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Characterization of Nanocomposite Mixture Polyvinyl Alcohol and Rice Husk Ash

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ABSTRACT

Rice husk ash (RHA) nanoparticles were prepared to be applied as a filler in the formation of Polyvinyl Alcohol (PVA) nanocomposites. The manufacture of rice husk ash nanoparticles involved the Ball Mill method and the coprecipitation method, while the manufacture of Polyvinyl Alcohol nanocomposite membranes and rice husk ash was carried out by the sol-gel method. The results of XRD analysis using Match software indicated that the crystal structure of rice husk ash is monoclinic with a particle size of 16.55 nm. The mechanical test results obtained the largest elastic modulus of 29.28 MPa in 3% rice husk ash mixture, the largest tensile test of 8.83 MPa in 1% rice husk ash mixture, and the largest elongation at break of 82.08% in 4% rice husk ash mixture. The addition of rice husk ash as a filler can improve the mechanical properties of PVA/rice husk ash nanocomposites.

Keywords: nanocomposite, PVA, rice husk ash, filler

INTRODUCTION

Rice husk is one of the agricultural wastes that has not been widely used as a product that has added value (Christopher, et al., 2017). Rice husk ash is a waste obtained from burning rice husk which contains silica. This rice husk is burned at high temperatures to produce pure silica content of 86.9–97.2%. Rice husk ash contains chemical components namely SiO_2, CaO, Na_2O, K_2O, Al_2O_3, and MgO. The higher the combustion temperature, the higher the pure silica content (Abdul, et al., 2020).

Rice husk ash has been used in mortar to improve physical and mechanical properties (Mahmud, et al., 2016) in addition to mixed cement and aggregate recycling (Qiang Su, et al., 2023; Musa, et al., 2022; Srinivasreddy, et al., 2013 Rice husk is mixed with animal dung to produce biogas (Ali, et al., 2016) and rice husk ash is used as an adsorbent for heavy metals and catalysts (Malahayati, 2021; Taha et al., 2014).

Rice husk ash has been synthesized as a nano-catalyst in producing biodiesel (Hazmi, et al., 2021) and a nano-bifunctional super magnetic catalyst (Balkis, et al., 2020). The addition of rice husk ash composition affects the physical and chemical properties of the compost, whereas the addition of rice husk ash improves the physical and chemical properties of the compost (Hisham and Ramli, 2019).

One type of environmentally friendly polymer the application of which is increasing and being observed is polyvinyl alcohol (PVA). The main functional uses of PVA include filtration, catalysts, membranes, optics, enzyme mobilization, and tissue engineering (Silverio, 2013) when mixed with rice husk ash, it can be employed in ultrafiltration and dye removal (Khairul, et al., 2022; Haq, et al., 2020). PVA has several superior properties, including oxygen resistance, mechanical properties, chemical resistance, film-forming ability, and water solubility (Tian, et al., 2017). PVA is an excellent material as an emulsifier and adhesive for a material because it is colorless, odorless, non-toxic, and has elasticity, flexibility, as well as high oxygen content (Goodship, et al., 2009). PVA is the most widely produced polymer today, especially for industrial fiber applications, especially in pharmaceutical, biomedical, biochemical applications, due to its biocompatibility, biodegradability, and water-soluble properties (Liu, et al., 2016).

The addition of nanocellulose to PVA films improves mechanical and thermal properties (Qiu, et al., (2012; Ibrahim, et al., 2010). The ability of nanocellulose to improve film characteristics is influenced by the size, diversity, source, nanocellulose content, and plasticizer. Sirait, et al. (2021) synthesized limestone mixed with polyvinyl alcohol to obtain a nanocomposite membrane that has good mechanical properties in a 1% mixture. Polyvinyl alcohol is used as a matrix to be mixed with collagen as a wound dressing to prevent bacterial growth in the wound as well as accelerate wound healing and growth of new tissue (Sudirman, et al., 2020). This study aimed to utilize rice husk ash as a filler to produce nano-composites that can improve their mechanical properties.

