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Research Article

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Effect of Resin Type to Physical and Mechanical Properties of Oriented Strand Board Made from *Gmelina arborea* Wood

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Abstract Adhesive and wood is main raw materials to make of OSB. Phenol Formaldehyde (PF) and MDI Isocyanat adhesive were common used in OSB manufacturing. The objective of this research was to evaluate the influence of adhesive type to properties of OSB made from Gmelina wood. The resin level of MDI, Urea Formaldehyde (UF) and PF were using amount of 5, 10, and 8 % respectively based on the oven dry weight of strand. OSB was produced with the size 25 by 25 cm^2 and the density and thickness target were 0.7 gcm^{-3} and 1 cm respectively. Strand was oriented of perpendicular between surface and core layers. The ratio of face:core:back layers was set at 1:2:1. After mat forming, mold was pressed at 160°C (MDI), 170°C (PF), 130°C (UF), for 10 minutes at 25 $kgcm^{-2}$ pressure. The results showed that MDI resin for exterior adhesive resulted the better properties. In general, boards that produces with MDI resin almost met of standard excepted for MoE parameter. MDI and PF were suitable for binding in the manufacturing process of OSB made from Gmelina wood.

Keywords UF, PF, MDI Isocyanat, OSB, Gmelina Wood

Introduction

Oriented Strand Board (OSB) is a structural wood panels made of *strands* arranged in crossing direction for each layers, bonded with adhesive and compressed using hotpress machine [1-2]. Adhesive and wood as main materials to made of OSB. As we know that commonly there are two type adhesive in wood based composites namely thermoplastic and themosetting resin. Thermoplastic resin commonly used for particleboard product in wood composite, however for OSB product was using thermosetting resin type. PF and MDI Isocyanat adhesive were common used in OSB manufacturing.

Furthermore for woods, tropical wood was very suaitable for OSB materials. Indonesia has many tropical wood species that harvested from timber estates and community forest. That forest to develope of fast growing species like Acacia mangium, Eucalyptus, Gmelina arborea, Albizia falcataria, etc. Unfortunately, most of the wood belong to the lower quality. It also contains a lot of natural defect, has a low dimensional stabilization and low natural durability. Hence, the species of wood are not suitable for solid wood, but very promising as raw materials for wood composites product.

Several research had conducted in order to utilization of fast growing wood for OSB materials. It was reported that fast growing such as Mangium, eukalyptus, Albizia, Mahagony, Maesopsis resulted better properties for OSB raw materials. In order to explore the utilization of fast growing species, focus of this research was to evaluate the influence of adhesive type to properties of OSB made from Gmelina wood [3-5].

Materials and Methods

Materials: *Gmelina arborea* wood was collected from community forest at Dramaga-Bogor, Indonesia. Commercial isocyanate (MDI) type H3M, Urea Formaldehyde (UF) UA-140 type and Phenol Formaldehyde (PF) PA 125 type as adhesive for manufacturing. The resin level of MDI, UF and PF were using amount of 5, 10, and 8 % respectively based on the oven dry weight of strand. All strands were dried reach of 5% moisture content.

Strand manufacturing:
The manufacturing of strand in this research refers to Iswanto et al. (2010) [4]. The disk–flaker used to manufacture the strands. The strand thickness depended on the width of the gap between the cutting knife and the disc. The size of strand was 70 mm in length, 25 mm in width and 0.5 mm in thickness

Manufacturing of OSB:
Three layered OSB were produced with the size 25 by 25 cm^2 and the density and thickness target were 0.7 gcm^{-3} and 1 cm respectively. The strand was oriented of perpendicular between surface and core layers. The ratio of face:core:back layers was set at 1:2:1. Rotary blender used for mixing of strand and adhesive. After mat forming, mold was pressed at 160°C (MDI), 170°C (PF), 130°C (UF), for 10 minutes at 25 $kgcm^{-2}$ pressure. Boards were conditioned for 7 days at room temperature.

