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Journal of Chemical Natural Resources

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Effect of Natural Zeolite Powder on Physical and Mechanical Properties of PP-g-MA Particle Boards and Divinylbenzene Using Palm Oil Stem Powder with Soaking Chloroacetic Acid 3%

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Abstract. The effect of natural zeolite stem on physical and mechanical properties of particle boards from PP-g-MA and divinylbenzene with palm stem oil has been conducted soaked with 3% chloroacetic acid. It was performed in three steps. The first was soaking palm oil trunk in 3% chloroacetic acid for 24 hours, then filtering and rinsing until neutral. The second was polypropylene functionalization with maleic anhydride to form PP-gM A with the reflux method. PP-g-MA degree of grafting, melting point, and FT-IR analysis analyzed MA. The degree of grafting maleic anhydride of polypropylene was 9 .467 %, 1 62.06 o C melting point used for particle board adhesive. The third was particle board manufacture consisting of palm oil trunk, polypropylene, PP-g-MA, benzoyl peroxide, divinyl benzene, and zeolite with ratios of (7 0: 4 0: 3 0:2: 3: 0)g, (70: 4 0: 3 0:2:3 :3)g, (70: 4 0: 3 0:2: 3: 6) g, (70: 4 0: 3 0:2: 3: 9) g, (70: 4 0: 3 0:2: 3: 12) g and (70: 4 0: 3 0:2: 3: 15) g as specimens I, II, III, IV, V, VI respectively. Physical and mechanical analysis for particle boards based on SNI 03-2105-2006 includes density, water content, swelling, modulus of rupture, and modulus of elasticity. SEM was used to analyze broken fragments of boards. From the characterizations obtained, specimen I V was the best result. All of the physical properties' values matched with particle board quality standard, with the value of MoE being 32438.53 KgF/cm^2. The value of MoR was 86.50 KgF/cm^2; SEM analysis showed an effect of zeolite on particle boards.

Keywords: Natural Zeolite, Particle Board, Physical Properties, Mechanical Properties, PP-g-MA.

Received [17 April 2022] | Revised [16 June 2022] | Accepted [12 August 2022]

1 Introduction

Particle board is a form of an artificial board with the primary material being wood particles (palm sawdust used in this study) using an adhesive, hot and cold pressed to form sheets that have a specific size according to their function and use. The advantage of composite board is that the primary material comes from wood or lignin cellulose which is obtained from nature and is made relatively inexpensively (Yang et al., 2006). Ritonga (2017) has researched the

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effect of adding divinyl benzene with variations of 0;3;6;9;12, and 15 g by immersing the powder using 3% chloroacetic acid; from this study, it was shown with the addition of divinyl benzene had a significant effect on the value of the test results. Still, overall the particle board with the addition of 3 g divinylbenzene met the standards, but the MoR value did not meet the requirements.

In the manufacture of particle board, it is necessary to functionalize degraded polypropylene first using benzoyl peroxide, maleic anhydride, and divinylbenzene as particle board adhesives and add additives as fillers so that the value of the mechanical test results from particle board made is in a ratio of 0; 3; 6; 9;12 and 15 g can meet the quality standard of particle board according to SNI 03-2105-2006. Bukit, N (2011) has added natural zeolite as a nano-composite filler. In this study, the boards produced met SNI quality standards.

Zeolite has a very regular crystal shape with interconnected cavities, which causes an extensive surface area of zeolite, so it is very well used as an adsorbent (Sutarti and Rachmawati, 1994). Adding zeolite as a filler to thermoplastic polypropylene can increase Young's modulus and impact strength (N.Zahhri, N.Othman, 2010).

Palm wood is one of the wastes that has not been utilized optimally by the people of Indonesia. So far, palm oil wood has only been cut down, burned, and left to rot in the field. According to BPS (2011), Indonesia's palm oil production is estimated to reach 21,985,120 tons. Oil palm wood is a solid waste produced by the oil palm plantation industry. The components contained in oil palm wood are 30.77% α-cellulose, 17.22% lignin, 12.05% water, and 2.25% ash (Tomimura, 1992).

