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Optimum Cocopeat grain size of particle board based on Cocopeat and liquid rubber compound

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Abstract

Particle board research made from cocopeat and liquid rubber compound with various grain size has been done. First particle board was made by mixing various cocopeat grain size were > 10 mesh, 10-25 mesh, 25-50 mesh, 50-75 mesh and < 75 mesh with 30% of liquid rubber compound to obtain a particle board with length, width and height of 5 x 10 x 7.5 cm and then dried by drying. Subsequently the particle board pressed to a thickness of 2.5 cm and then tested the modulus of elasticity (MOE), the modulus of rupture (MOR), the screws hold strength, FTIR and DTA-TG. The results indicated that the best condition was obtained on the use of grain size 50-75 mesh. In this condition, the MOR, MOE and the screws hold strength were 11.363 N/mm^2; 454.66 N/mm^2 and 435.02 N/mm^2 respectively. DTA-TG testing results show that the heat resistance of particle board was 240 °C.

Keywords: Particle board, Cocopeat, Liquid rubber compound, MOR, MOE.

Full length article **Corresponding Author*, e-mail: tejads@unib.ac.id

1. Introduction

Particle board was a board made from wood particles or other lignocellulose materials bonded with an adhesive and then heat-treated. There are many previous studies have reported on lignocellulose-based particle boards [1-4]. The advantages of this board was the size and density can be adjusted to the needs in addition to the quality can be set. In addition, the particles used can be obtained from materials that were generally waste that has been no longer used, as has been reported by previous studies [5-9]. One of the lignocellulose materials that can be used to make particle board was cocopeat which was a fine powder of coconut fiber that has been separated from the fibres. Several previous research reports related to the use of this material and its modifications have been reported [10-14]. Cocopeat was a material that can be obtained easily in Indonesia, because Indonesia is the one of world's major coconut producer and this is a waste material that has not been widely used. In this research, natural polymers, namely liquid rubber compounds, were used as particle board adhesives which was a mixture of concentrated latex with certain chemicals to improve its properties [15-16]. Concentrated latex as a raw material for liquid rubber compound is very easy to obtain in Indonesia considering that Indonesia is one of the world's natural rubber producers, so that sustainability in making particle board using cocopeat raw materials and liquid rubber compound adhesive will not result in a shortage of raw materials for a long period of time. The problem that exists is research how to make particle board using cocopeat and liquid rubber compound as adhesive. No one has reported it until now, because cocopeat is only seen as a waste material from the remainder of the coconut fibre process, even though the chemical structure can be said to be almost similar to the coconut fibre. But from the physical properties the fibre size is different. So, research to the production and characterization of alternative board composites from cocopeat and liquid rubber compounds as particle board is very interesting to carry out. The purpose of this research was to determine the optimum cocopeat grain size for making particle board based of cocopeat and liquid rubber compound. Testing changes in the physicochemical properties of particle board was done by determination the change value of the modulus of rupture (MOR), the modulus of elasticity (MOE), the screw hold strength, FTIR and thermal test (DTA-TG).

2. Materials and methods

The materials used in this study consisted of cocopeat with various grain sizes, namely > 10 mesh, 10-25 mesh, 25-50 mesh, 50-75 mesh and < 75 mesh, distilled water, concentrated latex with 60% dry rubber content and chemicals. Rubber additives consisting of stearic acid, zinc oxide (ZnO), sulfur (S), benzo thiazyl disulfide (MBTS), tetramethyl thiuram disulfide (TMTD).

