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PHYSICO CHEMISTRY PROPERTIES OF PARTICLE BOARD BASED ON COCO DUST AND LIQUID NATURAL RUBBER

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ABSTRACT
A particle board is a board made of lignocellulosic material and together with an adhesive and then pressed. In this research, a particle board is made by mixing coco dust with a number of liquid natural rubber percentages. Next particle board is molded then dried and pressed to get 2,5 cm thickness and further characterization is carried out which consists of MOR, MOE, pull out the screw, content of water, density, thickness development, FTIR, and SEM test. FTIR spectrum was recorded on wave number 4000–400 cm^{-1} whereas micrograph SEM was recorded at 5000 times magnification. The test results show that the best conditions for making particle boards are obtained when using 50% liquid natural rubber. Under these conditions, the quality of the particle board which includes MOR, MOE, the screw hold strength, water content, density, and thickness development is 381.41 g/mm^2, 198.40 g/mm^2, 24440 g/mm^2, 1.94%, 1.6047 g/cm^3, and 7.5% respectively
Keywords: Coco dust, Liquid Natural Rubber, MOE, MOR, Particle Board, Screw Hold Strength.
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INTRODUCTION
A particle board is a board made of lignocellulosic material glued together with an adhesive and then pressed.[1-3] The advantages of particleboard compared to ordinary wooden boards are the size, shape, and quality can be adjusted as desired. Various waste materials from agricultural products contain lignocellulosic material so it can be used to make particle boards.[4-7]
One of the remaining agricultural products that contain lignocellulosic material and can be used to make particleboard is coconut coir powder known as coco dust.[8-10] Cocodust is a residual material from agricultural products that is very easy to obtain in Indonesia because Indonesia is one of the main coconut-producing countries in the world.[11] As an adhesive in this study, one of the natural ingredients that are also widely available in Indonesia will be used, namely liquid natural rubber.[12-13] Liquid natural rubber is a natural polymer obtained by tapping the sap of the rubber tree (*Hevea brasiliensis*) which is then concentrated. Considering that Indonesia is one of the main producers of natural rubber besides coconut the sustainable production of particle board with basic ingredients of coco dust and liquid natural rubber as the adhesive will be very easy to do. So far, coco dust is only considered as waste material from coconuts that have not been widely used, so research on the use of coco dust as an alternative base material for the manufacture of particle board with liquid natural rubber adhesive becomes very interesting to do.
The purpose of this research was to produce a particle board from coco dust with a number of liquid natural rubber percentages. The characterization of the particleboard made includes physical chemistry properties test consisting of MOR, MOE, pull out the screw, content of water, density, thickness development, functional group test with Fourier Transform Infrared (FTIR) spectroscopy, and surface uniformity test with Scanning Electron Microscopy (SEM).

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EXPERIMENTAL

Material and Methods

Cocodust is obtained by separating it from coconut fiber and then sifting it to get a size of 75 mesh. Liquid natural rubber or concentrated latex with a dry rubber content of 60% obtained from Bogor, West Java, is used as an adhesive.

General Procedure

The experiment of making particle board started by mixing 55 grams of coconut powder with 10%, 20%, 30%, 40%, and 50% liquid natural rubber.1 Furthermore, the mixture is molded to get a test piece of particle board with size 10 x 5 x 7.5 cm in length, width, and height then dried. The next step is pressing the particle board test piece to get 2.5 cm of thickness.