Evaluating of physical and mechanical parameters: The parameters were evaluating in this experimeny included of air-dry density, moisture content (MC), water absorption (WA), thickness swelling (TS), modulus of rupture (MOR), modulus of elasticity (MOE) in bending, and internal bond (IB). The dimensions of specimens for evaluation in air-dry density and MC of boards is 10 by 10 cm^2. The specimen weighed immediately after dried in the oven at 103±2°C until reached constant weight. For WA and TS tests, the dimension of specimens is 5 by 5 cm^2. The specimen also weighed immediately. Average thickness was determined by taking several measurements at specific location. After 24 hours of soaking in the water, specimens were dripped and wiped for cleaning of any surface water, the weight and thickness of specimens were measured. Mechanical parameters such as MOE, MOR, and IB were tested by using universal testing machine (UTM) equipped with a load cell with capacity of 10,000 N. The dimension of specimens in bending tests is 20 by 5 cm^2. MOE and MOR measured in dry states in their long dimension parallel to the major axis of panel. While for IB test, the dimension of specimens is 5 by 5 cm^2. Triplicate of boards were prepared for each treatment.

Results and Discussion

Density and Moisture Content

The average of density and moisture content of boards were presented in Fig 1.

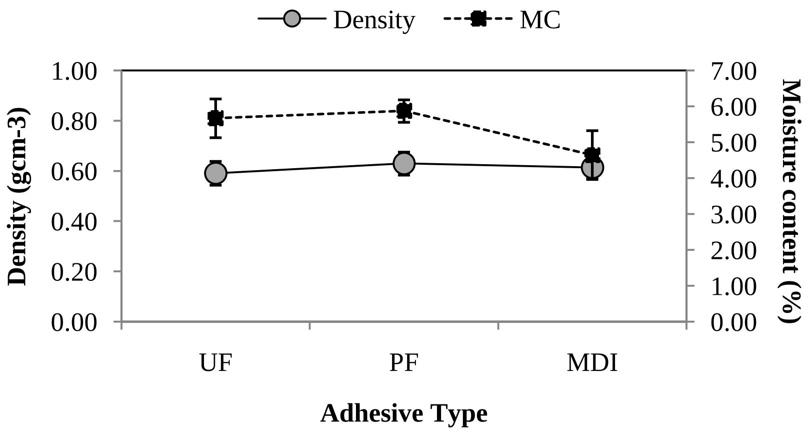

Fig 1. The density and moisture content of OSB

According to Fig 1, the density value was not significantly different. The resulting board density ranged between of 0.59 to 0.63 gcm^{-3}. UF boards resulted the lowest density value, while the highest obtained of PF boards. Overall the density value did not met the density target. It was due to springback effect (reversible of thickness) of board after conditioning process. The thickness swelling of board after conditioning resulted in the increasing volume so that concequence of decreasing the density value. The density in this research was classified into medium density of board. Maloney (1993) stated that board had ranged density between of 0,59-0,80 g/cm^3 was categorized of medium density particleboard [6]. Bowyer *et al.* (2003) stated that the objective of composite board manufacturing is not only to produce board with high density, however to produce of light board with higher strength [7]. In general, boards resulted from this research had met JIS A 5908-2003 that required of board density ranged between of 0.4 to 0.9 gcm^{-3} [8].

Furthermore for the moisture content value ranged between of 4.65 to 5.87%. The lowest moisture content obtained on the MDI boards, while the highest obtained on the PF boards. According to the Fig 1 that PF and UF boards showed the similar value in moisture content. It was presumed by PF had lowest resin solid content so that it caused high water content in resin. Haygreen and Bowyer (1996) explains that correlation between of adhesive content and board moisture content, the increasing of adhesive content resuted in increasing of board moisture content around 4 to 6%. Overall, boards produced from this research had met JIS A 5908-2003 that required of board moisture content ranged between of 5 to 13% [8,9].

Water Absorption and Thickness Swelling

The average of water absorption and thickness swelling of boards were presented in Fig 2.

