



(RESEARCH ARTICLE)



Study of tensile strength and morphology of polyester matrix composite materials reinforced *Hibiscus tiliaceust bark powder* as raw material of rear bumper vehicle

Sujita Darmo Darmo ^{1,*} and Rudy Sutanto Sutanto ²

Department of Mechanical Engineering, Faculty Engineering, University of Mataram, Majapahit Street 62, Mataram 83125, Indonesia.

Global Journal of Engineering and Technology Advances, 2021, 07(01), 085–090

Publication history: Received on 10 March 2021; revised on 12 April 2021; accepted on 15 April 2021

Article DOI: <https://doi.org/10.30574/gjeta.2021.7.1.0056>

Abstract

Fibrous composite materials continue to be researched and developed with the long-term goal of becoming an alternative to metal substitutes. Due to the nature of the fiber reinforced composite material, its high tensile strength, and low density compared to metal. In general, the composition of the composite consists of reinforcing fibers and a matrix as the binding material. The potential of natural fibers as a reinforcing composite material is still being developed and investigated. The research that has been done aims to determine the characteristics of the tensile strength of the composite strengthened with *Hibiscus tiliaceust* bark powder (HTBP) with alkaline NaOH and KOH treatment. The reinforcing material used is HTBP and the matrix is polyester resin, with volume fraction of 5%, 10% and 20% with an alkaline treatment of 5% NaOH and 5% KOH with immersion for 2 hours, 4 hours, 6 hours and 8 hours. Tensile testing specimens and procedures refer to ASTM D3039 standard. The results of this study showed the highest tensile strength of 34.96 MPa in the alkaline treatment of 5% KOH, soaking time of 8 hours with a volume fraction of 10% and the lowest tensile strength of 21.96 MPa of 5% KOH alkaline treatment, soaking time of 6 hours with a volume fraction of 20%. .with 10% volume fraction of 34.96 MPa and the lowest tensile strength was 5% KOH alkaline treatment at 6 hours immersion with 20% volume fraction.

Keywords: Fibrous composite materials; *Hibiscus tiliaceust* bark powder; NaOH; KOH; Volume fraction; Tensile strength

1. Introduction

The rear bumper is one part of the vehicle that has a very important role, apart from being aerodynamic and aesthetically pleasing to attract consumers, the bumper also functions as a collision damper from the rear that occurs in the vehicle. Therefore, the material used as the rear bumper often gets damaged during a collision, so it requires a material that has good impact toughness, is light, ductile and corrosion resistant.

Composite material is a type of engineering material that is made by combining two or more types of materials that have different mechanical properties into one new material with better mechanical properties. Composites have advantages such as strong, lightweight, corrosion resistant, economical and so on [1]. Composite material components consist of matrix and reinforcement. The function of the matrix as a binder is in the form of: polyester, metal and ceramics. The reinforcement as a reinforcement, which holds, transmits the force or load on the composite, in the form of fibers and particles. Fibers in the form of synthetic fibers: E-Glass, Kevlar-49, Carbon/Graphite, Silicone Carbide, Aluminum Oxide, and Boron, and natural fibers (derived from plants). The emergence of the issue of non-organic waste problems, the use of synthetic fibers is starting to be abandoned, on the other hand, natural fibers are getting attention

* Corresponding author: Sujita Darmo Darmo

Department of Mechanical Engineering, Faculty Engineering, University OF Mataram, Majapahit Street 62, Mataram 83125, Indonesia.

again as a composite reinforcing material because they are environmentally friendly and have relatively lower production costs. Composites made of fiber (fibrous composite) continue to research and developed to become an alternative material to replace metal, this is due to the nature of the fiber composite which is strong and has a lighter weight compared to metal.

