

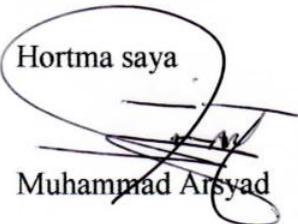
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International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 4 (2015) pp. 9561-9570 © Research India Publications
<http://www.ripublication.com> Bonding Ability Of Coconut Fiber With Polyester Matrix As A Result Of Chemical Treatment Muhammad Arsyad¹, I.N.G. Wardana², Pratikto², Yudy Surya Irawan² 1 Department of Mechanical Engineering, State Polytechnic of Ujung Pandang, Makassar, Indonesia, 2 Department of Mechanical Engineering, Brawijaya University, Malang, Indonesia. 1muhammadarsyadhabe@yahoo.co.id ABSTRACT The purpose of this study was to determine the behavior of the bonding ability of coconut fiber against polyester matrix with chemical treatment.

First treatments, coconut fiber was soaked into NaOH solution, the second into KMnO₄ solution and the third into H₂O₂ solution, each at various concentration for 3 hours. Between each treatment, the fibre was dried at temperature of 90 °C for 5 hours. The ability of fiber and matrix adhesion was tested with embed of a single fiber as deep as 2 mm.

The results show that the chemical treatment causes the fiber surface becomes rough, forming pores or grooves. The highest average interfacial shear stress is obtained in the H₂ treatment, because of the rough fiber surface and small grooves so that when the fibers were implanted into the matrix, the matrix has a strong grip resulting in a good bonding between the fibers with the matrix.

While the fiber highest average tensile stress was obtained in N₄ treatment, because fiber was draped by small crystals which are unified so that it increase the ability of the fiber receives a tensile load and slow fiber rupture. Keywords: coconut fiber, bonding, chemical treatment, single fiber pull out test INTRODUCTION Lignocellulosic materials

usage as a composite amplifier component has received enormous attention because it gave several advantages than other inorganic material, such as low density, larger deformability and lower production costs. Natural fibers cellulose has a hydrophilic nature, so that it can absorb water from environment freely.

High water content can reduce bonding ability with hydrophobic matrix [1]. Moreover, surface of natural fibers also contain impurities, dirt, and other substances that may affect the bonding ability between fiber and matrix. Main content of natural 9562 Muhammad Arsyad et al fibers were cellulose, hemicellulose, and lignin [2, 3, 4].

Content percentage was subject to conditions, place, and climate of natural fiber which was grown or raised. Compatibility between lignocellulosic material and matrix plays an important role to determine the composite properties. Various treatments have been done to improve the compatibility of natural fibers with hydrophilic nature, either physical or chemical treatment.

To improve the natural fibers properties such as surface morphology, removal of dirt, grime, fiber strength, and interaction between fiber and matrix, chemical treatment was one method that should be considered to be done [5]. Chemical treatment that was often used in natural fiber was an alkaline treatment. Alkali treatment was expected to remove some hemicellulose, lignin, wax, or oil soluble alkali, until the fiber surface becomes rough due to reduced fiber aggregation [1]. The reduced amount of lignin can reduce water absorption and thickness swelling of fiber [2]. Interface bonding ability very affect on strengthening fiber composite.

This was related to a combination of composite materials compiler with different mechanical and chemical properties. Interface bonding ability very affect on strengthening fiber composite. Method to determine interface strength was single fiber pull out test, single fiber fragmentation and multi fiber test, and micro indentation test.

Several factors that affect the strength of natural fiber composites are fiber form, fiber lay out, fiber length, and fiber bonding with matrix [3]. One way to know for composite strength or ductility was the bonding ability between the surface of fiber and matrix [6]. The bonding between fiber and matrix was influenced by void that was created gap between fiber and matrix [3].

Compatibility between fiber and matrix determines the composite properties [2]. Interface on a composite surface was created together from bond between fiber and matrix to make connection bond that required in load transfer. Good interface can transfer the load from matrix to fiber properly to increasing of composite strength [4].

