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Effect of particle geometry on the properties of binderless particleboard manufactured from oil palm trunk

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ABSTRACT

Experimental binderless composite panels were manufactured using fine particles and strands of oil palm (*Elaeis guineensis*) trunks. Modulus of rupture (MOR), internal bond strength (IB), dimensional stability, and surface roughness of the panels made with a target density of 0.80 g/cm^3 were evaluated. Strand type samples had MOR and IB values of 24.95 and 0.95 MPa, respectively. Corresponding values for the fine particle type samples were 4.04 and 0.49 MPa. Panels made from strands met MOR requirement stated in Japanese Industrial Standard (JIS). Enhanced bonding between strands observed by micrographs taken using scanning electron microscopy (SEM) also supported the findings. However, the samples having fine particles had lower MOR values than minimum requirement listed in JIS. Strand type panels had 41.6% thickness swelling which is only 4.6% lower than that of the panels made from fine particles. It appears that dimensional stability of both types of panels exhibited insufficient results according to JIS. Surface roughness quality of the samples made from fine particles had average surface roughness values comparable to those of panels made in past studies. Based on initial results of this work, raw material from oil palm trunks can have some potential to be used to manufacture binderless panels without using any adhesives. This study revealed that mechanical and physical properties of such experimental panels were influenced by the particle geometry. It would be important to consider possible addition of chemical or wax in the particles to improve their dimensional stability in further studies.

1. Introduction

Oil palm (*Elaeis guineensis*) which is native species from Africa has the largest plantation land among other agricultural crops in Malaysia. It has a significant commercial value in the form of oil that can be produced from the mesocarp of the fruit. Currently Malaysia is one of the largest producers of palm oil in the world. Increasing land area of oil palm plantation has been leaving substantial amount of residue in harvesting sites. It is estimated that overall oil palm industry generates at least 30 million tonnes of lignocellulosic biomass per year in the form of trunks, fronds, empty fruit bunches, and leaves [1]. Unfortunately the resource is not used very effectively, open burning and land filling are common practices to eliminate oil palm residue which cause environmental pollution and put adverse impact on the ecosystem.

Oil palm being lignocellulosic material that could be considered to produce value-added composite panels similar to other non-wood resources such as bagasse, wheat straw, or kenaf [2–5]. Composite panels including particleboard and fiberboards are widely used as substrate for thin overlay to manufacture furniture units.

Manufacture of wood composite panels normally requires using different types of binder to have proper physical and mechanical characteristics of the final product. The choice of the adhesive normally depends on the end use of the composites. Urea formaldehyde is the most common adhesive used in the industry [6]. It is also the least expensive compared to other wood adhesives. Although it has a low cost, it still makes up about 60% of overall cost of particleboard production even if it is used only 8–10% based on oven dry furnish weight [7]. Formaldehyde based adhesive such as urea formaldehyde poses a problem of formaldehyde emission from panels that could cause health concerns [6,7]. Therefore, manufacture of composite panels made without using any resins known as binderless panels is an alternative method to keep low cost of the final product without having any adverse health

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influence. Shen [8] made binderless boards using sugar cane and sorghum stalks in their natural form. The process for manufacturing binderless composite products from sugar containing such lignocellulosic materials was patented. Bonding of the particles was accomplished by the existence of free sugar, carbohydrates, or saccharides that served as bonding and bulking agent pressed at a temperature of 180 °C. Mobarak et al. [9] studied the mechanism of binderless panels made from lignocelluloses of bagasse. The work showed bonding of particles were achieved as a result of the ability of the particles to compress closely together which can be attributed by the high lumen to cell wall ratio of bagasse.

Information on binderless particleboard from oil palm trunk is very limited and no solid data on properties of the panels have been reported yet. Suzuki et al. [10] prepared binderless boards from oil palm fronds from steam exploded pulps. Similar technique has also been reported by Laemsak and Okuma [11] who attempted to use steam exploded oil palm fronds to manufacture binderless medium density fiberboard.