For this reason, many researchers use palm oil wood as a raw material for particle board by hot pressing a mixture of wood particles with organic adhesives and other materials by converting them into powder first. Pramudita R (2017) has examined the effect of soaking palm sawdust with chloroacetic acid with variations of 0,3,6,9,12 and 15% on the mechanical and physical properties of particle board with the addition of 10 g divinylbenzene from this study was shown that Soaking with chloroacetic acid did not have a significant effect on the physical test value, but soaking the powder in 3% chloroacetic acid increased the mechanical test value of the particle board. Still, the MoE value did not meet the standard.

Based on the description above, the manufacture of particle board using a mixture of modified maleic anhydride (PP-g-AM) with palm sawdust (KKS) which has been soaked in 3% chloroacetic acid solution with the addition of DVB 3 g and with the addition of additives as fillers, namely natural zeolite with variations of 0;3;6;9;12;15 g will then be investigated how the physical and mechanical properties of the particle board. In addition, the authors hope this research can reduce the problem of solid waste from oil palm plantations.

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2 Materials and Methods

2.1 Equipment

The tools used in this study include burettes, stirrer heaters, sieves, aluminum foil, socket tools, Fischer, Liebig coolers, blenders, mixers, analytical balances, ovens, magnetic stirrers, vacuum pumps, internal mixers, SEM, FTIR, DSC, hydraulic pree test system and universal testing machine.

2.2 Materials

The materials used in this study included palm oil stalks, polypropylene (PP), divinylbenzene (DVB), benzoyl peroxide (BPO), natural zeolite, chloroacetic acid, maleic anhydride (MA), acetone, methanol, KOH, HCl, $H_2SO_{4\ (p)}$, xylene, phenolphthalein indicator, universal indicator, water and distilled water.

2.3 Procedure

2.3.1 Raw Material Preparation

The non-productive palm wood powder removed from its skin is dried, ground, and sifted through an 80-mesh sieve. It was then soaked in 3% Chloroacetic Acid for 24 hours at room temperature, filtered, rinsed with distilled water, and dried.

2.3.2 PP-g-MA Manufacturing Process

Polypropylene, maleic anhydride, and benzoyl peroxide were mixed in a 28.5 g: 0.9 g: 0.6g by refluxing using xylene solvent at 135 ° C for 10 minutes, and then the FTIR spectrum was tested. Before the results were re-analyzed, PP-g-MA was purified by precipitating it using acetone, then washed with methanol repeatedly and dried in an oven at 120°C for 6 hours. The resulting PP-g-MA was characterized by its melting point, degree of grafting, and FTIR spectrum.

2.3.3 Grafting Degree Determination PP-g-MA

The PP-g-MA residue purified and dried was then put into a flask and refluxed with 100 mL xylene until dissolved. After the mixture has dissolved, add three drops of water, and reflux is continued for 15 minutes, then add three drops of 1% phenolphthalein indicator and titrate with 0.05 N KOH in a hot condition. The titration was stopped when the color changed to rose red, and the volume of 0.05N KOH used was recorded.

2.3.4. Particle Board Manufacturing

Manufacture of particle board from a mixture of palm sawdust, polypropylene, PP-g-MA, divinyl benzene, benzoyl peroxide, and natural zeolite powder using the Hydraulic Press Test

System, with free variations, namely the weight of the zeolite powder 0, 3, 6, 9, 12, and 15 g, the dependent variables are MoE, MoR, density, moisture content, thickness expansion, and SEM analysis and the fixed variables are the weight of palm sawdust 70g, the weight of polypropylene 40g, the weight of PP-g-MA 30g, the weight of 3g divinyl benzene and the importance of 2g benzoyl peroxide with a pressing temperature of 170 °C and an imperative time of 30 minutes.

