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Effect of sodium hydroxide concentration on the tensile strength of coconut fiber
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2arsyadhabe@poliupg.ac.id Abstract.

The purpose of this research is to determine the effect of the concentration of sodium hydroxide on the tensile strength of coconut fiber. The materials used are coconut fiber, sodium hydroxide solution, distilled water, tensile testing machine, carton, glue. Coconut fibers are soaked for 3 hours in sodium hydroxide solution with concentrations of 25%, 30%, 35%, 40%, 45%, 50%, and 55%.

After that, coconut coir fibers are rinsed with distilled water, then shredded in the oven at a temperature of 90oC for 5 hours. After that, coconut fibers were divided into 3 groups. The first group, coconut fiber is used for hydrolysis test which aims to determine the amount of lignin, cellulose, and hemicellulose contained in coconut fiber.

The second group, coconut fiber is given a tensile test with standard ASTM 3379-02 to determine the tensile strength of coconut fiber. The third group, coconut fiber is used to observe the surface of coconut fiber with using SEM equipment. Based on the results of hydrolysis and tensile test It was concluded that (a) the concentration of sodium hydroxide had an effect on the amount of lignin, cellulose, and hemicellulose contained in coconut fiber, the tensile strength of coconut fiber, and the roughness of coconut fiber surface, (b) the coconut fiber surface is increasingly rough which allows an increase in bonding strength between coconut fiber and resin, (c) the highest tensile strength was obtained at 30% sodium hydroxide soaking 226,1 N/mm². Keyword: soak,

treatment, tensile, coir Introduction At present, the development of materials is progressing rapidly.

This is supported by the need for materials that can meet certain desired characteristics. One result is composite material. The ability to be easily shaped according to needs, both in terms of strength and shape and superiority in the strength to weight ratio, encourages the use of composites as a substitute for conventional metal materials on various products.

Composites are formed from two or more materials that remain separate and different to form a new single component. composites have many advantages, such as lighter weight, higher strength, corrosion resistance and lower production costs and are environmentally friendly. Natural fibers are hydrophilic and have polar groups in their structure.

In addition, natural fibers also consist of several basic fibers associated with cellulose, hemicellulose, pectin, lignin, and others. Various treatment methods have been carried out to increase the bond between natural fibers and resin. Both physically and chemically, the treatment given to natural fibers aims to modify the surface of the fiber. One method that is often used is chemical treatment.

Chemical treatment will improve the properties of natural fibers such as surface geometry, release impurities on the surface of the fiber, increase fiber strength, and improve the interaction between fiber and resin [1]. Chemical treatment can be done in two ways, namely using a base solution or an acid solution. Among the two types of solvents, solvents that are more effective at breaking down lignin are alkaline solvents such as sodium hydroxide.

However, the use of chemical compounds with high concentrations will have a negative impact on the environment, can produce toxic compounds which will actually inhibit the hydrolysis process of polysaccharides in the next stage [2]. The treatment is expected to be able to release candles or other impurities so that the surface of natural fibers will become more rough.

The rough natural fiber surface can increase the bonding ability between natural fibers and the resin used [3]. An important result of the treatment of sodium hydroxide is that it disrupts hydrogen bonds in the structure of the fiber network, so that it can make the fiber surface more rough.

In addition, the treatment also removes a number of lignin, waxes and oils that cover the

outer surface of the fiber cell wall, and depolymerizes cellulose [4]. Khan reported that natural fibers treated with sodium hydroxide, decreased the amount of hemicellulose. The decrease in cellulose and lignin is proportional to the increase in the concentration of alkaline solution [5].

Soaking coco fiber in sodium hydroxide solution for 3 hours with a concentration of 5%, 10%, 15%, and 20% has been done. The results obtained showed that the higher the sodium hydroxide concentration, the lower cellulose and lignin content, but the hemicellulose content increased [6]. Another study reported that composites using natural fibers were soaked in solution of sodium hydroxide for 24 hours with concentrations of 1%, 5% and 10%, increasing their flexural strength by about 60% compared to composites using untreated natural fibers [7]. Natural fibers, can come from plants, animals, or come from minerals.

Natural fiber composite is not only renewable but also has several advantages such as: light weight, specific strength, high modulus, less tool wear and saving energy and the safe process of the manufacturing process. Natural fiber composites can be applied in the fields of construction, packaging, furniture, and the automotive field.

Vegetable natural fibers are lignocellulosic consisting of cellulose, hemicellulose, lignin, pectin and wax. Lignin is a complex hydrocarbon polymer that gives stiffness to the stem. This provides protection against fiber from biological attacks. The crystallinity of cellulose determines the ability to strengthen fiber. Hemicellulose forms a cementing matrix and is hydrophilic.