The characteristics of natural fiber are having a hydrophilic nature [2]. In addition, the surface of natural fibers also has dirt and other substances that may affect the bonding strength of the fibers with the matrix. Therefore, various studies have been done to improve the surface of natural fibers in order to have a good bonding strength between natural fibers with the matrix. Coconut fiber is very good to be used as a filler in the composite because it has several advantages such as: strong, lightweight, heat resistant, salt water resistant, cheap, and easily obtained [3,4]. Many ways of treatment has been done to improve the compatibility of natural fibers. The treatment, both physically and chemically, aims to modify the fiber surface. Chemical treatment is one method for improving the properties of natural fibers such as surface geometry, dirt removal, fiber strength, and the interaction between the fiber and the matrix [5]. Chemical treatment often used in natural fiber is alkali treatment. Alkali treatment is expected to remove most of hemicelluloses, lignin, waxes, and oils soluble in alkali, so that the fiber surface became rough because of reduced fiber aggregation [6]. Study on alkali treatment of the coconut fiber has been done by many researches [7, 8, 9]. There was a decrease in the fatigue life for a large stress composite reinforced with coconut fiber treated with sodium hydroxide [10].

The works [12] investigated the effect of chemical treatment on the coconut fiber surface morphology. This study is divided into three stages, preparation of materials, treatment and testing of coconut fiber. The first treatment is coconut fiber soaked in a solution of NaOH for 3 hours with concentration, respectively 5%, 10%, 15%, and 20%. The second treatment is coconut fiber soaked in KMnO₄ solution with a concentration of 0.25%, 0.5%, 0.75%, and 1% for 3 hours. The third treatment is coconut fiber is soaked in H₂O₂ solution with a concentration of 5%, 10%, 15%, and 20% for 3 hours. At each treatment the fiber is dried in an oven at a temperature of 90°C for 5 hours. The result shows that the highest tensile strength of the fiber obtained in the first treatment. In general the mechanical strength of the fiber decrease slightly however, the fiber surface morphology becomes rough. NaOH treatments cause crystallization on the surface of the fiber. Crystallinity index was decreased with increasing concentration of NaOH. The second treatment caused the trench grooves on the surface of the fiber that can improve bonding between fiber and matrix

In general, treated natural fibers used as a composite reinforce treatment give tensile strength and modulus of elasticity greater than the untreated natural fiber composites. Therefore, modification of the fiber surface treatment is considered to increase the strength of natural fiber Composite [10]. Surface treatment using stearic acid and potassium permanganate other than NaOH provide a better performance than the untreated fibers [11]. Hydrogen peroxide (H₂O₂) was also used in coconut fiber treatment [6]. In addition to chemical treatment, coconut fiber is treated by washing and boiling to remove dirt on the surface of the fiber so as to produce a cavity [13]. Structural characteristics and chemical composition made tensile strength and modulus of elasticity of coconut fiber relatively low compared to other natural fibers. However, coconut fiber has special advantages such as large strain, low density, and weather resistant so that it is good for functional material [14].

This study aims to determine the mechanical properties (tensile strength and morphology) of polyester matrix compocite reinforced *Hibiscus tiliaceust* bark powder (HTBP), for the feasibility of these composites as an alternative solution to the replacement material for vehicle bumpers categorized as Multi-Purpose Vehicle (MPV) which in its application is closely related to safety usage especially in the automotive sector.

2. Material and methods

2.1. Materials

The research materials are (*Hibiscus tiliaceust* bark powder) HTBP, Polyester matrix type 157 BQTN and G3253T, MEKPO catalyst, 5% KOH, 5% NaOH, HTBP with a grain size of 200 mesh, shawn in Figure1. The equipment used are Universal Testing Machine (Tensilon RTG-1310), Scanning Electron Microscope (FEI inspect S50), composite mold made of silicon, with a thickness of 6 mm standard and composite fabrication equipment for specimens according to the ASTM D3039, as shawn in Figure 2.



Figure 1 The making process of HTBP, a. Taking *Hibiscus tiliaceust* bark, b.Drying, c. Grinding, d. Screening.

