

Analysis physical properties of composites polymer from cocofiber and polypropylene plastic waste with maleic anhydrate as crosslinking agent

E Pelita¹, T R Hidayani¹, A Akbar²

¹Analysis Chemistry, Polytechnic of ATI Padang, Bungo Pasang Tabing, Padang, 25147, Indonesia

²Chemical Engineering, Polytechnic of ATI Padang, Bungo Pasang Tabing, Padang, 25147, Indonesia

E-mail : rachmihidayani@yahoo.com

Abstract. This research was conducted with the aim to produce composites polymer with polypropylene plastic waste materials and cocofiber which aims to produce wood replacement material in the home furnishings industry. This research was conducted with several stages. The first stage is the process of soaking coco fiber with detergent to remove oil and 2% NaOH. The second stage is to combine the polypropylene plastic waste with cocofiber is a chemical bond, modification by adding maleic anhydride as a crosslinking agent and benzoyl peroxide as an initiator each as much as 1%. Mixing materials done by reflux method using xylene solvent. In this study, carried out a wide range of weight variation of coco fiber are added to the 10, 20, 30, 40 and 50%. The third stage is a polymer composite molding process using hot press at a temperature of 158°C. The results of polymer composites Showed optimum condition on the addition of 40% cocofiber with supple tensile strength value of 90.800 kgf /cm² and value of elongation break at 3.6726 x 10⁴ (kgf/cm²), melting point at 160.02°C, burning point 463.43°C, residue of TGA is 19%, the density of 0.84 g/mL. From these data, conclude that the resulting polymer composites meet the SNI 03-2105-2006 about ordinary composite polymer and polymer composite structural type 8 regular types from 17.5 to 10.5.

1. Introduction

Wood needs increase rapidly while availability decreases, especially for furniture, so it is necessary to find a solution scarcity of wood [1]. Today the wood plastic composite (Wood-Plastic Composite) is one of the most dynamic sectors of the plastics industry. This material consists of a mixture of wood fibers or the like with a polymer that is a thermoplastic such as polyethylene (PE), polypropylene (PP) and so on [2]. Thermoplastic polymer would be soft when heated and hardens when cool. These properties allow other materials such as wood particles or the like can be mixed with this type of plastic to form a composite material [3]. Composite is a material system consist of mixture or combination from two or more different macro constituents that are not mutually dissolve [4]. Composite consist of matrix and reinforcement. Matrix is the major constituent of composite while the minor constituent called reinforcement [5]. PP is a plastic that is solid, hard, and water-resistant, which is difficult to be degraded naturally, and has a strong potential of environmental pollution [6]. The utilization of plastic waste is an effort to surpress the plastic waste in extent to save resources and reduce dependence on imported raw materials. The utilization of plastic waste devided into reuse and recycle. Almost all types of plastics waste (80%) can be recycle and reuse back into the original item, although it must be mixing with new



raw materials and additives to improve its quality [7]. The utilization of polypropylene waste for biodegradable plastic has been done with the addition of starch from durian seed [8]. Utilization of plastic to be particle board was done [9] which utilizes sawdust from the forest with a mixture of plastic, particle board produced has less than maximum adhesion between the plastic with wood shavings. Coco fiber is a substantial part of the coconut fruit, namely 35% of the total weight of the fruit. Coconut fiber consist of fiber and cork connecting one fiber with other fibers. Each coconut contains 525 g of fiber (75% of the coco fiber), and cork 175 g (25% of coco fiber) [10]. Today coco fiber is only used as a medium of plants (cocopeat) and compost. The use of composite boards for home furniture which are widely used by community such as *Olympic* and *Ligna*, generally using a water-soluble adhesive, so the product can easily be damaged if exposed to water, especially for the people who live in coastal areas [11]. Manufacture of composite particle board by using matrix of recycled plastic, in addition to improving the efficiency of wood utilization that can be substituted for other fibers, can also reduce the environmental burden from plastic waste and delivering innovative products as a substitute for wood furniture. The advantages of this product include: cheaper production costs, abundant raw material, flexible manufacturing process, low density, biodegradable (rather than plastic), better properties than the raw material, as well as can be recycled [12]. The advantage of wood plastic composites compared with natural wood is consistency and uniform shape, not decayed and eaten by insects, not absorb water and not require periodic painting.