Several factors to affect the bond between fiber and matrix are (i) physical and chemical adhesion, (ii) mechanical components such as bonding, and (iii) friction [6]. Interface properties play an important role in analyzing the mechanical behavior of fiber composites. Interface bonding characteristics between fiber and matrix was usually studied experimentally by examining several of physical parameters in various bonding conditions.

Pull out test of single fiber has become one of representative method, and has become an important technology in experimental study of mechanical behavior of strengthening fiber composite [6]. Tensile force is equivalent with increasing length of embedded fiber while shear strength does not change significantly [7]. Fibers with a combination of both alkali and silane treatment can improve the efficiency of stress transfer at interface of more than 40% than without fiber treatment.

Similarly, tensile test of a single fiber, fiber-matrix polyester with low viscosity have higher shear stress than high viscosity matrix [8]. In this paper, a study was done on the effects of chemical treatment on the ability of the engagement between coconut fiber with polyester matrix. The study was conducted based on the results of the single fiber pull out, and SEM test.

Bonding Ability Of Coconut Fiber With Polyester Matrix 9563 MATERIAL AND METHODS
Materials used are coconut fiber, sodium hydroxide (NaOH), potassium permanganate (KMnO₄), hydrogen peroxide (H₂O₂), polyester resin, aquades, MEKPO catalyst (methyl ethyl peroxide cartoons). Coconut fiber was obtained by separating fiber from coconut husk the attached cork was removed manually by hand.

Coconut fiber was derived from society at Sindenreng Rappang District, South Sulawesi Province, Indonesia. NaOH solution is obtained by mixing aquades with a concentration of NaOH and NaOH respectively: 5%, 10%, 15%, and 20%. KMnO₄ solution is obtained by mixing aquades with a concentration of KMnO₄ and KMnO₄ respectively: 0,25%, 0,5%, 0,75%, and 1%.

H₂O₂ solution is obtained by mixing aquades with a concentration of H₂O₂ and H₂O₂ respectively: 5%, 10%, 15%, and 20%. Polyester resin has the specifications Yukalac BQTN-EX Lot No. T1580818TS production of PT. Justus Sakti Raya, Jakarta, Indonesia. Coconut fiber was given three treatments as shown in Table 1. Coconut fiber without treatment was given as WT notation.

The first treatment was coconut fiber treated with each N1, N2, N3, and N4 for 3 hours.

After the first treatment, coconut fiber was dried in oven at temperature of 90 °C for 5 hours. After that, fiber was cooled at room temperature. For the second treatment, coconut fiber was treated with K1, K2, K3, and K4 for 3 hours.

After the second treatment, the fiber was dried in oven at a temperature of 90 °C for 5 hours. After that the fiber was cooled at room temperature. For the third treatment, coconut fiber was treated with H1, H2, H3, and H4 for 3 hours. After soaking, the fiber was dried in an oven at a temperature of 90 °C for 5 hours. After that the fiber was cooled at room temperature.

Single fiber pull out test was performed by test equipment of Testometric M500-25CT DBBMTCL pull-2500 kg Rochdale ENGLAND. Single fiber Pull out testing was done by tensile speed of 1 mm/min on an embedded fiber length of 2 mm depth in the matrix. Maximum force value (N), maximum tensile (N/mm²), and strain (%) automatically calculated by test equipment.