3 RESULT AND DISCUSSION

3.1 Grafting Degree Determination Results PP-g-MA

Table 1. Maleic anhydrate grafted with polypropylene

PP (%)	MA (%)	BPO (%)	Residue (g)	KOH 0.05 N (mL)	Average Volume	Grafted Degree
95	3	2	0.5	1.95	1.94	9.467
			0.5	1.93		
			0.5	1.941		

Table 1 shows the % of maleic anhydrate grafted with polypropylene, namely 9.467%. Adding maleic anhydrate that exceeds its optimum limit will decrease the degree of grafting. This is due to the formation of the maleic anhydrous phase and the polypropylene phase. Thus, maleic anhydrate will tend to react with the maleic anhydrate molecule to form maleic poly anhydrate (Bettini, 1999). In determining the degree of grafting, three drops of water are added to open the anhydrous maleic ring so that it becomes an acidic carboxylic group and can be titrated with a base.

3.2 Determination of Melting Point

Determination of the melting point of PP and PP-g-MA was carried out using the DSC method. The data obtained shows that the melting point of PP after being functionalized with Maleic Anhydrous increased from 160.89oC with a decomposition point of 394.78°C to 162.06°C with a decomposition point of 430.44°C. It shows a change in structure between PP and PP that has been grafted with maleic anhydride so that it changes its melting point and decomposition point.

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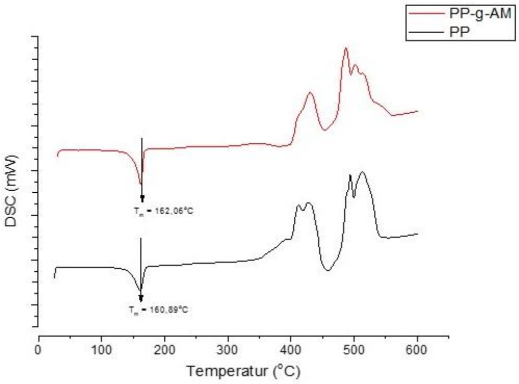

.**Figure 1**. Melting point of PP and PP-g-MA

3.3 FTIR Spectrum Analysis

The FTIR spectra showed that there had been a graft reaction between maleic anhydride in polypropylene and PP-g-MA formed. Before purification, from the spectrum, there appears to be an absorption peak at wave number 1651.07 cm^{-1}, which is the absorption peak of the double bond of maleic anhydride. It shows that maleic anhydride still has not reacted before purification (Edyanto, 2006). After purification, this absorption peak disappears. The presence of a typical absorption peak at wave number 170 5.07 cm^{-1} is an asymmetric carbonyl absorption of the maleic anhydride carbonyl group from PP-g-MA before purification and 1712.79 cm^{-1} after cleansing. The formation of PP-g-MA is also supported by the presence of a CO group at wave number 1271.03 cm^{-1}, which comes from maleic anhydride.

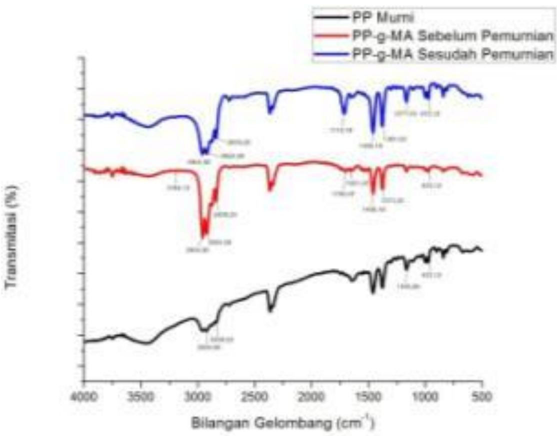

Figure 2. FTIR spectra

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3.4 Particle Board Characteristics Analysis

Table 2. Analysis particle board of specimen

Specimen	Density (g/cm^3)	Water Content (%)	Swelling (%)	MoR (kgf/cm^2)	MoE (kgf/cm^2)
I	0.475113	3.24	6.35	49.9020	18713.25
II	0.5157	3.11	6.01	39.8977	14961.65
III	0.5279	3.07	5.72	69.4575	26046.56
IV	0.5456	2.94	5.43	86.5027	32438.53
V	0.5574	2.82	4.92	32.0302	12011.34
VI	0.5803	2.74	4.68	55.5525	20832.18

3.4.1 Density

Board density is defined as the mass or weight per unit volume. According to Haygreen and Bowyer (1966), the higher the particle board density, the higher the toughness. According to Iswanto (2009), adding additives to particle board can function as a compatibilizer, namely a material to increase cohesiveness.

