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The Influence of Alkali Treatment and Multi Fraction Cantala Fiber Reinforced Carbon Nanotube Composite on Mechanical Properties and Morphological

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The aim of the study was to determine the effect of alkali treatment and multi-fraction on tensile strength, flexure, modulus of elasticity, SEM, and water absorption in composites reinforced with carbon nanotubes. The fibers were extracted manually from 9 months old cantala leaves. 6 wt% sodium hydroxide and distilled water were prepared to soak the fiber for 6 hours. The fibers were dried in the open air for 72 hours and put in an oven for 6 hours at 60 ºC. Carbon nanotubes (CNT) were mixed with unsaturated polyester (UPRs) with a composition of 5% by weight and stirred using a magnetic stirrer with a rotational speed of 250 r.p.m, at a temperature of 40 ºC, for 30 minutes. Composite molding uses a vacuum infusion process system. The results showed that the alkaline treatment of the fiber increased the tensile and flexural strength. Morphologically, the fiber is cleaner because it has been removed from hemicellulose, pectin and other amourphus. The addition of CNT to the composite is able to close the holes in the composite so that its strength increases. Water absorption shows that the fiber has not been alkaline, it absorbs more water.

Keywords: Cantala fiber; CNTs; mechanical properties; composite

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Agave was a fiber-producing plant that grows in Yogyakarta, Sulawesi and West Java. Agave plants are grouped into 3 namely ageve sisalana, cantala, and agustifolia [1]. Agave fiber is obtained from the decortication of the separation of agave fibers and leaves. Agave cantala has a leaf length of 132 cm, a leaf width of 10.48 with a plant age of 9 months. Agave cantala fiber is extracted by manual extraction. This process is used to extract fiber from the leaves without damaging the components that bind cellulose, namely hemicellulose, pectin, lignin, and other impurities. The use of natural fibers as a substitute for synthetic fibers continues to be developed in the manufacture of natural fiber composites. Utilization of natural fiber as a composite reinforcement has many advantages such as unlimited availability, biodegradability, and high toughness [2]. Environmentally friendly, low price, renewable, energy efficient, high rigidity, renewable, difficult to decompose, many types and variations [3]. Lack of natural fiber as a composite reinforcement is not abrasive, polarity is too high, and lack of compatibility with polymer [4] Various approaches have been made to improve fiber and matrix compatibility with various treatments such as permanganate, alkali, silane [5, 6], fumigation [7]. Alkali treatment has been able to show coexistence in treating natural fibers so that they can bind to the polymer matrix, so as to improve the mechanical properties of the composite [8, 9]. The addition of carbon nanotubes as reinforcement can increase the strength of the matrix because the small size is able to close the voids in the composite. Dispersion homogeneity of CNT/polymer composite has been able to improve the mechanical properties of fibers in the interaction between polymer and CNT, able to control the number of CNTs and improve orientation in the matrix [10]. The formation of multi-fraction in the fiber is expected to improve the mechanical properties of the composite.

MATERIAL DAN METHOD

Materials

Agave cantala fiber was obtained from local farmers in Kuloprogo, Sleman, Yogyakarta, Indonesia. The fibers were extracted manually from the fibers, cleaned with running water and dried at room temperature for 96 hours. Sodium hydroxide (NaOH) and aquades were obtained from CJ Kimia Purwokerto. Unsaturated polyester with type Yucalac BQTN 157 with a density of 1.2 gram/cm^3 and Methyl ethyl ketone perioxide as catalyst was obtained from PT Justus Kimia Raya Semarang Indonesia. Carnon Nano Tubes (CNTs) with a density of 2.6 grams/cm^3 from PT Sigma Aldrich Jakarta Indonesia.

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Table 2.1. Nomeclatur Of Process Treatment.

