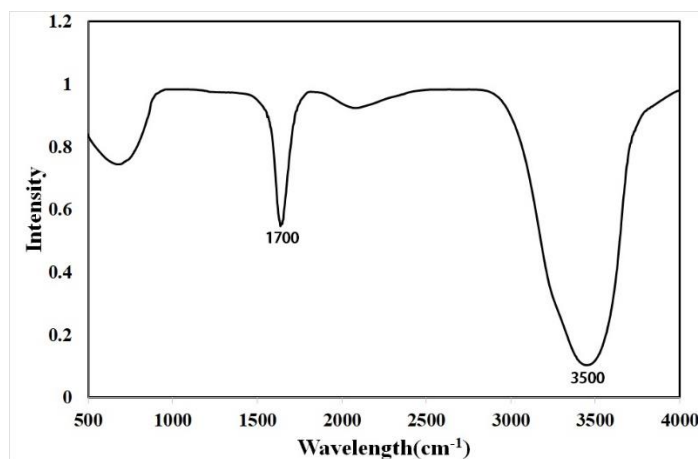


Figure 8. FTIR spectrum of zinc oxide composite nanofibers

The nano and other potential functions of the produced zinc oxide nanofibers were investigated using Fourier transform infrared (FTIR). Is. O-H stretching vibrations appeared in the range of $3500[cm]^{-1}$. The peak appeared in the range of $1700 [cm]^{-1}$ due to the symmetric stretching of the C=O bond.

Currently, the measurement of sound absorption coefficient is done using a device called impedance tube [14],[15]. The use of the impedance tube itself has two methods: 1) the static wave method and 2) the transmission function method to measure the acoustic absorption coefficient of materials [16]. In this experimental study using static wave method based on available equipment and to measure the sound absorption coefficient using an impedance tube in accordance with ISO10534-1 has been done. The transfer function method is a very fast method that requires more equipment [17, 18,19, and 20].

As shown in Figure 1, in this study, to measure the acoustic absorption coefficient of polyurethane foam, the impedance tube was constructed consisting of a polyethylene pipe with a length of 1.75m and a diameter of 90 mm, a speaker, a microphone, and an acoustic meter. This device is made in such a way that at the end of the sample (foam) and the beginning of the speaker and inside it there is a microphone that the microphone inside the tube is moved back and forth by a string. An audiometer is used to record the minimum and maximum sound that is produced and a computer

device to determine the frequencies. In this study, the frequency range of 0 to 4000 Hz was investigated) Figure1(.



Figure 9. Impedance tube

The sample (foam) was obtained from two combinations of poly and ISO. To prepare the sample (foam), two combinations of poly and ISO were used. These two materials, isocyanate, and polyol, were combined together until the foam foamed and rise, and finally, we cut the foam by 5 cm. The prepared foam was then placed in the impedance tube and measurements were performed to obtain the acoustic absorption coefficient of the foam. The following figure shows the acoustic absorption coefficient of a polyurethane prepared using an impedance tube.

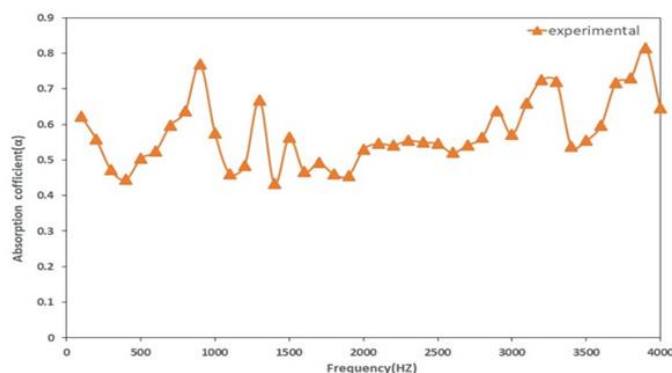


Figure 10. Sound absorption coefficient of zinc oxide with polyurethane foam

4. Conclusion

In this research, the synthesis of zinc oxide nanofibers by electrospinning method and the acoustic absorption coefficient of zinc oxide were investigated. In this research, thin nanofibers of zinc oxide were produced by calcining PVA zinc acetate composite fibers obtained from the electrospinning process at 500 degrees Celsius. The characteristics of the nanofibers obtained with

The use of X-ray diffraction (XRD), scanning electron microscopy (SEM), visible-ultraviolet (UV) spectroscopy, photoluminescence (PL) spectroscopy, and Fourier transform infrared spectrometry (FTIR) were studied. In this research, the synthesis of zinc oxide nanofibers was carried out at a temperature of 500 degrees, and according to the analysis, zinc oxide nanofibers were prepared well. This research showed that the synthesis of zinc oxide nanofibers was formed in the best state by the electrolysis method.

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