Synthesis and morphology of polyvinyl alcohol /zinc sulfide nanocomposite

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Abstract. Polyvinyl alcohol (PVA) nanocomposites have been synthesized. The nanocomposites which prepared by sol-gel method were mixed to various concentrations of PVA using magnetic stirrer bar of 500 rpm at 80°C. After the solvent evaporates, the white suspensions were casted on to a flat metal and the film-like composites formed. Those samples were characterized including tensile for mechanical test follow ISO-527-2 and melting points for thermal analysis using DSC operated at 20°C/min with the temperature range of 30-300°C. The most homogeny and Young modulus samples were obtained at ratio 98:2 w/w % of PVA/ZnS, and the highest melting point were found at ratio 97:3% of PVA/ZnS.

1. Introduction

Nanotechnology describes the knowledge about the system as well as the proportion of equipment nanometers. One nanometer is equal to one millionth of a millimeter. Nanotechnology has been impact in science and engineering as well as each side of human life. Many people believe nanotechnology is able to cure the majority of medical diseases in humans. Indeed, most of the application of innovation in the field of nanotechnology is currently only speculative and theoretical, but already many are becoming practical applicative. For example, carbon nano-tubes, tubular carbon molecules are structurally unique and have the properties of electric currents better. Carbon nano-tubes has been applied to the high-resolution screen and reinforce the materials in the industry. Other practical applications of nanotechnology those are for packing, the health and automotive sector [1-3].

The nanoparticles used in the prevention of dirty clothes on the surface where the feathers attached with nano size so similar to taro leaf surface. Polymer nano sizes ranging from 10 nm to 100 nm is used for exterior wall paint, adhesives, paper coatings, upholstery fabrics, cosmetics as well as retaining UV rays. Retaining sunlight is also an example of the use of nanoparticles. It caused UV rays can be easily to disperse and adsorb to nanoparticles. The use of light barrier is very widespread in Australia to dominate the market by 60%. Nanoparticles of aluminium used to mix propellant (fuel) which is able to accelerate the burning of up to two times. Nanocopper mixed lubricating oil to prevent engine wear. Nanocalsium and phosphate composite is used as synthetic bone substitute human bone. The use of composites has advantages such as: lightweight, corrosion resistance, longer service life and has high elasticity properties. Nanoparticle technology, particularly in semiconductors has been expanding applications in biological and biomedical fields. Compound semiconductor nanoscale dimensions can be used as sensors to the cells of the human body, capable of detecting the cancer so that treatment would be more effective [4-8].

Polyvinyl alcohol (PVA) is one type of hydrophilic polymer that is widely used in various fields, especially chemistry, pharmaceuticals and health. PVA can be mixed with other materials to obtain a composite that better suit its usefulness [9]. Gea (2010) [10] has been mixing PVA with bacterial cellulose increase Young's modulus, Campos [11] mixing PVA with silver (Ag) to obtain a higher conductivity properties. Zhang *et al.,* (2011) [12] adds graphene oxide on PVA to produce a composite that has high tensile strength. The products produced as a result of this process generally has good physical properties, non-toxic and have the ability to absorb the relatively high water and biocompatible [13]. PVA hydrogel crosslinked is one of the PVA polymer modified. The hydrogel has a three-dimensional network structure which allows the inclusion of other substances into it. Therefore, the hydrogel matrix used for immobilization drugs, cells, enzymes, and polysaccharides [14].

PVA hydrogel is one type of hydrogel which in recent years have been developed for applications both for the purposes in the field of chemistry, health and biomedicine. It has unique properties, among others,PVA is sensitive to temperature and has a transition temperature of 58^{o}C with partially hydrolyzed to 85^{o}C with a degree of hydrolyzed. Because the melting point of PVA is relatively low, it is necessary to have an amplifier that can improve the physical properties of the material. So in the research, the addition of ZnS improved the mechanical and thermal properties of PVA/ZnS nanocomposite.