From all the above issues then sought an alternative to particle board of wood plastic composite that has a good mechanical strength, does not absorb water, anti-microbial, abundant raw materials and readily available, inexpensive and environmentally friendly [13]. Therefore, the researchers want to make particle board from plastic waste PP and coconut fiber with a cross linking agent maleic anhydride and benzoyl peroxide as initiator. The use of maleic anhydride as a cross linking agent aims to produce chemical interaction between coco fiber with plastic so that it can improve physical strength composite board [14]. The use of maleic anhydride as a cross linking agent with the aid of benzoyl peroxide initiator has been done in the research manufacture of biodegradable plastics from starch durian seeds and waste polypropylene plastic with optimum composition of maleic anhydride and benzoyl peroxide as much as 1% [15, 17].

From all the above issues then sought an alternative method to make particle board of wood plastic composite that has a good mechanical strength, does not absorb water, anti-microbial, raw materials are plentiful and readily available, inexpensive and environmentally friendly. Therefore, the researchers want to make particle board manufacture from plastic waste from the packaging of mineral water with coconut coir fiber which is the result of a major agricultural region of Pariaman, West Sumatra. PP plastic waste powder preparation was conducted by reflux with the solvent xylene, coco fiber

preparation by washing with water to remove the oil, and soaking with 2% NaOH to remove lignin and carbohydrates [13]. Mixing materials done by the reflux method and crosslinking agents maleic anhydride and benzoyl peroxide initiator and solvent xylene. The use of maleic anhydride as a crosslinking agent aims to produce chemical interaction between coco fiber with plastic so that it can improve physical strength composite board. The use of maleic anhydride as a crosslinking agent with the aid of benzoyl peroxide initiator has been done in the research manufacture of biodegradable plastics from starch durian seeds and waste polypropylene plastic with optimum composition of maleic anhydride and benzoyl peroxide as much as 1% [11]. The particle board printing method using a hot press. To know the characteristics of particle board conducted tests on physical properties include density, mechanical properties include tensile strength, modulus of elasticity, DTA and SEM. The resulting composite board is expected to have strong physical properties, it can be a composite board as the basic material of home furnishings at a cheap price compared to particle board of wood powder.

2. Materials and Method

2.1 Equipment and Materials

The materials used in this study are as follows: Waste plastic polypropylene from mineral water packing, Coconut Fiber (agricultural product waste from Pariaman, Sumatera Barat), NaOH, Maleic Anhydride PA (Peekay Agencies Pvt. Ltd) , Benzoyl Peroxide (Merck), Methanol (Merck), Xylene (Merck). The equipment used in this study are as follows : DTA and TGA DT-30 Shimatzu Japan, Universal testing Machine tool sets, tool sets hot-press Type: IL.70.110 / 220V.

2.2 Procedure

2.2.1 Treatment on Coconut to Extract Cocofiber

Cocofiber is separated from the hard, cut or chopped to form short fibers and weighed as much as 2.5 kg, then soaked with detergent for ± 2 h to remove the oil content. Then the fiber is washed and dried under sun burned. Cocofiber is separated from the foam (cork) with a metal brush. Furthermore, weighed 80 g NaOH and dissolved into 5 L of distilled water and stir until dissolved NaOH. 2% NaOH solution was poured into coco fiber and stir until completely submerged and left for 24 h to eliminate the levels of carbohydrates in fiber, after the immersion of coco fiber - NaOH washed with clean water several times until the washing water is clear. Then coco fiber is dried in an oven at a temperature of 50-60°C blower to dry, then cut into small coco fiber size of 1-1.5 cm and is ready for use [14].

2.2.2 Grafted Polypropylene Plastics Waste and mixing with Coconut Fiber

Polypropylene plastic waste to be cleaned using water mixed with detergent, rinsed with water and then dried in the sun. Then PP plastic waste that has a clean cut to size $\pm 0.5\text{cm} \times 0.5\text{cm}$. Waste plastics PP, maleic anhydride 1% and 1% benzoyl peroxide is refluxed using xylene solvent of 500 mL for 2 h at 165°C, to produce PP-g-MA in a solvent mixture of xylene. Coco fiber is inserted into the flask reflux and then refluxed for 15 min and then precipitated with 100 mL of methanol. A mixture of PP-g-MA and coconut coir fiber (polyblend) is dried in the oven at a temperature of 80°C.