It also includes butyl hydroxytoluene (BHT), calcium carbonate ($CaCO_3$), potassium hydroxide (KOH) and sodium naphthalene sulfonate (Darvan). The tools used in this study were the analytical balance Sartorius BP 4100 type, Fisson magnetic stirrer, Kao Tieh tensile strength tester model KT 7010A, Memmert oven and Ball Mill. The experiment began with making a liquid rubber compound by mixing concentrated latex with various compound additives consisting of activator, accelerator, vulcanizator, stabilizer, antioxidant and filler [15]. Furthermore, a particle board test piece of 10 x 5 x 7.5 cm was prepared by mixing 55 gr cocopeat with various grain size were > 10 mesh, 10-25 mesh, 25-50 mesh, 50-75 mesh and < 75 mesh with 30% of liquid rubber compound to obtain a particle board with the length, width and height of 5 x 10 x 7.5 cm and then dried by drying. The next step is testing the physico chemical properties of particle board that have been made include modulus of rupture (MOR), modulus of of elasticity (MOE), screw hold strength, FTIR and DTA-TG test in accordance American National category Standards Institute, ANSI/A208.1-1999 with prior pressing particle board to obtain a thickness of 2.5 cm. The experiment of making particle board and FTIR Test were done in chemistry laboratory, Faculty of Mathematics and Natural Sciences, University of Bengkulu, while for testing of MOR, MOE and screw hold strength were done in laboratory of material, Faculty of Mechanical Engineering Gadjah Mada University Yogyakarta. Thermal testing (DTA-TG) was done in material laboratory of Leather Technology Academy, Yogyakarta. The scheme for making particle board is shown in the Figure 1.

3. Results and Discussions

3.1. Modulus of Rupture (MOR)

The MOR test results of particle board at various cocopeat grain size were shown in Figure 2. The Figure 2 shows that MOR value of particle board increases on the smaller grain size of cocopeat, reaching maximum at the use of grain size of 50-75 mesh, then decreased on the use of smaller grain size. This is because the smaller cocopeat grain size, the greater the surface area so that the interactions that occur between lignocellulose from cocopeat and polyisoprene from liquid rubber compounds will be more intensive so that the bonding that occurs will also increase and the resulting particleboard will also be stronger. It was indicated that the particle board made has the highest strength when the cocopeat grain size of 50-75 mesh was used. In this condition the MOR value of particle board was 11.363 N/mm^2. Previous research has reported that the MOR value of particle board-based Pine (*Pinus pinea* L.) wood was 13.90 N/mm^2 for melamine formaldehyde adhesives and 10.97 N/mm^2 for urea formaldehyde adhesives [17]. Other previous studies have also reported that MOR value of particle board in the range of 9.5 N/mm^2 to 14 N/mm^2 [18]. The results of this study show that the MOR value is included in the American National category Standards Institute, ANSI/A208.1-1999 for general-use particleboards.

3.2. Modulus of Elasticity (MOE)

The MOE test results of particle board on various cocopeat grain size were as shown in Figure 3. Figure 3 shows that the MOE value of particle board increases with the smaller cocopeat grain size used, reaching maximum on the use of 50-75 mesh cocopeat grain size, then decrease on the use of smaller grain size. This is because the smaller cocopeat grain size, the greater surface area so that the interactions that occur between lignocellulose from cocopeat and polyisoprene from liquid rubber compounds will be more intensive so that chemical bonding that occurs will also increase and the resulting particle board is more flexible. It was show that at the use of 50-75 mesh cocopeat grain size, the particle board made show the highest flexibility. In this condition, the MOR value of the particle board was 454.66 N/mm^2. Previous research has reported that MOE value of particle board based of pine (*Pinus pinea* L.) wood was 1,515.80 N/mm^2 with melamine formaldehyde adhesives, and 1,326.81 N/mm^2 with urea formaldehyde adhesives [17]. The American National Standard Institute specifies that the minimum modulus of elasticity was 550 N/mm^2 and while the maximum is 3,100 N/mm^2 [18].

3.3. Screw Hold Strength

The screw hold strength testing result of the particle board at various cocopeat grain size was as shown in Figure 4. From the Figure shows that particle board screw hold strength was increase on the decrease of cocopeat grain size and reaching the maximum value on the use of 50-75 mesh grain size then decrease at smaller grain size. This is because the smaller cocopeat grain size, the greater the surface area so that the interaction between lignocellulose from cocopeat and polyisoprene from liquid rubber compounds will be more intensive so that the bonding that occurs will also increase and the resulting particle board will also be stronger to hold the screw. At the best conditions the value of screw hold strength was 435.02 N/mm^2. The Screw Hold Strength results obtained are still in the category required by ANSI as in previous research reports [18].

