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Development a new method for pilot scale production of high grade oil palm plywood: Effect of hot-pressing time

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ABSTRACT

The main objective in this study were to investigate the physical properties, mechanical properties and bonding qualities of oil palm stem (OPS) plywood pre-preg using low molecular weight phenol–formaldehyde (LmwPF). The properties evaluated were physical properties (resin uptake, weight percent gain), mechanical properties (bending strength) and bonding qualities (dry test, WPB test). The results showed that, the physical properties of OPS plywood were significant at resin concentration and veneer moisture content. Moreover, the mechanical properties and bonding performance of the pre-preg OPS plywood were influenced by the pressing time. The high grade OPS plywood with improved at least 227% MOR and 348% MOE compared to commercial OPS plywood, with greater in MOR (31%) and MOE (12%) higher compared than the commercial tropical mix light hardwood (MLHW) plywood. All the shear strength of pre-preg OPS plywood panel were achieved with their minimum requirements and satisfied all the specific testing based on the standard European Norms EN 314-1 and EN 314-2 for the interior and exterior application purposes. The output of this pilot scale study proved that high performance OPS plywood could produced through pre-preg enhancement method in the current plywood mills in which provides broader area of applications compared with conventional OPS plywood. For instant, the pre-preg OPS plywood which is suitable for structural application, concrete formwork, heavy duty interior structuring board, load bearing plywood, marine grade plywood, was obtained, thus consequently increases the price of OPS plywood panels.

1. Introduction

The plywood industry has been the 2nd largest wood-base industry in Malaysia after the wooden furniture industry which has contributed approximately RM 6.52 billion through worldwide exports. In year 2010, the plywood industry in Malaysia contributed up to RM 5.15 billion export revenue based on the total plywood production which was amounted at 480,000 m^3. Statistically reported by Malaysia Timber Industry Board (MTIB), the major country of plywood exporter includes, Japan (42%), Korea (14.1%), Taiwan (10%), Yewen (2.4%), USA (4.4%), UAE (2.4%), United Kingdom (4.4%), Egypt (2.1%), Philippines (2.3%) and others (13.7%) [1]. The commonly used types of wood species in Malaysia's plywood industry are Mempisang, Kedondong, Chengal, Meranti (*Shorea* spp.) and Keruing. To date, the public conservation conscious and sustainability is focused on Malaysia wood-based industry. Through utilizing sustainable materials such as agricultural by-products provides a promising alternative raw material in replacing with the scarce hardwood source. Agricultural crops by products such as kenaf (*Hibicus malaccensis*), rice husk, oil palm (*Elaeis guineensis*), empty fruit brunch, oil palm front, coconut coir and coconut trunk are available abundantly in Malaysia and are potential as raw material for wood plastic composite (WPC), particleboard (PB), medium density fibreboard (MDF), chipboard as well as plywood manufacturing. The Malaysian wood-based industry is working extensively in utilizing these agricultural mass prior to overcome the higher price of raw materials and shortage of timber supply over time.

No doubt, oil palm tree is an ingenious resource which can be obtained at any plantation around in Malaysia. Oil palm trees were felled every 25 years due to the reduction in fruit oil production. In general, these agriculture residues were chopped into small disk and left in plantations for natural degradation which serves the purpose biomass as fertilizer for next replanting rotation. In addition, some of these are used as fuel and land field, however many are left unused. Consequently, large amount of oil palm trunk can be produced, hence subject to explore and utilisations. Theses lignocellulosic material from oil palm trunk materials it able to be value-added under well management and implication. According to Anis et al. [2], Malaysia produces about 13.9 million tonnes (dry weight) of oil palm biomass, which includes trunk, fronds and

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Table 1
Specifications of LmwPF resin.

Specific of phenolic resin	
Basic solid content	45%
Molecular weight	500–600 mw
Specific gravity	1.30
Viscosity	1.10 poise
pH at 25 °C	10.9
Formaldehyde emission	0.50%
Gel time at 100 °C	60 min

Table 2
Plywood production of treated OPS plywood panel at different hot pressing parameter.

Plywood panel	Variable of pressing time (min)
Panel A	14
Panel B	16
Panel C	18
Panel D	20

Note: Total five panels were produced. Pressure parameter was 20 bars for the first 5 min, increased to 50 until for the less. The MC in OPS veneers where ⩽19%.

empty fruit bunches annually. Hasim et al. [3] reported that this amount tends to increase substantially when the total planted hectare of oil palm in Malaysia reaches 5.1 million hectares in year 2020. These agricultural biomass is reasonably cheaper, abundant, as well as sustainably. Therefore, the oil palm stem (OPS) has been utilized as potential raw material for plywood manufacture in Malaysia more than 10 years.

