THE PARTICLEBOARD MADE FROM KENAF AND ITS PROPERTIES

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Abstract: The development of particleboard from kenaf (*Hibiscus cannabinus L., Malvaceae*) was carried out. The kenaf core fiber with sizes 1-2 mm was used to produce homogeneous layer of particleboard with UF (urea formaldehyde) and PF (phenol formaldehyde) loading at 10% and 12%. Three series of target density of board were produced, i.e., 500, 600 and 700kg/m^3. The board was evaluated based on its property performance via mechanical, dimensional stability as well as formaldehyde emission tests. The preliminary result indicated that the mechanical properties of board especially at density of 600-700 kg/m^3 are comply with the EN 312-3 (1996) specification, which is suitable for interior fitments (including furniture) use in dry conditions. The study found that UF-bonded board better of mechanical properties than PF-bonded board especially at 12% resin loading. Thickness swelling and formaldehyde emission tests were conducted where the results exhibit the low percentages and formaldehyde emission, respectively for board containing PF resin than UF resin.

Keywords: Particleboard, Kenaf, Urea formaldehyde, Phenol formaldehyde

INTRODUCTION

Kenaf is a warm season annual fiber crop closely related to cotton (*Gossypium hirsutum L., Malvaceae*) and okra (*Abelmoschus esculentus L., Malvaceae*) (Charles *et al.*, 2002) [1]. The advantages of kenaf that it's components can be commercialized including the bark, bast, core fiber, and the leaves. The diverse new uses for kenaf include its utilization in paper products, building materials, absorbents, textiles, and livestock feed (Charles *et al.*, 2001)[2]. It is also possible compress the core in board (James *et al.*, 1999) [3]. Due to dwindling of material supplied especially from rubber wood in the wood based industry in Malaysia, kenaf would become a good alternative material in the such industry for the coming years because of it's fast growing (almost 6 months) and feasible cultivated in Malaysia which is a tropical country. The research of kenaf material for the wood based industry in Malaysia still at the minimum level and as far as concern, no existing of wood based industry in Malaysia that using kenaf as their main sources. UF resin is by far the dominant adhesive for medium density fiberboard (MDF) and particleboard (PB). It provides a strong adhesion in a permanently dry environment, cures fast, and is relatively cheap. Meanwhile, the PF resin is by far the dominant adhesive for hardboard (HB), oriented strand board (OSB) and LVL, but twice expensive than UF. It provides a strong adhesion in a dry environment with a potential for an exposure to liquid water for a duration measured in hours. For examples, a stack of OSB panels sitting at a construction site can be exposed to rain without losing its performance in a critical way. The danger in using this product indoors is the emission of formaldehyde and poisonous phenyl, which affects the central nervous system. In this paper, the investigation will emphasized on the performance of the boards that using PF and UF as their binders.

MATERIALS AND METHODS

Raw Materials

Kenaf chips: Kenaf stalks was harvested from the MARDI sub-station at Sabak Bernam, Selangor, Malaysia. The kenaf stalks with almost 5 m height was stored for several weeks prior to a chips making process.

Chemical: Urea formaldehyde and phenol formaldehyde, which are at 64% and 42% solids content respectively, were supplied by Malayan Adhesive Chemical Sdn. Bhd., Shah Alam, Selangor. Other chemicals that were added in the UF bonded boards including ammonium chloride as a hardener (20% solids content) and wax paraffin (60% solids content) as a water resistant agent.

Methodology

Preparation of chips: The drum chipper machine model Pallmann PZ 8 has been used to disintegrate the whole stalk kenaf into a chip form. The separations of bark and kenaf core were achieved by using vibrating screener. The core chips was refined further, with knife ring flaker machine model Pallmann PHT 120/430 in order to obtain size 1-2 mm of the chips. A chip was dried in an oven at 106^{0}C for 48 hours to achieve moisture contents at 5% and below.

Mixing process: The mixing process between kenaf core chips, urea formaldehyde, hardener and wax were mixed in a blender machine. Phenol formaldehyde was blended in the blender machine with the chips without hardener and wax. The percentages of resin loading were 10% and 12% (based on a dry basis weight of fiber). The mixing was carried out for about 6 minutes until all resin was sprayed on the kenaf chips.

