

## Control of Dielectric Constant and Anti-Bacterial Activity of PVA-PEG/x-SnO<sub>2</sub> Nanofiber

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**Abstract.** Research in the utilization of organic natural materials for electronic devices and for the biological application becoming extensively studied. We report a comprehensive review of the role of SnO<sub>2</sub> nanoparticle and the effect of light intensity on toxicity properties, antibacterial activity, microstructure and electrical properties of PVA-PEG nanofiber films. The PVA-PEG/SnO<sub>2</sub> nanofiber structure has been successfully fabricated on the ITO-glass substrate. Characterization was performed on samples using FTIR, XRD, SEM, toxicity and antibacterial tests, as well as LCR measurement. The presence of various light intensities has also measured the dielectric constant. The addition of SnO<sub>2</sub> nanoparticle influenced the structure of the PVA-PEG/SnO<sub>2</sub> nanofiber bonding functional group indicated by the appearance of Sn-O-Sn peaks at 648.08 cm<sup>-1</sup> and 958 cm<sup>-1</sup> wavenumbers. The addition of SnO<sub>2</sub> nanoparticles affects the grain size of SnO<sub>2</sub>. Addition of SnO<sub>2</sub> nanoparticles increases the detected toxicity voltage but is still below the threshold. It means the compound is not toxic, or safe to use in the body. The film lacks the antibacterial power of *S. Aurelius*. The addition of nanoparticles SnO<sub>2</sub> increases the dielectric constant but decreases with increasing frequency of input voltage and the intensity of light employed to PVA-PEG/SnO<sub>2</sub> nanofiber. The application of the light intensity reduces the dielectric constant of the PVA-PEG/SnO<sub>2</sub> nanofiber in all nanoparticle doping ranges.

**Keywords.** Dielectric constant, light intensity, nanoparticles, PVA-PEG/SnO<sub>2</sub> nanofibers, SnO<sub>2</sub>, and toxicity.

### 1. Introduction

Nanoparticle materials have shown a unique of physical, chemical, electrical properties, and magnetic properties [1]. Commonly, many researchers interest to nanoparticles materials especially on the metal oxide such as Fe<sub>3</sub>O<sub>4</sub>, organic material such as cellulose acetate, polyaniline and its composite [2, 3]. One of them is indicated by a well-known semiconductor of Tin (II) Oxide (SnO<sub>2</sub>). SnO<sub>2</sub> is an n-type semiconductor that has a non-stoichiometric structure and wide band gap ( $E_g = 3.6 \text{ eV}$  to  $3.8 \text{ eV}$ ) [4]. Also, SnO<sub>2</sub> has excellent optical and electrical properties. This oxide also relatively inexpensive, and not toxic [5]. In the previous research, SnO<sub>2</sub> is synthesized as powder, bulk, thin film. It also has kind



of surface morphology such as micro or nano spherical, fiber [6], rod [7], or wire [8]. SnO<sub>2</sub> nanofiber is applied as active material like anode of Li battery to enhance its specific capacitance [9–11]. On the other hand, SnO<sub>2</sub> as the primary precursor of synthesis nanofiber desire another material as a binder. Polymer regularly is used as binders such as PVDF [11] and PVA [11–13]. The function of the adhesive is giving elasticity on the nanofiber fabrication. Commonly, electrospinning method is used to fabricate fiber.

In the previous research, PVA-SnO<sub>2</sub> nanofiber has been synthesized well which obtain SnO<sub>2</sub> grain size about 100 nm to 300 nm and not homogeneous yield. Therefore, in this study will be done homogenization and reduce the size of a grain of PVA-SnO<sub>2</sub> nanofiber by adding PEG as a template.

