

EVALUATION OF BASIC PROPERTIES OF KENAF (*Hibiscus Cannabinus* L.) PARTICLES AS RAW MATERIAL FOR PARTICLEBOARD

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1 Introduction

Kenaf has been the interest of many researchers due to the fast maturity and extreme fibre quality. One of the products that have been studied is particleboard. This paper discussed the basic properties of kenaf; height, density, moisture content, particle yield, and adhesion of kenaf as a raw material for particleboard manufacture. In Malaysia, kenaf was just recently introduced in Malaysia by National Kenaf and Tobacco Board (NKTB) especially for fibre to partially replace tobacco. Kenaf is a tropical plant from the family of *Hibiscus* is fast growing, maturing at the age of between four until five months. This factor has made kenaf a sought after plant for the production of fibres. Basically, kenaf stem consists of two types of material; the long, stiff bast fibre and the short and sponge-like fibre known as core material. Both materials differ significantly in appearance anatomical structure and properties [1]. Since kenaf consists of two different materials, separation of kenaf core and bast is technically possible but not economic. Therefore, the consumption of whole kenaf stem perhaps can reduce the cost of separation process and save the time. However, the bonding mechanism of these materials may differ.

Particleboard is one of the most important wood-based panel products in the market [2]. It is a conventional composite material and it produced by mechanically reducing the raw material into small particles, applying with thermosetting adhesive and consolidating a loose mat of the particles with heat and pressure to produce a panel product. In particleboard industry, good quality of particleboard depends on the wood density. Hence, to obtain a high strength value, a certain compaction ratio is needed. Basic requirement in the fabrication of

particleboards is by using low density wood species, so the compaction rate, i.e., the relation between the density of the board and that of the wood, is at least 1.3 to ensure that the densification needed for the formation of the board will occur [3].

The strength of particleboard comes from raw material itself and the adhesive used for particles bonding. Therefore in the basic study of particles were required to evaluate the performance of the panel. The modulus of elasticity (MOE) and modulus of rupture (MOR) are strongly influenced by the particleboard's compaction rate, particle geometry, percentage of adhesives and density [3]. In this study, kenaf with light in weight and low density able to produced a high compaction ratio perhaps will resulting better contact among the kenaf core, kenaf bast and rubberwood particles. However, there is always a greater swelling in thickness when the density of the board increases because of the increasing of volume of raw material. This study is essential to evaluate the true potential of using kenaf stem particle as partial substitution of rubberwood in particleboard manufacture. If the particleboard is to be made from a mixture of rubberwood and kenaf stem, it will contain essentially three types of particles i.e. rubberwood, kenaf bast and kenaf core. The performances of particleboards were also evaluated.

2 Materials and Methods

2.1 Determination of Height, Moisture Content and Density of Kenaf

Kenaf (*Hibiscus cannabinus* L.) stem of from variety 36 (V36) was used in this study were harvested from Kelantan, Malaysia. Five month-old kenaf was selected to be used in this study. For height evaluation, twenty stems of kenaf were

randomly selected to measure the high of green kenaf after harvesting. The stems were harvested at approximately 10 cm above the ground. The stems were then divided and cut into three parts; namely, bottom, middle and top. The bast was separated manually from the stem to obtain the core for density and moisture content study using densitometer and oven dried methods, respectively.

2.2 Evaluation of Kenaf Wettability

The samples were obtained from both the outer and inner parts of kenaf core and kenaf bast. For the evaluation of wettability, the samples were dried up to 5% moisture content before dropped with distilled water, acid (0.1N HCl) and alkali (0.1N NaOH) on the horizontal solid surface of samples. The measurement was done using AB Lorentzen and Wettre (L-W) surface wettability tester and the experiment were carried out in three replicates for each type of materials.

2.3 Evaluation of pH and Buffering Capacity Properties

The aqueous kenaf stem extract was prepared by boiling 15g of dry chips in 200 ml distilled water. Then, the mixtures were filtered using glass crucible. The pH solution was measured before titrated manually using titrate with 0.1N hydrochloric acid (HCl) until it reached pH 3.0. The pH value was recorded after every 1 ml of titration. The procedure was repeated to 0.1N sodium hydroxide (NaOH) until it reaches pH 10.0. The experiment was carried out in three replicates. In addition, rubberwood was undergo the same method to obtained the pH and the buffer value.

2.4 Production of Kenaf Particles

Kenaf stem, core and bast were first chipped separately using a wood chipper (Model Pallmann) and then, the chips' size was reduced using Pallmann knife ring flaker. Then, the particles were screened into different sizes on a vibrator fibre screen machine and the yield recovery was determined. The particles were classified into four sizes; <0.5 mm, 0.5-1.0 mm, 1.0-2.0 mm and >2.0 mm. In this study, only 0.5-1.0 mm and 1.0-2.0 mm particles were used to fabricate the particleboard.