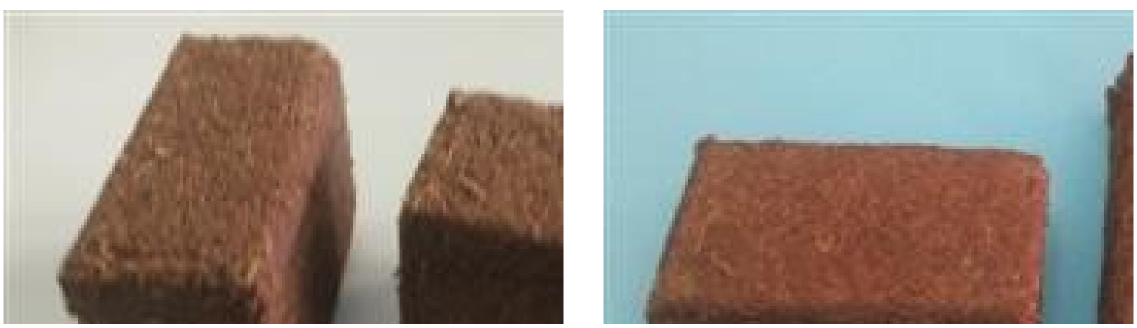
Detection Method

Testing the physicochemical properties of particle board in accordance with the SNI 03-2105-2006 which includes MOR, MOE, pull out the screw, water content, density, thickness development, a functional group with Fourier Transform Infrared (FTIR) spectroscopy, and surface uniformity with Scanning Electron Microscopy (SEM)[10-11]. Functional group testing was carried out using an FTIR spectrophotometer Bruker alpha II FTIR spectrometer, while MOR, MOE and pull out the screw test was done by tensile strength tester KT 7010A, and testing of SEM was done by SEM EVO MA 10.

RESULTS AND DISCUSSION

Particle Board Test Pieces

Prior to testing, a dried test piece of particle board with a size of 10 x 5 x 7.5 cm was pressed up to 2.5 cm thickness as the particle board thickness on the market. Particle board test pieces were made before and after pressing as can be seen in Fig.-1.



(a) Test Pieces Before (b) Test Pieces After

Fig.-1: Test Pieces of Particle Board Before and After Pressing

MOR and MOE

The results of MOR and MOE testing of particle board from coco dust and liquid natural rubber are shown in the curve of Fig.-2.

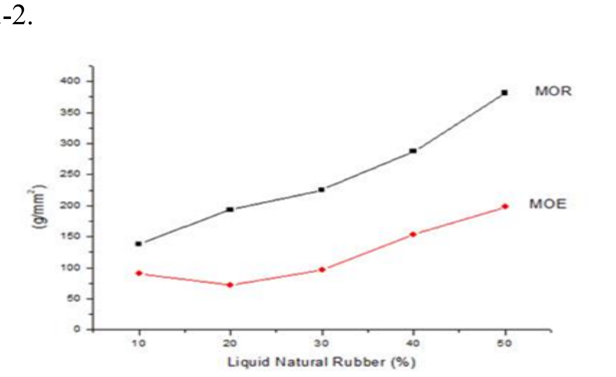


Fig.-2: Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) of Particle Board at Various percentages of Liquid Natural Rubber

In Fig.-2, it can be seen that the MOR and MOE values for particle boards are getting bigger when using liquid natural rubber with a higher percentage. The maximum value of MOR and MOE was reached with the use of 50% liquid natural rubber. This is because the higher the percentage of liquid natural rubber used, there will be more chemical bonds between lignocellulose from coco dust and polyisoprene from liquid natural rubber, as a result, the resulting particleboard becomes stronger and more flexible. On the best component mixture ratio, the MOR and MOE value of particle board is 381.41 g/mm^2 and 198.40 g/mm^2 respectively.

The Screw Holds Strength

The results of pulling out the screw test of particle board from coco dust and liquid natural rubber as an adhesive are shown in the curve of Fig.-3.

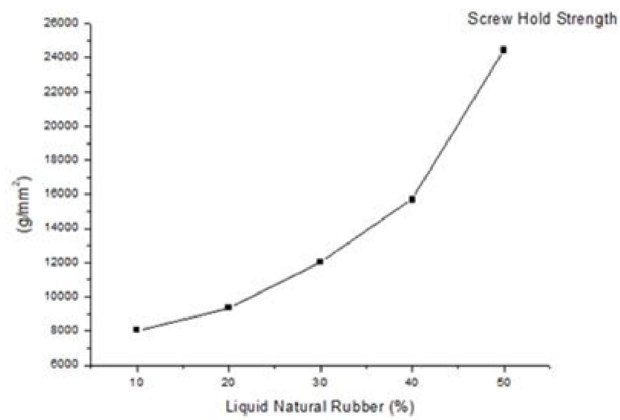


Fig.-3: Pull Out of the Screw of Particle Board of Some Liquid Natural Rubber Percentages