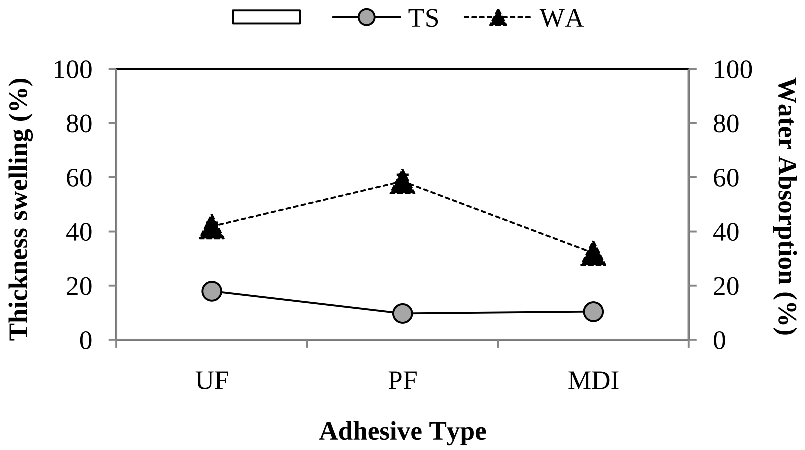

Figure 2. Water absorption and thickness swelling of OSB

According to the Fig 2, water absorption value ranged between of 29.7 to 54.09%. Low water absorbption values obtained on the MDI boards, while the highest obtained on UF boards. MDI boards in low adhesive level produces the lowest WA value compared with other resin in this research. Teco (2005) and Mara (1993) stated that adhesive bond between of MDI and lignocellulosic materials is chemical bond that resulted higher strength and more stable compared with mechanical bond like PF and UF resin [10]. Wood has hydroxil group and MDI in isocyanat group (–N=C=O) reacted to form urethane link. Combination of nonpolar and aromatic compound of MDI resulted in more resistant to hydrolysis. Based on that fact, as exterior application MDI adhesive has better performance than PF resin. Rowell (1998) explained that hemicellulose is is more responsible to water absorption besides of cellulose, lignin and surface of crystaline cellulose.

For the thickness swelling parameters, that value ranged between of 11.87 to 21.82% (Fig 2). Low thickness swelling values obtained on the MDI boards, while the highest obtained on UF boards. As interior application, UF resin had several disadvantages such as no water resistance and weather, high formaldehyde effect, and susceptible to hydrolysis. Tsoumis (1991) reported that UF resin suitable for furniture and other interior application which unnecessary of durability properties. Primary weakness of UF resin susceptible to hydrolysis. Humidity, base and high acidity at medium to high temperature were factors that caused of breakage in hydrogen bonding. Overall, boards produced from this research had met JIS A 5908-2003 that required of maximum thickness swelling of 25% [8,11].

Linear expansion

The average of linear expansion of boards were presented in Fig 3.

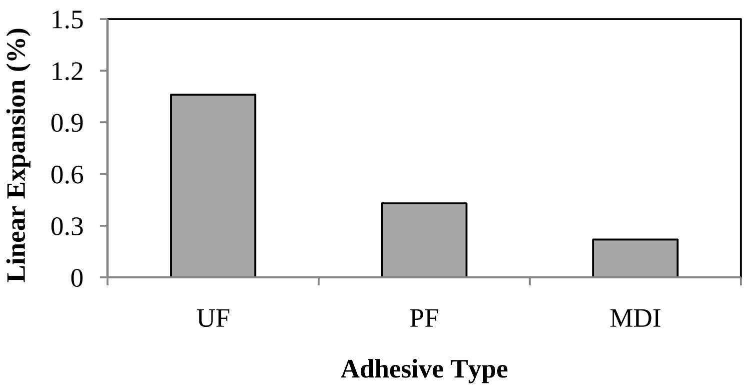

Figure 3. Linear expansion of OSB

According to the Fig 3, linear expansion value ranged between of 0.22 to 1.06%. Low linear expansion values obtained on the MDI boards, while the highest value on UF boards. Adhesive type and level also determined of linear expantion parameters. Linear expansion value is similar with longitudinal direction swelling in wood. Linear expansion is lower than thickness swelling value. JIS A 5908-2003 did not required linear expansion value.

Modulus of Rupture (MoR) and Modulus of Elasticity (MoE)

The average of MoR and MoE of boards were presented in Fig 4.