2.2.3 Pressing Composites Polymer With Molding Method

Compression molding tool temperature is set at a temperature of 158°C, further polyblend placed into a mold in a frame made of steel with the size of the 25.0 cm x 15.0 cm x 1.0 cm where the steel plate was coated with aluminum foil. Polyblend sample is then placed between two heating to a temperature of 163°C for ± 10 min without pressure from the tool. Then proceed with the pressure bit by bit for ± 20 min. After it was given a maximum pressure of 40 bar (4 MPa) for ± 20 min. Then the hot-press switched off and allowed to cool to a temperature of $\pm 90^\circ\text{C}$ [3]. Furthermore, the samples are removed from the hot-press and put into the water and released from the mold, then allowed to reach room temperature. Composites polymer ready to be cut in accordance with the needs of characterization.

2.3 Characterization

2.3.1 Mechanical Test Analysis

Specimens particle board with a thickness of 1 cm cut into specimens for tensile test. Tensile strength testing by ASTM D-1822 type L with a load of 100 kgf and a rate of 50 mm/min with a specimen thickness of 1 cm. Initially turned *Torsee's* Electronic System and allowed to stand for 1 h. Specimens clipped to tensile test equipment then the strain, stress and the unit determined by using griff. Then the recorder is turned on, pressed the start button and the value of the stroke and the load is made under conditions of zero. Record the value of load and stroke when the sample broke up. Do the same treatment for each sample. Rated load and stroke are acquired, used to calculate the value of tensile strength and elongation of the specimen [7].

2.3.2 Thermogravimetric Analysis

Thermogravimetric analysis (TGA) studies on the samples were carried out on Q-500 series TGA Analyzer (TA Instruments, USA). The weight of each sample was 5–10 mg and temperature range was 35–750 °C with a heating rate of 20 °C/min. An inert atmo- sphere was maintained by the continuous flow of nitrogen at 50 mL/min [6].

2.3.3 Differential Thermal Analysis (DTA)

Differential thermal analysis (DTA), which measures the difference in temperature (T), between the referent sample with inert material as a function of temperature. DTA can be used as a characterization tool or material analysis. In a sample whose identity is not known, the use of DTA alone will not be much help in identification. In the field of polymer blends (polyblends) observation glass transition temperature (T_g) is very important to predict the interaction between the chain and the mechanisms of blending polymers. Homogeneous polymer blend will show a single sharp T_g peak (exothermic) as a function of the composition. T_g mixture usually located between T_g of both components, because the homogeneous mixing is used to lower the T_g, as well as a plasticizer with a liquid plasticizer [18].

3. Result and Discussion

3.1 Analysis of Tensile Strength and Modulus of Elasticity Bending

Analysis of tensile strength and modulus of elasticity with different variations of filler composition is an important factor for determining the mechanical properties of the desired material. From the data Table 1 can be seen that the variations of the composition of the particle board that meets the standards of particle boards SNI 03-2105-2006 [16] are PP waste-g-MA : Coco fiber (90:10), (80:20), and (60:40). The rest of variation not meet the standards. This is probably caused by the value of the tensile strength of the resulting particle board.

Table 1. The result of Analysis of Bending Modulus and Modulus of Elasticity Bending.

No	Ratio (Composition and mass) (%)	Load (kgF)	Deflection (cm)	Tensile Strength(kgf/c m ²)	Modulus of Elasticity(kgf/ cm ²) (10 ⁴)
1	PP Waste (100)	7.397	0.058	118.352	3.136
2	PP Waste-g-MA:Coco fiber (90 : 10)	7.165	0.062	114.640	2.476
3	PP Waste-g-MA : Coco fiber (80 : 20)	6.300	0.058	100.800	2.693
4	PP Waste-g-MA : Coco fiber (70 : 30)	6.079	0.033	97.264	0.412
5	PP Waste-g-MA : Coco fiber (60 : 40)	5.675	0.054	90.800	3.673
6	PP Waste-g-MA : Coco fiber (50 : 50)	1.675	0.155	26.800	2.047

PP Waste-g-MA : Coco fiber (60 : 40) has a value of tensile strength 90.8 kgf/cm² and modulus of elasticity 3.6726x10⁴ kgf/cm² that meet the standards SNI 03-2105-2006 [16] about general particle board type 8 and general particle board structural type 17.5 -10.5. The other types did not reach the optimum value because less of mixture homogeneity. On a particle board with other comparisons, a low

mixing rate may occur because of the ratio of the composition between the matrix with the unequal filler, or more dominantly the syntethic polymer (polyprophylene).

