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The Influence of Coconut Cocoa Damage Time Using H2SO4 Solution as Material to Make Filter Cover with Polyester Matrix

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Abstract— *The purpose of this study was to determine the tensile and bending strength of coconut fiber composites using a polyester matrix. The manufacturing method used is the Hand Lay Up method. This composite was made with variations in coconut coir soaking time of 35 minutes, 45 minutes, 55 minutes, and 65 minutes against a 2.5% H2SO4 solution and then dried in the sun. Tests carried out according to the ASTM D 638-03 standard for tensile testing and bending testing using the ASTM D 790-02 standard with the three point bending method. From these tests, the best results will be taken to be used as samples for making vehicle components in the form of cover filters. After conducting research on coconut coir composites using H2SO4 as a threatment and variations of damping 35 minutes, 45 minutes, 55 minutes, and 65 minutes, the results obtained are the highest tensile test strength at the threatment time of 55 minutes with a value of 38.53 MPa and the lowest tensile strength, namely threatment time 35 minutes with a value of 28.08 MPa. As for the highest bending strength at the threatment time of 45 minutes with a value of 91.94 MPa and the lowest bending strength at the time of threatment of 65 minutes with a value of 61.33 MPa.*

Keywords— *Composite, Coconut coir, Polyester, H2SO4, Cover filter.*

I. Introduction

The advancement of science and technology in the industrial world today has resulted in an increasing need for materials for a product. The use of metal materials in the production process of a product has decreased. This is because metal materials are heavy, not resistant to corrosion, expensive, and difficult processes. One of the materials that is currently being developed is resin composites. [1]

Composite is a combination of two or more materials that are different in form, chemical composition, and between materials that do not dissolve each other where one material functions as a reinforcement and the other material functions as a binder to maintain the unity of its elements. One type of composite that is currently being widely developed is natural fiber composite. The use of natural fibers tends to reduce the use of composite materials over synthetic fibers. This is because the nature of natural fibers is corrosion-resistant, environmentally friendly, easy and safe manufacturing process, and cheap in terms of cost [2]

Natural fibers that can be used in making composites include sugar cane fiber, pineapple leaves, coconut fiber. Coconut fiber is a material containing lignocellulose that can be used as an alternative raw material for coconut fiber, coconut skin consisting of fibers found between the hard inner skin (shell), making up approximately 35% of the total weight of mature coconuts. In general, it can be said that the function of fiber is as a reinforcing material to strengthen the composite so that its mechanical properties are stiffer, tougher and more solid compared to without reinforcing fibers, in addition, fiber also saves on resin usage.[3]

In the research of Wardani & Kusumawardini, (2012), it is explained that in several studies, delignification generally uses NaOH and H_2SO_4. In the study on H_2SO_4 which compared pretreatment using chemical methods with bagasse, namely with H_2SO_4 (0.25% and 0.5%) and variations in heating time using an autoclave with a temperature of 121°C for 15, 30, and 45 minutes. Based on the results of the analysis, in the pretreatment method using 0.5% H_2SO_4 at a heating time of 30 minutes there was a decrease in lignin content from 21.11% to 12.97%. [4] Jonathan Oroh et al.'s explanation (2013) explains that Composite comes from the verb "to compose" which means to compose or combine. Composite is a series of two or more materials combined into one material microscopically where the constituent materials still look like the original and have a working relationship between them so that they are able to display properties that [1]

Another explanation of Composite According to Matthews et al. (1993) a composite is a material formed from a combination of two or more constituent materials through a non-homogeneous mixture, where the mechanical properties of each constituent material are different. From this mixture, a composite material will be produced that has different mechanical properties and characteristics from the constituent materials so that we are free to plan the strength of the composite material that we want by adjusting the composition of the constituent materials. Therefore, a composite is a series of multi-component systems with cohesive properties, i.e., a combination of matrix and adhesive and reinforcing materials.[5]

In the study of Fena Retyo Titani et al. (2018) explained that this material is considered to have light strength and is stronger than aluminum alloy. Fiber glass composites have light and strong properties, but the production costs are more expensive starting from the price of the basic materials and the manufacturing process and formation of the composite is relatively long. In addition, fiber glass is easily damaged at high pressure. Because fiberglass requires a different material than natural fibers, coconut fiber is another.[6]