3.4. Functional Group Test

The results of functional group tests with FTIR from concentrated latex, compound and particle board on the optimum cocopeat grain size were as shown in Figure 5. In the FTIR spectrum shown in Figure 5, it can be seen that there is a change in functional groups of latex and liquid rubber compounds, especially at the wave number of $1018 cm^{-1}$. This indicates the formation of C-S bonds in the vulcanization process of polyisoprene from concentrated latex with rubber additives [19-20]. From the FTIR spectrum it is also seen that there is interaction between lignocellulosic molecules from cocopeat and polyisoprene molecules from liquid rubber compounds that shown in the changes in the intensity of the spectrum of several functional groups in liquid rubber compounds before and after being used as adhesives on particle boards. Changes in transmittance intensity mainly occurred at wave numbers $3400 cm^{-1}$, $2918 cm^{-1}$, $1625 cm^{-1}$, $1018 cm^{-1}$ and $675 cm^{-1}$. The decrease in transmittance intensity at the wave number of $3400 cm^{-1}$ indicates there was a decrease in the number of OH groups derived from protein in the liquid rubber compound because it interacted with lignocellulosic molecules from cocopeat.

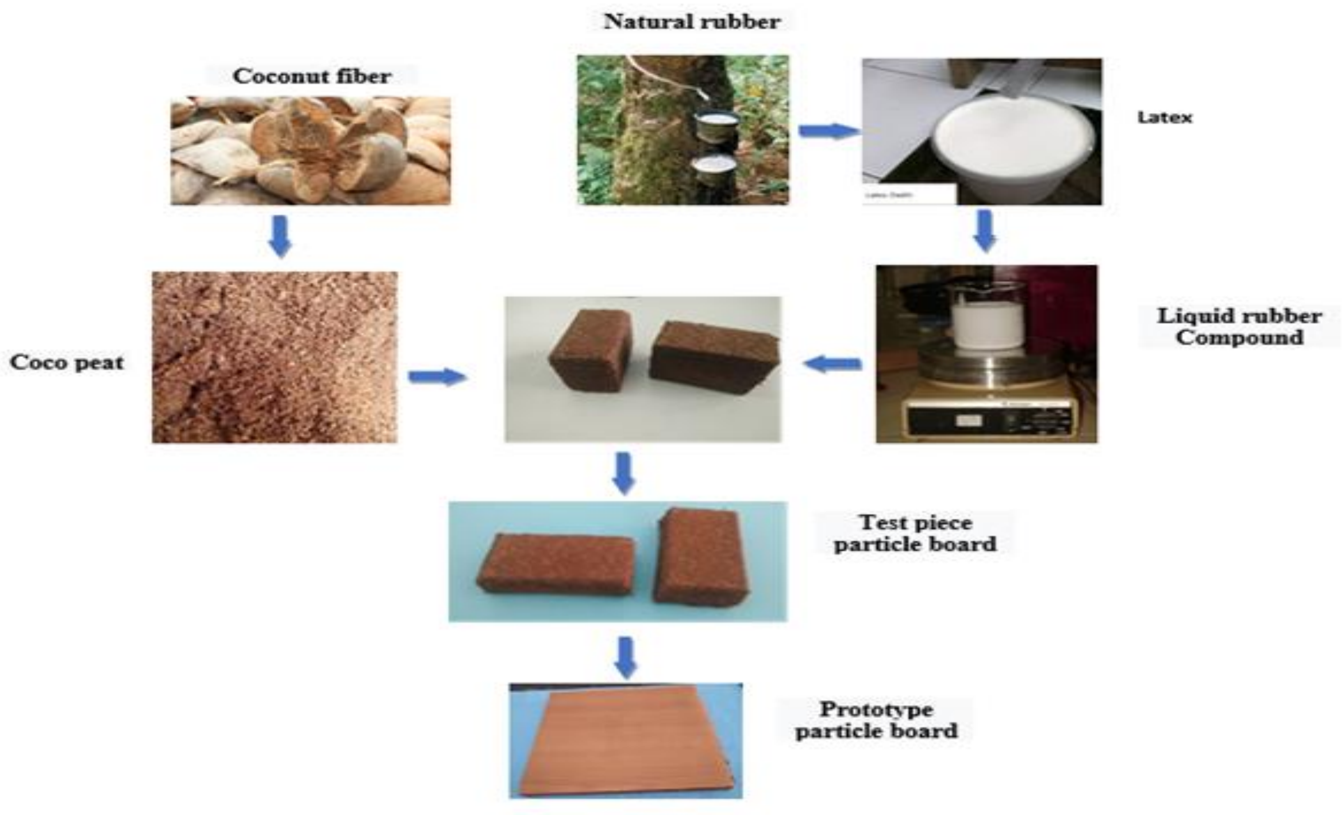

Figure 1: The scheme for making particle board.

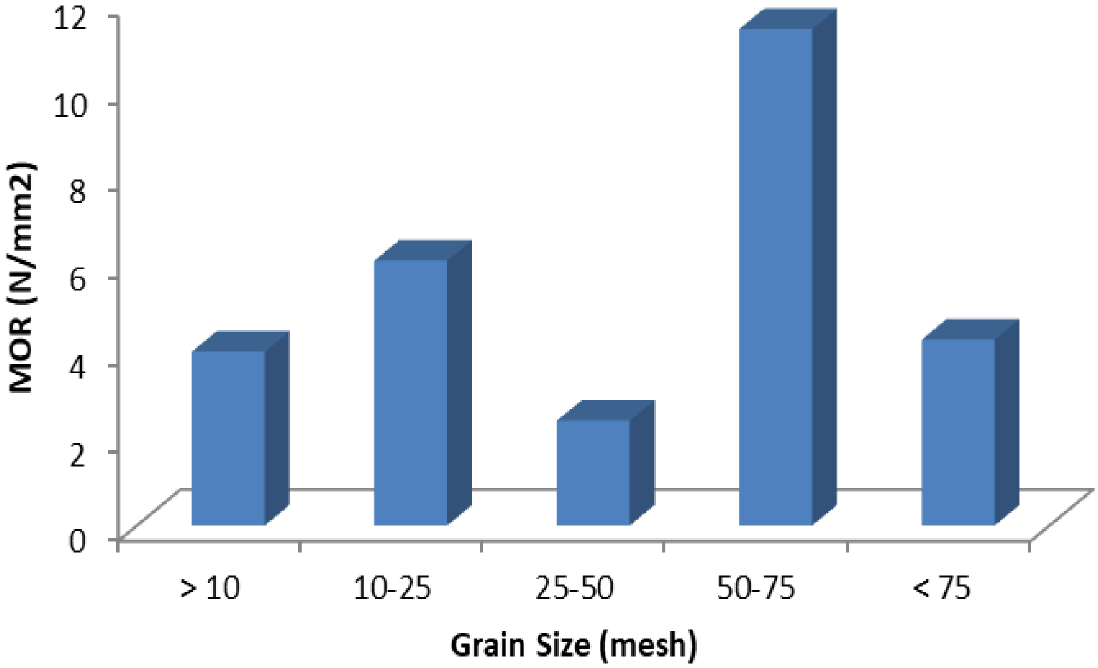

Figure 2: MOR of Particle Board at Various Cocopeat Grain Size.