Board making: The kenaf material upon blended with adhesives were manually consolidated to form a mat in the mould with dimensions of 340 × 340 × 12 mm. The mat was pre-pressed in the cold press at 35kg/cm^2 of pressure at ambient temperature and subsequently pressed in the hot press machine model Taihei at 180^{0}C until the thickness required for 6 minutes. Three level of board density were produced, i.e. 500, 600 and 700kg/m^3. Three replicate of boards were prepared for each series of particleboard manufactured. For making the PF-bonded boards, the same procedures were followed, except of temperature is at 200^{0}C for 12 minutes have been applied for hot pressing activity.

Testing process: All samples prior to testing were kept in a constant chamber with 65% humidity at temperature of 20^{0}C for approximately 3 days. The mechanical tests of samples were carried out for bending test (MOR, MOE) with dimensions 290 × 50 × 12 mm and internal bond (IB) test with dimensions 50 × 50 × 12 mm. The test was carried out using Instron Universal testing machine Model 4204. The dimensional stability tests, i.e. a thickness swelling test was calculated after immersing the samples with size 50 × 50 × 12 mm in the water at 20^{0}C for 24 hours. Ten samples were tested for each series. The mechanical and thickness swelling tests were followed the BS EN 310: 1993 specification [7]. A formaldehyde emission test was conducted according to desiccators (JIS A 1460: 2001) [10] and perforator methods (EN 120: 1992) [12]. This test is conducted to measure the free formaldehyde emitted from the boards that containing a difference of resin.

RESULTS AND DISCUSSIONS

The figure 1 shows MOR results. Generally, the MOR values increased with the increasing of resin contents and board density. Since the modulus of rupture (MOR) indicates the ability of a specimen to withstand a transverse (bending) force perpendicular to its longitudinal axis (Jacobs *et al.*, 1994) [4], MOR results of the board at high density and resin contents are able to withstand such force. Other researchers (Jacob *et al.*, 1994) [4] in the same fields of research also reported similar trends. This trend, however, only happened to the UF-bonded boards, but did not happen to the PF-bonded boards as resin loading is increased, as shown in a figure 1. Its may due to over optimum needed of PF for the boards, which is the optimum level perhaps can be reached at below 10% of PF loading, as the over optimum of PF loading will deteriorated the board performances. James *et al.*, (1999) [3] reported that boards at 7% of PF loading showed increasing of MOR than at 3% and 12% of PF loading. For comparison, at various of board densities, board containing UF resin is better than PF only at 12% resin input, but similar values of MOR was obtained at 10% of resin input. The MOR values of UF-bonded and PF-bonded board at the density of 600 and 700 kg/m^3 met the minimum EN 312-3 (1996) standard requirement, except for board at 500kg/m^3.