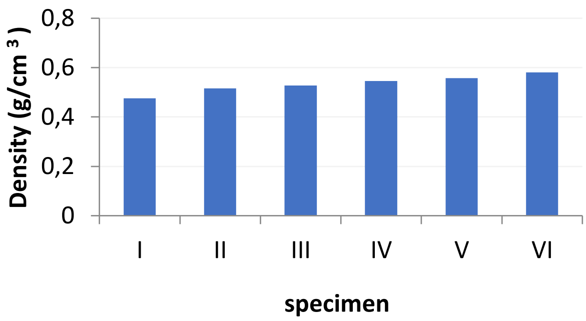

Figure 3. Graph of Board Density Test Values

From the bar chart of the particle board density test results above, it can be seen that the density increases with the addition of an additive, namely activated natural zeolite. From the density test results, all particleboard density values met the SNI 03-2015-2006 quality standards: density values ranging from 0.4 – 0.9 g/cm^3.

3.4.2 Water Content

Moisture content is the amount of free water content in the particle board. It is presented as a percentage (%) of the particle board's weight ratio to the particle board's absolute dry weight (Sulaeman and Sribudiani, 2016).

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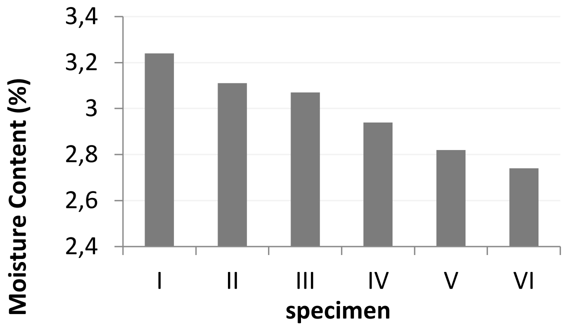

Figure 4. Graph of Board Moisture Content Values Particle

The diagram above shows that the test value for the water content of particle board I to VI has decreased. This is related to the density; where the thickness increases, the water content decreases. According to Muharam (1995), the increased density value causes denser contact between particles, making vapor water challenging to enter. From the data above, all the results of the water content test have met the SNI 03-2105-2006 quality standard, namely a maximum of 14%

3.4.3 Thick Development

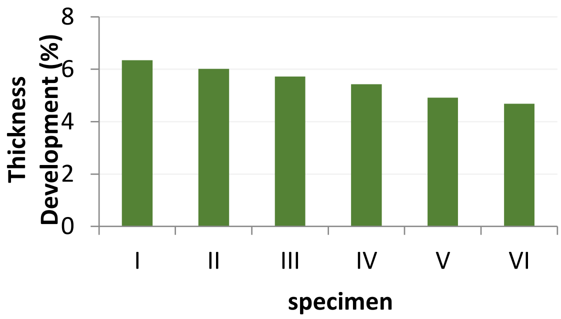

Figure 5. Graph of development test results from particle board thickness

Thickness was expanded by soaking in water for 24 hours to increase the board's thickness due to water filling the cavities (Haygreen and Bowyer, 2003). Figure 5 shows that the thickness development of the boards from specimens I to VI experienced a decrease. The thickness development is related to the density value, where the more significant the density value, the fewer pores, so water is more challenging to enter into the board. From the results of the thickness development test, it meets the quality standards of SNI 03-2015-2006, namely a maximum of 25% for boards with a thickness of ≤ 12.7 mm.

3.4.4 Dry Flexural Toughness (MoR)

Modulus of Rapture (MoR) is a mechanical property that shows the board's strength shown in Figure 6.