MATERIALS AND METHODS

Materials

The main materials used in this study were rice husk and fully hydrolyzed polyvinyl alcohol Sigma Aldrich, 5M HCl, NH_4OH Emsure Merck, and *Aquadest Pro Analysis*.

Methods

Synthesis of rice husk ash nanoparticles

Rice husk was cleaned and dried and then burned using a furnace at 700 °C for 2 hours. Then it was milled with a Ball Mill for 6 hours until smooth to obtain nanoparticle size. After that, the rice husk ash was chemically cleaned with 5M HCl with a 300 rpm magnetic stirrer for 4 hours and stirred with NH_4OH solution until the pH was neutral, then filtered through filter paper and dried in the oven.

Preparation of nanocomposites PVA/RHA

Preparation of polyvinyl alcohol nanocomposite membranes with a mixture of rice husk ash using the sol-gel method. Polyvinyl alcohol was weighed in the amount of 20 g and then dissolved in 200 ml of distilled water, and rice husk ash was dissolved in distilled water then both were mixed while stirring with a magnetic stirrer on a hot plate and heated at 80 °C to form a gel, then placed into the mold and released until dry. Rice husk ash powder (RHA) mixed with polyvinyl alcohol (PVA) with variations in composition (PVA: RHA) are (100:0)%; (98:2)%; (96:4)%; (94:6)% and (92:8)%. After that it was characterized by XRD test to determine its structure, SEM for morphology. Samples were formed with ASTM D636 type 5 for mechanical testing with the Universal Testing Machine.

RESULTS AND DISCUSSION

The results of the synthesis of rice husk ash using the ball mill and coprecipitation method are shown in Figure 1. Figure 1a) Rice husk ash in a furnace at 700 °C for 2 hours has a reddish color. Figure 1 b) is the result after chemical cleaning in a ball mill and is whitish and finer in color.

The XRD used has a Cu-Kα wavelength of 1.54056 Å with the resulting pattern as shown in Figure 2. The size of the resulting rice husk ash nanoparticles is 16.55 nm with a density of 2.250 g/cm^3. The content of rice husk ash is mostly composed of silicate hydrate, silicate oxide, and aluminum phosphate. In Figure 2 it can be seen that the peak of the highest pattern is at 2θ of 19.58°, 20.50°, 21.72°, 36.04°. The resulting crystal structure is monoclinic with crystal planes (dhkl) [0 0 4] and lattice parameters are as follows: a is 25.9190 Å, b is 5.0040 Å, c is 18.5400 Å.

Figure 3 is the morphology of the rice husk ash particles that have been synthesized at 1,500× and 5,500× magnification. From Figure 3(a) it can be seen that the rice husk ash particles are uneven and have lumps, this is also clarified in Figure 3(b) with a magnification of 5,500×. The particle size is still not homogeneous as can be seen from the presence of lumps that form on the surface, where the obtained surface is uneven and has lumps. This is due to imperfect synthesis processes such as in terms of ball mills, and less stable mixing during coprecipitation and heating. This is confirmed by the research of Nurdin, et al (2023).

Mechanical test using Universal Testing Machine with ASTM D638. This tool can determine the tensile test, elongation at break, and Young's

