Development of Particleboard from Eucalyptus Bark to Use as Decorative Materials

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DEVELOPMENT OF PARTICLEBOARD FROM EUCALYPTUS BARK TO USE AS DECORATIVE MATERIALS

Abstract: This research aims to develop the particleboard from eucalyptus bark for using as the decorative materials. The ratios of eucalyptus bark to polymeric diphenyl methane diisocyanate (pMDI) were designed into 6 ratios which were different in pMDI amount (3% and 7%), and bark size (6 mm, 10 mm, and 6 and 10 mm). The particleboard samples were casted by using heat 150 ^{o}C for 7 minutes and were tested the properties by following the TIS.876-2004 (particleboard product). According to the results, the properties of particle boards increased with the increasing of adhesive concentration (polymeric diphenyl methane diisocyanate; pMDI) and the selecting of crushed eucalyptus bark sizes. The proper ratios of particleboard from eucalyptus bark used the 700 kg/m^3 of density, 7% of pMDI amount, and 10 mm or 6 and 10 mm of bark sizes. These particleboards meet the requirement of standard (TIS.876-2004) excepted the bending strength and elastic modulus properties. The developed particleboards can use as decorative materials which are the thermal insulation better than the other construction materials such as gypsum board, brick, autoclaved aerated concrete.

Keywords: Particleboard; eucalyptus bark; decoration material

Introduction

Particleboard is an engineered wood product manufactured from wood chips and a synthetic resin or other suitable binder, which is pressed and extruded. Nowadays, particleboard is high demand trending product because it is more uniform and cheaper than real wood. However, the particleboard industry faced a shortage of wood chip problem from declining of forest resources (Yenjai et al., 2016).

Thus, the substituted materials were used to produce the particleboard which can be divided into two groups including: wood material group (eucalyptus wood, rubber wood, and other fast-growing wood) and non-wood material group (other agricultural fiber plants). Because of the wood material group is difficult to find, and non-wood material group is really difference to the real wood, the bark of fast growing tree is very interesting to use instead of wood chip, especially the eucalyptus barks which has a large quantity in all regions of Thailand. The eucalyptus bark is the wastes from wood processing plant. It refers to all the tissues outside the vascular cambium both the inner bark (living tissue) and the outer bark (dead tissue).

In this research, the objective aims to develop the particleboard from eucalyptus bark to use as decorative materials for above reasons. Moreover, this project selected the simply production processes that the small and medium enterprises can applying into the commercial.

Research Methodology

The research methodology of this project can conclude as following:

Materials and Equipment

The materials and equipment of this research included eucalyptus bark from Chachoengsao province (see Figure 1 and 2), polymeric diphenyl methane diisocyanate (pMDI), sprayer, fiber granulator with 6 and 10 mm of sieve size (see Figure 3), hot press compression molding machine (Figure 4), weighing machine, mold sized 300x300x10 mm, non-stick Teflon sheet, oven, universal testing machine (UTM), and thermal conductivity testing apparatus.

Figure 1 Eucalyptus bark.

Figure 2 Eucalyptus bark sieved through 6 and 10 mm of sieve size.

Figure 3 Fiber granulator.

Figure 4 Hot press compression molding machine.

Mix Design

In the mix design, the 6 mixture ratios were designed by varying the amount of pMDI to eucalyptus bark, and the size of eucalyptus bark as shown in Table 1.

Table 1 The mixture ratios of particleboard from eucalyptus bark by weight.

Ratio / Symbol	**Eucalyptus Bark Size**		**pMDI**
	Fine (6 mm)	**Coarse (10 mm)**	
6 mm 3%	1		0.03
6 mm 7%	1		0.07
10 mm 3%		1	0.03
10 mm 7%		1	0.07
6-10 mm 3%	0.5	0.5	0.03
6-10 mm 7%	0.5	0.5	0.07

Sample Casting

The sample casting processes of particleboard from eucalyptus bark including: 1) Mixed the eucalyptus bark and pMDI by using the sprayer as shown in Table 1. 2) Putted the eucalyptus bark mixed with pMDI into the mold. 3) Casted the particleboard from eucalyptus bark by using the hot press compression molding machine which controlled the condition included less than 10% of moisture content in eucalyptus bark, pressing temperature at 150 ^{o}C for 7 minutes, 280 ksc of pressure, and 700 kg/m^3 of density. 4) Cooled the particleboard from eucalyptus bark in the air. 5) Cutted the edge of particleboard from eucalyptus bark.