Polyethylene Glycol (PEG) possesses indispensable unique properties in areas such as biological, chemical, biomedical, and pharmaceutical applications. PEG shows excellent features such as non-toxic, immunogenicity, biocompatible, and water-soluble [14]. SnO<sub>2</sub> nanoparticles composite with PVA-PEG polymer using electrospinning technique obtained PVA-PEG /SnO<sub>2</sub> nanofiber. Specific applications of the SnO<sub>2</sub> nanofiber in the health are diagnosing diabetes, and detecting lung cancer [14]. From our knowledge, it is still difficult to find a comprehensive study of the effects of SnO<sub>2</sub> nanoparticles and light intensity on dielectrics of PVA-PEG/SnO<sub>2</sub> nanofiber on which to open the possibility as a bio environmentally compatible and body bioactive sensors. Therefore, a series of studies on nanoparticle SnO<sub>2</sub> to nanofiber especially PEG is needed. In this paper, we proposed the effect of nanoparticles SnO<sub>2</sub> and light intensity on the dielectric constant of PVA-PEG/SnO<sub>2</sub> nanofiber.

## 2. Materials and methods

The synthesis of nanoparticles SnO<sub>2</sub> was performed by using coprecipitation method from SnCl<sub>2</sub>. The SnCl<sub>2</sub> powder as much as 8 g dissolved in ethanol (C<sub>2</sub>H<sub>5</sub>OH) as much as 25 mL at 60 °C and stirred about 30 min using magnetic stirrer. Acetyl Acetone was then added as much as five mL and inserted one mL of PEG 6000 then reflux at 80 °C for 5 h. Furthermore, the solution was allowed to stand for 72 h at 30 °C until the sole was formed, then dried at 100 °C for 3 h. After drying, it was then calcined at 400 °C for 1 h to create the nanoparticles. The next step was deposition of the nanofiber of PVA-PEG/SnO<sub>2</sub> using electrospinning technique.

The first step was to insert 4.3 mL of aquades into 10 mL beaker glass and stirred about 350 rpm at 90 °C for 15 min. Afterwards, introducing 3.5% SnO<sub>2</sub> nanoparticles of total volume, 111 µL of PEG 400, and 12.23 µL of TMAH. Subsequently, the mixtures were stirred at 350 rpm with a temperature of 90 °C for 60 min. When a homogeneous has reached, it followed by ultrasonic irradiation for 1 h using an ultrasonic bath. The obtained then incorporated a 0.5 g PVA and stirred 700 rpm at 120 °C for 60 min and sonicated again for 2 h. The solution then ready for electrospinning to fabricate a PVA-PEG/SnO<sub>2</sub> nanofiber

## 3. Results and discussion

The addition of the SnO<sub>2</sub> nanoparticles to the PVA-PEG nanofiber produces the PVA-PEG/SnO<sub>2</sub> nanofiber spectrum shown in Figure 1. The results of FTIR spectrophotometric characterization of nanoparticles SnO<sub>2</sub>, PVA Gohsenol, PEG 400, and PVA-PEG/SnO<sub>2</sub> nanofiber are shown in Figure 1. SnO<sub>2</sub> nanoparticles show transmittance peaks at 3391 cm<sup>-1</sup>, and 1568 cm<sup>-1</sup> which are associated to the vibration of stretching OH, while peaks at a wave number of 625, 930, and 1635 cm<sup>-1</sup>, indicating the appearance of the stretching mode of Sn-O-Sn [14], [15]. The PVA-PEG/SnO<sub>2</sub> nanofiber in Figure 1 has a similar peak shape such as in PEG 400 and PVA compared to SnO<sub>2</sub> nanoparticles. The indistinguishable from the mixture may be caused the number of nanoparticles is less than the amount of PVA, so the transmittance of PVA is stronger appears in the PVA-PEG/SnO<sub>2</sub> nanofiber. The spectra of PEG-400 at (845 to 900) cm<sup>-1</sup> indicates the presence of O-O stretching [16], whereas the presence of 1109 cm<sup>-1</sup> peaks indicates symmetry C-O-C on aliphatic ether. Spectral peak at 1352 cm<sup>-1</sup> shows the presence of deforming of C-H alkyl while 2882 cm<sup>-1</sup> indicates the presence of str-C-H alkyl stretching.