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According to Suardana and Dwidiani (2007) who studied the effect of fiber treatment time on the mechanical properties of coconut filter fiber composites. In this study, the type of unsaturated polyester resin (UPRs) used was Yukalac 157 BQTN with a 10 mm long ivory coconut filter fiber composite. and using NaOH solution treatment materials. The coconut filter was dried naturally to remove water content. Separate the fibers and cut them into 10 mm lengths, then soak them in 5% NaOH chemical with variations in time for 2 hours, 4 hours, and 6 hours respectively, then rinse 14 with running water until clean. Drying was carried out in an oven at a temperature of 60 ° C for 24 hours. Cutting of test specimens was in accordance with ASTM D3039 standards for tensile tests and D790–03 for three-point bending tests. The results showed that increasing the NaOH treatment time resulted in a decrease in tensile strength, while increasing the NaOH treatment time increased the elastic modulus of the coconut filter fiber polyester composite. The highest tensile strength and tensile strain were achieved by the composite with 2 hours of NaOH treatment, namely 58.8 Mpa and 1.3%. While the highest modulus of elasticity was achieved by the composite with 6 hours of NaOH treatment, namely 13.55 Gpa. [7]

The results of the study showed that the hybrid composite was able to produce better tensile strength values compared to a mixture of coconut fiber (C: Matrix) and pineapple leaf fiber (B: Matrix). The shortcomings of single fiber composites that have less than optimal characteristic properties can be improved by combining two or more types of fibers in the matrix so that it will produce a composite that has better mechanical characteristic properties. Recent studies of polyester composites have produced promising results with hybridization of natural fibers as reinforcement. Bending tests carried out on composite test specimens showed that composites reinforced by long fibers (3cm) had higher bending strength compared to composites reinforced by short fibers (1cm and 2cm).

From the explanation above, a study was conducted on the manufacture of alternative materials, namely natural fiber reinforced composites, namely coconut fiber. Composite materials can combine the superior properties of their constituent materials to produce new materials with better properties. This study was conducted to obtain data on mechanical capabilities in the form of tensile and bending strengths on baggase composites using polyester matrices in the manufacture of filter shield covers.

II. MATERIAL AND METHOD

A. *Material*

The materials used in this research include:

1. Coconut Coir: The primary raw material used in this study is coconut coir, sourced from mature coconuts. The fibers were extracted from the husk and cleaned to remove impurities.
2. Sulfuric Acid (H2SO4): A 2.5% sulfuric acid solution was prepared for the treatment of coconut coir. The concentration was chosen based on preliminary studies that suggested its effectiveness in enhancing fiber properties without causing excessive degradation.
3. Polyester Resin: A standard unsaturated polyester resin was used as the matrix material. The resin was chosen for its good mechanical properties, ease of processing, and compatibility with natural fibers.
4. Catalyst and Hardener: Methyl ethyl ketone peroxide (MEKP) was used as a catalyst to initiate the curing of the polyester resin. A suitable hardener was also mixed to ensure proper cross-linking of the resin.

B. *Preparation of Coconut Coir*

1. Soaking Process: Coconut coir fibers were cut to a uniform length and immersed in the prepared 2.5% H2SO4 solution for varying durations: 35, 45, 55, and 65 minutes. The fibers were stirred periodically to ensure even exposure to the acid.
2. Rinsing and Drying: After soaking, the fibers were thoroughly rinsed with distilled water to remove any residual acid. Subsequently, they were dried under sunlight for 24 hours to eliminate moisture before incorporation into the composite..

C. *Composite Fabrication*

Hand Lay-Up Method: The Hand Lay-Up technique was employed for the fabrication of coconut coir/polyester composites. The steps included:

1. Preparation of Molds: Molds were prepared using a release agent to facilitate easy removal of the cured composite.
2. Resin Mixing: The polyester resin was mixed with the catalyst (MEKP) and hardener in accordance with the manufacturer's specifications to ensure proper curing.
3. Layering of Fibers and Resin: A layer of the treated coconut coir fibers was placed in the mold, followed by pouring the mixed polyester resin over the fibers. A brush or roller was used to ensure thorough wetting of the fibers.
4. Repeat Layers: This layering process was repeated until the desired thickness of the composite was achieved.
5. Curing: The composite was left to cure at room temperature for 24 to 48 hours, depending on the ambient conditions, until it was fully set.

D. *Mechanical Testing*

1. Tensile Strength Testing: The tensile properties of the composites were evaluated according to ASTM D 638-03. Standard dumbbell-shaped specimens were prepared and tested using a universal testing machine. The tensile strength was recorded at the point of failure.