2.2. Methods

The specimens (polyester matrix composite reinforce HTBP) are made by using the press mold method. The composite tensile test specimen refer to the D3039 standart, as shown in Figure 2. The fracture section of the test specimen is subjected to a macro photo to identify the pattern failure.

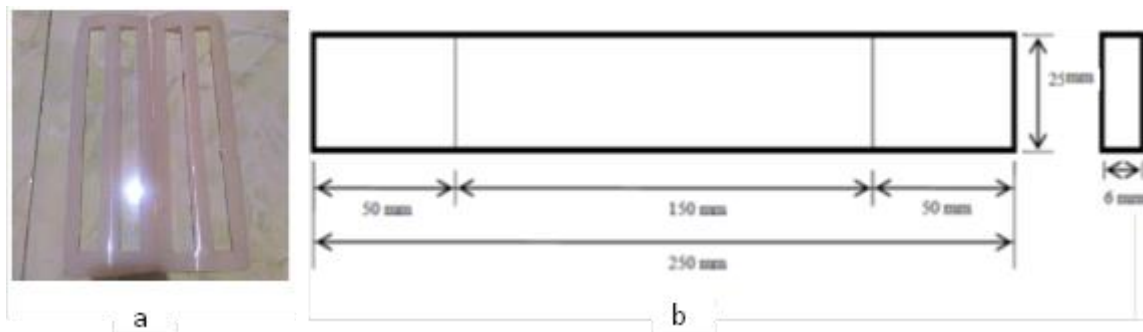


Figure 2 Composite material mold and specimen, a. Composite material mold, b.Specimens ASTM D3039 standart.

After the preparation is complete, tensile and observational tests are carried out with SEM, with the research design as shown in Table 1.

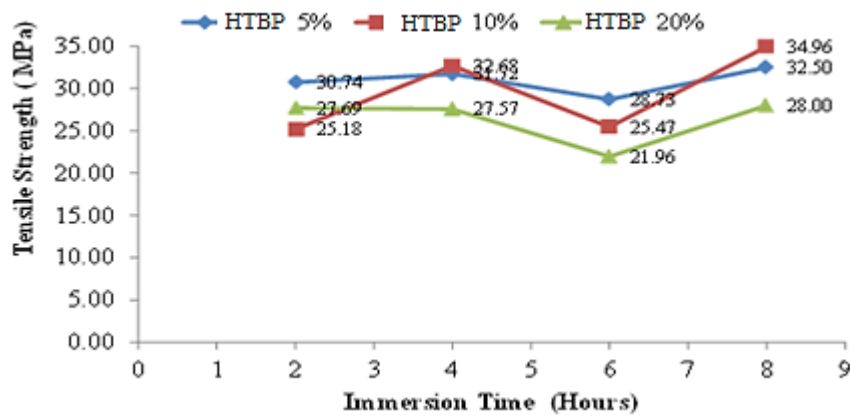
Table 1 Research Design

Specimens	5% NaOH Treatment (Hours)				5% KOH Treatment (Hours)			
	2	4	6	8	2	4	6	8
Volume Fraction 5 % HTBP	3	3	3	3	3	3	3	3
Volume Fraction 5 % HTBP	3	3	3	3	3	3	3	3
Volume Fraction 5 % HTBP	3	3	3	3	3	3	3	3
Specimens for SEM	2				2			