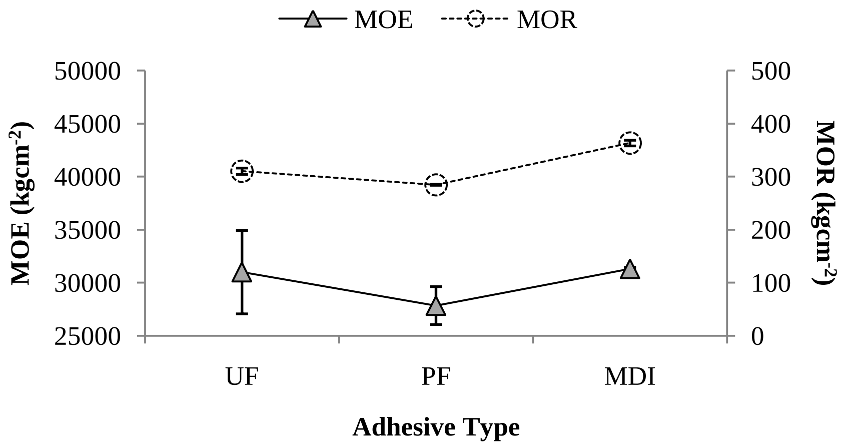

Figure 4. MoR and MoE of OSB

According to the Fig 4, MoR value ranged between of 257 to 338 kgcm^{-2}. Low MoR values obtained on the PF boards, while the highest value on MDI boards. The adhesive type is important factor to determine of MoR parameter. MDI for exterior adhesive had superior properties, the lower level amount of adhesive resulted better MoR than other adhesive with higher level. Chemical bond of MDI caused of higher compatibility between of adhesive and wood strand compared with mechanical bond. The utilization of Gmelina wood for OSB materials resulted good bending properties. Low acid properties of Gmelina wood with pH of 6.8 [4] resulted better compatibility for MDI. Maloney (1993) stated that MoR affected by level and type of adhesive, adhesive bond and fiber length [6]. Overall, boards produced from this research had met of JIS A 5908-2003 that required of minimum MoR of 245 kgcm^{-2} [8].

Furthermore refers to Fig 3, MoR value ranged between of 27,838 to 31,300 kgcm^{-2}. Similar condition with MoR was also occured in MoE parameter. Low MoE values obtained on the PF boards, while the highest value on MDI boards. Adhesive concentration level and wood type were presumed as a factors to affect of MoE value in this research. Compared with the previous research, Iswanto et al (2010) reported that MoE parameter of Sentang wood OSB ranged between of 45,513 to 65,905 kgcm^{-2} [4]. That research using amount 7% MDI to manufature of board. Overall, boards produced from this research had not met of JIS A 5908-2003 that required of minimum MoE of 40,800 kgcm^{-2} [8].

Internal Bond (IB)

The average of internal bond of boards were presented in Fig 5.

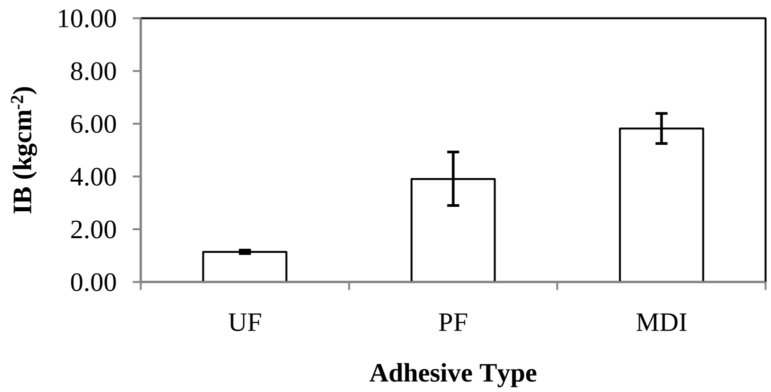

Figure 5. Internal bond of OSB

According to the Fig 4, MoR value ranged between of 1.14 to 5.81 kgcm^{-2}. Low IB values obtained on the UF boards, while the highest value on MDI boards. Acidity as a factor to determine of bonding quality. Adhesive bond was determined by raw materials and manufacturing process. According to Fengel & Wegener (1984) that subtropical woods have a pH range of 3.3 to 6.4 while for tropical woods pH range of 3,7 to 8.2. Iswanto et al (2011) reported that Gmelina wood has low acidity with pH of 6.8 [12]. The low acidity of Gmelina wood strand resulted in UF resin had lowest value of IB compared with other resin in this experiment. Nawawi et al (2005) showed that the bonding strength of plywood adhesives Urea Formaldehyde (UF) for wood punak with a pH of 6.03 is lower than gerunggang which has a pH of 4.68. Wood with pH ranged between of more than 4 resulted good bonding for MDI [13]. Kwon (2007) reported that wood with high acidity (less than 4 of pH) such as Kapur with pH of 3.8 showed the low IB value of flakeboard [14]. MDI has more sensitif to pH, buffering capacity and wood extractive. The boards produced from this research had met of JIS A 5908-2003 that required of minimum IB of 3.06 $kgcm^{-2}$ [8] excepted of UF boards.

Conclusions

Compared with PF resin, MDI resin for adhesive in the manufacturing of Gmelina wood OSB resulted the better properties. In general, boards that produces with MDI resin almost met of standard excepted for MoE parameter. According to the results, exterior application such as PF and MDI adhesives had good quality as resin in the OSB manufacturing.

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