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MECHANICAL PROPERTIES OF HIGH-DENSITY POLYETHYLENE (HDPE) WITH TiO_2 NANOPARTICLE FILLER PEG 6000

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ABSTRACT
Titanium dioxide (TiO_2) is a semiconductor material that has great stability so that it can be utilized as a filler material for High Density Polyethylene (HDPE) thermoplastics. This study was conducted to determine the effect of TiO_2 PEG 6000 nanoparticle filler composition on the mechanical properties of HDPE thermoplastics. TiO_2 was synthesized with sol gel method and then mixed with PEG 6000. Nanocomposites are made by mixing HDPE with TiO_2 nano filler in a rheomixer tool with variations in filler composition (2, 4, 6, 8, 10) %wt, then molded using injection molding tools with ASTM 638 type V standards and analyzing mechanical properties using UTM (Universal Testing Machine) test equipment which includes tensile strength, elongation at break and elastic modulus. The results of XRD analysis produced a particle size of 22nm and SEM tests showed that the surface of TiO_2 nanoparticles had a smooth and even surface. The sample with 8% wt filler composition variation is the sample with the best tensile strength value of 84.72 MPa, the highest elongation at break value in the sample with 4% filler of 35.5% and the highest elastic modulus in the sample with 8%wt filler composition of 729.33 MPa.Keywords: Titanium dioxide, HDPE thermoplastic, PEG 6000, Tensile test.

Keywords: Lava Effect, Mount Sinabung, Subsurface Structures, Geoelectricity, Landsat Image

INTRODUCTION

The development of the times is accompanied by technology that creates practical materials with durability. This has led users to attempt to create materials with enhanced strength while maintaining a lighter weight. Nanomaterials possess several advantages in physical and chemical properties compared to bulk materials, and currently, the development of methods for synthesizing nanoscale materials is an area that attracts the attention of many researchers (Abdullah, Virgus, et al., 2008). Nanomaterials can form naturally or can also be created by humans. The synthesis of nanomaterials refers to the process of creating materials with particle sizes of up to 100 nm and altering their properties or functions (Abdullah, Si, et al., 2008).

Plastic is one of many types of macromolecules formed through the process of combining several simple molecules (monomers and polymers), a process known as polymerization. Plastics can be divided into two categories: thermoplastics and thermosetting plastics. Thermoplastics are plastics that will melt when heated to a certain temperature and are easily recyclable as they can be reshaped simply by reheating. In contrast, thermosetting plastics can only be formed once; unlike thermoplastics, thermosetting plastics cannot be melted repeatedly through heating (Gultom, 2019).

Previous research on HDPE includes a study (Gea, 2015) that investigated HDPE mixed with Fe3O4 (magnetite) nanoparticle fillers derived from iron sand. The results showed the best mechanical testing outcomes, including a tensile strength of 22.145 MPa, a fracture elongation of 16.963 mm, and a Young's modulus of 643.20 MPa for sample compositions with filler weight percentages of 2%, 2%, and 6%. To determine the mechanical properties, tensile testing, as well as SEM and XRD tests, were conducted to assess the physical properties of the HDPE thermoplastic nanocomposites.

RESEARCH METHOD

Location, Material and Tool

Sample preparation, processing, and testing were conducted at the Physics Laboratory of Medan State University, the National Research and Innovation Agency (BRIN) in Cibinong, and the Mechanical Engineering Laboratory of the University of North Sumatra from March to May 2023.

The tools used include a furnace, ball mill, digital scale, magnetic stirrer, HAAKE rheomixer, ASTM 638 type V injection molding machine, sieve, beaker, measuring cylinder, filter paper, dropper, oven, XRD, SEM, and tissue. The materials used are TiCl4, HDPE, PEG 6000, aquades, NH4OH, and ethanol.

Preparation of TiO_2 Nanoparticles with PEG 6000

The nanoparticles produced using the sol-gel method are mixed with PEG 6000 in a composition of 15 g of TiO_2 and 45 g of PEG, which is then filtered and dried in an oven at 60°C for 2 hours.

Preparation of HDPE Nanocomposites

The HDPE thermoplastic is mixed with TiO_2 PEG 6000 filler using a rheomixer at a speed of 60 rpm and a temperature of 150°C for 10 minutes.

Table 1. Composition of nanocomposite mixture in the rheomixer

Bahan	Komposisi				
	S_1	S_2	S_3	S_4	S_5
HDPE	98	96	94	92	90
TiO_2 Peg 6000	2	4	6	8	10

S= sampel

The resulting mixture is then placed into an injection molding machine following ASTM 638 type v standards.

RESULT AND DISCUSSION

Result

The results of the SEM test on the TiO_2 PEG 6000 nanoparticles show that the surface structure is smooth and uniform.