Property Testing

The particleboards from eucalyptus bark were tested by using the TIS.876-2004 standard (particleboard product) (TISI, 2004) and related standards such as ASTM C177 (ASTM, 2010). The property testing of particleboard from eucalyptus bark included general characteristic, density, moisture content, water absorption, thickness swelling, tensile strength perpendicular to surface, adhesive surface, bending strength, elastic modulus, and thermal conductivity. Each ratio was tested by using the 5 samples per ratio.

Results and Discussion

From the property testing of particleboard from eucalyptus bark, the results and discussion were shown as following:

General Characteristic

The general characteristic of 6 ratios of particleboards from eucalyptus bark were considered by following the TIS.876-2004 standard. Sharp edges and smooth surface are the general characteristic of particleboard which all ratios of particleboards from eucalyptus bark can pass (TISI, 2004). However, the different size of eucalyptus bark in particleboards from eucalyptus bark affected to the smooth of surface (see Figure 5) (Cheng et al., 2016). The 6 mm, and 6 and 10 mm of eucalyptus bark sizes had more smooth than the 10 mm of eucalyptus bark size.

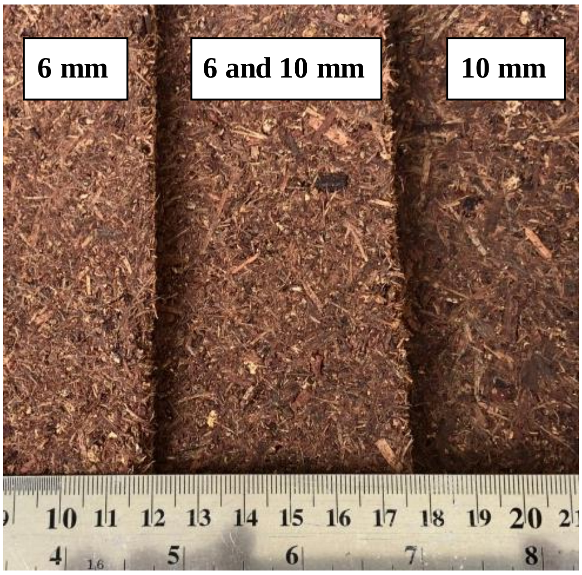

Figure 5 Surfaces of particleboards with different sizes of eucalyptus bark.

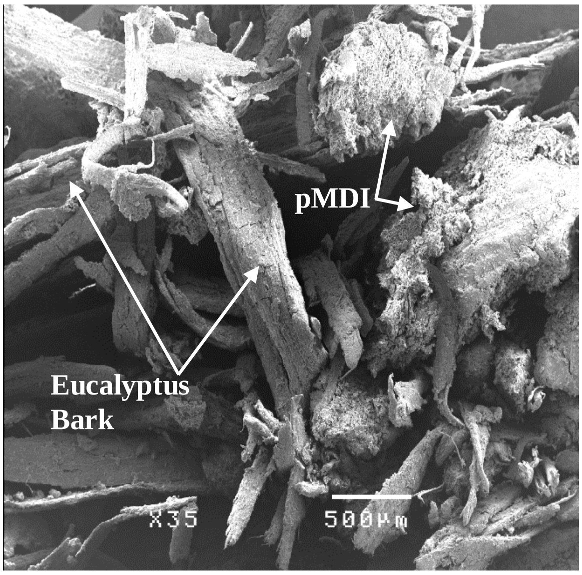

Figure 6 SEM of particleboard from eucalyptus bark at x35.

Density and Moisture Content

The density of 6 ratios of particleboards from eucalyptus bark in Figure 7 were approximate to the density that were measured from Table 1. When compared to the TIS.876-2004 standard, all ratios of particleboards from eucalyptus can pass the density properties (400 – 900 kg/m^3). In the moisture content test results (Figure 8), the 6 ratios of particleboards from eucalyptus bark were in range of the TIS.876-2004 standard (4 - 13 %) (TISI, 2004).

Thickness Swelling and Water Absorption

The results of thickness swelling test of particleboards from eucalyptus bark could be summarized as Figure 9. The 6 mm 7% and 6-10 mm 7% ratios of particleboards can pass the TIS. 876-2004 standard which required the thickness swelling must be less than 12% (TISI, 2004). When compared these ratios and other ratios of particleboards from eucalyptus bark, the texture of 6 mm 7% and 6-10 mm 7% ratios had denser than other ratios. So the 6 mm 7% and 6-10 mm 7% ratios of particleboards had the thickness swelling and water absorption less than the other ratios (see Figure 9 and 10). From the results of thickness swelling and water absorption, it had shown that the high pMDI amount and proper eucalyptus bark gradation affected to reduce the thickness swelling and water absorption properties (Yenjai et al., 2016; Nemli et al., 2005).