The interfacial shear stress between fiber and matrix was calculated by equation 1. Morphology of bonding fiber and matrix was tested by electron microscopy Vega3 Tescan at 5kV (SEM, Scanning Electron Microscope). 9564 Muhammad Arsyad et al Table 1: Notation of Coconut Fiber Surface Treatment NOTATION TREATMENT Without Treatment WT Without Treatment The First Treatment (NaOH) N1 NaOH 5% N2 NaOH 10% N3 NaOH 15% N4 NaOH 20% The Second Treatment (NaOH then KMnO₄) K1 N1 soaked in KMnO₄ 0,25% K2 N2 soaked in KMnO₄ 0,50% K3 N3 soaked in KMnO₄ 0,75% K4 N4 soaked in KMnO₄ 1,00% The Third Treatment (NaOH then KMnO₄ then H₂O₂) H1 K1 soaked in H₂O₂ 5% H2 K2 soaked in H₂O₂ 10% H3 K3 soaked in H₂O₂ 15% H4 K4 soaked in H₂O₂ 20% In Figure 1, a single fiber embeded in the matrix with depth L is then given axial tensile load of F.

The Load F was expected able to pull out the embeded fibers and assumed that shear stress along the embed fiber surface was uniform. Interfacial shear stress between fiber and matrix can be calculated by formula : $\tau = \frac{F}{dL}$ (1) with F was maximum load, d was fiber diameter, and L was length of embeded fiber [9,10].

Figure 1: Tensile and shear force of interface between fiber and matrix [9,10] $\tau = \frac{F}{dL}$ Matrix Fiber d Bonding Ability Of Coconut Fiber With Polyester Matrix 9565 Interfacial shear stress depends on length of embeded fiber. Fibers length that embeded will decrease glue force of fiber-matrix surface, but will increase the friction resistance.

Debonding can occur if the stress friction in fiber-matrix interface was greater than the bonding strength of fiber-matrix surface [11]. This study purpose was to determine the

bonding ability behavior of coconut fibers that chemical treated with polyester matrix. The behavior was discussed based on single fiber pull out test, fiber tensile test, and results of observation by Scanning Electron Microscope (SEM).

RESULTS AND DISCUSSION Chemical treatment with different concentrations resulted in coconut fiber surface becomes rough, raised pores or grooves as shown in Figure 2, 3, and 4. The rough surface of fiber can increase the ability of fiber to resist friction forces so that the fibers tend to defend themselves when given tensile force.

Porous or grooved surfaces can be filled by the matrix and form a strong engagement between the fibers with the matrix. Figure 2a shows the surface of the untreated fiber, the fiber surface appears smooth because of the persistence of the wax, or other impurities attached to the fiber. While Figure 2b-e show the fiber surface that had been treated first (NaOH).

Fiber surface seems have bulges and irregular grooves very different from the fiber surface without treatment. When Figure 2b-e considered properly, so Figure 2e which is the N4 treatment showed that although the fiber surface roughness is not too big but looks solid and mutually united.

This roughness caused by grains of sodium (Na) are crystallized and wrap the fiber as a result of fiber drying in an oven at a temperature of 90o for 5 hours. The granules are wrapping the fiber surface so as to increase the bonding of the fiber and matrix. Based on the single fiber pull out tests, the average highest of interfacial shear and tensile stress in the first treatment is obtained on treatment N4 respectively 3.1 N/mm² as shown in Figure 5, and 345.78 N/mm² as shown in Figure 5 and 6.

The grains of crystallization that occurs in the first treatment is only temporary because the next treatment (second treatment) the grains disappear as illustrated in Figure 3a-d. Na crystallization that occurs in the first treatment disappeared after fiber is immersed in KMnO₄ solution. In the second treatment, as shown in Figure 3a-d, Figure 3d shows the fiber surface rougher than the other surface, and the grains due to the first treatment does not appear, but the emergence of bulges and grooves are greater. This indicates that the KMnO₄ solution dissolving the grains of sodium.

The roughness of surface with the bulges and grooves are straight and large as shown in Figure 3d. This indicates that the higher the concentration of KMnO₄ the rougher the fiber surface with the large bulge and groove. The roughness of surface is expected to increase the bonding between the fibers with the matrix.

However, the higher interfacial shear stress was obtained in the K2 treatment which is 2.8 N/mm² (Figure 5). This happens because the form of grooves on the surface of fiber in other treatments are very large and straight compared to the K2 treatment, so that the release of fiber from the matrix more easily than in the K2 treatment which has a groove that is not too large and branched.