2.5 Board Manufacture and Testing

A total of 12 boards of size 340 mm x 340 mm x 12 mm were fabricated. Particleboard made from 100% rubberwood (RW) (as control), 100% kenaf stem (K), admixture kenaf stem-rubberwood particles; 30K: 70RW and 50K: 50RW was manufactured. The fabrication of the particleboard was conducted manually after blending with 10% Urea Formaldehyde (UF) resins and formed in a wooden former. The mat was pre-pressed manually prior to hot pressing. Subsequently, the mat was pressed in a hot press and all the boards were stabilized by in a conditioning room at the temperature of 20°C and 65% relative humidity (RH) for one week before cutting and testing the test specimens. The mechanical and physical tests were conducted according to the Japanese Industrial Standard JIS A 5908 [4]. The implement tests were; bending strength (BS), internal bonding (IB), thickness swelling (TS), and water absorption (WA). The data were then analyzed statistically through Analysis of Variance (ANOVA) and mean separation using Least Significant Different (LSD) method. All the statistical analysis was done at probability values less than .05.

3 Results and Discussion

3.1 Evaluation of Height, Density and Moisture Content of Kenaf Stem

The height of kenaf stem was between 312-425 cm. Figure 1 (a) and (b) show mean values of dry density and moisture content (MC) for the three positions (bottom, middle, top). The density of kenaf ranged between 0.319 and 0.369 g/cm³ (stems) and 0.269 and 0.307 g/cm³ (core). Figure 1 (a) indicates the densities of kenaf stem and core increase from the bottom to the top. It was similar to the previous study reported that the density of kenaf core increase from the base to the top of the tree [1]. From the figures, the density trend was inversely with the moisture content along the kenaf stem.

3.2 Evaluation of Wettability of Kenaf

Figure 2 indicates the contact angle of wettability of different layers of kenaf (outer and inner) using different types of liquid. It shows that the contact angle between the outer and inner surface of kenaf core was not differs significantly. For all types of liquid (distilled water, acid and alkali) on different substrates as a function of time, kenaf core

illustrated highly wettability since it was found easier to wet, almost experiencing spontaneous within 1 minute wetting. This may due to the difference in specific gravity between the two surfaces. Besides, kenaf core gives lower contact angle, thus indicates better wettability as compared to the bast. Nonetheless, both the outer and inner layers kenaf bast has high contact angle and consequently interpreted low wetting ability irrespective of the type of liquid used. Previous study [5] indicated that both the outer and inner layers of kenaf bast were the most difficult to be wet irrespective of the type of liquid used. This might be due to the higher extractive content of kenaf bast (5.5%) in contrast to of 4.7% in kenaf core [6], which affected the wettability of the fibres. A study [7] showed that extractives have a significant effect on water wettability of wood which may occur in two conditions; one is direct on the wettability of the true surface, and the other effect was a blockage by extractives of the openings between the cells, thus preventing penetration of a droplet below the surface of the wood.

3.3 Evaluation of pH and Buffering Capacity Properties

Buffering capacity is a measure of resistance of the wood to change in acidity or alkalinity. From the observation, kenaf stem gives higher pH value compared to control (rubberwood). As shown by a steeper slope in Figure 3, rubberwood was greater in the rate of change in pH as compared to kenaf stem. Thus, kenaf stem was observed to be more resistant in both acid and alkali conditions, where the amount of 0.1N HCl and 0.1N NaOH required to change the pH value were 15.5 ml and 11.7 ml, respectively. However, a study [5] reported that was greater in kenaf core compared with rubberwood and kenaf bast.

3.4. Production of Kenaf Particle and Board Performance

Green kenaf stem with 148% (MC) can produced into fine particles suitable for making particleboard at a recovery rate of 74% (based on oven dry weight). Figure 4 shows the distribution of particles sizes produced after chipping, flaking and drying was skewed towards larger sizes particles with

majority having >1.0mm. On the other hand, Table 1 demonstrated the strength and stability properties of particleboard made from rubberwood (RW) and kenaf stem (K). Generally, the admixture boards (RW: K) show better strength compared to homogenous kenaf stem (100% K). The best board comes from board comprising combination of 70% RW and 30% K. All types of board met the minimum requirement stated in JIS A5908: 2003 (Type 8) for MOR and IB. However, all boards were failed to meet the minimum requirement in JIS A5908: 2003 (Type 8) for MOE. This might be because of kenaf having low density, since it requires high board density (0.7g/cm^3), it required high volume of materials. Therefore at the same resin level, there were insufficient resin hence contributes to low internal bonding of those board requires higher percentages of kenaf board incorporated. Apparently, the rubberwood particles increased the strength and stiffness of admixture boards. Nonetheless, as kenaf stem particles incorporate were high, the lower the MOE and IB are resulted.