Tensile Strength Perpendicular to Surface and Adhesive Surface

According to the test results of tensile strength perpendicular to surface and adhesive surface of particleboards from eucalyptus bark in Figure 11, only the 6 mm 7% and 6-10 mm 7% ratios of particleboards from eucalyptus bark that can pass the TIS. 876-2004 standard (it must more than 0.45 MPa) (TISI, 2004). Because of the pMDI is a high tensile strength material, it can help the bonding of eucalyptus bark in particleboards (see Figure 6) (Yenjai et al., 2016; Bledzki and Gassan, 1999). However, the poor gradation of eucalyptus bark also affected to decrease the tensile strength perpendicular to surface and adhesive surface of particleboards, especially the small size of eucalyptus bark (less than 6 mm).

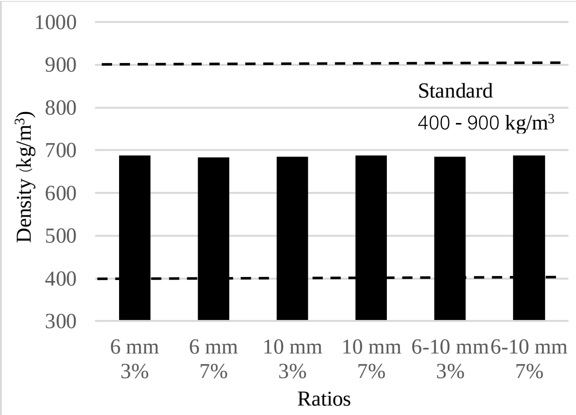

Figure 7 Density of particleboards.

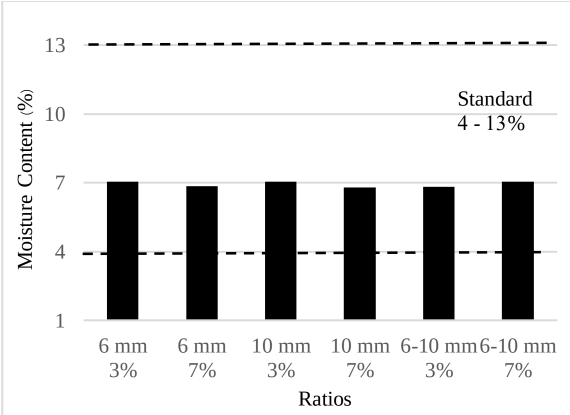

Figure 8 Moisture content of particleboards.

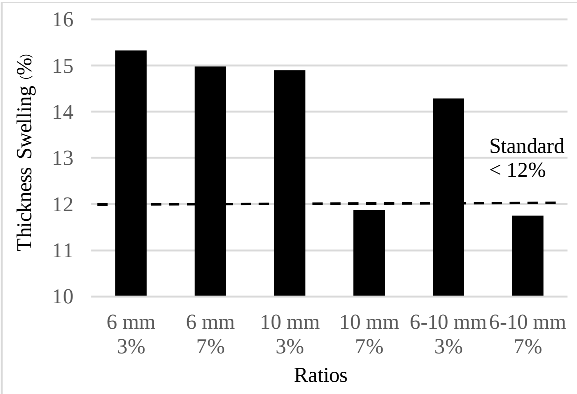

Figure 9 Thickness swelling of particleboards.

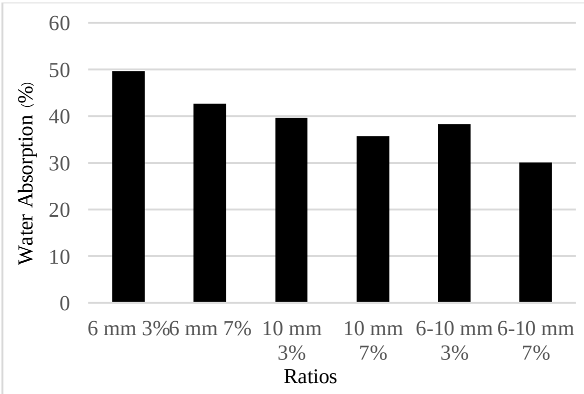

Figure 10 Water absorption of particleboards.