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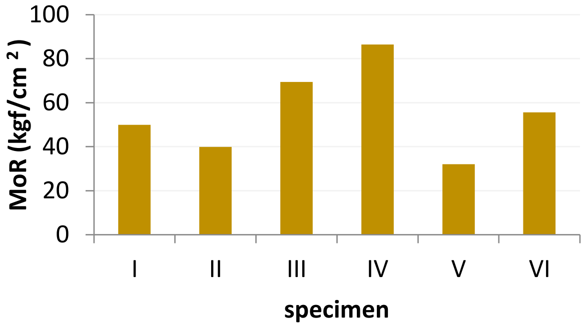

Figure 6. Graph of dry flexural toughness (MoR)

The test results found that the maximum MoR value on adding 9 g zeolite, namely 86.5027 kgf/cm^2 met the SNI 03-2105-2006 standard, where the minimum fracture strength value of the board was 82 kgf/cm^2. However, the boards decreased when 12 g of zeolite was added and increased again when 15 g of zeolite was added. This is because the density value of the board with the addition of 12 g of zeolite is only slightly compared to 9 g of zeolite, which is 0.0118 g/cm^3, where the dry flexural strength value produced is closely related to a density where if the board has cavities or empty spaces it results in imperfect particle bonding so that the MoR value tends to decrease because the particles break easily (Idawati et al., 2012).

3.4.5 Elasticity Modulus

Modulus of Elasticity (MoE) measures the resilience of wood in maintaining deformation due to loads and is in direct contact with wood (Muhdi et al., 2013).

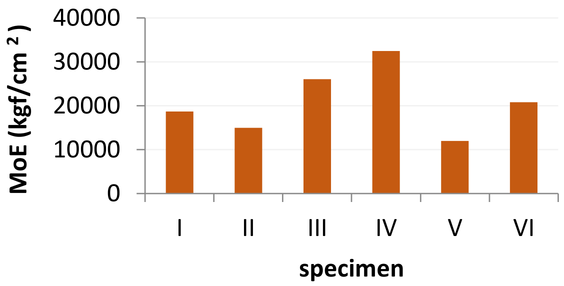

Figure 7. Graph of flexural elasticity modulus (MoE)

The test results found that the maximum MoE value when adding 9 g of zeolite was 32438.53 kgf/cm^2, illustrated in Figure 7, which met the SNI 03-2105-2006 standard was 20400.00 kgf/cm^2. However, the board decreased with the addition of 12 g of zeolite. As is the case with MoR, with the addition of a lot of zeolites, a specific bond occurs between the zeolite itself. In specimen V, there was a very significant decrease in MoR and MoE values, and this was alleged because when testing, the specimen had not cooled down completely, so it broke more quickly because the thermally labile crosslinks would break by heating and rebind by cooling (Steven, 2001)

3.5 SEM Morphology Analysis

The SEM analysis in Figure 8 shows that the particle board, without adding additives, namely natural zeolite, has many cavities. Still, with the addition of 9 g of zeolite, it can be seen that the holes are getting smaller. This reduction in cavities is due to an increased excellent adhesion process between the matrix and the filler. Small particle sizes can produce good interfacial interactions between the matrix and fillers (Bukit, N. 2011).

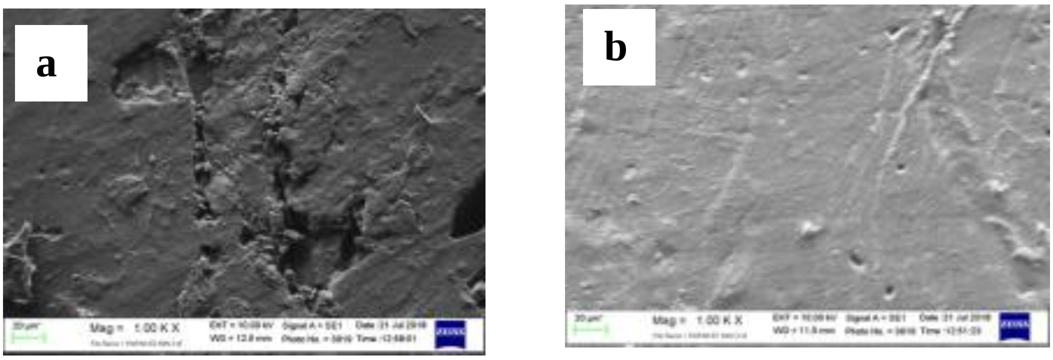

Figure 8. PSC Particle Board: PP-g-MA: BPO: DVB: Zeolite (a). 70:40:30:2:3:0 and (b). 70:40:30:2:3:9