Generally, the increasing of specimens' thickness resulted the increasing of water uptake in all types of boards. Board type a comprised admixture of kenaf stem-rubberwood board experienced the lowest swelling within 24 hours soaking compared to 100% RW and 100% K and apparently more stable. Such stability maybe imposed by the presence of kenaf bast that fill the void among the kenaf core particle, thus may retained the swelling and water uptake. On the other hand, kenaf core consists of short fibrous material that is able to absorb water in its open porous cell system [8], therefore encouraged the water uptake of such board.

4. Conclusion

As the conclusion, density of kenaf stem was much dense compared to the core. The green moisture content was higher in the bottom to the top in both kenaf stem and core. Kenaf stem can be processed into fine particles suitable for making particleboard at a recovery rate of 74% (based on oven dry weight). After screening, the highest particle distribution of kenaf particles was given by size 1.0-2.0mm. Kenaf core is highly wettability for all types of liquid (distilled water, acid and alkali). Kenaf stem was higher buffering capacity compared to

rubberwood, hence its required higher amount of acid and alkali to reach pH 3.0 and pH 10.0. Among the particles ratios applied, the board made from combination of 70% rubberwood and 30% kenaf with 10% resin content was most stabled. Among the all properties, MOE is the most difficult to achieve the minimum requirement of JIS A 5908:2003. As the amount of kenaf increased, both the stability and strength of the board were reduced. These properties perhaps can be improved when higher resin content was used.

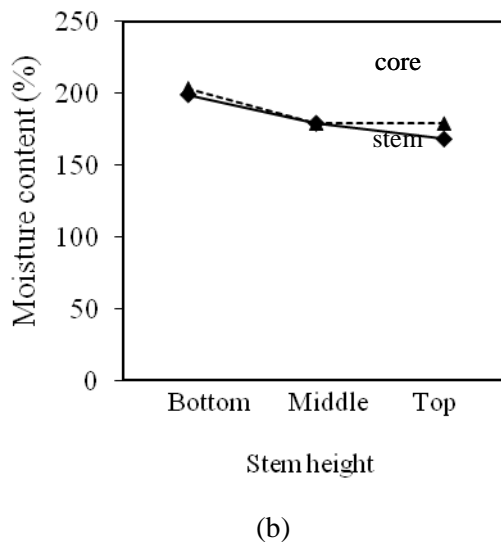
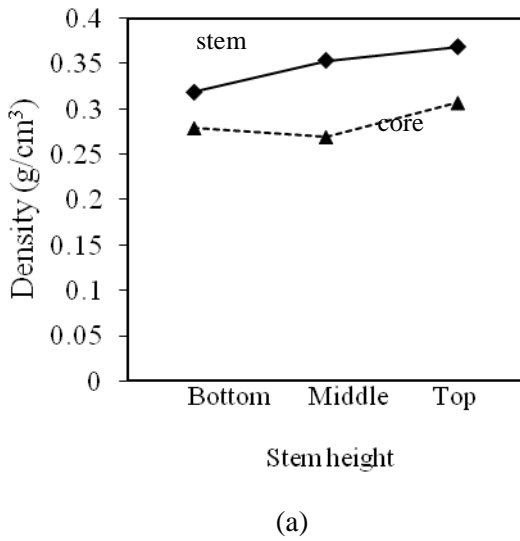


Fig. 1. Density variation of kenaf stem and kenaf core (a) and variation of moisture content of kenaf stem and kenaf core (b)