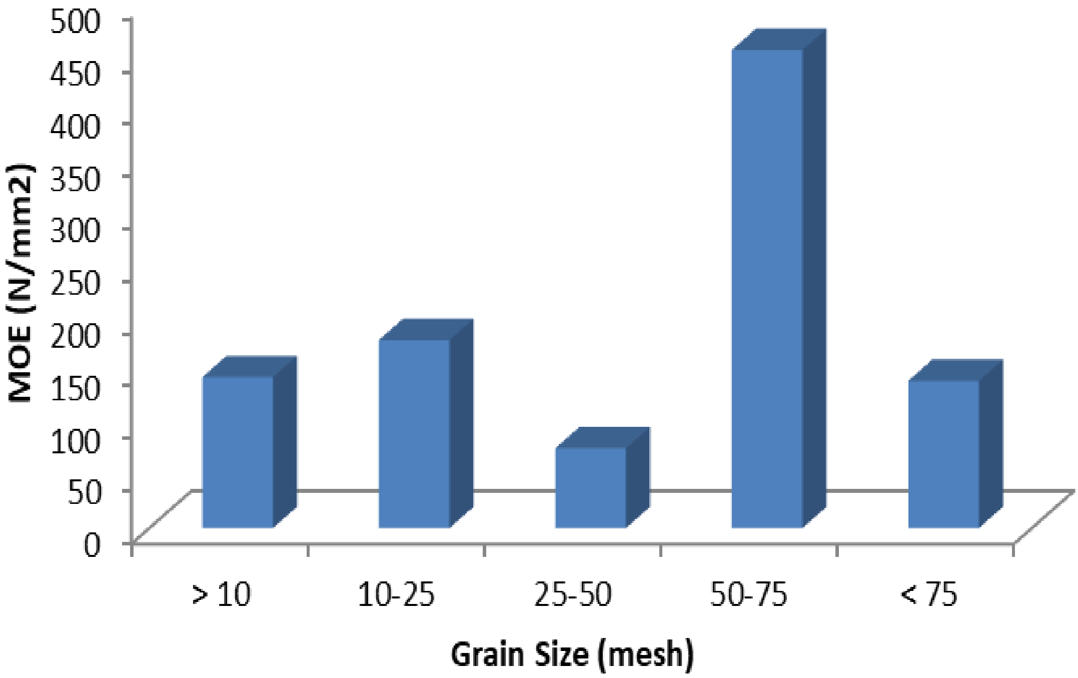

Figure 3: MOE of Particle Board on Various Cocopeat Grain Size.

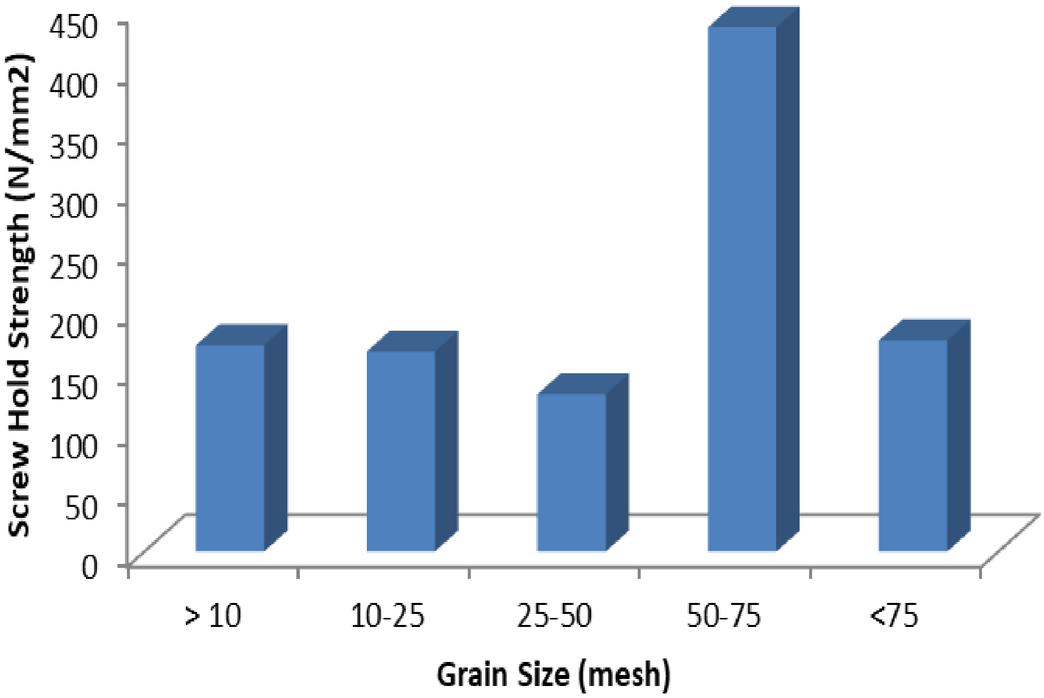

Figure 4: Screw Hold Strength of Particle Board on Various Grain Size of Cocopeat.