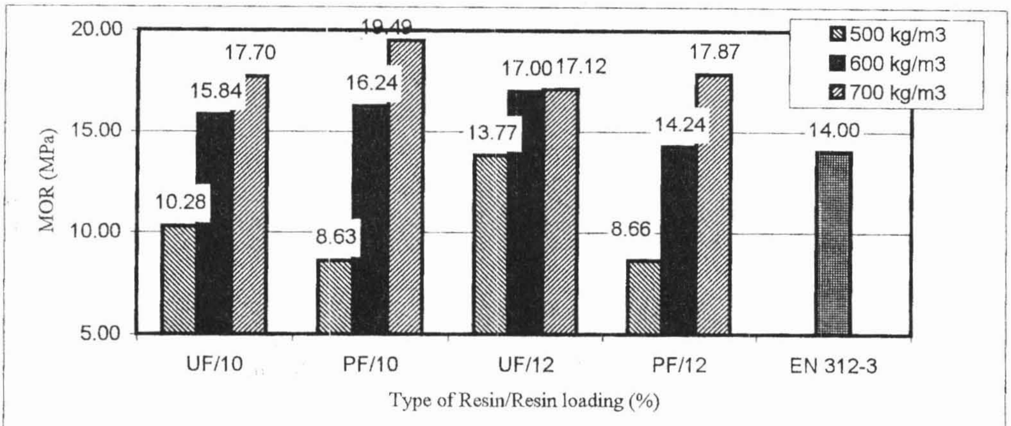

Figure 1: The MOR values of particleboard with a different adhesive

Similar trends also display by MOE results as shown in figure 2, in terms of resin gaining from 10% to 12%, that not contributed to the increases of MOE values especially for the PF-bonded boards as compared to the UF-bonded boards. The similar trend also was observed from previous studies (James *et al.*, 1999) [3]. The UF-boards that manufactured performed better MOE at various density and at 12% resin loading than the PF-boards, which is could be due to the contribution of the higher solid contents of the UF binder than the PF. Terry *et a*l (1996) [5] reported that the uses of UF in the particleboard manufacture gave better MOE than PF. There are no different of MOE between UF and PF board at 10% resin loading and various of board density was performed. Furthermore, the figure 2 also depicts particles loading on the MOE. As expected, the MOE values increased with the increasing of kenaf particle loading on the PF and UF-boards that manufactured. Its may be due to the inherent stiffness of the kenaf particles may positively contribute to the overall stiffness of the boards. Generally, the values of MOE at different board density and resin, except the board at 500kg/m^3 was exceeded the minimum requirements in the EN 312-3(1996) standards.

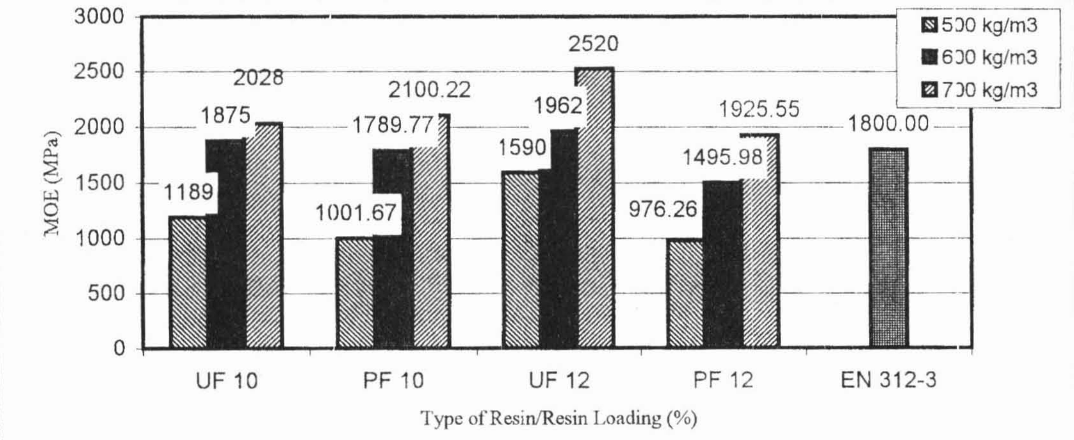

Figure 2: The MOE values of kenaf particleboard with a different resin

Inspection on the figure 3 shows that by increasing the resin and particle in the boards, the IB strength also increased for both types of the boards. As comparison, the IB values of both types of the boards seem similar at various of board densities and resin input, excluded boards at 500 kg/m^3 and 10-12% resin input which is display of better strength of UF-bonded boards than PF boards. The IB strength values for all types of board are higher than the minimum requirement of EN 312-3 (1996) standards.