3.2 Heat Resistance Analysis

Table 2. Result of DTA Analysis Composite Board

No	Ratio (Composition and Mass) (%)	Melting Point (°C)	Flash point (°C)
1	PP Waste (100)	164.62	462.03
2	PP Waste-g-MA : Coco fiber (90 : 10)	163.21	460.55
3	PP Waste-g-MA : Coco fiber (80 : 20)	162.43	461.65
4	PP Waste-g-MA : Coco fiber (70 : 30)	162.09	462.65
5	PP Waste-g-MA : Coco fiber (60 : 40)	160.02	463.43
6	PP Waste-g-MA:Coco fiber (50:50)	161.47	462.19

Analysis of thermal properties provides information about physical changes in particle board, for example, the melting point, the chemical process that includes polymerization, degradation and decomposition. The result show that the addition of coco fiber raise the flash point of particle board due to mixing with other compounds in this case coco fiber. The melting point of board particle after mixing with coco fiber is decrease compare with before mixing. The change of melting point and flash point of board particle from the initial state indicate that the interaction between waste PP and coco fiber. Expected positive result is the addition of coco fiber as filler does not significantly change the initial properties of polypropylene, but produces an increase in the value of the flash point. The optimum condition of board particle can be seen in the variation of waste PP : coco fiber (60 : 40) wherein the melting point is 160.02 °C and the flash point is 160.02°C while the other variations did not reach the optimum value caused by less of homogeneity. The level of homogeneity of particle board based on the data that shows the SEM image of particle board electromagnetic plastic mixture with coconut coir (Figure 1-6).

3.3 TGA Result

Table 3. Result of TGA Analysis Composite Board

No	Ratio (Composition and Mass) (%)	Decomposition point (°C)	Residue (%)
1	PP Waste (100)	471.38	0.01
2	PP Waste-g-MA:Coco fiber (90:10)	470.59	2.82
3	PP Waste-g-MA : Coco fiber (80:20)	471.00	5.46
4	PP Waste-g-MA : Coco fiber (70:30)	471.12	4.68
5	PP Waste-g-MA : Coco fiber (60:40)	471.89	19.00
6	PP Waste-g-MA : Coco fiber (50:50)	472.03	14.14

TGA is typically used in research to determine the characteristics of materials such as polymers, temperature decreases, absorbed material content, inorganic and organic components in materials, decomposition of explosive materials, and solvent residues. In the mixing of polymeric materials of the natural polymer type and synthetic polymer, the expected percentage of residual carbon atoms is greater than 10% to show the involvement of natural polymers in the mixing process.

From the TGA result can be seen that the more coco fiber added so the residue also increased. The optimum result can be seen in variation PP waste-g-MA : Coco fiber (60 : 40) with 19 % residue. In variation PP waste : Coco fiber (50 : 50) has the lower residue. This is caused by plastic waste polypropylene which minimum number cut into short chain, so that the fibers bonded to plastic, thus lowering the value of residuals.

3.4 SEM Result

SEM analysis is used in order to homogeneity between a mixture of fibers and plastics can be seen. any variation blend homogeneity can be seen from the surface structure using SEM so that later can be seen best from mixing composition. The result indicate that increasing the number of coco fiber is added to the plastic PP waste, so the structure more evenly.



Figure 1. PP waste 100%

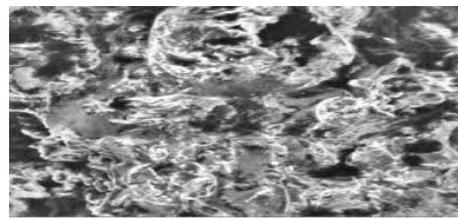


Figure 2. PP waste-g-MA : Coco fiber (90:10)

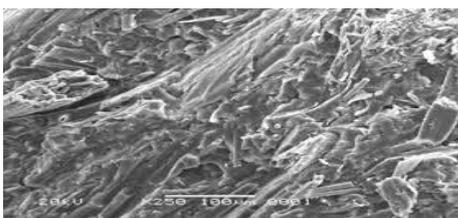


Figure 3. PP waste-g-MA : Coco fiber (80:20)