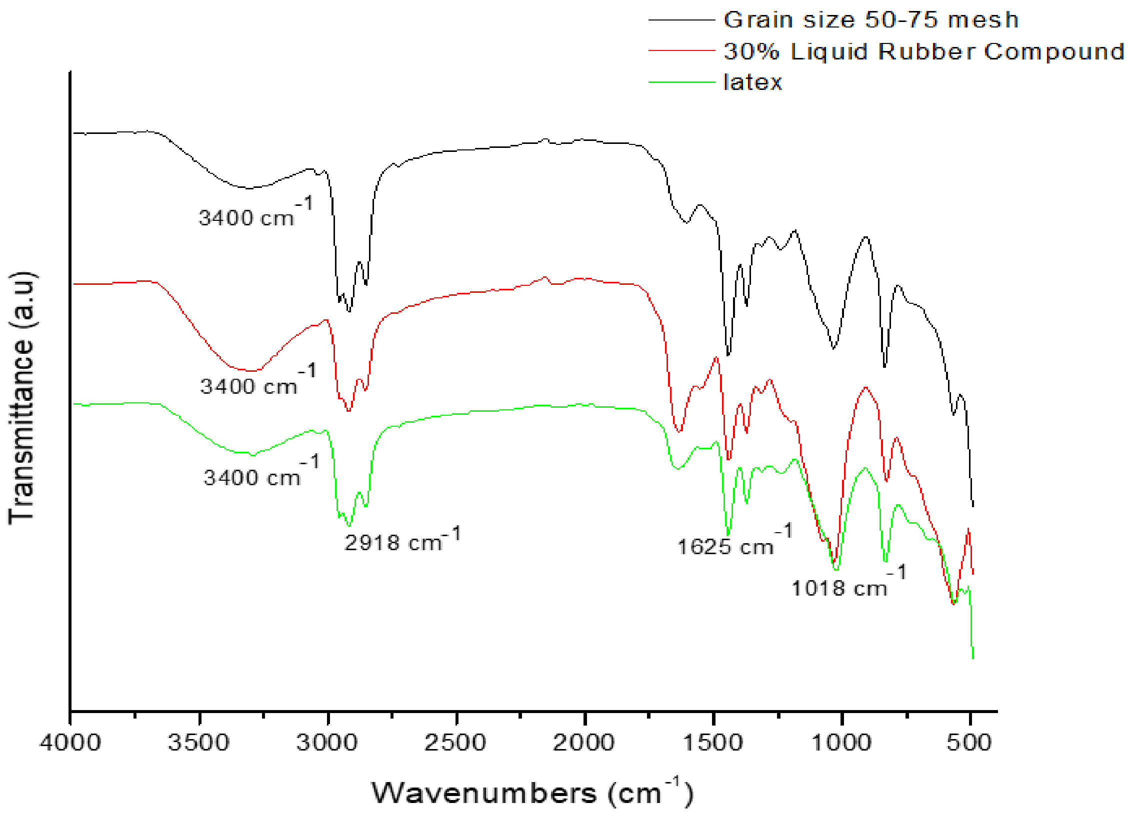

Figure 5: FTIR Test Results of Particle Board at the Best Cocopeat Grain Size.

