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Modification of Kenaf Fibers Composite and Empty Oil Palm Bunch With Silane Coupling Agent Addition

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Abstract—This study reports the effect of coating Silane Coupling Agent (SCA) on composite surfaces with different formulation variations of 0%, 0.25%, 0.50%, 0.75%, 1% in weight fraction to the mass of kenaf fiber composites and empty oil palm bunches using epoxy resin. Composites made from composite particulate passing 50 mesh sieves. The particle board compacting process was carried out using a Hydrolic Press compacting machine with a pressure of 20 Bars, holding time 10 minutes in the initial stages, and continued using a Hot Press compacting machine with a pressure of 20 Bars, temperature 150 ^oC, holding time 15 minutes. The process of treating the Silane Coupling Agent solution on the composite surface is done manually layered on the composite surface. Composites were tested for flexibility using the Universal Testing Machine Galdabini Gallarate referring to ASTM D 790-03 and tested for density using ASTM D 792-13. Composites in this study have fulfilled SNI 03-3527-1994 type III strong class so that the kenaf composite and empty oil palm bunches can be used as an alternative replacing wood in buildings with high densities ranging from 1,1 – 1,3 g/cm^3.

Keywords - Particle Board, Wood, Composite, Kenaf, Empty Oil Palm Bunc, Silane Coupling Agent

I. INTRODUCTION

The use of composites with the use of fibers originating from nature in various fields is inseparable from the superior properties possessed by fiber composites that are lightweight, strong, rigid and resistant to corrosion. The basic advantages possessed by fibers originating from nature are abundant quantities, can be renewed and recycled and do not pollute the environment [1].

Indonesia is the second largest producer of oil palm in the world and one of the main problems associated with processing palm fruit is the amount of solid waste produced. This solid waste includes empty oil palm bunches, palm fiber and oil palm shells. Waste of empty oil palm bunches can be utilized and processed for manufacturing as natural fibers that are used for various purposes of making fiber composite materials, since fibers from the palm frond are useful for reinforcing (fillers) [2].

Kenaf fiber is a 4000 year old plant originating from ancient Africa, one of the common industrial plants in Indonesia, where this fiber contributes to the development of environmentally friendly industries, used for the sports, automotive, food packaging, furniture, textile, paper pulp and fiber board based industries. [3]. Kenaf plants can grow up to 4.5 m in 4-5 months [4] with an estimated annual yield of 6–10 tons of dry fiber/acre, producing four times more than pine trees yield [5]. Kenaf requires a short plantation cycle, low quantity of pesticide and flexible to various environmental conditions. Furthermore, Kenaf has great potential to be used as an alternative raw material to replace synthetic fibers in the particle board manufacturing industry [7].

The process of making composites requires a good adhesive to produce composites with physical and mechanical properties that meet the required standards. Epoxy resin is an adhesive that has good dimensional stability, wear resistance and better shock resistance than other resins [8]. In addition, epoxy resins when compared to polyester type resins have better bonding strength due to the presence of polar hydroxyl groups and ether in their chemical formulas [9]. Epoxy resin is a resin that is commonly used for the manufacture of natural fiber composites. To improve its quality, this resin is continuously modified to meet the use of high technology applications.

Efforts are made to reduce the absorption of water, blocking phenolic hydroxyl groups that exist in epoxy resins are through chemical or physical reactions to fuse with phenolic hydroxyl [10-11]. Silane Coupling Agent is commonly used as a modification additive because it is an environmentally friendly, non-toxicity agent, tends to be low on water absorption, high thermal stability and has good flexibility. Silane Coupling Agent can be used as an additive in thermoplastics. This silane can be used as an additive to improve the composite properties [12]

II. MATERIAL METHOD

A. Material

Kenaf fiber is obtained from kenaf farmers from Kampar regency, Riau province. The fiber is soaked with water for 7 days. After soaking, it is dried using an oven at a temperature of 60^0 C until the kenaf fibers to remove water content. Then, the fiber is cut to the size of 5 cm. Empty oil palm bunches are obtained from oil

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palm mill waste from PT. Johan Sentosa in Bangkinang, Kampar. The empty oil palm bunch fiber is cut to a size of 3 cm. Fiber is washed using water until the oil content in the water in the fiber is lost. After that, it is dried for 2 days. Epoxy resins were obtained from the chemical company called Megah Kimia, consisting of epoxy resins and hardener in a ratio of 2: 1. Silane (OFS-6030) was obtained from PT. Biopolytech Innovation.