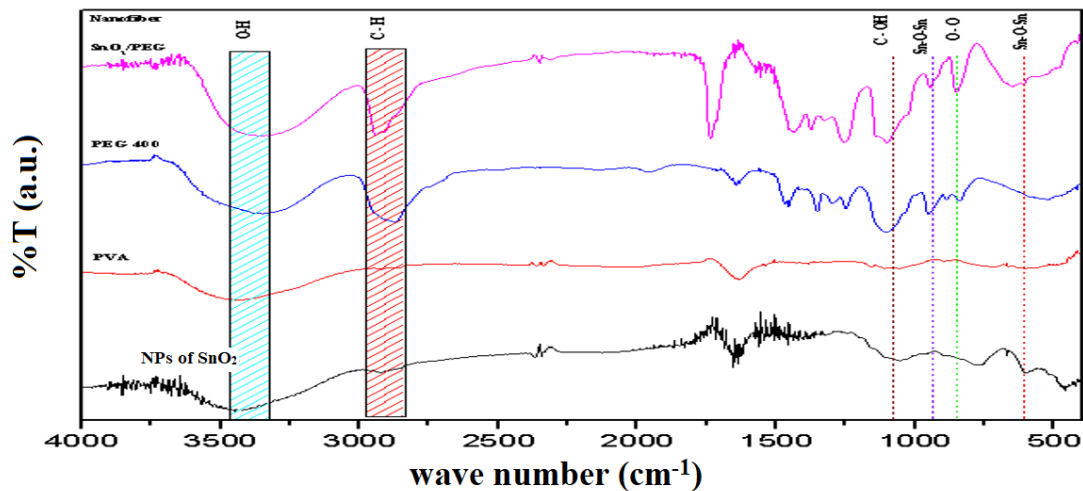


**Figure 1.** FT-IR Spectra of SnO<sub>2</sub> NPs, PVA, PEG, and PVA-PEG/SnO<sub>2</sub> Nanofiber.

### 3.1. Structure of PVA-PEG/SnO<sub>2</sub> Nanofiber Analyses

The diffraction patterns of PVA-PEG/SnO<sub>2</sub> nanofiber films is displayed in Figure 2. The X-ray diffraction pattern of nanoparticle synthesized by the sol-gel method is shown in Figure 2. X-ray diffraction pattern of nanoparticles of SnO<sub>2</sub> showed the result of crystalline according to the previous study [17]. The grain size of SnO<sub>2</sub> nanoparticles of 36.11 nm was obtained by diffraction using Origin program with PearsonVII function obtained FWHM value of 0.25182, then analyzed using Debye Scherer equation. Using the same method, the grain size of SnO<sub>2</sub> nanoparticles in PVA-PEG/SnO<sub>2</sub> nanofiber was 26.94 nm with the FWHM value of 0.33761. The SnO<sub>2</sub> nanoparticles were also analyzed using Rietica program with model data from AMCSO with code 2101853. We obtained that the lattice constant is  $a = b = 4.73735 \text{ \AA}$  and  $c = 3.18640 \text{ \AA}$ . With these values indicating that the SnO<sub>2</sub> nanoparticles fit with a tetragonal crystal structure under  $P4_2/mnm$  space group. The diffraction peak of the SnO<sub>2</sub> nanoparticles is positioned at a diffraction angle of 26.58°, 33.85°, 37.94°, 51.76°, 54.74° and 65.94°.