4 Conclusion

The addition of natural zeolite affects the quality of the particle board produced. This is evident from the results of physical and mechanical tests showing promising results. But not all variations meet the requirements for the mechanical properties of particle board according to SNI 03-2105-2006, only specimen IV meets the standard quality, namely MoE 32438.53 kgf/cm 2 and MoR 86.50 kgf/cm 2. Meanwhile, for the physical and mechanical properties of the particle board, only specimen IV met the quality standards, namely the MoE 32438.53 kgf/cm 2 and the MoR 86.50 kgf/cm^2. In contrast, in specimens, I, II, III, V, and VI, mechanical values do not meet the quality standards of SNI 03-2105-2006 when viewed from the density of the obtained particle board, including particle board with low density with a thickness between < 0.59 – 0.80 g/ cm 3.

References

Bettini, SH, Agnelli, JAM 1999. Fatting of Maliic Anhydride on Polypropilene by Reaction Process : Effect of Maleic Anhydride and Peroxide Concentratin on The Reaction . J. Appl. Polym, Sci., 74, 247- 255.

Bukit, N. 2011. Processing of Natural Zeolite as a Nano Composite Filler Polypropylene and Natural Careers SIR-20 with Maleic Anhydride – Grafted-Polypropylene Compatible. Medan: University of Sumatra Dissertation North.

Eddyanto. 2007. Functionalization of Polymers: Reactive Processing. Dissertation, Aston University, Birmingham, UK

Haygreen, JG, and Bowyer, JL 1996. Forest Products and Wood Science. Yogyakarta: Gadjah Mada UniversityPress.

Haygreen, JG, and Bowyer, JL 2003. Forest Products and Wood Science An Introduction 4th Edition. IOWA State Press A Blackwell Public, USA

Idawati., Setyawati, D., and Diba, F., 2012 . Composite Board Quality of Palm Tree Stems and Polypropylene Plastic Waste Various Ratios and Addition of Maleic Anhydride. Journal of Tanjungpura University Pontianak National Power Road

Iswanto. 2009. Use of Initiators to Improve Plastic Composite Boards. Journal of the University of North Sumatra

Muharam, A. 1995. The Effect of Particle Size and Sheet Density on the Physical and Mechanical Properties of Sugarcane Bagasse Particle Boards. Bogor. Bogor Agricultural Institute

N. Othman and N. Zahhari. 2010. Optimization of Zeolite as Filler

Pramudita, R. 2010. Effect of Soaking Oil Palm Powder with Monochloro Acetate on the Mechanical Properties and Physical Properties of Particle Boards. Medan: Thesis of the University of North Sumatra

Ritonga, I. 2017. The Effect of Divinylbenzene on the Physical Properties and Mechanical Properties of Polypropylene Particle Boards and Palm Oil Stem Powder with 3% Chloroacetic Acid Soaking. Sumatra University Thesis North

Sulaeman and Sribudiani, 2016. Improving the Quality of Particle Boards from Sawdust of Sengon Wood (*Paraserianthes falcataria*) and Polypropylene Plastic Waste: The Role of Maleic Anhydride as Compatibilizer. Faculty Thesis Bogor Agricultural University Forestry

Sutarti, M and Rachmawati, M. 1994. Zeolite Literature Review. LIPI Jakarta Scientific Documentation and Information Center

SNI (Indonesian National Standard) 03-2105-2006. Particle Board. Body National Standardization

Stevens. MP 2001. Polymer Chemistry. First Print. Pradnya Paramita. Jakarta

Tomimura., 1992. Chemical Characteristics of Palm Trunk, J. Japan Agric . 2.

Yang, H., Wolcott, MP, Hee-Soo, K., Sumin, K., and Hyun-Joong, K. 2006.Effect of Different Compatibilizing Agents on the Mechanical Properties of Lignocellulosic Material Filled Polyethylene Bio-composites. Elsevier. South Korea.

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