Pectin provides fiber flexibility [8]. Natural fibers are used as reinforcing materials because they are renewable, can be recycled, are neutral to carbon dioxide, and are natural. Natural fiber reinforced polymer composites provide several advantages, for example; good mechanical and thermal properties, low production costs, low energy consumption, not abrasive to instruments, non-toxic, and can replace conventional synthetic or inorganic polymer composites which are strengthened in several applications.

Natural fibers are hydrophilic and hygroscopic because of the presence of cellulose, hemicellulose, lignin, which contain hydroxyl groups (-OH), so that they have poor compatibility with hydrophobic thermoplastic polymer resins [9]. Historically natural fibers have been added to polymers as fillers or reinforcement composites that hold natural fibers.

Advantages of natural fiber compared to inorganic materials are low production costs,

low density, high specific strength to density ratio, biodegradability, low abrasion [10]. Several methods can be used on natural fibers to improve their properties, namely: microbiological, physical, and chemical methods. The commonly used method is the chemical method, where this method can make the fiber surface more rough.

Some advantages of this method such as easy to implement, fast and effective, energy is used little. [11]. The surface of coconut fiber contains various impurities and unwanted substances. These impurities cause the surface of the coconut fiber to be smooth and smooth, thereby reducing the ability to bond coconut fiber with resin.

One treatment is carried out to remove impurities on the surface of the coconut fiber, namely chemical treatment. Chemical substances that are widely used are sodium hydroxide with various concentrations. Therefore, this research is important to determine the effect of sodium hydroxide concentration on the tensile strength of coconut fiber.

To achieve this goal, the hydrolysis test, tensile test, and SEM test will be carried out. Materials and Methods The materials used are sodium hydroxide, cardboard, glue, coconut fiber, distilled water, oven. Coconut fibers were obtained from Sidenreng Rappang Regency, South Sulawesi Province, while chemicals were obtained from chemical stores in Makassar City.

Fiber Treatment Coconut fiber is immersed for 3 hours in solution of sodium hydroxide with 25%, 30%, 35%, 40%, 45%, 50%, and 55% concentration. After that, coconut fiber is rinsed with distilled water, then dried in an oven for 5 hours at a temperature of 90°C. Furthermore, coconut fibers are divided into 3 groups.

The first group is used for hydrolysis test which functions to determine the amount of lignin, cellulose, and hemicellulose. While the second group is used for tensile testing which serves to determine the coconut fiber tensile strength. The last groups, coconut fiber is used to observe changes that occur on the surface of coconut fiber using SEM equipment.

Hydrolysis Process The hydrolysis process is carried out using the Chesson Method. A mixture containing 1 g of dry coconut fiber (W_a) and 150 ml of distilled water, a glass tube at a temperature of 90-100°C for 1 hour. The filter was filtered and the residue was washed with 300 ml of hot water. The residue was dried in an oven until its weight is constant (W_b).

Dry residue (W_b) mixed with 150 ml of 1 N H_2SO_4 then heated in a glass tube at a

temperature of 90-100°C for 1 hour. The mixture was filtered and washed with 300 ml of distilled water and then dried residue (Wc). Dry residue (Wc) immersed with 10 ml of 72% H2SO4 at room temperature for 4 hours.

After that, 150 ml of 1 N H2SO4 was added to the mixture and refluxed in a glass tube at a temperature of 90-100 °C for 1 hour. The solids are washed with 400 ml of distilled water, heated in an oven at 105 °C and weighed to constant weight (D). The last, the solids (Wd) is heated until become ashes and weighed (We) [6].

The percentage of hemicellulose (Ha), cellulose (Ca), and lignin (La) are calculated using the following equation: (1) (2) (3) Tensile Test Single fiber tensile test coconut fiber length of 30 mm in accordance with ASTM 3379-02 standard by using a tensile test LR10K Plus 10 kN Universal Materials Testing Machine. Stress values (MPa) and strain (%) is automatically calculated by the tensile test equipment.

The model of specimens for single fiber tensile test in accordance with the ASTM 3379-02 is shown in Figure 1. To determine the tensile strength, and elongation, use the following equation: (4) (5) with: (max=Maximum Tensile Strength (N/mm²), Fmax= Maximum load (N), A=sectional area (mm), (ε=elongation (%), L0=initial length (mm), L1= end length (mm). Figura 1.

Specimen of single fiber tensile test with ASTM 3379-02 standard SEM Observation The coconut fiber that has not been and has been soaked in sodium hydroxide solution, the surface was observed using Scanning Electron Microscope (SEM) Vega3 Tescan. Observation using SEM equipment aims to see or observe the surface of coconut fiber, both untreated and treated.

