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Characteristics of Particle Board Composite of Natural Fiber from *Musa Acuminate L.* That Was Increased in Abstract Position with Resin Polymer Matrix

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ABSTRACT

This research started with the removal of banana bark fiber and then did the pretreatment that is process to eliminate lignin in raw material. It used NaOH with variation 0%; 3%; 5% and 7%, after that printing with abstract composition. The characteristic test performed on this particle board is physical characteristic with parameters used are density, moisture content, water absorption every 24 hours and 72 hours and the development of thickness at immersion 24 hours and 72 hours. The density values obtained from each composition are 0.7696 g/cm^3; 0.7776 g/cm^3; 0.7824 g/cm^3; 0.7872 g/cm^3. The resulting water content is 15.1839%; 7,1073%; 6.2544%; 7,0472%. Absorption of water obtained in abstract position with 0% NaOH concentration; 3%; 5% and 7%, on the immersion of 24 hours generated 20.7125%; 11.7536%; 10,3788; 11.5477%. Meanwhile, on immersion 72 hours generated 24.7819%; 11.9799%; 10,8888%; 11.9789%. The value of thick development obtained at 24 hours of immersion that is 98.2465%; 43,7819%; 31.7889%; 36,1121%, while the thick development value obtained at 72 hours of immersion that is 98,4819%; 43.8129%; 32.1588%; 37.9569%.
KEYWORDS: Banana fiber, Particle Board Composite Materials, Pretreatment, Physical Characteristics.

INTRODUCTION

Increasing population causes the need for building/construction[1] and for household furniture[2] to increase, even faster than the population growth itself. The need for solid wood as industrial and construction[1] raw materials is increasing as the population grows. The shortage of supply of solid wood needs to be anticipated because it will endanger the sustainability of the forest on one side and the continuity of the industry on the other hand One way to overcome this by substituting solid wood with non-timber materials that are still not optimally utilized. One of them is waste of banana stem fiber (Musa Acuminate L.). The availability of such materials in Indonesia is quite abundant, so the opportunity of utilization as raw material of composite material[1,2,3,4,5,6,7] is very possible. If this technology can be developed it will increase the use value of banana stem waste, so that banana stem waste is not just a waste from plantation but can be utilized to be something more economical[3].

Composites are materials formed by the combination of two or more different components[12]. In general, composites are composed of two material[1,2,3,4,5,8,9,10,11] components, namely material matrix and reinforcement or amplifier, the two parts of this material are interconnected with each other based on the function of each part. The substrate or filler serves to strengthen the matrix because in general the substrate is much stronger than the matrix and will reinforce the formation of the material by affecting the physical and mechanical properties of the material formed. While the polymer matrix serves as a substrate protector rather than environmental effects and collision damage[13]. In addition, the composite material[1,2,3,4,9,10,11] comprises 2 or more phases (matrices phase and dispersed phase) and has properties significantly different from each component. Matrices phase is the primary phase which has continuous character. Matrices are usually more elastic and slightly hard. The matrix holds the dispersed phase and divides its load by the dispersed phase. The dispersed phase (reinforcement) is embedded within the matrix in a non-continuous form. The dispersed phase is usually stronger than the matrix, so it is sometimes called the booster phase[14].

Preparation of this composite[2,4,7,8,13,14] material beforehand must go through a treatment that is the process of delignification is done for fiber uptake because if the banana stalk is used without treatment / delignification will cause the surface of the fibers to become dirty and formed wax that can cause the surface of the fiber becomes softer, so the fiber bond with the matrix become weak and decrease the tensile strength[20], one of the fluids that can be used for the treatment process is NaOH.

Natural Fiber

Fiber is a strong material[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19], stiff, brittle. Because the fibers mainly resist the outer forces, there are two things that make the fiber resist the force that is: bonding between the fiber and the matrix (intervarsial bonding) is very good and strong so it is not easily separated from the matrix (debonding), aspec ratio the ratio between fiber length and fiber diameter is quite large. Fiber is characterized by its very high modulus and strength, elongation (good span

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strength), good heat stability, the ability to be transformed into filaments and a number of other properties that depend on usage[29].

In general it can be said that the function of fiber is as a reinforcement material to strengthen the composite [2,5,15,20,24,25,26,28,29] so that its mechanical properties are more rigid, tough and stronger than with no reinforcing fibers, in addition to fiber also save the use of resin. In the combination of fibers and resins, the fibers act as reinforcements which typically have high strength and stiffness, while the resin serves as an adhesive or matrix to maintain the position of the fibers, transmits shear forces and also serves as a fiber coating[30].