From Fig.-3, it can be seen that the value of the screw hold strength of particle board is getting bigger when using liquid natural rubber adhesive with a higher percentage This is because the higher the percentage of liquid natural rubber used, the more the possibility of chemical bonds occurred between lignocellulosic molecules from coco dust and polyisoprene molecules from liquid natural rubber so that the resulting particle board can hold the screws stronger. Particle board strength to hold screws reaches a maximum value at the use of 50% liquid natural rubber. On this percentage of liquid natural rubber, the particle board strength to hold the screw was 24440 g/mm^2.

Water Content

The results of the water content testing of particle board on some percentages of liquid natural rubber are shown in the curve of Fig.-4.

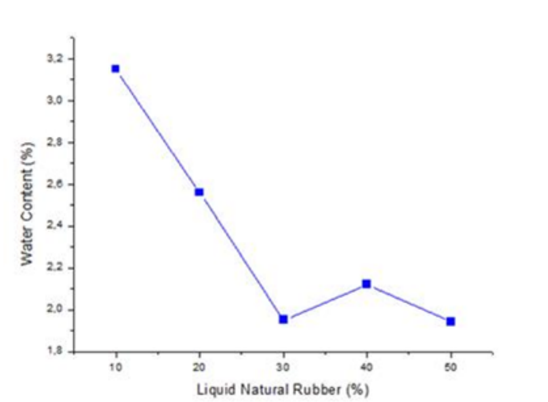


Fig.-4: Particle Board Water Content on Some Liquid Natural Rubber Percentages

From Fig.-4 it can be seen that the water content of the particle board is getting smaller when using liquid natural rubber as adhesives with a higher percentage. This is because the greater the percentage of liquid natural rubber used, the greater the number of polyisoprene molecules from liquid natural rubber that participate in the formation of chemical bonds with lignocellulosic molecules from coco dust so that the chemical bonds that occur will be more tightly and consequently there will be fewer water molecules. which will be able to enter between the chemical bonds so that the water content in the particle board made is also less. The lowest water content is obtained when using liquid natural rubber with a percentage of 50%. In this percentage of liquid natural rubber, the particle board made has 1.94% water content.

Density

Results of the particle board density test from coco dust with liquid natural rubber adhesives with some percentages of liquid natural rubber are as shown in the curve of Fig.-5. In Fig.-5, it can be seen that the density of the particle board is higher when using liquid natural rubber with a greater percentage. This is because the greater percentage of liquid natural rubber used for the manufacture of particle board means that more polyisoprene molecules will participate in interacting with lignocellulosic molecules from coco dust so that there will be more chemical bonds and the resulting density of particleboard will also be greater. The best conditions were obtained when using liquid natural rubber with a percentage of 50%. At this percentage of liquid natural rubber, the particle board made has a density of 1.6047 g/cm^3.

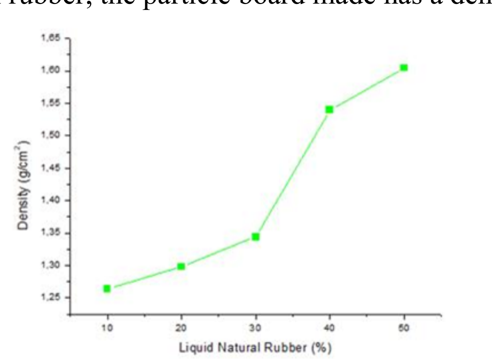


Fig.-5: Particle Board Density on Some Liquid Natural Rubber Percentages

Thickness Development

The particle board thickness development test result from coco dust with liquid natural rubber adhesive is as shown in the curve of Fig.-6.