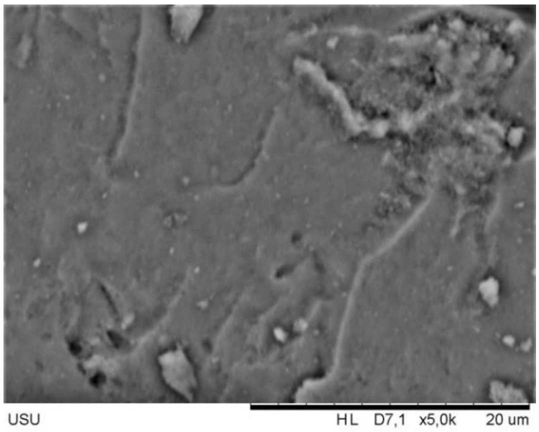

Figure 1. SEM Test Results of TiO_2 PEG 6000 Nanoparticles

Based on the results of mechanical testing conducted with a universal testing machine (UTM), which includes tensile strength, elongation at break, and elastic modulus, the findings are presented in the following table.

Table 2. Data on the Mechanical Properties Testing of Nanocomposites

Sample	Tensile strength (Mpa)	Elongation at break (%)	Elastic modulus (Mpa)
Sample 1	74.45	30.65	675.62

Sample 2	80.11	35.30	669.89
Sample 3	56.24	29.06	522.79
Sample 4	84.72	34.10	729.33
Sample 5	67.20	31.45	565.22

From the tensile test results, the HDPE/TiO_2 PEG 6000 nanocomposite data is presented in a graph processed using Microsoft Excel, as shown in the following figure.

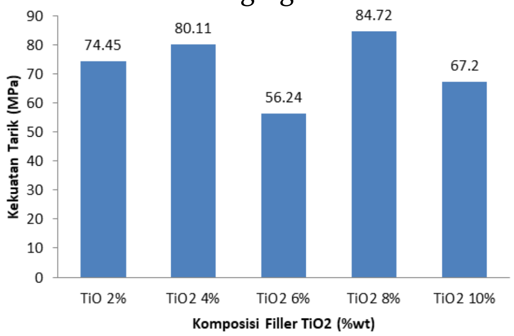

Figure 2. The Relationship between Tensile Strength and the Composition of TiO_2 PEG 6000 Nanoparticles

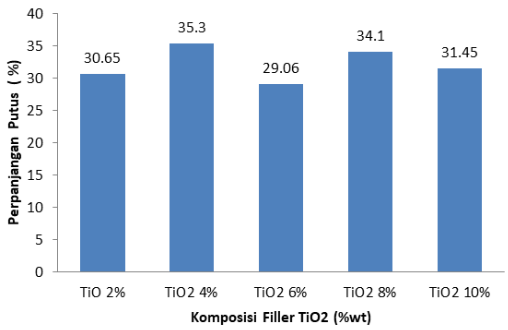

Figure 3. The Relationship between Elongation at Break and the Composition of TiO_2 PEG 6000 Nanoparticles

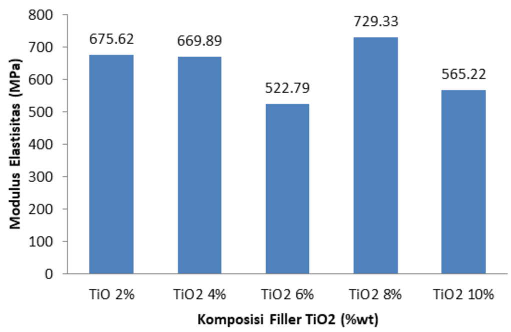

Figure 4. The Relationship between Elastic Modulus and the Composition of TiO_2 PEG 6000 Nanoparticles

Discussion

After conducting SEM analysis using ImageJ software, TiO_2 PEG 6000 nanoparticles with a size of 22 nm were obtained. The mechanical testing data for each sample revealed that the sample with the highest tensile strength was the one with an 8% wt filler composition, measuring 84.72 MPa. The highest elongation at break was observed in the sample with a 4% wt filler composition, measuring 35.3%, and the highest elastic modulus was obtained in the sample with an 8% wt filler composition, measuring 729.33 MPa. In the study by Batee (2023), a composite of HDPE with palm oil boiler ash (ABKS)/TiO_2 (70/30) showed the highest tensile strength of 66.60 MPa, the highest elongation at break of 14.19%, and the highest elastic modulus of 1.50 GPa. The addition of TiO_2 PEG 6000 nanoparticle filler resulted in increased tensile strength and elongation at break compared to the previous study using ABKS/TiO_2 filler.

CONCLUSION AND SUGGESTION

Conclusion

Based on the mechanical property tests conducted, the best tensile strength was obtained in sample S4 with a composition of HDPE/filler (92/8) measuring 84.72 MPa. The best elongation at break was found in sample S2 with a composition of HDPE/filler (96/4) measuring 35.5%, and the best elastic modulus was achieved in sample S5 with a composition of HDPE/filler (92/8) measuring 729.33 MPa.

Suggestion

The TiO_2 PEG 6000 samples should be dried again to prevent clumping during SEM testing. In future research, efforts should be made to ensure that the resulting mixture is homogeneous and does not clump to obtain more accurate data.

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