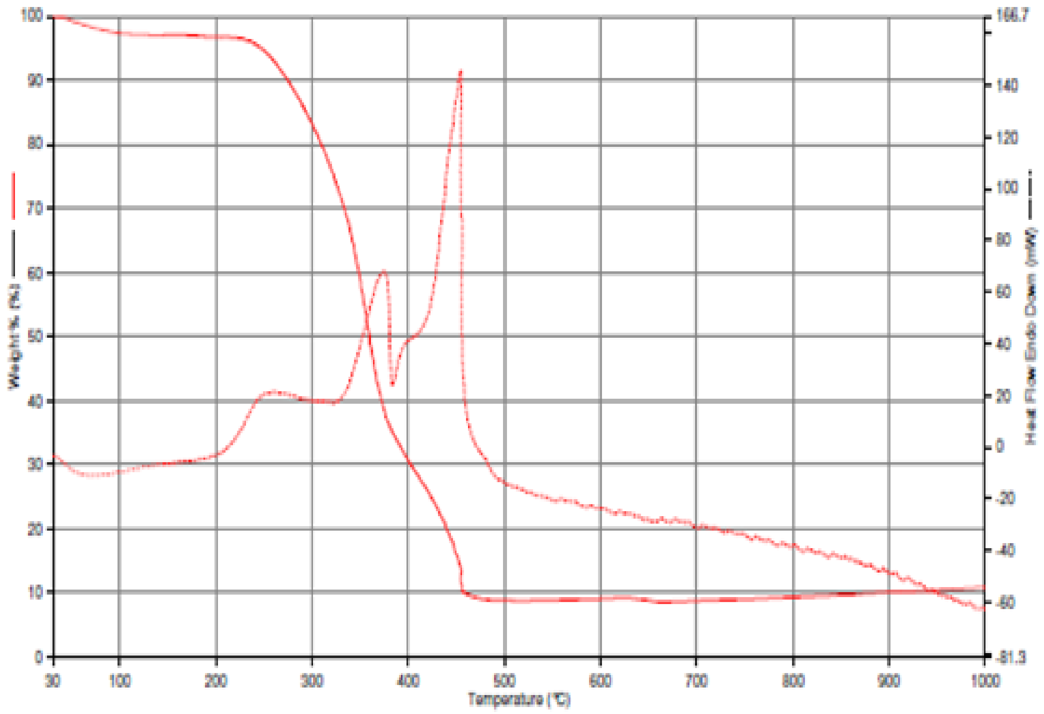

Figure 6: Thermal Test Results of Particle Board at the Best Grain Size of Cocopeat.

The decrease in intensity at a wave number of 1625cm^{-1} and 675cm^{-1} indicates a reduction in the C=C double bond of polyisoprene in liquid rubber compounds because it interacts with lignocellulose molecules from cocopeat. a large decrease in intensity at a wave number of 1018cm^{-1} indicates a decrease in the number of C-O bonds originating from proteins in liquid rubber compounds [21].

3.5. Thermal Test Result (DTA-TG)

The results of thermal testing (DTA-TG) of particle board at the best cocopeat grain size was shown in Figure 6. From the TGA curve in Figure 6, it can be seen that there is a decrease in the mass of the particle board at temperatures between 100℃ to 240℃ which comes from the evaporation of the remaining water contained in the particle board. At a temperature of 240℃ to 330℃, the first degradation process of lignocellulosic compounds from cocopeat occurs by releasing hemicellulose molecules. At a temperature of 330℃ to 380℃, there was a considerable decrease in mass due to the release of cellulose molecules. At a temperature of 380℃ to 450℃ the final degradation of the lignocellulosic molecule occurs with the release of the lignin molecule so that what remains is ash. At a temperature of 240℃ to 450℃ there is also a degradation of polyisoprene molecules from rubber compounds by producing an oil or wax phase so that in that temperature area there is a sharp decrease in mass. This oil or wax phase will only turn into gas and leave ash at a temperature of 680℃. The remaining oil or wax phase in the rubber compound degradation process is only a small part of the rubber compound, so the change in the oil or wax phase to ash while releasing gas only results in a small decrease in the remaining mass. From the DTA-TG curve above shows that the particle board from cocopeat composite with liquid rubber compound has thermal resistance up to 240°C. This can be seen from the start of a decrease in particle board mass at this temperature. From the curve above also seen that the second and third degradation processes, namely the release of cellulose and lignin molecules, are exothermic processes [22-23]

4. Conclusions

The cocopeat grain size were greatly affects the chemical and mechanical properties of particle board. The best condition was obtained on the use of 50-75 mesh cocopeat grain size of. Under this best conditions, the value of MOR, MOE and strength of the screw has qualified as a normal particle board grade LD-1 according to American National category Standards Institute, ANSI/A208.1-1999. DTA-TG testing results show that the heat resistance of particle board from cocopeat and liquid rubber compound was 240 ℃.

Conflict of Interest

The author reports no conflicts of interest in this work.

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Ethical statement

None.

Availability of data and material

We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

Code availability

Not applicable.

Consent to participate

All authors participated in this research study.

Consent for publication

All authors submitted consent to publish this article research in IJCBS.

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