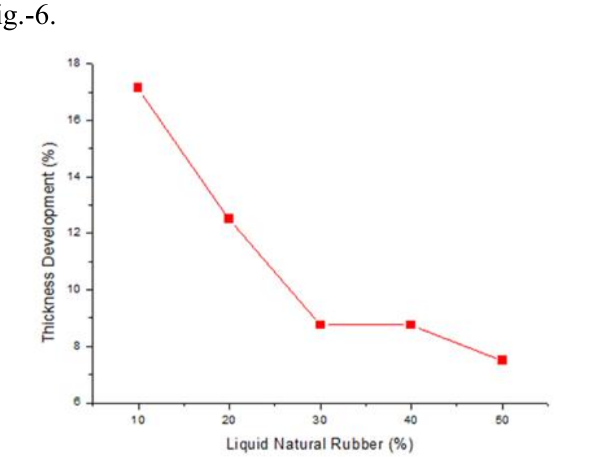


Fig.-6: Particle Board Thickness Development on Some Liquid Natural Rubber Percentages

In Fig.-6, it can be seen that the thickness development of the particle board is getting smaller when using liquid natural rubber with a higher percentage. This is because the higher the percentage of liquid natural rubber used as an adhesive in the manufacture of particle board, the more polyisoprene molecules will participate in the formation of chemical bonds with lignocellulosic molecules from coco dust so that more and more chemical bonds will form and consequently the resulting product of particle board will have a higher density. The denser the particle board, the fewer water molecules that can enter the cavities between the particles of the coco dust, and this results in a smaller thickness of the produced particle board. The lowest thickness development was obtained when using liquid natural rubber with a percentage of 50%. At this percentage, the thickness development of the particle board is 7.5%.

FTIR Test Result

The spectrum of the particle board test results from coco dust with some percentages of liquid natural rubber as the adhesive is shown in Fig.-7.

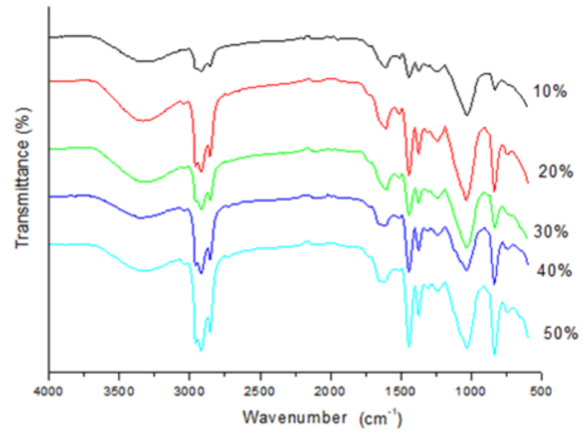


Fig.-7: Particle board FTIR Spectrum at a Number of Liquid Natural Rubber Percentages