9566 Muhammad Arsyad et al Figure 2: Coconut fiber surface with and the first treatment (a) WT, (b) N1, (c) N2, (d) N3, (d) N4 granules grooves (a) (e) 20 ? m (d) 20 ? m 20 ? m (c) granules granules granules grooves grooves grooves Bonding Ability Of Coconut Fiber With Polyester Matrix 9567 Figure 3: Coconut fiber surface as result of the second treatment (a) K1, (b) K2, (c) K3, (d) K4 Figure 4 shows the fiber surface as a result of the third treatment.

The third treatment also makes the fiber surface becomes rough, even irregular compared to the previous treatment. The rough surface makes certain the engagement providing greater strength compared to previous treatment. Figure 4a-d, Figure 4b and Figure 4c show rather rough surface and sturdy compared to other images.

Figure 4b shows the existence of bulges along and the grooves along fiber surface in H2 treatment. The bulges and grooves are very influential on the shear strength when fiber is embedded in the matrix and highest interfacial shear stress is obtained in this treatment. While Figure 4c shows that H3 treatment only result in small bulges so that the interfacial shear stress is lower (Figure 5).

In H4 treatment (Figure 4d), the bulges is smaller than that in H3 treatment so that the interfacial shear stress is further smaller. (d) (c) (b) 20 ? m 20 ? m 20 ? m (a) 20 ? m bulges grooves bulges grooves bulges grooves bulges grooves 9568 Muhammad Arsyad et al Figure 4: Coconut fiber surface as result of the third treatment H1, (b) H2, (c) H3, (d) H4 Figure 5: Fiber and Matrix Interfacial Shear Stress (d) (c) 20 ? m (a) 20 ? m (b) 20 ? m 20 ? m bulges grooves bulges grooves bulges grooves bulges grooves Bonding Ability Of Coconut Fiber With Polyester Matrix 9569 Figure 6: Fiber Tensile Stress As shown in Figure 6, each treatment resulted in different fiber tensile strength.

In general the wrapped of fiber, either as a result of the first treatments, N4 (Figure 2) or the third treatments, H2 (Figure 4) cause of fiber tensile stress is higher than the fiber that is not draped as a result of the K3 chemical treatments (Figure 3). The natrium crystals and hydrogen peroxide, the wrapped of fiber will certainly increase the ability of fiber to receive a tensile load and slow the broken of fiber.

Therefore, the highest average of tensile stress is obtained in N4 treatments which is

higher than those of H2 and K3 treatments. This is due to the fact that the N4 treatment results in small granules, sturdy, and unite of the crystals of sodium that wrap the fiber will increase the ability of the fiber to receive a tensile load.

From those mentioned above, then if needed, composites with high strength of fiber but the bonding between the fiber and matrix is sufficiently lower, the N4 treatment is enough. This process is brief that will be economically valuable. However if needed composites with high bonding strength between the fibers and matrix while the strength of the fiber is slightly lower, so coconut fiber is treated with H2 treatment. This process is quite long, and of course need a greater cost than the N4 treatment.

CONCLUSIONS Based on the test results of chemical treatment of coconut fiber, it can be concluded that: a. The treatments of NaOH, KMnO₄, and H₂O₂ can increase bonding between coconut fiber and polyester matrix. b. The highest average of interfacial shear stress was obtained at coconut fiber with H2 treatment which is 4.1 N/mm². 9570 Muhammad Arsyad et al c.

The highest average of tensile stress was obtained at coconut fiber with N4 treatment that is 345.78 N/mm² ACKNOWLEDGEMENTS The author would like to thank all those who have helped on the implementation of this study, especially to the Director of State Polytechnic Ungu Pandang, and Rector of the State University of Makassar on the facilities that have been used. REFERENCES [1] Dixit S, Verma P., 2012.

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