2. Materials and Methods

Materials used in this study are zinc asetat 99%, Thiourea 99%, Polyvynil Alcohol 98% each of Merck Darmstadt Germany. Tools used in this study are X-Ray Difraction (Philips Analitycal PW 1710 Based), Scanning Electron Microscopy (SEM) (Zeiss and JOEL Model), Universal Testing Mechanic (Laryee Universal Testing Mechine Wdw-10 model), Differential Scanning Calorimetry (Mettler Toledo type 821).

The method used for the manufacture of nanocomposite PVA/ZnS is a sol-gel method. PVA weighed 20 g dissolved in 200 mL of distilled water and stirred using a magnetic stirrer while heated with a hot plate until late at all. ZnS nanoparticles weighed 0.2 g (1% weight) dissolved in 200 mL of distilled water and stirred until dissolved. Both of these solutions incorporated into the three-neck

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flask and stirred using a magnetic stirrer with a speed of 500 rpm while heated with a hot plate to a temperature of 80ºC. After distilled water evaporates and thickens like a gel solution, inserted into the glass mold that has been formed and allowed to dry and harden. The procedure is repeated with variations PVA:ZnS at ratio (100:0)%, (99:1)%, (98:2)%, (97:3)%, and (96:4)%. According to Mikrajuddin (2008) [15], percentage weight of nanoparticulate inserted very small about 0.5% to 5%. Samples were formed according to the sample test, tensile test to ISO 527-2 and DSC test with ASTM D3418-03. SEM used to determine the morphology of the sample surface.

3. Results and Discussion

Nanocomposite PVA/ZnS have been synthesized by sol-gel method. The product was formed in ISO 527-2 tensile testing with a length of 26 mm, 4 mm wide and 1.124 mm thickness. Every sample was made 5 pieces for each variation to obtain more accurate results and the resluts of measurements be averaged. Sample with only PVA seem translucent and transparent. Sample with a mixture of PVA and variations ZnS nanoparticles white colored slightly darker than the sample with only PVA. With only 1% mixture of ZnS nanoparticles are visible differences in terms of color samples, as well as for samples with a mixture of PVA and ZnS nanoparticles (98:2)%, (97:3)% and (96:4)% more white color and not transparent, this is due to the amount of nanoparticles are mixed more.

Tensile test was performed to determine the tensile strength, elongation at break, strain and Young's modulus. These samples were tested by tensile test equipment UCT with 5 variations mixture of PVA and ZnS nanoparticles. Recording the results of tensile tests nanocomposite PVA/ZnS nanoparticles to a mixture of PVA and ZnS.

Figure 1 shown Young’s modulus represent of most reckoned by mechanic properties because it representing comparison of stress and strain, this properties show the delaying of a material. The Young’s modulus of mixture PVA and nanoparticle ZnS at 98:2 % wt. The addition of 2% ZnS will multiply the number of cross-linking between the molecular chains that affect mechanical properties. It shown the largest Young's modulus obtained on the composition of PVA: ZnS (98:2)% which is 190.73 MPa. So the composition of the obtained ZnS 2% greater stress and smaller strain. PVA with a little amount of crosslinking will be relatively soft and flexible with the amount of the PVA crosslinking more. A reduction in compressive strength with the addition of PVA was also reported in previous research studies [16].