According Chandrabakty[31] there are several reasons to use natural fiber[2,23]as a composite amplifier as follows:

a. More environmentally friendly and biodegradable compared to synthetic fibers
b. Natural fiber weight is smaller
c. It has a weight-modulus ratio better than E-glass fiber
d. Natural fiber composites have higher acoustic damping power than E-glass fiber composites and carbon fibers
e. Natural fibers are more economical than glass fibers and carbon fibers

The requirement for fiber placement and different fiber directions makes fiber-reinforced composites differentiated into several parts [14] :

a. Continuous fiber composite (composite reinforced with fibers continue)
   Continuous or uni-directional, has a long and straight fiber arrangement, forming a lamina between the matrices. This type of composite is most commonly used. This type has a weakness in the separation between layers. This is because the power between layers is influenced by the matrix
b. Woven fiber composite (composite reinforced with fiber webbing)
   This composite is not easily influenced by the separation between layers because the fiber arrangement also binds between layers. However, the composition of the longitudinal fibers that are not so straight result in strength and stiffness will weaken. The composite consists of a matrix layer followed by a layer of fiber webbing
c. *Discontinuous Fiber Composite*
   Composites with short, random-type fibers are often used in large volume production because of their cheaper manufacturing cost factors. The disadvantages of this type of random fiber are the mechanical properties that are still below the strengthening with the straight fibers on the same fiber type.
d. *Hybrid fiber composite*
   Hybrid fiber composite is a composite combination of straight fiber types with random fibers. This type is used in order to replace the deficiencies of the two types and can combine the advantages.

Banana Fiber Composition(Musa Acuminate L.)

Banana fiber obtained from the banana tree kepok (Musa Acuminate L.) is a fiber that has good mechanical properties. The mechanical properties of banana stem fiber have a density of 1.35 g / cm 3, the cellulose is 63-64%, hemicellulose (20%), 5% lignin content, 600 Mpa average tensile strength, average tensile modulus 17,85 Gpa and the increase of length 3,36%[32].

Pretreatment

The purpose of pretreatment is to open the lignocellulosic structure so that there will be structural changes both physically and chemically. In this study, the pretreatment process uses an alkali solution ieNaOH. According to Sreekala et al.[33], the alkaline solution will provide high stability and maximum moisture retention.

Polymer Resin Matrix

The properties of the polymer will determine the exact application. The main advantages of the polymer as a matrix are low price, easy processing, good chemical resistance and low density. Conversely, low strength, low modulus and low operating temperatures limit their use[34]. Polymer composites are very popular because of their low price and simple manufacturing methods. Strengthening the polymer with a strong fiber network, has the following characteristics[22]:

a. High strength
b. High stiffness
c. High resistance to breaking / breaking
d. Good abrasion resistance
e. Good impact resistance
f. Good corrosion resistance
g. Resilience to fatigue (fatigue) is good
h. Low cost

While the major disadvantages of composite polymers are:

a. Low thermal resistance
b. High thermal expansion coefficient

Commonly used polymers are thermoplastic polymers, thermosetting polymers, elastomers and mixtures thereof, but in this study polymer resins are included in the thermosetting polymer classes. In the liquid thermoset resin polymers are converted into hard and brittle solids formed by chemical crosslinks forming very strong polymer chains. Thermoset resins do not melt due to heating. At the time of printing, this resin does not need to be applied pressure, because when it is liquid it has a relatively low viscosity, hardened at room temperature with the use of a catalyst without producing gas (unlike other thermoset resins)[15].

The mechanical properties of the composite[2,5,15,20,24,25,26,28,29] particle board can be known by examining the physical properties of the composite particle board. Physical testing can be:

1. **Density**
   To find out the physical properties of composite particle board, density test (ρ) was done. The mass density of a homogeneous material is defined as the mass of volume unity. Mathematically writable:
   $$\rho = \frac{m}{v}$$
   Where :
   ρ = density (gr/cm^3);
   m = mass of the test sample (gram);
   v = volume of test sample (cm^3)

2. **Water content**
   Particle board moisture content calculated from the initial weight and final weight after a drying in an oven for 24 hours.composite particle board moisture content calculated using the formula:
   $$\text{Water content} = \frac{BA-BB}{BB} x\ 100\%$$
   Where :
   KA = moisture content (%)
   BA = initial weight of test sample (gram)
   BB = fixed weight of test sample after drying (gram)