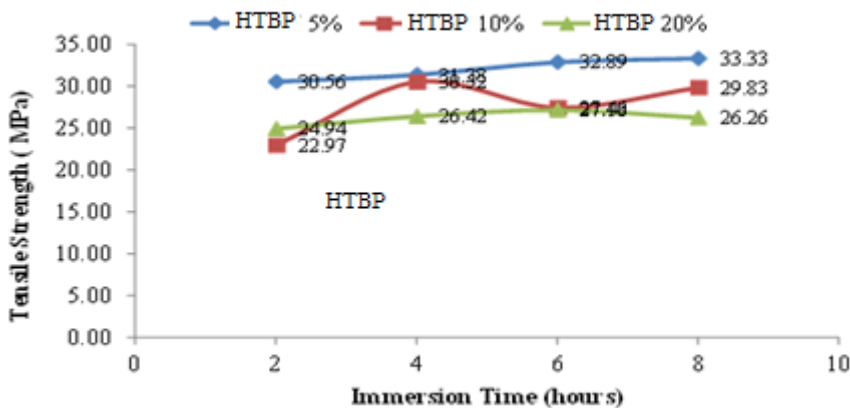
3. Results and discussion

3.1. The tensile strength of polyestire matrix compocite reinforce HTBP

From the results of the tensile test, the tensile strength of the specimens was obtained by immersion treatment with 5% NaOH, time variations of 2 hours, 4 hours, 6 hours, 8 hours and variations in the volume fraction of 5%, 10% and 20% SKW as shown in Figure 3a and soaking with 5% KOH, time variation and the same HTBP volume fraction is shown in Figure 3b. Immersion with 5% NaOH, the highest tensile strength of 33.33 MPa, immersion time for 8 hours with a volume fraction of 5% HTBD. Meanwhile, the lowest strength value was 22.97 MPa for 2 hours of immersion of powder with 10% powder volume fraction. The increase in tensile strength occurs due to the result of the 5% NaOH alkaline treatment which causes the coarse powder surface (damaged) so that the bond between the HTBD and the matrix becomes better. Meanwhile, the decrease in tensile strength occurs due to the presence of voids (cavities) in the specimen. The highest tensile strength value with 5% KOH immersion was 34.96 MPa, for soaking for 8 hours with 10% SKW volume fraction, the lowest strength value was 21.96 MPa at immersion for 6 hours with 20% HTBD volume fraction. The tensile strength by immersing 5% KOH is higher than 5% NaOH. Because the KOH solution is classified as a strong base, its solubility is greater than weak base, with the same concentration and immersion time, relatively more hemicellulose and lignin layers in the fiber that can be broken down by the solution, so that the fiber is cleaner and more porous which has an impact on increased adhesion strength between fiber surface and matrix [4,6].



a



b

Figure 3 The effect of immersion time on the tensile strength of the specimens.
 a. Immersion with 5% NaOH, b. Immersion with 5% KOH

3.2. The microstructure of polyestire matrix compocite reinforced HTBP

The results of SEM observations of specimens with the highest tensile strength values and the lowest tensile strength values with immersion of 5% NaOH are shown in Figure 4a and Figure 4b. In the specimen with the highest tensile strength value, it can be seen that the bond between the HTBP and the bonded matrix is very good, has a few voids, the specimen with the lowest tensile strength value, it can be seen that the number of HTBP experiences a pullout because the mixture between the HTBP and the matrix is not perfect, there are also many voids. which causes a decreasing the tensile strength of the composite. In accordance with the results of research [12] which states that the pulsed pullout and debonding mechanism causes the mechanical strength of the composite to be quite low.