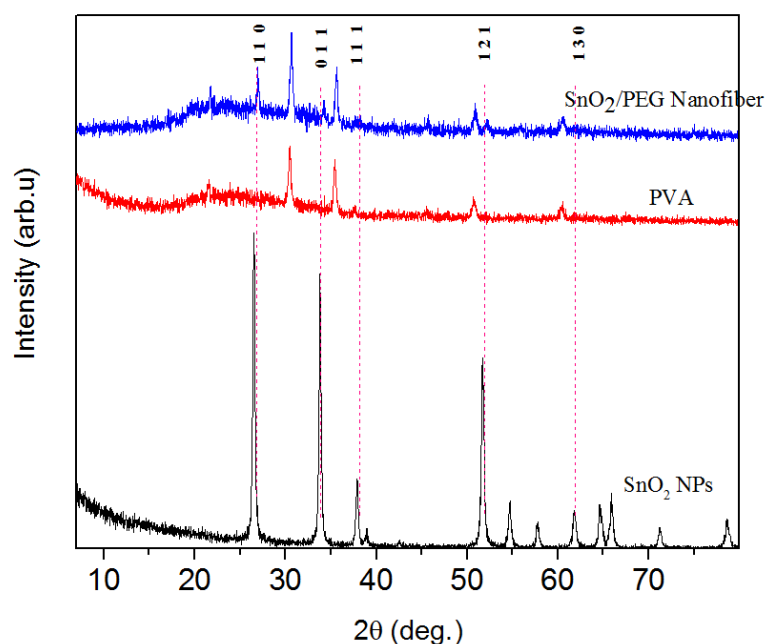


**Figure 2.** X-Ray Diffraction patterns of Nano SnO<sub>2</sub>, PVA, and PVA-PEG/SnO<sub>2</sub> Nanofiber

### 3.2. Micro structure and morphology of PVA-PEG/SnO<sub>2</sub> nanofiber

A typical EDAX and SEM image of PVA-PEG/SnO<sub>2</sub> Nanofiber is shown in Figure 3. Information from EDAX in Table 3 shows the element of comparison between C, O, and Sn of 11.96 %, 29.46 %, and 03.53 %. Elements C and O are elements of the formation of PEG, while the Sn element comes from the doping given [18]. Based on the information, it shows the formation of PVA-PEG / SnO<sub>2</sub> nanofiber in the presence of C, O, and Sn compositions.

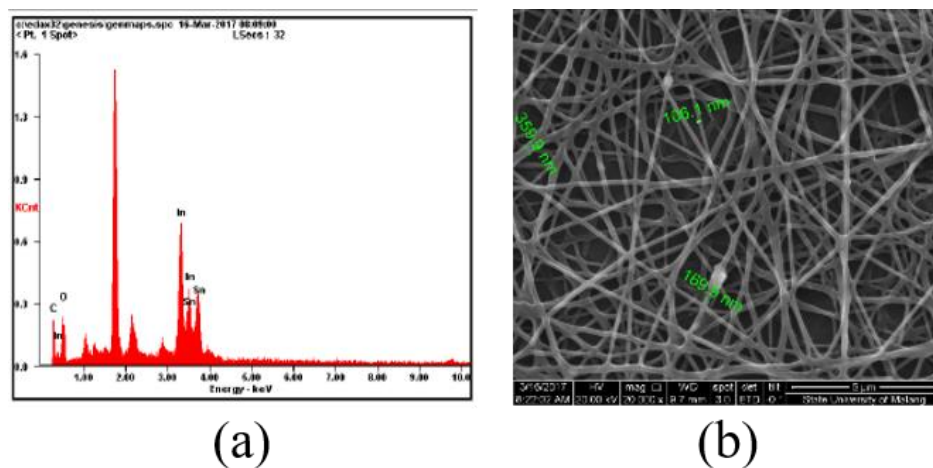


**Figure 3.** EDAX analyses (a) and SEM image (b) of PVA-PEG/SnO<sub>2</sub> nanofiber

### 3.3. Toxicity test of PVA-PEG/SnO<sub>2</sub> Nanofiber

All series of PVA-PEG/SnO<sub>2</sub> Nanofiber have been tested for their toxicity using animal intestinal mus musculus. An example of them is presented in Figure 4. Present a record of intestinal contractions in animals Mus musculus shows the intestine contracts indicated by the wave peaks. In Figure 4 is a record of regular intestinal contractions when compared with intestinal contractions when sampled in Figure 4, the contractions do not change significantly. Based on this, the composition of the PVA-PEG/SnO<sub>2</sub> nanofiber variation sample did not cause the rejection response to the organ.