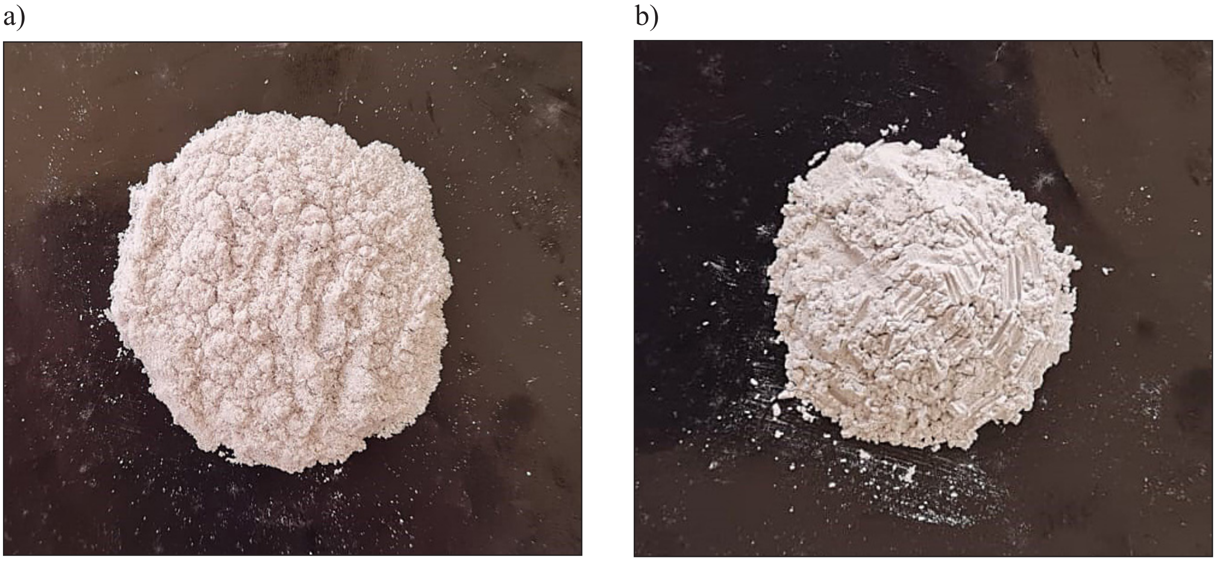

Figure 1. Rice husk ash results (a) furnaces and (b) ball mills

modulus. The results of the mechanical test characterization of the nanocomposite mixture of polyvinyl alcohol and rice husk ash with variations in the composition of rice husk ash (RHA) were 0%, 1%, 2%, 3%, and 4% as shown in the following graph.

Figure 4 shows the relationship between tensile strength and the composition of RHA. The highest tensile strength was found in the addition of 1% composition RHA is 8.83 MPa, while the lowest tensile strength was in the composition of 3% rice husk ash is 7.31 MPa. From the graph above, it can be concluded that the more rice husk ash is added to polyvinyl alcohol, the more the tensile strength tends to increase (Pereira, et al., 2014).

Figure 5 shows the relationship between the elongation at break and the composition of rice husk ash, where the highest elongation at break was 82.02% with the addition of 4% composition RHA. Thus, the addition of rice husk ash to polyvinyl alcohol can increase the flexural properties of nanocomposites, this is also according to the research by Pakravan, et al., 2018. Meanwhile, the lowest elongation at break was 25.47% with the addition of 3% RHA. A decrease in elongation at break can occur due to a lack of homogeneity when the process of mixing rice husk ash with a solution of the polyvinyl alcohol composite or the pore size of the nanocomposite is too high.

Figure 6 shows the relationship between Young's Modulus with the composition of rice