3. **Water Absorption**
   At the moment there is the possibility to form a sample of air trapped in the layer of aggregate or occur due to decomposition of minerals that formed due to weather changes, then formed small holes or cavities in the aggregate grains (pore). The pores in the sample vary and spread throughout the granules. The pores may be a free water reservoir inside the aggregate. The percentage of water weight absorbed by aggregates and fiber in water is called water absorption[26], while the amount of water contained in aggregate and fiber is called water content[35].
   $$\text{Water Absorption} = \frac{Mb-Mk}{Mk} x100\%$$
   Where :
   Mb = initial mass
   Mk = final mass

4. **Thick Development**
   The thick development[40] is defined as a quantity that expresses the thickness of the test sample in percent against the initial thickness. The thick development is measured using the formula:
   $$\text{Thick Development} = \frac{T2-T1}{T1}\text{x}100\%$$
   Where :
   T1 = Thick Initial
   T2 = Thick end

MATERIAL AND METHOD

Raw Material Preparation

Raw material such as banana bark is cleaned and dried for 1 week, then crushed with a wire brush and drawn fiber. After the fiber was obtained, the fiber was immersed in NaOH solution with each concentration of 3%, 5% and 7% for 2 hours. Then the fiber is washed with aquadest and drained.

Composite Manufacture

The banana fiber is arranged in abstract mold, then doused with a resin matrix according to the predefined composition.

Composite Testing

Tests carried out in this study were density[27]values, water content, water absorption[26] and thick development[40] using Japanese Industrial Standard (JIS) standards for Particleboard A 5905-2003[36] and Japanese Industrial Standard (JIS) for Particleboard A 5908-2003[37].

RESULTS AND DISCUSSION

Composite Particle Density

One of the physical properties of composite[3,5,15,16,21,22,23,24,25,26,27] boards that greatly affect the mechanical properties of the composite particle board is density[27]. The result of measurement of density value on composite particle board in this study ranged between 0,7696 g/cm^3 – 0,7872 g/cm^3.

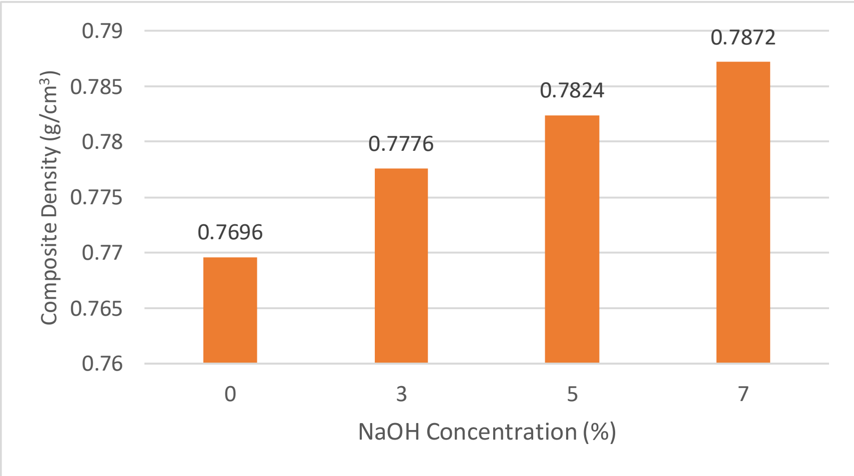

Figure 1. Graph of the relationship between the density values of the composite particle board with concentration of NaOH

Based on Figure 1, it can be seen that the density test results on composite board particles produced the highest density of 0.7872 g/cm^3 at 7% NaOH concentration and the lowest density 0.7696 g/cm^3 at 0% concentration. This suggests that composite boards fall into categories meeting the standards required by JIS A 5908-2003[37] which require a density of between 0.4 g/cm^3-0.9 g/cm^3. As well as the category the density required to meet the standards JIS A 5905-2003[36] which require density fiberboard ranging from 0.35 g/cm^3- 0.8 g/cm^3. In the composite particle board that has been through a treatment process using NaOH showed a greater density than the absence of prior treatment. According to JIS A 5908-2003 [37] for composite particle board is included in the medium density category.

Water content of Composite Particle Board

One of the physical properties that shows the water content of the composite particle board in a state of equilibrium with its environment is the moisture content.