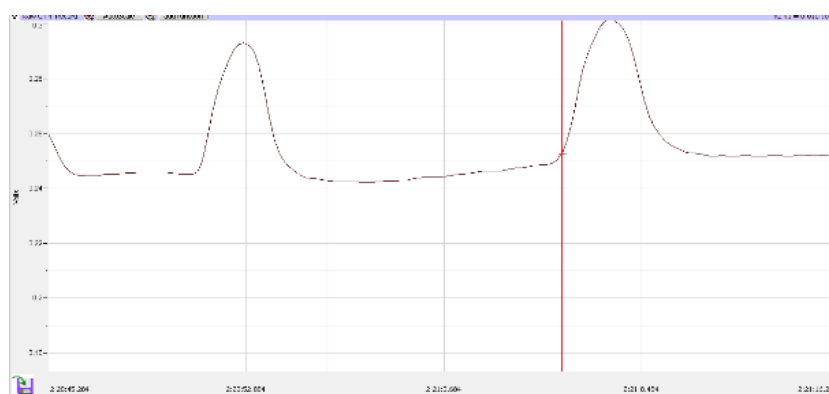


**Figure 4.** Example of intestinal contraction record after inserting PVA-PEG/SnO<sub>2</sub> Nanofiber

### 3.4. Antibacterial activity of PVA-PEG/SnO<sub>2</sub> Nanofiber

An example of antibacterial activity for E. Coli of PVA-PEG/SnO<sub>2</sub> Nanofiber is shown in Figure 5. Based on an antibacterial test using S.Aureus bacteria from PVA-PEG/SnO<sub>2</sub> nanofiber did not show the antibacterial power of the material in the absence of clear zone in Figure 5. From the previous study, the antibacterial activity of nanoSnO<sub>2</sub> particles using E.Coli bacteria with different

concentration of solution indicated the clear presence zone [19, 20]. When compared with antibacterial trials using *S. Aureus* bacteria there is no clear zone; this suggests the antibacterial ability of SnO<sub>2</sub> nanoparticles present in *E. coli* bacteria.



**Figure 5.** A typical pictogram of Antibacterial PVA-PEG/SnO<sub>2</sub> Nanofiber for E.Coli

### 3.5. Dielectricity

The prepared samples have been characterized using LCR meter for various frequency. The real part of dielectric constant for all samples of PVA-PEG/SnO<sub>2</sub> Nanofiber are presented compactly in Figure 6. Further analyses were performed for dielectric measurement using LCR meter at various light intensity is depicted in 7.