B. Fiber Alkalization Process

Alkalization process for kenaf fibers and empty oil palm bunches was done respectively by soaking using NaOH. NaOH solution is prepared in the ratio of 5% (weight) from distilled water. The kenaf fiber and empty oil palm bunch are soaked with NaOH solution until the entire surface of the kenaf fiber and empty oil palm bunch are submerged. Kenaf fiber is soaked for 1x24 hours, while empty oil palm bunches are immersed for 2 hours at room temperature in different containers. After being soaked, kenaf fiber and empty oil palm bunch are washed using water. This fiber washing is done by running water on kenaf fiber and empty oil palm bunch to remove the NaOH solution and neutralize the fiber from NaOH. The fibers are dried by being placed in a container with a temperature of ±24 ºC then aerated for 1x24 hours. The fiber is then dried again in an oven at ± 60 ° C for 10 hours to ensure the water content contained in the kenaf fibers and empty oil palm bunches has been lost.

C. Fiber Refining Process (grinding)

Kenaf fibers and empty oil palm bunches are grinded using a grinding machine to obtain fine particle fibers that pass the 50 mesh sieve.

D. Weighing of Raw Materials

Kenaf fibers and empty oil palm bunches are dried at 103 ºC until the water content decreases at 3.0% [13], then mixed with the fractions according to Table I. Based on previous research, we have carried out research into making composites by varying the amount of weight of kenaf fibers and empty oil palm empty bunches. Composites with optimum mechanical test values are found in composites with a ratio of 1:1, also use 30:70 fiber and resin variations by different mass fractions.

TABLE I. KENAF RATIO MASS FRACTION:EMPTY OIL PALM BUNCHES:EPOXY

Composite Name	*Kenaf (%)*	*Empty Oil Palm Bunches (%)*	*Epoxy (%)*
K-TKKS	15	15	70

E. Composite Fabrication

Kenaf fiber, empty oil palm bunches and epoxy are stirred using a mixer at the highest speed for 5 minutes. All materials that have been mixed are put into a 20x15x2 cm mold then flattened and made using a hydrolic press with a pressure of 2 MPa with a holding time of 10 minutes. Then, the composite is made using a Hot Press machine. The selected processing parameters are at a temperature of 150^0 C, based on the commonly used Green Composite Fabrication method, for hot press temperatures of 150-180 ºC [13], in this study we use the lowest temperature parameters to avoid the charred composites. The most commonly used parameter is to use a pressure of 20 Bars with a fairly short containment time of 10 s, so in this study we chose a pressure of 20 Bars with a holding time of 15 minutes, so that the kenaf fibers and oil palm empty bunches that were initially clotted can spread evenly and avoid voids.

F. Composite Surface Coating

Silane is dissolved into a solution consisting of ethanol and aquades. The mass fraction of silane is 20%, ethanol is 72% and aquades is 8% of the total mass [14]. The concentration of Silane coated solution on the K-TKKS composite was 0%, 0.25%, 0.50%, 0.75%, 1% in the mass fraction. Composites are labeled K-TKKS-S (0%), K-TKKS-S (0.25%), K-TKKS-S (0.5%), K-TKKS-S (0.75%) and K -TKKS-S (1%). K-TKKS composites that have been coated with silane solution are dried in the oven for 2 hours at 80 ºC, then allowed to stand for 24 hours for the conditioning process.

G. K-TKKS Composite Density Test

Composite board density testing is carried out under air-dry conditions, then weighed in mass with a 5 cm x 5 cm test sample. Furthermore, the average length is measured with two measurement points, and the direction of the width of the two measurement points and thickness with four measurement points to determine the volume of the test sample (ASTM D 792-13)[15]. The composite board density values are calculated by using the following formula:

$\rho = m/V$ .... (1)

Description:
ρ = density (g/cm^3)
m = weight of the air dry test sample (g)
V = test sample volume (cm^3)

H. K-TKKS Composite Flexural Test

Flexural test is to determine flexural strength or stress, flexural or deflection and elasticity. This testing phase is carried out when the material receives a load until it changes shape (deformation) from elastic to plastic until finally the material is damaged (broken). Flexural testing is carried out using the Universal Testing Machine Galdabini Gallarate machine referring to ASTM D 790-03 [16].