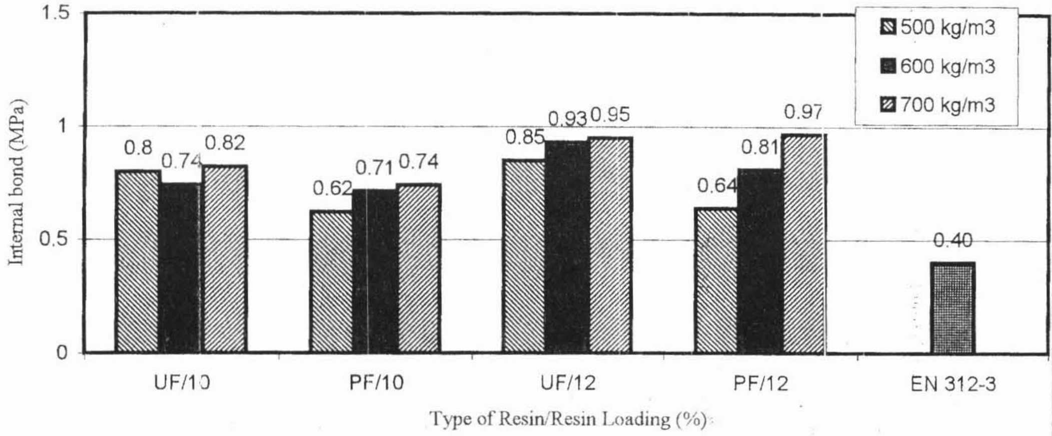

Figure 3: The internal bond of kenaf particleboard with a different adhesives

In average, the thickness swelling (figure 4) for every level of the boards were decreased as the resin content increased. Since the formaldehyde is one of the chemical component in UF and PF that could be capable to cross-link with the hydroxyl groups of the kenaf than a water was revealed a low water penetration into the board. Furthermore, the result of thickness swelling increases as the kenaf particle loading is increased. James *et al.* (1999) [3] also demonstrated same trends. A PF-bonded board shows the better thickness swelling results as compared with an UF-bonded board. Low emission of formaldehyde of PF-bonded boards due to the most formaldehyde bonded within the three-dimensionally crosslinked PF network was resulted of less hydrogen bonding between formaldehyde and a water, thus was arose a water resistant property of the boards. Edmone (1993) [6] noted that the lesser of free formaldehyde, the better thickness swelling.

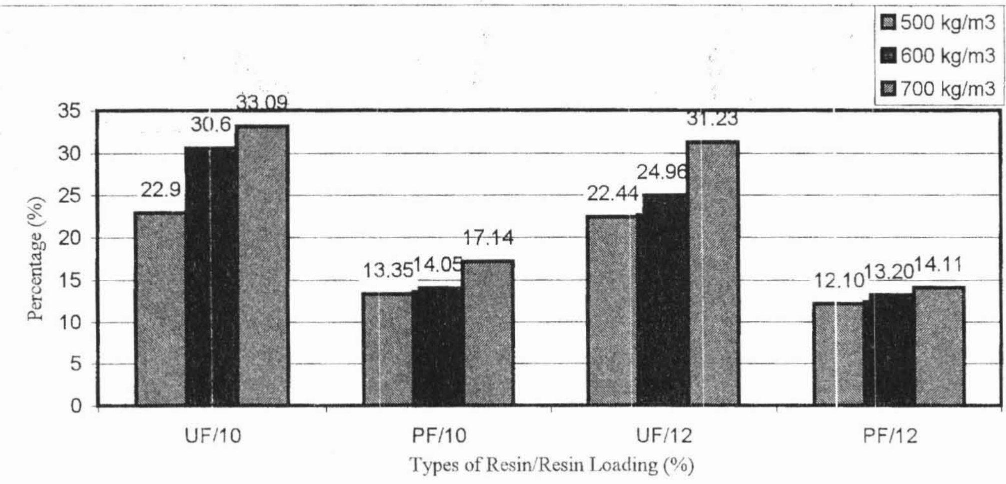

Figure 4: Thickness swelling of kenaf particleboard with a different adhesives

From the figure 5 and 6, there are about the results of formaldehyde emission tests. The low emission of formaldehyde by PF-bonded samples is established compared to the UF-bonded boards. Its might be due to the less of free formaldehyde produce from the PF boards because of formaldehyde was permanently bonded with PF network, while UF board which has not such thing has produced more. Values of emission for the PF and UF boards are categorized as class A (same or below 9 mg/100g) for the perforator methods, although they are in the same classes, the PF boards give the lower emission number than the Ufs as the former exhibits the lowest values within two types of the resins (figure 6). Meanwhile, a similar trends was displayed from the desiccators methods, the PF and UF boards were obtained F**** (0.3 mg/L or under) and F** (1.5 mg/L or under) respectively, means that the former is produce low emission compared to the latter (figure 5). From both figures, the values of formaldehyde emission are slightly the same as the resin increased in the boards.