No	Treatment Type	Description	Code
1	Untreated	Fiber without treatment 20 %	AT 20
2	Alkali	Fiber alkali treatment 20 %	AL 20
3		Fiber alkali treatment 25 %	AL 25
4		Fiber alkali treatment 30 %	AL 30
5		Fiber alkali treatment 35 %	AL 35

Method

The fiber was soaked in an alkaline solution (6% NaOH by weight and Aquades) with a concentration of soaking for 6 hours at room temperature. The cantala fibers were cleaned with tap water until the pH was close to 7. The fibers were dried at room temperature for 72 hours to prepare for molding.

Composite Density

The fiber density test uses the ASTM 792 – 13 standard in 2013. The method uses a Precisa XT 220 A balance (Jakarta Indonesia) by comparing the weight in the fluid and in the air with the formula:

$$\text{Density (gran/ gram}^3\text{)} = \frac{a}{b+a} x.\delta.f \qquad (1)$$

Where a, is spesific gravity (g/cm^3) in the air and b, is the spesific gravity (g/cm^3) in fluida. Test were performed at room temperatur using biodiesel with a density of 0.867 g/cm$^{3.}$

Composite Fabrication

Composite fabrication by cutting 10 mm long fibers and arranged randomly on a composite mold. Mixing UPRs and CNTs using a magnetic stirrer with a rotating speed of 250 r.p.m, at a temperature of 40 ºC, for 30 minutes [11, 12]. Add 1% Methyl ethyl ketone catalyst to the matrix mixture and the CNTs are poured into the mold provided. Composite printing uses a Vacuum infusion process system. The composite impression was placed in the open for 180 minutes before cutting the sample.

Tensile and Flexural Strength

Tensile and flexural strength testing using the Universal testing machine was carried out at the University of Muhammadiyah Semarang. The composite tensile strength test used the ASTM D638 – 03 (2003) standard. The composite flexural test used the ASTM D 790-03 (2003) standard.

Observation Scanning Electrone Microscopy

Scanning electron microscopy (SEM) testing was carried out at Diponegoro University, Semarang, Indonesia using the JSM-610 PLUS/LV instrument model from JEOL. Observational SEM was used to capture two-dimensional images of treated and untreated fiber composites. The composite flexural fracture test results with a small size fit on a platinum sheet coated with aluminum and observed carefully for 1 minute at a pressure of 2 bar.

Water Absorption

The water absorption test on the composite was used to test the composite's ability to absorb water at a certain time. Water absorption in the composite will result in an increase in weight, volume, and bonding ability of the composite structure. Testing water absorption using ASTM D 5229 with the formula:

$$\text{Water Absorption : } = \frac{W-D}{D} x100\%$$

W = Gross weight (gram)
D = Dry weight (gran)

Table 1

No	Treatment Type	Code	Densitas (gram/cm3)
1	Untreated	AT 20	1.34
2	Alkali	AL 20	1.37
3		AL 25	1.39
4		AL 30	1.41
5		AL 35	1.42.

RESULTS AND DISCUSSION

Density Test

The results of the density test of cantala fiber composites that have been and have not been alkalized are as shown in Table 1.

The test results showed an increase in the density of the fiber-reinforced composite that had been treated with alkali. The increase occurred because the fiber had been cleaned due to the loss of amorphous in the cantala fiber such as hemicellulose, pectin and lignin. The increase in density is due to the removal of low-density non-cellulose material [13] Alkali treatment will remove impurities and low density amorphous components. In addition, alkaline treatment will form a new structure of cellulose II components which are more stable and compact when compared to cellulose I [14]. The increase in fiber density due to alkaline treatment was also found in alkaline treatment of flax fiber and borassus fiber [15]. The increase in density is also due to the volume fraction of the fiber.

Tensile Strength Test Results

The results of the tensile strength test as shown in Figure 1.