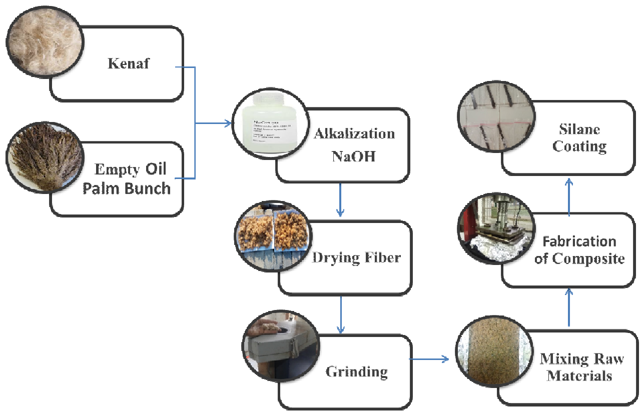

Figure. I. Schematic of Experimental Procedure

III. Results And Discussion

A. Density

In Figure I it can be seen that the greater the value of Silane given, the greater the density value. This is due to the function of the Silane solution which can increase the bond between the matrix of epoxy resin with filler, which is kenaf fibers and empty oil palm bunches. Based on Table II we can see that the density of the composite is in compliance with standard SNI wood for building, with density values above 0.9 g/cm^3. The density test results obtained satisfactory results of this composite based on SNI 03-3527-1994[17]. As seen in Table II, it is classified as a class I strong wood building.

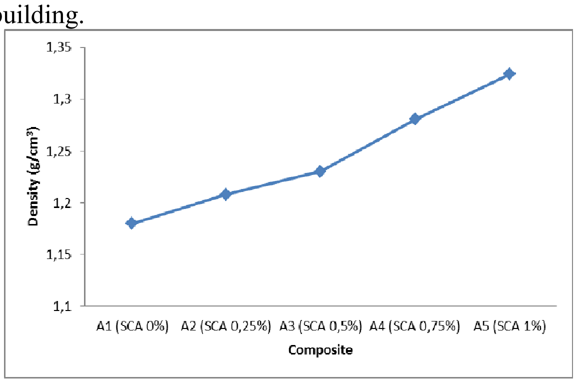

Figure II. The Graphic of Composite Density

B. Results of Flexural Strength

The powder fillers used in this study are inorganic and offer poor covalent bonding with an organic polymer resin. The weak bonding between these two components can be improved by silane coupling agent (SCA) addition. The results of the composite flexural test can be seen in Figure II. The test results showed a significant increase in strength between composites without silane and with silane. The K-TKKS-S composite (0%) is a composite without silane treatment having a flexural strength value of 425 Kgf/cm^2 while the K-TKKS-S composite (1%) has a flexural strength value of 524 Kgf/cm^2. The flexural strength of composites increases by up to 20%. The flexural test results also obtained satisfactory results of this composite based on SNI 03-3527-1994. Although the composite density testing in this study already meets SNI standards on wood for building type I, but for the flexural strength yet. As seen in Table II, it is classified as a class III strong wood building, meaning that this composite is strong to withstand the load and not easily broken or bent.

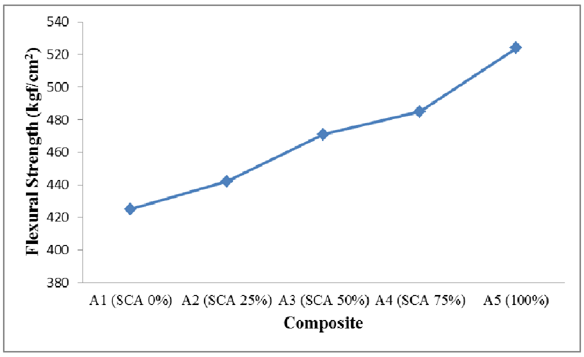

Figure III. Graphic of Composite Flexural Strength

TABLE II. COMPARATION RESULT WITH SNI 03-3527-1994 WOOD FOR BUILDING

Strength of Class	Density (gr/cm^3)	Density Composite (gr/cm^3)	Flexural Strength (Kgf/cm^2)	Flexural Strength Composite (Kgf/cm^2)
I	>0,9	1,17 – 1,32	>1221	-
II	0,6 - 0,9	-	795	-
III	0,6 – 0,6	-	437	425-524
IV	0,3 – 0,4	-	278	-
V	<0,3	-	<278	-

IV. Conclusion

Based on the research results, silane coatings have succeeded in increasing the bond between kenaf fibers, empty oil palm bunches and epoxy by increasing the amount of silane solution coated on the surface of the kenaf fiber composite and empty oil palm bunches. This can be seen from the increase in composite density. Composites in this study have fulfilled SNI SNI 03-3527-1994 type III strong class so that the kenaf composite and empty oil palm bunches can be used as an alternative to replace wood in buildings with high densities ranging from 1.1 - 1.3 g/cm^3.

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