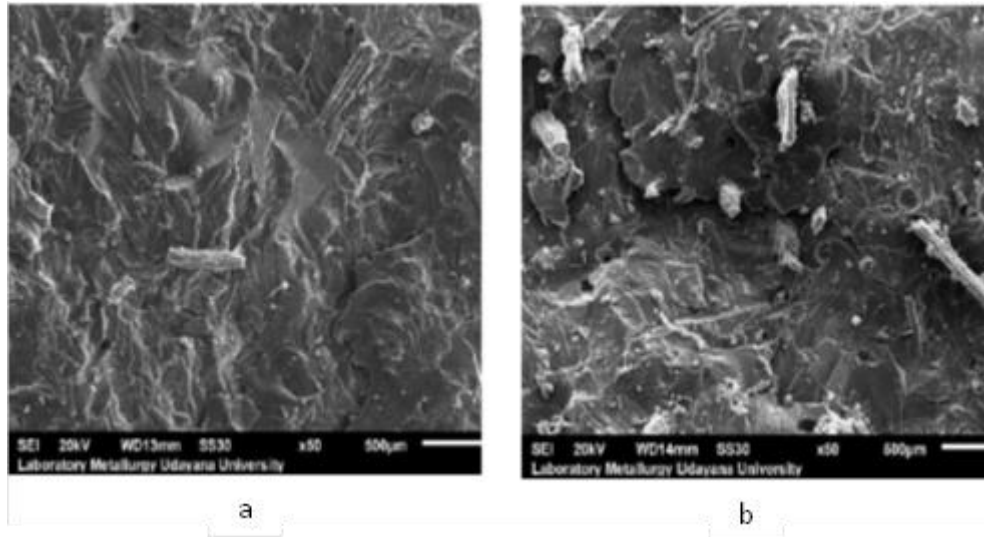


Figure 4 Observations of SEM test results with 5% NaOH immersion, a. Specimen with the highest tensile strength, b. Specimen with the lowest tensile strength

From the results of SEM observations taken from the specimen sample with the highest tensile strength value and the lowest tensile strength value with 5% KOH alkaline treatment, as shown in Figure 5a. and Figure 5b. The specimens with high tensile strength due to the visible powder and matrix bonded well and a little cavity, as in Figure 5a. The tensile strength of the specimen is lower because there is a deeper and bigger cavity as shown in Figure 5b.

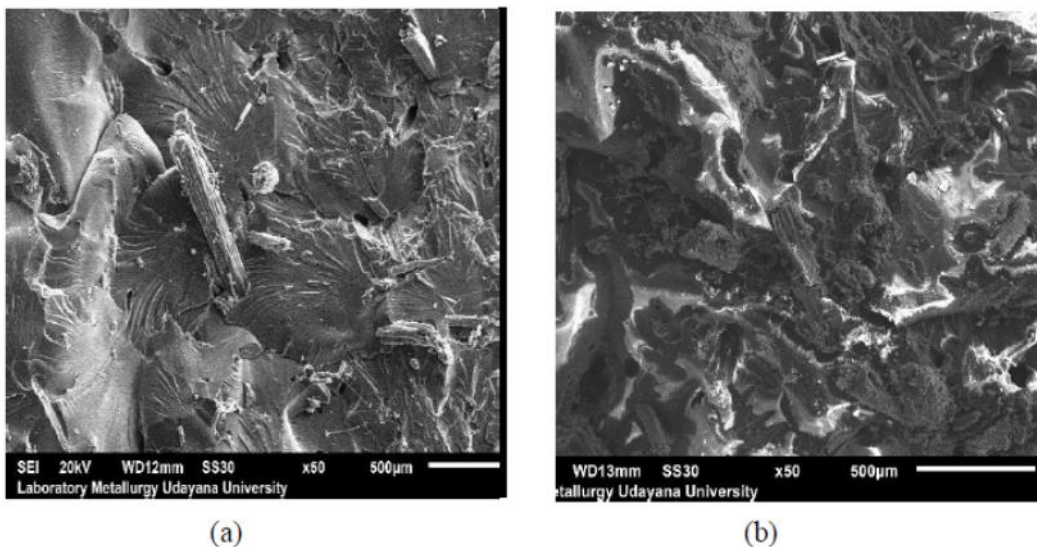


Figure 5 Observations of SEM test results with 5% KOH immersion, a. Specimen with the highest tensile strength, b. Specimen with the lowest tensile strength.

4. Conclusion

From the results of the tensile test, the tensile strength of the composites with immersion of 5% KOH is higher than with 5% NaOH. The resulting tensile strength was 34.96 MPa with 10% HTBP volume fraction for 8 hours of immersion, while for the tensile strength of immersion with 5% NaOH was 33.33 MPa with 5% HTBP volume fraction for 8 hours of immersion. Based on the results of the high tensile strength, the polyester matrix composite reinforced HTBP which is soaked with 5% KOH during 8 hours to be used as a rear bumper vehicle.