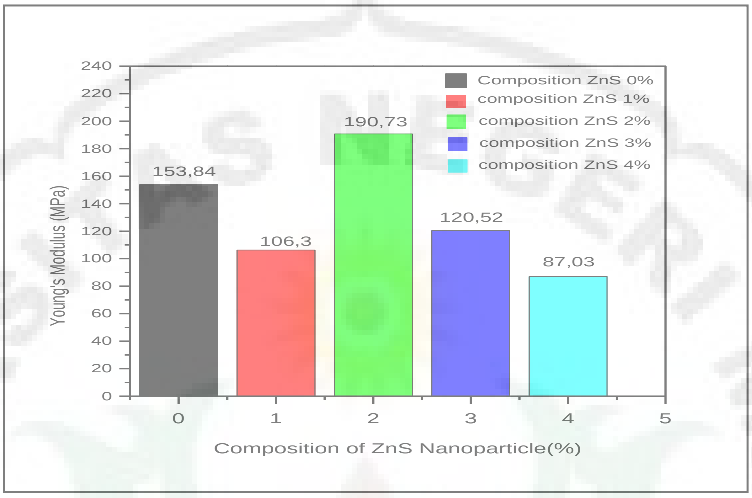

Figure 1. Bar charts Young's modulus of the composition of ZnS nanoparticles.

Thermal tests performed using diferential scanning calorimetry (DSC) to determine the melting point of the nanocomposite PVA/ZnS. DSC analysis with a mass of 6.8 mg using nitrogen gas with a flow rate of 20 mL / min and the heating rate was 20 °C/min. For the nanocomposite sample variation between PVA and ZnS nanoparticle mixture (0,1,2,3,4)% obtained thermogram results as Figure 2. It can be seen that in general the addition of nanoparticles gives rise from the melting point, but in the nanocomposite mixture of PVA/ZnS (98:2)% and (96:4) % are down. It can be caused by uneven mixture of nanoparticles and also the process of making that less than the maximum, in terms of mixing and drying. Greatest value of the melting temperature of the mixture contained in the nanocomposite PVA/ZnS in composition (97:3) % is 224.39 ^{0}C.

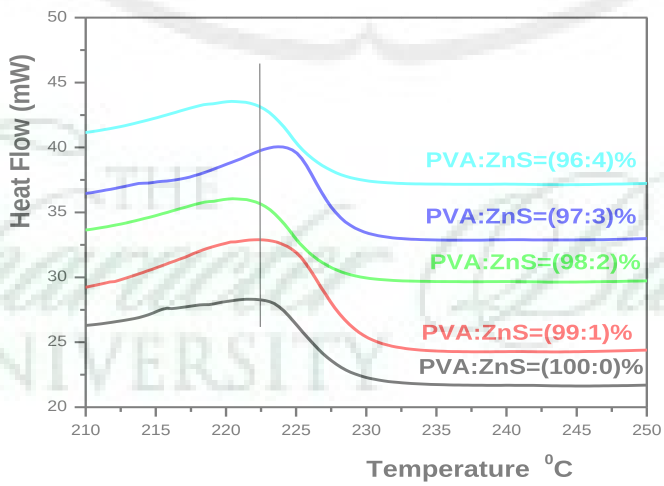

Figure 2. DSC thermograms of PVA/ZnS nanocomposite with ZnS composition of 0, 1, 2, 3, and 4%