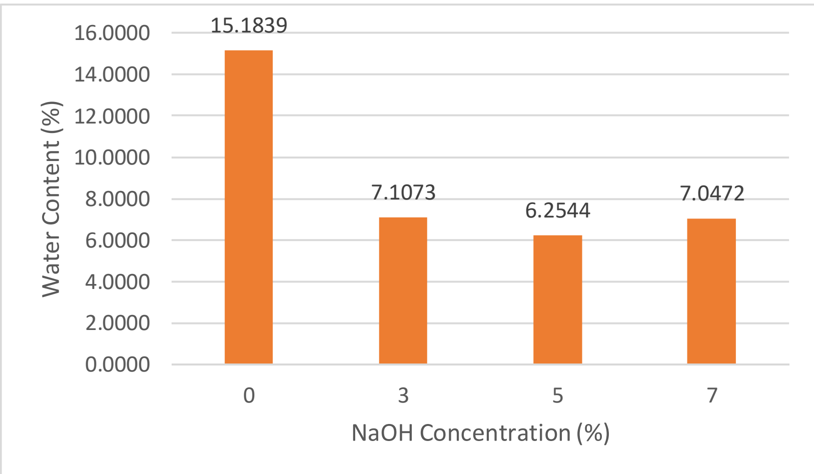

Figure 2. Graph of the relationship between the water content of the composite particle board with the concentration of NaOH

Based on Figure 2, the highest water content of 15.1839% was obtained at 0% NaOH concentration (without NaOH treatment) and the lowest water content was 6.2544% with 5% NaOH concentration. This indicates that the composite particle board meets the requirements of JIS A 5908-1994[37] and JIS A 5905-1994[36] for the fiberboard which requires the particle board and board values between 5% -13%.

According to Haygreen and Bowyer[38] that the water content of raw materials greatly determines the water content of the resulting composite board, the higher the water content of raw materials, the higher the water content of composite boards because not all water vapor can be removed from the composite board. In the manufacture[3,5,6,11,19] of composite board raw materials must be dry with water content of about 2% -5%, so that if added adhesive then the water content of raw materials will increase up to 4% -6%. Composite board without treatment shows high water content, this is because banana bark fiber has hygroscopic properties, but also due to drying of raw materials only about 2 hours. This is done to avoid damage to the fiber is relatively small. Meanwhile, banana stem fiber treated with NaOH reacts to form a highly reactive alkaline cellulose that, according to Kollmann and Cote[39], the composite board will have high water repellent properties. Hence it can cause hygroscopic properties on the composite particle board to decrease.

Water Absorption

One of the physical properties of composite[3,5,15,16,21,22,23,24,25,26,27] particle board that shows the ability to absorb water is the water absorption.In this study the immersion was done at 24 hours and 72 hours.

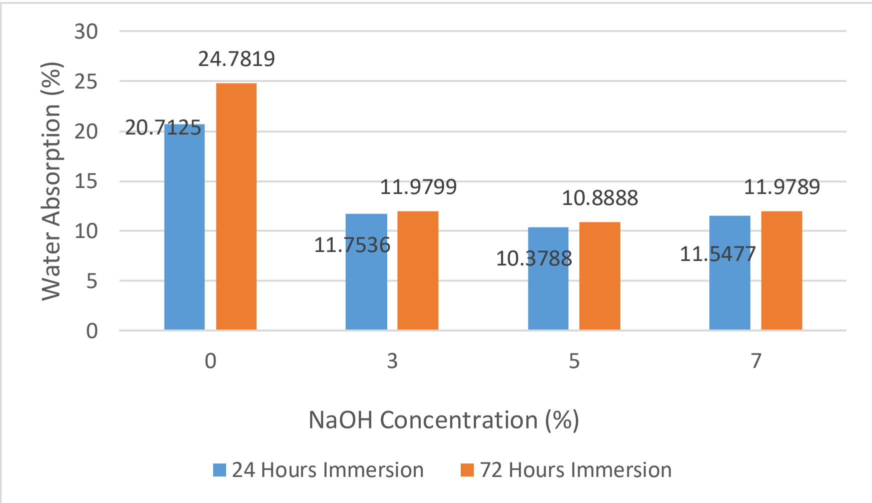

Figure 3. Graph of the relationship between water absorption capacity of composite particle board with NaOH concentration

Based on Fig. 3, the highest water absorption value was 20.7125% at 24 hours and 24.7819% for immersion for 72 hours with 0% NaOH concentration (without NaOH treatment) and lowest absorption of 10.3788% at soaking for 24 hours and 10,8888% at immersion for 72 hours with 5% NaOH concentration. This may be due to the banana midstring fiber having hygroscopic properties. However, in banana stem fibers treated with NaOH will react to form highly reactive alkaline cellulose so that according to Kollmann and Cote[34] the composite board will have high water repellent properties. Hence it can cause hygroscopic properties on the composite particle board to decrease. However, JIS A 5908-1994[37] and JIS A 5905-1994[36] do not require water absorption on composite boards.