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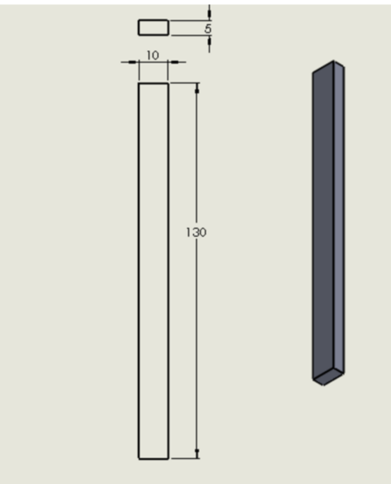

Fig. 1. ASTM D 790-02 Bending Test Specimen Design

2. Bending Strength Testing: Bending strength was measured following ASTM D 790-02 standards using a three-point bending setup. Specimens were subjected to a controlled load until fracture, and the maximum load and deflection were recorded to calculate bending strength.

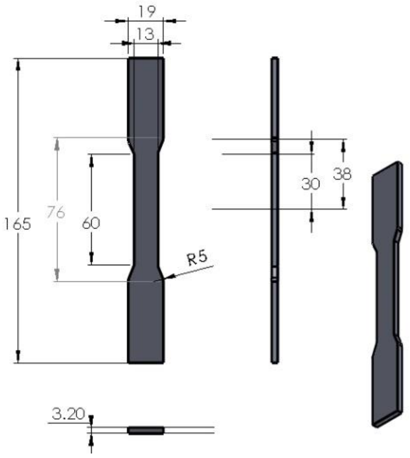

Fig. 2. ASTM D 638-03 Tensile Test Specimen Design Drawing

E. Data Analysis

The data obtained from tensile and bending strength tests were analyzed statistically to determine the significance of the effects of soaking time on mechanical properties. A comparison was made between the different soaking durations to identify the optimal treatment time for the best performance characteristics.

III. Results and Discussion

A. Composite Manufacturing Process

The process of manufacturing the coconut coir composite using H_2SO_4 solution and a polyester matrix involved several steps:

1. Coconut Coir Preparation.

The coconut coir fibers used in this research were locally sourced and thoroughly cleaned to remove any impurities. The washed fibers are dried under the sun to remove moisture.

Fig. 3. Coconut Coir Preparation.

2. Soaking in H_2SO_4 Solution

The dried coconut coir was soaked in a 2.5% H_2SO_4 solution for varying durations of 35, 45, 55, and 65 minutes. This soaking process served to modify the surface of the coir fibers, aiming to improve the interfacial bonding with the polyester matrix. After soaking, the fibers were again dried in sunlight.

Fig. 4. Soaking in H_2SO_4 Solution.

3. Composite Formation Using the Hand Lay-Up Method

Once dried, the treated coconut coir fibers were manually arranged and layered onto a mold. A polyester resin was then applied to the fiber layers using the Hand Lay-Up method. The fibers were thoroughly impregnated with the resin to ensure even distribution. After applying the resin, a hardener was added to initiate the curing process.

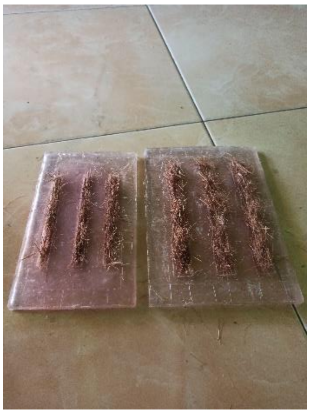

Fig. 5. Composite Formation

4. Curing and Finalization

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The composite was left to cure at room temperature until it hardened completely. Once cured, the composite sheets were removed from the mold and trimmed to the required dimensions for testing.


Fig. 6. Curing and Finalization

B. Tensile Test Results

The tensile strength test was conducted based on the ASTM D 638-03 standard. The results for each soaking time are presented in Table 1.

TABLE 1. Tensile Test Results

Time Variation (minutes)	Tensile Test Results (Mpa)
35 minutes	28.08 Mpa
45 minutes	37.56 Mpa
55 minutes	38.53 Mpa
65 minutes	36.12 Mpa

From the results, it is observed that the tensile strength increased with the soaking time, reaching a maximum value of 38.53 MPa at 55 minutes. Beyond this point, the tensile strength declined, with the lowest value of 28.08 MPa recorded for a soaking time of 35 minutes. The improved tensile strength at 55 minutes suggests that the surface treatment of the coir fibers at this duration achieved optimal adhesion with the polyester matrix. However, excessive soaking (65 minutes) likely caused fiber degradation, weakening the composite.

C. Bending Test Results

The bending test, performed using the ASTM D 790-02 standard with the three-point bending method, yielded the results shown in Table 2.