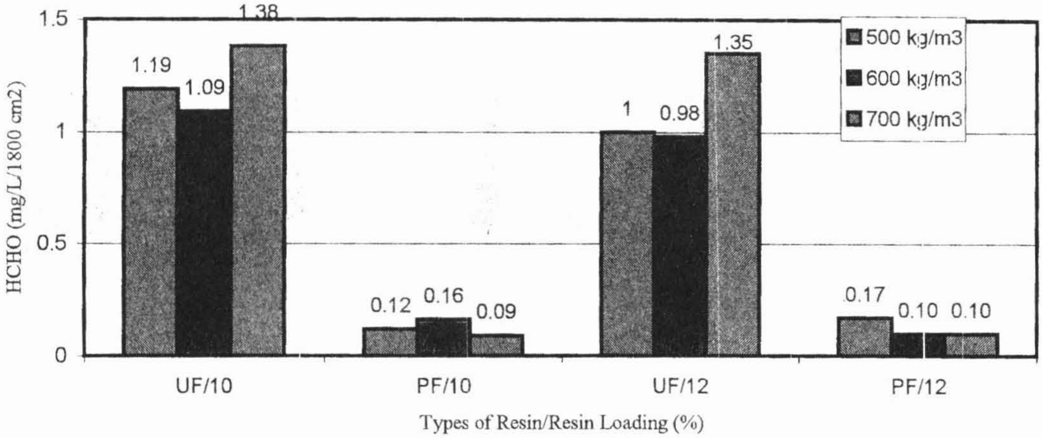

Figure 5: The formaldehyde emission tests on the kenaf particleboard (desiccator methods)

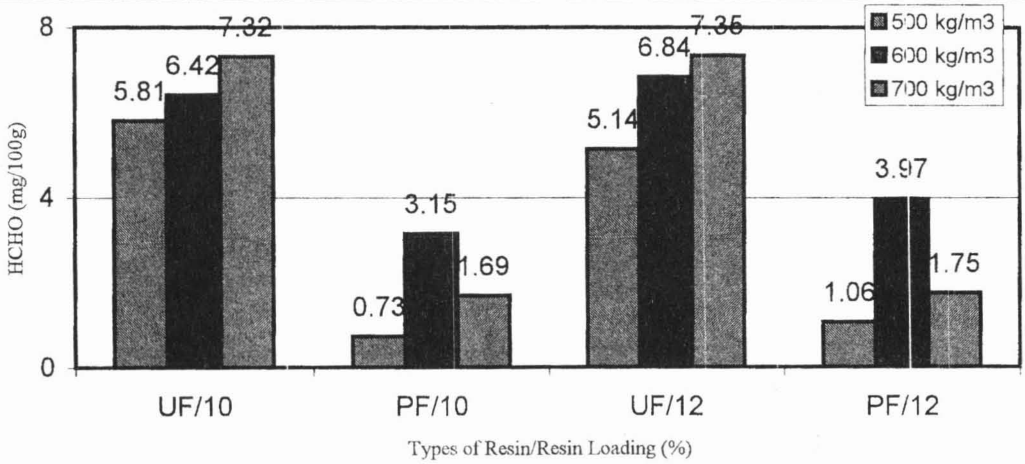

Figure 6: The formaldehyde emission tests on the kenaf particleboard (perforator methods)

CONCLUSIONS

As conclusion, the UF-bonded boards showed better performance than PF-bonded board for mechanical properties at 12% resin loading and similar of such property at 10% resin loading, whereas the latter displayed the best performance for the thickness swelling and emission of formaldehyde tests than the former at both resin loading. The UF and PF boards were exceeded the minimum requirements of the standard (EN 312-1996) for the mechanical properties especially at 600-700 kg/m^3 of the boards density.

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