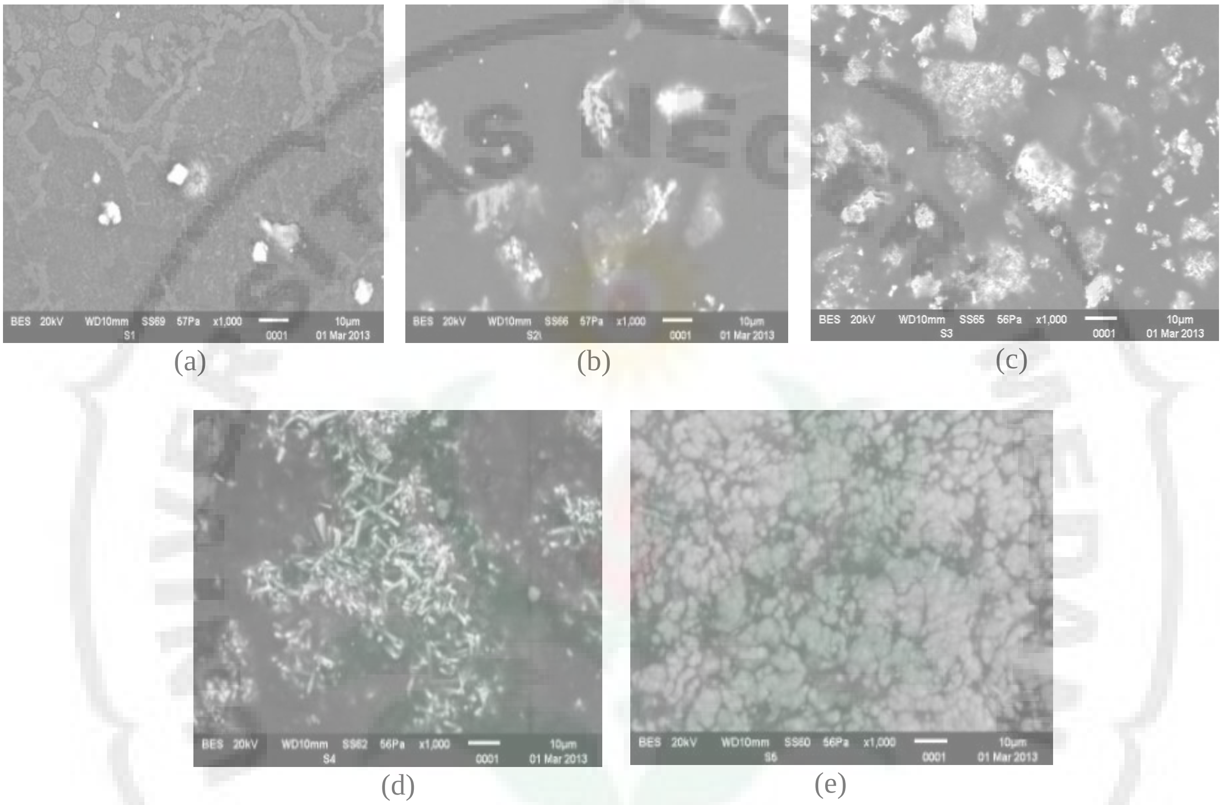

Figure 3. SEM morphology of PVA/ZnS nanocomposite with (a) 0%, (b) 1%, (c) 2%, (d) 3%, and (e) 4% ZnS in x1000 magnification.

The result of Figure 3c is better than other variations mixture made. The morphology of the surface has a uniform and homogeneous mixture. The results of mechanical tests also obtain better mechanical properties in this mixture. It is seen from Figure 3 that PVA/ZnS nanocomposite hydrogel with 2% ZnS contains lot of micro holes and the ZnS powder particles are uniformly distributed in the PVA matrix and well packed by the hydrogel. However, many micro holes minimize and even close because of the lower water content. For PVA/ZnS nanocomposite hydrogel with 2% ZnS, there exist some ZnS nanoparticle agglomerates. In other variations mixture have agglomeration of ZnS at some point. This occurs due to less than perfect stirring and heating unevenly. SEM results also linear with respect to the results of testing mechanical properties. This suggest the addition of nanoparticles causes an increase in its mechanical properties PVA/ZnS nanocomposite hydrogel with 2% ZnS contains). Although in some samples decreased upon the addition of nanoparticles, is seen on the addition of the composition of ZnS 1, 3, and 4%. This occurs due to the increase in areas that do not interact, so that the material is not increased mechanical strength [17].

4. Conclusion

Based on the results of research and discussion in the manufacture of nanocomposite Polyvinyl Alcohol (PVA) with a mixture of PVA and the composition of ZnS nanoparticles of 0, 1, 2, 3 and 4% is concluded as follows:

The results mechanical tests of PVA/ZnS nanocomposite to a mixture of PVA and the composition ZnS (98:2)% gained an average of the largest Young's modulus is 190.73 MPa. In this mixture also obtained morphology uniform and homogeneous. Thermal properties is better occur in the composition (97:3)%, obtained by the melting temperature of 224.39 °C with enthalpy 15.1036 J/g and the heat of 93.642 mJ.

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