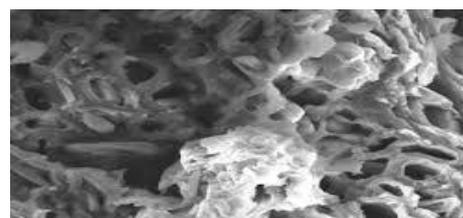


Figure 4. PP waste-g-MA : Coco fiber (70:30)

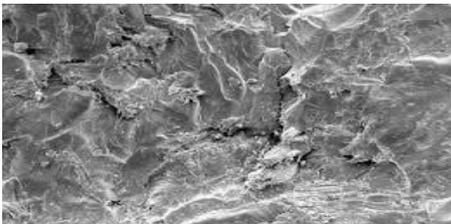


Figure 5. PP waste-g-MA : Coco fiber (60:40)

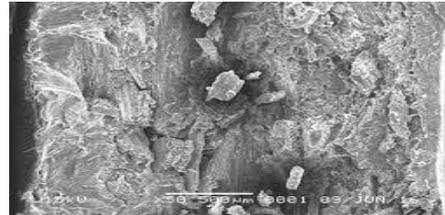


Figure 6. PP waste-g-MA : Coco fiber (50:50)

This happens because of their chemical interactions between synthetic polymers and natural polymers with the addition of maleic anhydride. n Particle Board with the addition of coconut fiber can be

differences in color and structure of the SEM results due to the addition of coconut fiber. However, the structure of the SEM results Particle Board unnoticeable among coconut coir fiber with plastic waste (yield homogeneous) with the help of maleic anhydride as a crosslinking agent between coconut coir dust and waste polypropylene plastic.

This is in accordance with the explanation [8] that the addition of maleic anhydride as a crosslinking agent in plastics waste polirpopilena with coconut coir fiber, preventing the formation of hydrogen bonds between coco fiber and causes the surface properties of coco fiber and polypropylene waste is becoming more homogeneous. The addition of maleic anhydride as crosslinking agents facilitate direct contact between coco fiber and matrix waste polypropylene, as well as increasing the spread of the matrix phase when the entire fiber has been covered by a layer of polypropylene matrix materials.

3.5 Density Analysis Composite Polymers

Table 4. Density Analysis Result

No	Ratio (Composition and Mass) (%)	Density (g/cm ³)	Water Content (%)
1	PP Waste (100)	0.8713	0.1527
2	PP Waste-g-MA : Coco fiber (90:10)	0.82793	0.6610
3	PP Waste-g-MA : Coco fiber (80:20)	0.80659	0.7342
4	PP Waste-g-MA : Coco fiber (70:30)	0.85819	0.9786
5	PP Waste-g-MA : Coco fiber (60:40)	0.83631	1.1387
6	PP Waste-g-MA : Coco fiber (50 : 50)	0.8499	1.590

The addition of coconut fiber to the matrix of PP waste result in a decrease density, but the value of the decrease is not too large. From the density test showed that the entire value of the density of the resulting polymer composites meet SNI 03-2105-2006 where values ranging from 0.40 - 0.90 g/cm³, while the density value of the resulting polymer composite is between 0.8 g/cm³.

Table 4 also shows the effect of fiber on water content. The result indicate that the addition of coconut fiber will increase the percent moisture content of polymer composites. This happens because the coco fiber has the large pores so it can absorb water well. Water content meet the requirements SNI 03-2105-2006 [16] about water content in the polymer composites that no more than 14%, where in the table can seen the water content in the resulting polymer composite is in the range between 0.1 to 1.6%.

4. Conclusion

From this research it has been found a good particle board composition, in order to overcome the problems of increasingly high price of wood for home furnishings materials, while utilizing waste plastics and waste oil. Particle board produced has the advantage of light weight properties, resistance to hot water and good mechanical properties that meet the standards set on particle board

The results of polymer composites showed optimum condition on the addition of 40% cocofiber with supple tensile strength value of 90.800 kgf / cm² and value of elangation break at 3.6726 x 10⁴ (kgf/cm²), melting point at 160.02°C, burning point 463.43°C, residue of TGA is 19%, the density of 0.83631 g/cm³. Reviews from these data, conclude that the resulting polymer composites meet the SNI 03-2105-2006 about ordinary composite polymer and polymer composite structural type 8 regular types from 17.5 to 10.5.

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