To date, the major market of OPS plywood still confine in local consumption as utilities grade end products with prior to the main problem of these material which relates to its natural anatomic structure and causing low mechanical properties, bonding properties and dimensional stability, limiting its the application compared to conventional tropical mix light hardwood (MLHW) plywood. In order to increase the value-added in plywood application, several studies have been investigated and reported on the products to improve its poor nature properties. This study was conducted to determine the effect of different pressing time and various solid content of resin on the strength and bonding properties of OPS. In generally, this new method requires an additional re-drying process for treated veneer and longer hot-press time compared to the conventional method for OPS plywood production using phenolic resin [4,5]. This work is the latter part of the previous paper reported on a pilot scale study of high grade OPS plywood through pre-preg method with resin.

2. Experiments

2.1. Material preparation

Three OPS (25 years old) were extracted from Sg. Bakap in north Malaysia. The OPS was then cut into 4 feet long and sent to OPS plywood processing mill for veneers peeled at 4.5–5.5 mm thickness as raw material. After debarking process, the OPS veneers were cut into smaller size (3 × 4 feet), then dried using a conventional industrial dryer to a relatively MC of 5–10%. Only the veneer from the middle and outer parts of the trunk were used as sample.

2.2. Preparation of LmwPF resin

The low molecular weight phenolic (LmwPF) resin, with desired solid content (20%, 30%, 40%) that was prepared according to Hoong et al. [6–8], which is by reacting phenol and formaldehyde in an alkaline condition were used as the filling agent in the pre-treatment of OPS veneer. The resin cooking procedure were as the normal PF resin cooking for plywood with, minor modified where the methylolation period was maintained less than 4 h. The specifications of the resin used in this study were shown in Table 1.

2.3. Veneer enhancement

The details of pre-preg method was carried out as described in published article of pilot scale production of high grade OPS plywood by Hoong et al. [9] complied with the specials method of OPS plywood manufacture flows in Fig. 1 and were reported by Loh and co-workers [10]. This study consists of two stages; first, pre-preg of OPS veneer with LmwPF; second, manufacturing of OPS plywood from the pre-preg OPS veneer. Before the pre-preg activity, the veneers were cut to sample sizes of 1 × 1 feet and dried to a relatively high MC ranged from 10% to 19%, 20% to 29% and 30% to 39%.

In the pre-preg stage, the treatment method developed for oil palm wood was adopted to treat OPS veneer. The dried veneers at respective MC were immersed in different solid content (20%, 30% and 40%) of LmwPF for 10 s. After immersing, veneer samples were roller-pressed to ensure a dapper penetration of the resin into

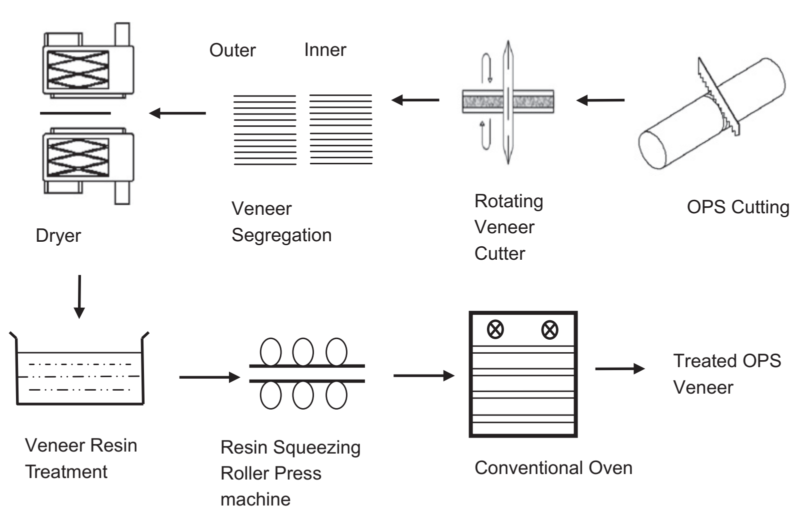

Fig. 1. Schematic diagram of process flow for production and treatment of OPS veneers [10].