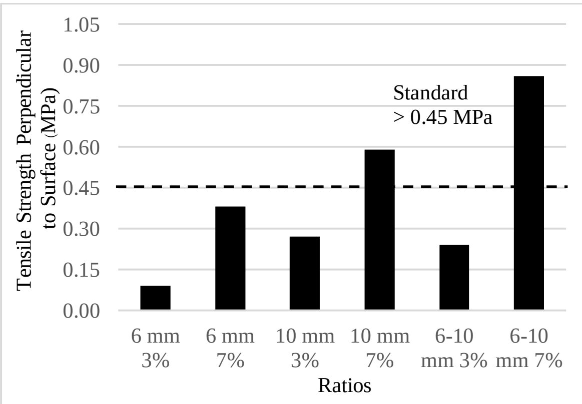

Figure 11 Tensile strength perpendicular to surface of particleboards.

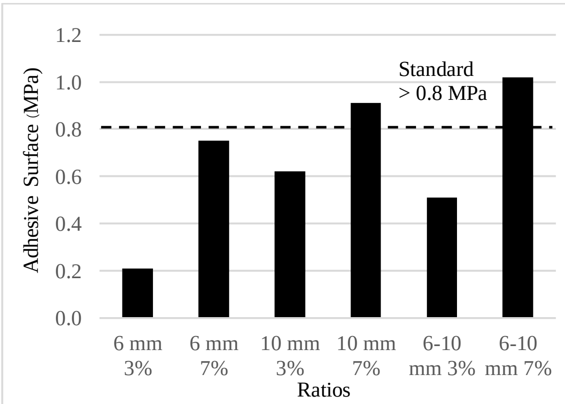

Figure 12 Adhesive surface of particleboards.

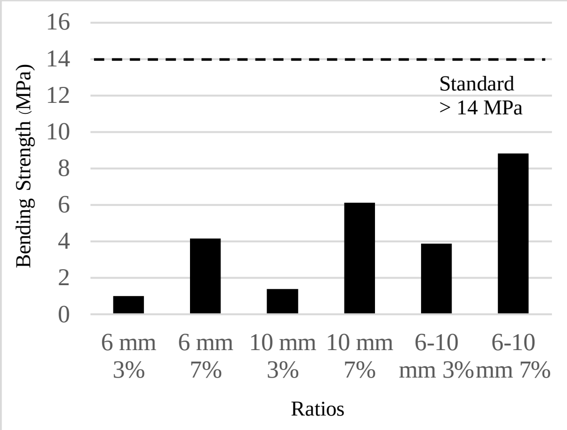

Figure 13 Bending strength of particleboards.

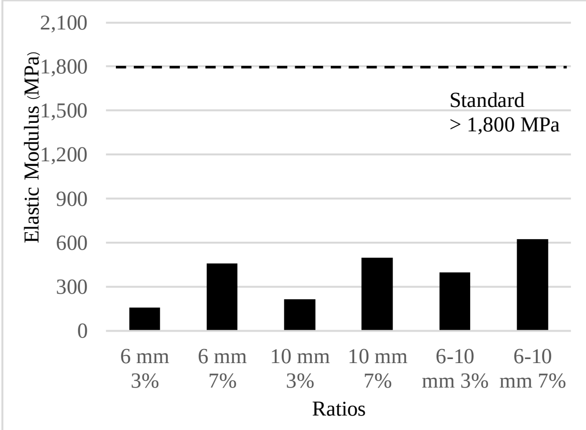

Figure 14 Elastic modulus of particleboards.

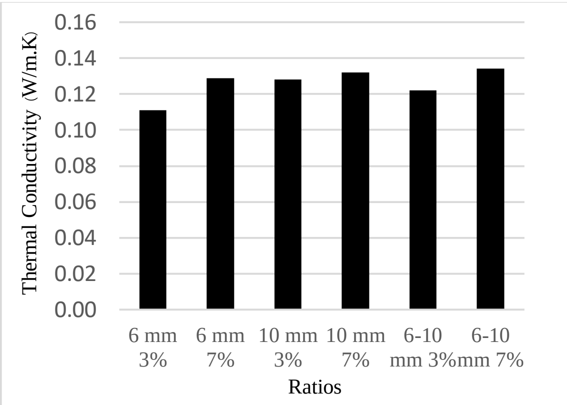

Figure 15 Thermal conductivity of particleboards.

Figure 16 The decoration of particleboards from eucalyptus bark.