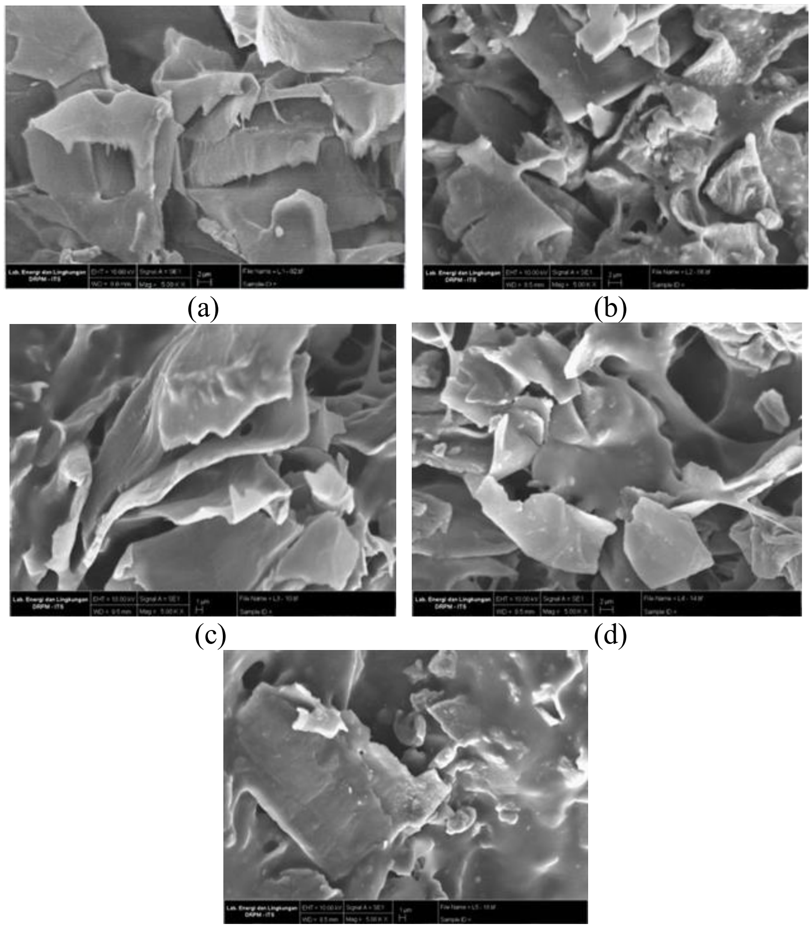
From the FTIR spectrum in Fig.-7, it can be seen that the use of liquid natural rubber with different percentages causes changes in the number of bonds between lignocellulose as the main component of coco dust and polyisoprene from liquid natural rubber as the adhesive. This can be seen from the change in the intensity of the transmittance spectrum, especially at wave numbers 3400 cm^{-1}, 2918 cm^{-1}, and 1443 cm^{-1}. The decrease in transmittance intensity at the wave number of 3400 cm^{-1} indicates a decrease in the number of OH groups from cellulose in the increasing use of liquid natural rubber. This shows that there is a chemical reaction between lignocellulose molecules from coco dust with polyisoprene molecules from liquid natural rubber. The increase in transmittance intensity at 2918 cm^{-1} indicates an increasing number of CH_3 groups in the use of liquid natural rubber with an increasing percentage. The increase in transmittance intensity in the area of 1443 cm^{-1} indicates the increasing number of CH_2 groups in the use of liquid natural rubber with a greater percentage.

SEM Test Results

The results of the SEM test of particle board from coco dust and natural liquid rubber with a magnification of 5000 times at a number of liquid natural rubber percentages are shown in Fig.-8. From the particle board micrograph in Fig.-8, it can be seen that the higher the percentage of liquid natural rubber used, the more evenly distributed it is as an adhesive in the formed particle board. In the use of liquid natural rubber by 50%, it is even seen that the coco dust particles as the main component in the manufactured particle board have been immersed in the liquid natural rubber adhesive environment. This causes the strength, flexibility, screw hold strength, and particleboard density to be higher when using liquid natural rubber with a higher percentage, and the best conditions are obtained when using liquid natural rubber as an adhesive by 50%. This situation also causes the water content and thickness of particle board to decrease when the percentage of liquid natural rubber used is getting smaller, and it reaches the lowest value when using liquid natural rubber as an adhesive by 50%.

CONCLUSION

The liquid natural rubber amount used is very influential on the physical-chemistry properties of the particle board produced. The best physio-chemistry properties of particle board in this study were obtained on the use of liquid natural rubber as much as 50% as an adhesive. On the use of adhesive with this percentage the value of MOR, MOE, pull out the screw, water content, density, and thickness development of particle board was 381.41 g/ mm^2, 198.40 g / mm^2, 24440 g/mm^2, 1.94%, 1.6047 g/cm^3 and 7.5% respectively.



(a) (b)
(c) (d)
(e)

Fig.-8: Particleboard Micrograph at Various Percentages Liquid Natural Rubber:
a. 10%; b. 20%; c. 30%; d. 4%; e. 50%

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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