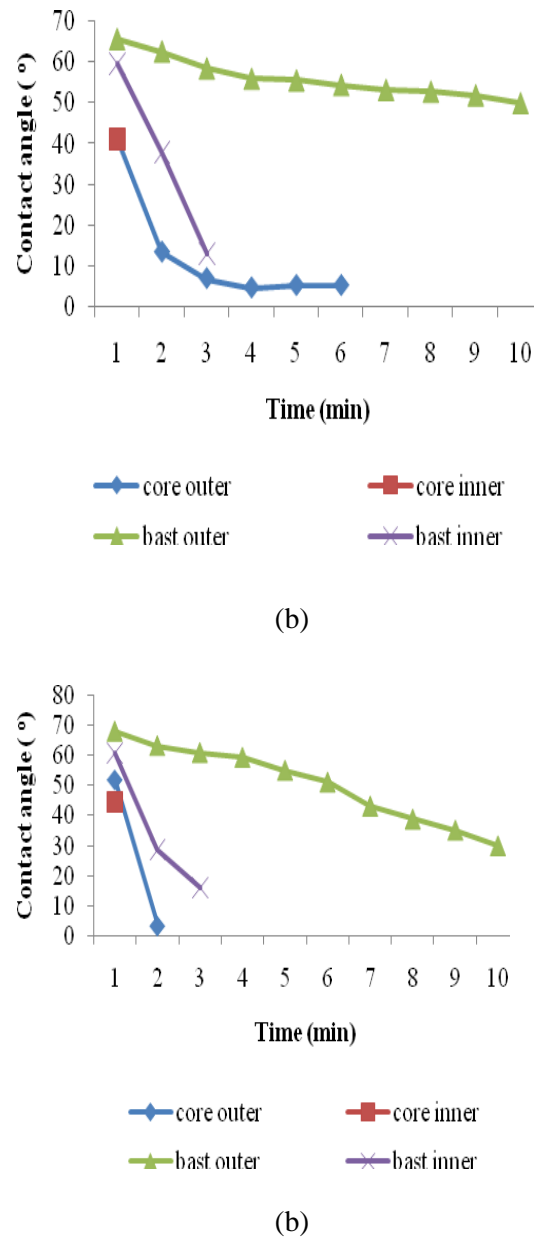
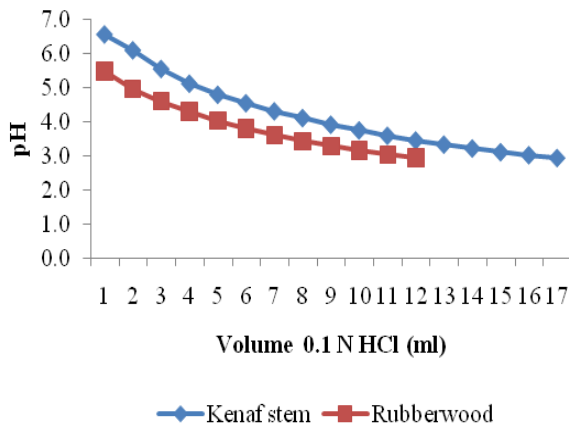
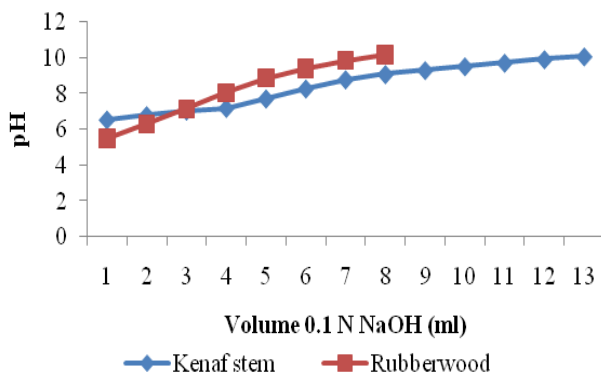


Fig. 2 Contact angle of (a) HCl 0.1N and (b) NaOH 0.1N on different substrates as a function of time



(a)



(b)

Fig. 3 Comparative stability of kenaf stem and rubberwood towards acid (a) and alkali (b)

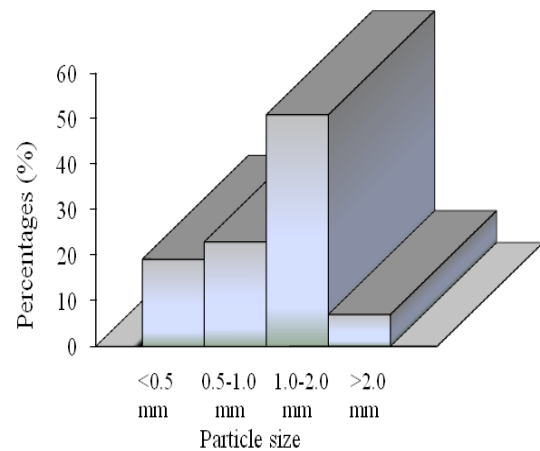


Fig. 4 . Distribution of particle sizes

Table 1. Strength properties of rubberwood and kenaf stem particleboards¹

Types of boards	MC (%)	MOE (N/mm ²)	MOR (N/mm ²)	IB (N/mm ²)	TS (%)	WA (%)
100RW	9.3	2712	19.6	1.52	34	70
100K	10.3	1559	15.1	0.51	28	77
70RW:30K	9.5	1756	17.0	0.90	26	65
50RW:50K	9.7	1616	16.6	1.1	28	68

¹ Strengths were normalized to 0.7g/cm³ board density

5. References

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