Bending Strength and Elastic Modulus

From the results of bending strength and elastic modulus properties of particleboards from eucalyptus bark in Figure 13 and 14, it was found that all ratios had the bending strength and elastic modulus properties less than the TIS.876-2004 standard (it must more than 14 MPa and 1,800 MPa, respectively) (TISI, 2004). These results shown that the eucalyptus bark fibers had too short, so the fibers were difficult to reinforce the bending strength and elastic modulus properties of particleboards (Cheng et al., 2016; Lin et al., 2008). However, when sequenced the ratios of particleboards of bending strength and elastic modulus properties, the high pMDI amount and proper eucalyptus bark gradation can improve the bending strength and elastic modulus properties of particleboards from eucalyptus bark (Sekaluvu et al., 2014).

Thermal Conductivity

The particleboards from eucalyptus bark were the good thermal insulation materials (see Figure 15), when compared to the other construction materials such as the gypsum board (0.191 W/m.K), brick (0.473 W/m.K), autoclaved aerated concrete (0.180 W/m.K). According to the thermal conductivity test results, it can conclude that the high mechanical properties (tensile strength perpendicular to surface, adhesive surface, bending strength, and elastic modulus) of particleboards from eucalyptus bark had the thermal conductivity higher than the low mechanical properties of particleboards. It because the porosity made the particleboards had a low thermal conductivity coefficient (Weeranukul et al., 2018; Hazrat et al., 2016).

Conclusion

In conclusion, the eucalyptus bark can be utilized as raw material for particleboard. The properties of particle boards increased with the increasing of adhesive concentration (polymeric diphenyl methane diisocyanate; pMDI) and the selecting of crushed eucalyptus bark sizes. From the results, the proper particleboards from eucalyptus bark which properties of the particleboards mostly meet the requirement of standard (TIS.876-2004) were produced by crushing the eucalyptus bark through 10 mm or 6 and 10 mm of sieve sizes, spraying the polymeric diphenyl methane diisocyanate (pMDI) for 7 % by weight of eucalyptus bark into the crushed eucalyptus bark, and casting the particleboard samples by heating 150 ^{o}C for 7 minutes and controlling the density 700 kg/m^3. These particleboards from eucalyptus bark meet the requirement of standard (TIS.876-2004) excepted the bending strength and elastic modulus properties. The developed particleboards can use as decorative materials which are the thermal insulation more than the other construction materials such as gypsum board, brick, autoclaved aerated concrete.

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References

American Society for Testing and Materials (ASTM). (2010). Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus (ASTM C177). Philadelphia: ASTM.

Bledzki, A.K., Gassan, J. (1999). Composites reinforced with cellulose based fibers. Progress in Polymer Science, 24(2), 221-274.

Cheng, X., He, X., Xie, J., Quan, P., Xu, K., Li, X., Cai, Z. (2016). Effect of the particle geometry and adhesive mass percentage on the physical and mechanical properties of particleboard made from peanut hull. Bio Resources, 11(3), 7271-7281.

Hazrat, B.M., Zarea, H.H., Daliri, S.M., Abginechi, Z., Hemmati, A. (2016). Mechanical and insulating performances of ultralight thick particleboard from sugarcane residues and woods planer shaving. Eur. J. Wood Prod., 74(2), 161–168.

Lin, C.J.S., Hiziroglu, S.M.K., Lai, H.W. (2008). Manufacturing particleboard panels from betel palm (*Areca catechu* Linn.). Journal of materials processing technology, 197(1-3), 445-448.

Nemli, G., Örs, Y., Kalaycıoğlu, H. (2005). The choosing of suitable decorative surface coating material types for interior end use applications of particleboard. Construction and Building Materials, 19(4), 307-312.

Sekaluvu, L., Tumutegyereize, P., Kiggundu, N. (2014). Investigation of factors affecting the production and properties of maize cob-particleboards. Waste Biomass Valor, 5(1), 27–32.

Thai Industrial Standards Institute (TISI). (2004). Thai industrial standard no.876-2004: particleboard product. Bangkok: TISI. (in Thai)

Weeranukul, P., Suweero, K., Weeranukul, I. (2018). Coconut coir ceiling board product with thermal insulation property. Journal of Engineering, RMUTT, 16(2), 129-38. (in Thai)

Yenjai, P., Jarusombuti, S., Veenin, T. (2016). Particleboard manufacturing from waste of cajuput (*Melaleuca cajuputi* Powell). VRU Research and Development Journal Science and Technology, 11 (2), 131-140. (in Thai)