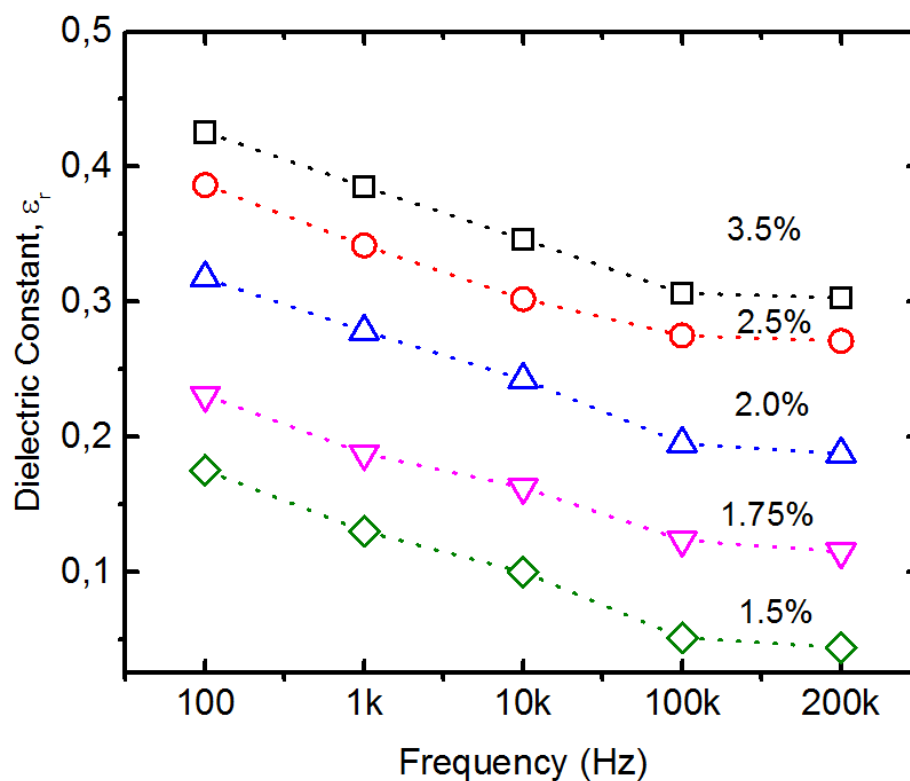


**Figure 6.** The dielectric constant as a function of Nano SnO and Frequency of PVA-PEG/SnO<sub>2</sub> Nanofiber

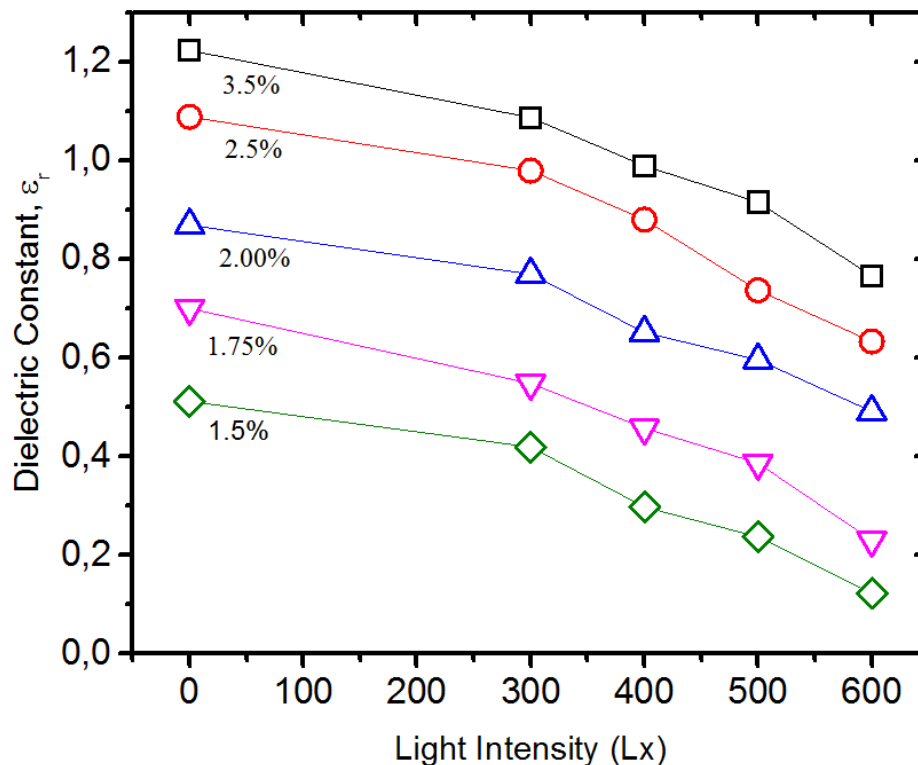


**Figure 7.** Dielectric constant of different light intensity PVA-PEG/SnO<sub>2</sub> Nanofiber

The higher the intensity of light employed, the dielectric constant decreases. The influence of light on the dielectric constant shows the interaction between light and sample. The light impinges on the sample provides the energy give rise to the excitation of electrons in the atom. This situation produces an atomic swelling that occurs as the radius of the atom gets more prominent. As the ionic radius increases, the electron binding energy becomes weaker, allowing for the electrons to be more easily oriented by the electric screw. In other words, in the view of electronic polarization, to produce the same displacement required a smaller electric field. That is why the dielectric constant decreases.

#### 4. Conclusions

Addition of nanoparticles SnO<sub>2</sub> increases IR spectra, increasing Sn-O-Sn peak in PVA-PEG/SnO<sub>2</sub> nanofiber. The addition of nanoparticles SnO<sub>2</sub> affects the stress of toxicity test in PVA-PEG/SnO<sub>2</sub> nanofiber, but not toxic when applied to the body. The addition of nanoparticles SnO<sub>2</sub> does not change the clear zone of antibacterial assays using *S. Aureus* microorganisms, so the PVA-PEG/SnO<sub>2</sub> nanofiber has non-antibacterial properties. The addition of nanoparticles SnO<sub>2</sub> the more significant the dielectric constant. The addition of light intensity given the PVA-PEG/SnO<sub>2</sub> nanofiber the smaller the dielectric constant.

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