TABLE 2. Bending Strength Test Results

Time Variation (minutes)	Bending Strength (MPa)
35 minutes	77.24 Mpa
45 minutes	91.94 Mpa
55 minutes	63.74 Mpa
65 minutes	61.33 Mpa

The highest bending strength of 91.94 MPa was recorded at a soaking time of 45 minutes, indicating that this was the optimal treatment time for bending performance. Soaking times longer than 45 minutes led to a decline in bending strength, with the lowest value of 61.33 MPa observed at 65 minutes. The reduction in bending strength can be attributed to the degradation of fiber integrity due to overexposure to the acidic solution.

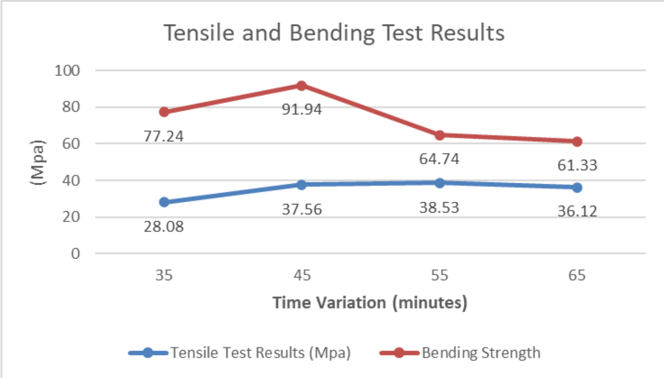

Fig. 3. Tensile and Bending Test Results

The tensile and bending test results of the coconut coir composite with varying soaking times in H_2SO_4 solution are presented in Figure X. The graph illustrates the relationship between soaking time and the mechanical properties, namely tensile and bending strength, measured in megapascals (MPa). The tensile strength, represented by the blue line, increases with soaking time, starting at 28.08 MPa for a soaking duration of 35 minutes. It continues to rise, reaching its peak value of 38.53 MPa at 55 minutes. After this point, a slight decline in tensile strength is observed, with a value of 36.12 MPa at 65 minutes.

Conversely, the bending strength, depicted by the red line, shows a different trend. It starts at 77.24 MPa for 35 minutes and reaches its maximum value of 91.94 MPa at 45 minutes. However, beyond 45 minutes, the bending strength begins to decrease, dropping to 64.74 MPa at 55 minutes and further to 61.33 MPa at 65 minutes.

These results suggest that the optimal soaking time for achieving the highest tensile strength is 55 minutes, while the optimal time for bending strength is 45 minutes. The decline in mechanical properties beyond these points can be attributed to the potential degradation of fiber integrity due to prolonged exposure to the acidic environment. Therefore, different soaking times may be needed depending on the desired mechanical property for the composite application.

D. Discussion

The results of both the tensile and bending tests demonstrate that the mechanical properties of the coconut coir composite are highly dependent on the soaking time in the H_2SO_4 solution. The surface modification of the fibers improved the bonding with the polyester matrix, particularly at the soaking times of 45 to 55 minutes.

However, prolonged exposure to the acid, as seen with the 65-minute soaking time, resulted in fiber weakening, leading to reduced tensile and bending performance. This suggests that while H_2SO_4 treatment is effective at enhancing mechanical properties, there is a critical point beyond which the fibers become overtreated and begin to lose strength.

Based on the results, a soaking time of 55 minutes provided

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the best tensile strength, while a time of 45 minutes was optimal for bending strength. These findings are crucial for optimizing the treatment process when manufacturing composite materials for vehicle filter covers or other structural applications.

IV. CONCLUSION

Based on the results of this study, it can be concluded that the soaking time of coconut coir fibers in a 2.5% H_2SO_4 solution significantly affects the mechanical properties of the resulting polyester matrix composite. The tensile and bending strength of the composite were tested, with the following conclusions:

1. Tensile Strength: The highest tensile strength was obtained with a soaking time of 55 minutes, reaching a value of 38.53 MPa. Soaking times shorter or longer than 55 minutes resulted in lower tensile strength, with the lowest value of 28.08 MPa observed at 35 minutes.
2. Bending Strength: The highest bending strength was achieved with a soaking time of 45 minutes, measuring 91.94 MPa. As the soaking time increased beyond this point, the bending strength decreased, with the lowest value of 61.33 MPa recorded at 65 minutes.

Overall, the optimal soaking times for improving the tensile and bending strengths of the composite are 55 minutes and 45 minutes, respectively. Prolonged exposure to the acidic solution led to fiber degradation, reducing the mechanical performance of the composite. These findings suggest that careful control of the soaking time is essential to optimize the mechanical properties of coconut coir fiber composites for applications such as vehicle filter covers.

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