The above results indicate that the tensile strength of the composite cantala fiber reinforced with CNTs has increased after alkali treatment and an increase in the number of reinforcing fractions. The increase was due to the cantala fiber being cleared of amorphous after alkaline treatment. Alkali treatment is able to remove hemicellulose, lignin, pectin and other impurities. [16]. Alkaline treatment was able to clean the amorphous in the fiber so that the cellulose becomes clean and smooth. The fiber can bind the matrix perfectly so that there was an increase in the interfacial bonding between the fiber and the matrix. The cantala fiber is clean and provides interlocking of the matrix for increased strength. Increasing the reinforcement fraction in the composite can increase the tensile strength of the composite. The modulus of elasticity of the composite has results that are comparable to the results of the tensile strength graph according to the results of the study [17].

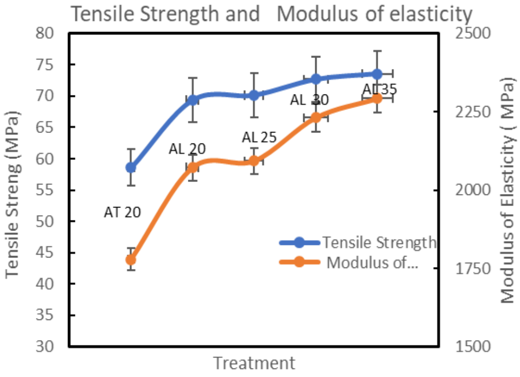

Figure 1. Tensile Strength and Modulus of elasticity.

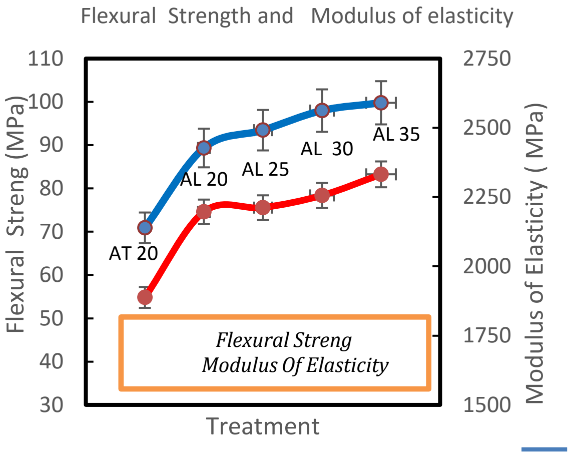

Figure 2. Flexural strength and Modulus of elasticity.

Flexural Strength Test Results

The results of the flexural strength test were as shown in Figure 2.

The results of the flexural strength test showed an increase after alkali treatment and the addition of cantala fiber fraction. The increase in flexural strength was dominated by alkali treatment of cantala fiber. Before treatment the flexural strength was 70, 89 MPa, after treatment 89, 32 MPa and the fiber fraction of 35% was 99,78 MPa. The increase in flexural strength of the composite was due to the cleaner cantala fibers after alkali treatment due to the loss of amourphus in the fibers. A fiber that can form an interfacial bond between the fiber and the matrix, thus forming interlocking in the composite. The addition of CNTs can increase the strength of the composite because of the pure carbon element in the CNTs [18]. Unsaturated polyester and CNTs are able to bind strongly so that the flexural strength of the composite increases. The small size of the CNTs can close the holes in the composite so that the strength of the composite increases. The results of the calculation of the elastic modulus show the same graph as the results of the bending test. This happens because the increase in flexural strength will be accompanied by the modulus of elasticity of the composite.

Observation Scanning Electrone Microscopy

Scanning electron microscopy observation results are shown in Figures 3a and 3b.