Particleboard is wood based composite basically consists of particles of varying shape and size bonded together with an adhesive and consolidated under heat and pressure [12]. Particle geometry including shape and size is a major parameter which can create a significant impact on the properties of the boards [13]. According to Suchsland [14], particle geometry plays more significant role on development of board properties than the actual mechanical properties of the fiber types panel. Variation of particle shape and size significantly influenced overall panel properties [13]. Study by Miyamoto et al. [15] showed that particle shape affected the linear expansion of particleboard. Sackey et al. [16] pointed out that the fines content and the ratio of all particle-size fractions strongly influenced the internal bond strength of the samples.

The objective of the work was to investigate properties of panels made from oil palm trunk without using any binders focusing on the effect of particle geometry in terms of size and shape. In such case, binding naturally is developed as a result of pressing of the mat at high temperature so that free sugars, carbohydrates or/and saccharides or any other chemical present in oil palm can be activated to form natural binding agents. Experimental panels were produced using commercial manufacturing parameters. Both mechanical and physical properties of such composite panels made of different particle geometry were evaluated. Also microscopic study was carried out to determine bonding quality of the experimental panels as function of particle geometry.

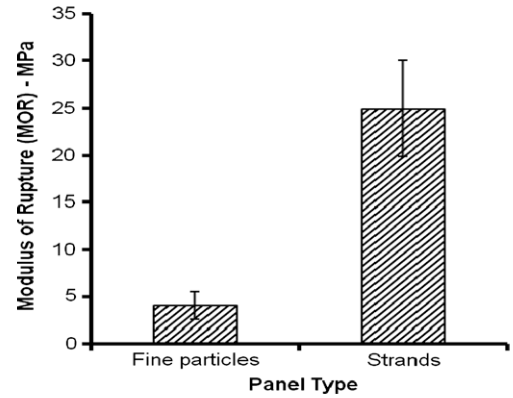

Fig. 2. Average modulus of rupture values of the samples.

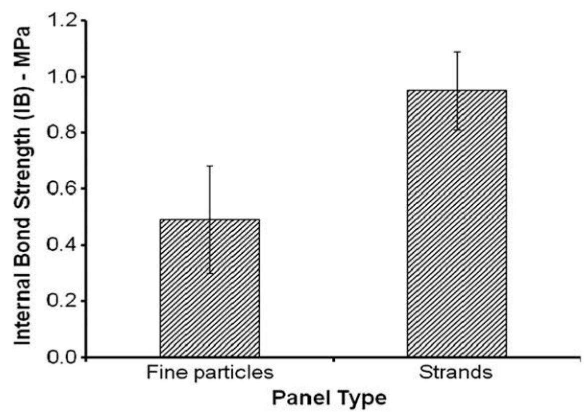

Fig. 3. Average internal bond values of the samples.

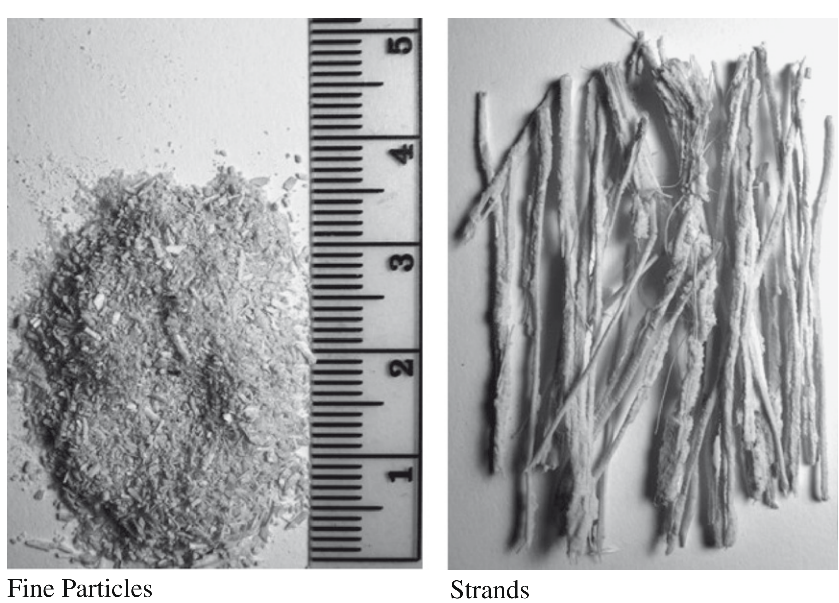

Fig. 1. Samples of fine particles and strands.