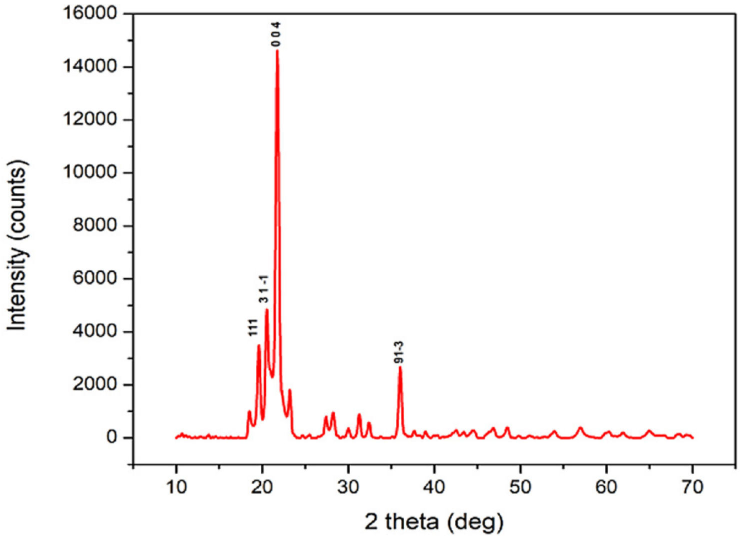

Figure 2. XRD difractogram rice husk ash

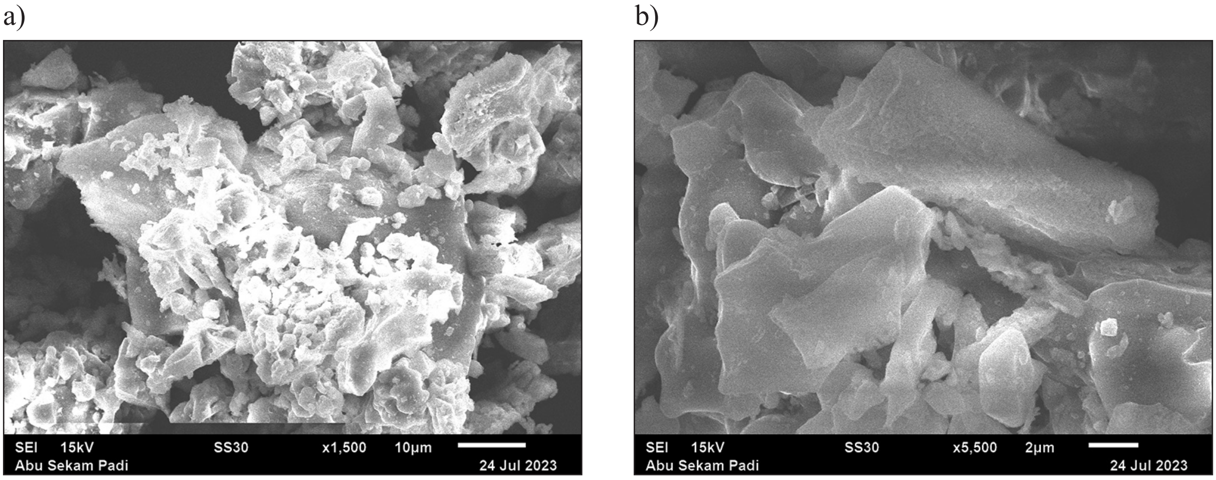

Figure 3. Morphology of rice husk ash with magnification: a) 1,500×; b) 5,500×

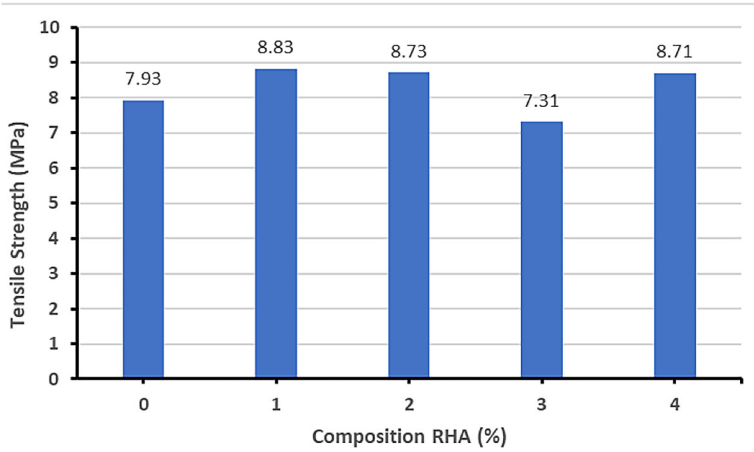

Figure 4. Tensile strength with composition RHA

husk ash, where the highest Young's Modulus is found in the addition of 3% rice husk ash, which is 29.28 MPa. Meanwhile, the lowest Young's Modulus was found in the addition of 4% rice husk ash, namely 10.76 MPa. It can be concluded that the addition of rice husk ash to polyvinyl alcohol can improve its mechanical properties, namely Young's modulus, where a 3% mixture produces 29.28 MPa higher than without other mixtures and mixtures. From the three figures above it can be seen that if the tensile strength is greater and the elongation at break is small, Young's Modulus