The results of SEM observations on the composite (Figure 3a) reinforced with untreated cantala fibers show that the fiber condition still looks smooth and there are several interphase gaps and was dominated by direct fiber pulling. Interphase was due to the fact that the fiber still contains a lot of hemicellulose, lignin, pectin, and other amourphages. Interphase was also caused by the hydrophilic and hydrophobic properties of the cantala fiber in the matrix, resulting in poor mechanical interlocking [19]. SEM observations on the alkali-treated cantala fiber-reinforced composite (Figure 3b) showed that the fiber condition looked coarser and increased the interfacial bond between the fiber and the matrix. Observations showed that the cantala fibers were broken at interphase with very tight bonds due to the loss of hemicellulose, pectin and lignin. The loss of amourphus in the fiber results in optimal transfer from matrix to fiber so that the composite strength increases. The addition of CNTs makes the surface smoother due to its small size and is able to close the holes in the composite so that strength increases.

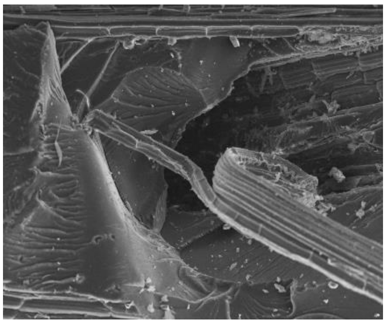

Figure 3a. Composit serat tanpa perlakuan (AT 20).

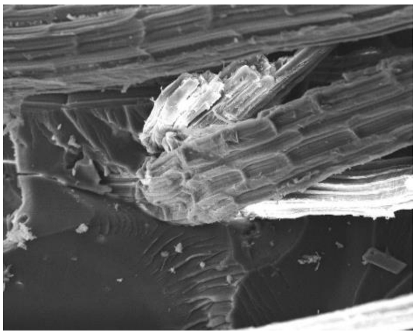

Figure 3b. Composit serat perlakuan (AL 35).

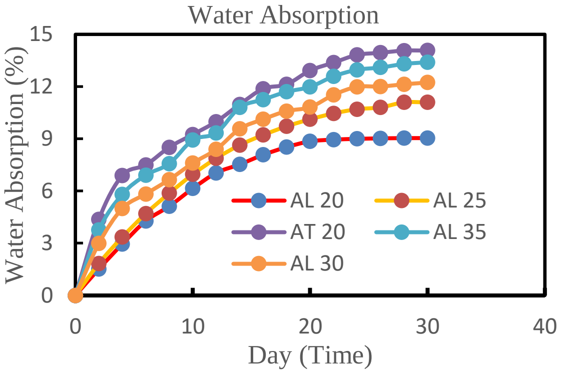

Figure 4. Water Absorption Composite.

CNTs have a fine microstructure and high strength so that they can bind the matrix and composite strength better and result in an increase in composite strength.

Water Absorption

The results of the water absorption test on the composite are as shown in Figure 4.

The results of the water absorption test show that the AT 20 composite has a higher water fiber capacity while the lowest water absorption is at AL 20. The water absorption of the composite in the first week shows a linear graph while in the third week it is slowing down. In the fourth week the chart begins to move towards equilibrium or near saturation conditions. This kind of absorption model is close to the frickian diffusion model [20]. Natural fibers such as cantala have water-absorbing properties because natural fibers are hydrophilic. Hemicellulose elements have a greater ability to absorb water than crystalline elements [21].

CONCLUSION

The results of the density test showed that the fiber-reinforced composite after treatment increased because the density of the cantala fiber after alkali increased. The test results of tensile strength and flexural strength increased after alkali treatment and the addition of cantala fiber fraction. The increase in tensile and flexural strength is also caused by the addition of carbon nanotubes to the composite. Carbon nanotubes are able to fuse with the matrix and form interlocking between the cantala fibers and the matrix, thereby increasing the tensile and flexural strength of the composite. Carbon nanotubes fill the holes in the composite due to the small size of the CNTs. SEM observations on the untreated cantala fiber-reinforced composite showed that there were several interphase gaps and was dominated by direct fiber pulling. SEM observations showed cantala fibers break at interphase with very tight bonds due to loss of hemicellulose, pectin and lignin. Water absorption in the composite is like the Fickian diffusion model because it forms linear at the beginning and saturates at the fourth week.

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