Thick Development

The nature of this thick development[40] is usually used as a reference to determine whether a composite board is used as an interior or exterior type composite board.

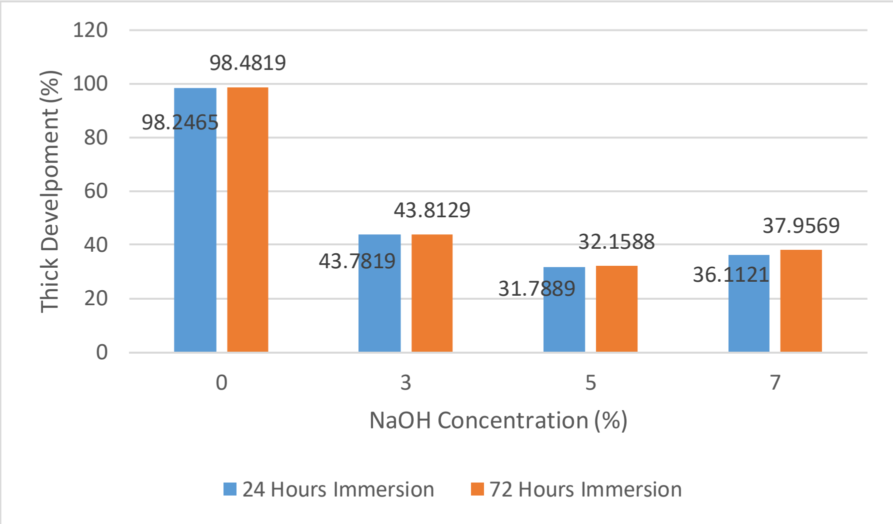

Figure 3. Graph of the relationship between thickness development of composite particle board with NaOH concentration

Based on Fig. 4, the highest thick development value of 98.2465% was achieved on immersion for 24 hours and 98.4819% for immersion for 72 hours with 0% NaOH concentration (without NaOH treatment) and lowest absorption of 31,7889% at immersion for 24 hours and 32.1588%.

JIS A 5908-1994 standard requires a maximum of 12% thick development while in JIS A 5905-1994 does not require the development of thick. In this study all the samples showed less qualified results in JIS A 5905-1994. This is thought to be because the psori midrib is very hygroscopic and includes a type of plant that has high water content. However, treatment using NAOH may have an effect on lowering the thickness rate even if the results are below standard.

CONCLUSION

Based on the results of the research, the following conclusions are obtained:

1. The density of the composite particle board produced the highest density of 0.7872 g/cm^3 at 7% NaOH concentration and the lowest density 0.7696 g/cm^3 at 0% concentration. This composite particle board belongs to the category compliant with JIS A 5908-1994 which requires a density of between 0.4 g/cm^3- 0.9 g/cm^3 for particleboard and also meets the required density standard JIS A 5905-1994 which requires a board the density fibers range from 0.35 g/cm^3 to 0.8 g/cm^3 so that the composite particle board is of medium density category.
2. The highest moisture value was 15,1839% at NaOH concentration 0% (without NaOH treatment) and lowest water content (best) equal to 6,2544% with 5% NaOH concentration. The composite particle board with NaOH treatment meets the requirements of JIS A 5908-1994 and JIS A 5908-1994 which requires a particle board particle value between 5% -13%. However, non-NaOH composite particle board does not meet the requirements required by JIS A 5908-1994 and JIS A 5905-1994.
3. The highest water absorption value was 20.7125% at immersion for 24 hours and 24.7819% for immersion for 72 hours with 0% NaOH concentration (without NaOH treatment) and the lowest absorbent (best) of 10.3788% at immersion during 24 hours and 10,8888% at immersion for 72 hours with 5% NaOH concentration. JIS A 5908-1994 and JIS A 5905-1994 do not require water absorption on composite boards.
4. Highest development value of 98.2465% for immersion for 24 hours and 98.4819% for immersion for 72 hours with 0% NaOH concentration (without NaOH treatment) and lowest absorbance (best) of 31.7889% at immersion for 24 hours and 32.1588%. Overall this composite particle board does not meet the requirements of JIS A 5908-1994 which requires the development of a maximum thickness of 12. Whereas, for the JIS A 5905-1994 fiber composite board does not require the development of thick.

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