This observation was conducted to determine the effect of the concentration of sodium hydroxide on changes in the roughness level of coconut fiber. To make it easier to distinguish between one specimen and another, then each specimen is given a sign as shown in Table.1. Table 1. Testing Notation Notation Treatment WT Without Treatment N25 25% Sodium Hydroxide Treatment N30 30% Sodium Hydroxide Treatment N35 35% Sodium Hydroxide Treatment N40 40% Sodium Hydroxide Treatment N45 45% Sodium Hydroxide Treatment N50 50% Sodium Hydroxide Treatment N55 55% Sodium Hydroxide Treatment Results and Discussion Table 2.

Amount of Hemicellulose, Cellulose, and Lignin in Coconut Fiber Treatment La (%) Ca (%) Ha (%) WT 33,5 37,9 15,5 N25 36,4 24,4 18,9 N30 35,4 26,8 16,7 N35 39,9 21,7 20,1 N40 31,2 29,2 16,6 N45 38,2 28,6 13,2 N50 39,9 27,3 12,1 N55 39,2 25,9 16,5 Figure 2. Amount of Hemicellulose, Cellulose,

and Lignin in Coconut Fiber Table 2 and Figure 2 show the results of hydrolysis testing of coconut coir fibers, both those which have not been soaked and those that have been soaked. Un-soaked coconut fiber contains 33.5% Lignin, 37.9% Cellulose, and 15.5% Hemicellulose.

The amount of content was different from that reported by Sumi, namely 32.7% Lignin, 35.6% Cellulose, and 15.4% Hemicellulose. This shows that the lignocellulose content is influenced by the growth of natural fibers, even though the type of fiber is the same [8]. After immersion, the cellulose content decreases compared to after immersion, the lowest content is obtained by immersing 35% NaOH which is 21.7%.

This shows that high NaOH concentration will damage the structure of the fiber, where sodium hydroxide solution dissolves and removes wax layers from coconut fiber surface so that coconut fiber surface becomes coarser [2, 8]. Figure 3. Surface of Coconut Fiber Before (a) and After Treatment in (b) 25% NaOH (c) 30% NaOH (d) 35% NaOH (e) 40% NaOH (f) 45% NaOH (g) 50% NaOH (h) 55% NaOH Figure 3a shows coconut fibers that have not been immersed in sodium hydroxide solution.

Figure 3a shows that the surface of coconut fibers is smooth which is covered by layers of substances, such as wax, pectin, and other impurities. Figure 3b - 3h respectively shows the surface of the coconut fiber fiber observed using SEM which has been immersed in sodium hydroxide solution with a concentration of 25%, 30%, 35%, 40%, 45%, 50%, and 55%. Figure 3b - 3h shows the surface of coconut fiber coarser compared to the surface of coconut fiber shown in Figure 3a.

This shows that sodium hydroxide solution successfully cleanses the surface of coconut fiber from impurities and coatings that adhere to the coconut fiber surface. The rough of surface will help the reaction of the mechanical bond between the surface of the fiber and the resin used so that it will increase the adhesion between fibers with resin [6,12]. For example, as shown in Figure 3b, the surface of the fiber becomes rough and grooved.

The rough fiber surface can increase the ability of fibers to resist friction forces on the resin so that fibers tend to defend themselves when given a tensile force. Porous or grooved surfaces can be filled by a resin so that a strong bond is formed between the fiber and the resin [3]. Table 3. Tensile Stress and Elongation of Coconut Fiber Treatment

Treatment	WT	Tensile Stress (N/mm ²)	Elongation (%)
N25	186,4	28,3	31,3
N30	226,1	30,8	35
N35	197,9	27,0	40
N40	180,0	26,8	45
N45	157,4	28,9	50
N50	151,5	31,0	55
N55	93,4	18,1	---

Figure 4.

Tensile Stress of Coconut Fiber Before and After Treatment Table 3 and Figure 4 show the tensile stress and strain of coconut fiber, both un-soaked coconut fiber and coconut coir fibers which have been immersed in sodium hydroxide solution. Non-soaked coconut fiber has a tensile stress of 186.4 N/mm². Whereas coconut fiber which has been immersed in sodium hydroxide solution has a fluctuating tensile stress, but generally decreases as shown in Figure 4.

The highest tensile stress of coconut fiber is obtained by immersing 30% sodium hydroxide which is 226,1 N/mm², then decreasing. This shows that the higher the concentration of sodium hydroxide causes the tensile strength of coconut fiber to decrease. The decrease in the value of tensile strength is due to a decrease in the cellulose content of coconut fiber as the sodium hydroxide concentration increases [13].

Conclusion The concentration of sodium hydroxide had an effect on the amount of lignin, cellulose, and hemicellulose contained in coconut fiber, the tensile strength of coconut fiber, and the roughness of coconut fiber surface. The soaking coconut fibers in sodium hydroxide solution with high concentrations results in decreased cellulose so that the tensile strength of coconut fibers also decreases. However, the coconut fiber surface is increasingly rough which allows an increase in bonding strength between coconut fiber and resin.

The highest tensile strength was obtained at 30% sodium hydroxide 226,1 N/mm²

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