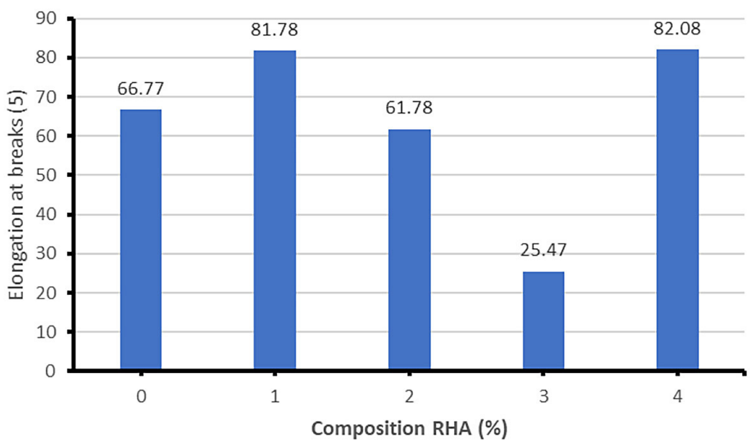

Figure 5. Elongation at break with composition RHA

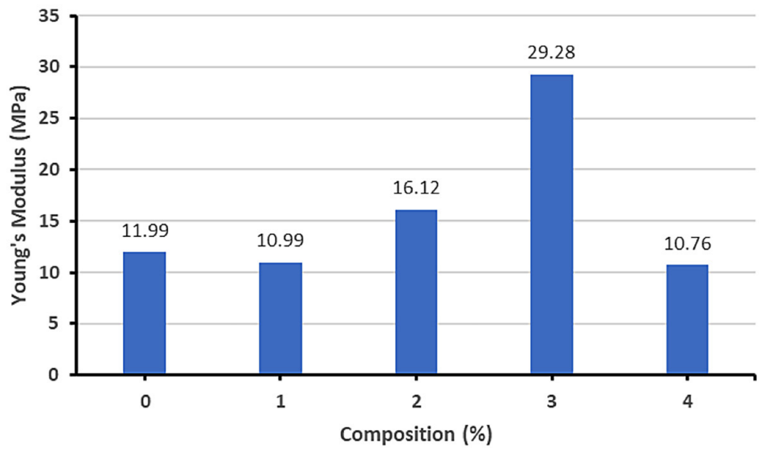

Figure 6. Young's modulus with composition RHA

is greater. In the composition of 3% rice husk ash, it can be seen that the mixture of rice husk ash is also more evenly distributed and the nanocomposite membrane has better features. The addition of rice husk ash to polyvinyl alcohol can improve modulus Young's and tensile strength (Ain, et al., 2020; Roohani, et al., 2008).

CONCLUSIONS

The results of the synthesis of rice husk ash using the ball mill method obtained a size of 16.55 nm, a monoclinic structure with the majority content of silicate hydrate, silicate oxide, and aluminum phosphate. The SEM results indicated that the morphology of the husk ash was still uneven and agglomeration or clumps still occurred. The mechanical test results obtained the largest elastic modulus of 29.28 MPa in 3% rice husk ash mixture, the largest tensile test was 8.83 MPa in 1% rice husk ash mixture and the largest elongation at break was 82.08% in 4% rice husk ash mixture. The addition of rice husk ash affected the tensile strength and Young's modulus, the more rice husk ash, the higher the tensile strength.

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