Compliance with ethical standards

Acknowledgments

The intellectual and moral contributions of Prof. Dr. Ir. Rudy Soenoko, M.Sc.Eng., Prof. Dr. Eng. Ir. IGN. Wardana, among others towards the success of this work are deeply appreciated.

Disclosure of conflict of interest

No conflict of interest.

References

- [1] Golushko Kseniya, Golushko Sergey, Yurchenko Andrey. On Modeling of Mechanical Properties of Fibrous Composites. Computational Science and High Performance Computing . 2011.
- [2] Dixit S, Verma P. The Effect Of Surface Modification On The Water Absorption Behavior Of Coir Fibers, Advances In Applied Science Research. 2000; 3(3): 1463-1465.
- [3] Sen T, Reddy HNJ. Application of Sisal, Bamboo, Coir and Jute Natural Composites in Structural Upgradation, International Journal Of Innofation, Management And Technology. 2011; 2(3): 186-191.
- [4] Rosa MF, Chiou B, Medeiros ES, Et Al. Effect of Fiber Treatment on Tensile and Thermal Properties Of Starch/Ethylene Vinyl Alcohol Copolymers/Coir Biocomposites, Bioresource Technology. 2009; 100: 5196-5202.
- [5] Ahad NA, Parimin N, Mahmed N, Et Al. Effect of Chimiical Treatment On The Surface Of Natural Fiber, Journal of Nuclear And Related Technologies. 2009; 6(1): 155-158.
- [6] Carvalho KCC, Mulinari DR, Voorwald HJC, Et Al. Chemical Modification Effect on the Mechanical Properties of Hips/Coconut Fiber Composites”, Bioresources. 2010; 5(2): 1143-1155.
- [7] Karthikeyan A, Balamurugan K, Effect of Alkali Treatment and Fiber Length on Impact Behavior of Coir Fiber Reinforced Epoxy Composites, Journal of Scientific & Industrial Research. 2012; 71: 627-631.
- [8] Karthikeyan A, Balamurugan K, Kalpana A, Et Al. The New Approach To Improve The Impact Property Fiber Reinforced Epoxy Composites Using Sodium Lauryl Sulfate Treatment, Journal Of Scientific & Industrial Research. February 2013; 72: 132-136.
- [9] Azmi MA, Yusoff MFC, Abdullah ZA, Et Al. Rigid Polyurethane Foam Reinforced Coconut Fiber Properties, International Journal Of Integrated Engineering. 2012; 4(1): 11-15.
- [10] Mulinari DR, Baptista CARP, Souza JVC, Et Al. Mechanical Properties of Coconut Fibers Reinforced Polyester Composites”, Procedia Engineering. 2011; 10: 2074-2079.
- [11] Lai CY, Sapuan SM, Ahmad M, Et Al. Mechanical and Electrical Properties of Coconut Coir Fiber-Reinforced Polypropylene Composites, Polymer-Plastics Technology and Engineering. 2005; 44: 619- 632.
- [12] Hussain SA, Pandurangadu V, Palanikuamr K, Et Al. Mechanical Properties of Green Coconut Fiber Reinforced HDPE Polymer Composite, International Journal of Engineering Science And Technology. 2011; 3(11): 7942-7952.
- [13] Arsyad Muhammad, Wardana I Nyoman Gede, Pratikto, Irawan Yudy Surya. The Morphology of Coconut Fiber Surface under Chemical Treatment. Matéria (Rio J.)[Online]. 2015; 20(1): 169-177.
- [14] Ferraz JM, Menezzi CHSD, Teixeira DE, Et Al. Effect of Treatment of Coir Fiber and Cement/Fiber Ratio on Properties of Cement-Bonded Composites”, Bioresources. 2011; 6(3): 3481-3492.