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Measurement of mechanical and physical properties of particleboard by hybridization of kenaf with rubberwood particles

M.T. Paridah [a], A.H. Juliana [a], Y.A. El-Shekeil [b], M. Jawaid [a,c,*], O.Y. Alothman [c]

[a] Department of Biocomposite Technology, Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[b] Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[c] Department of Chemical Engineering, College of Engineering, King Saud University, Riyadh, Saudi Arabia

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ABSTRACT

Kenaf is one of the potential raw materials available in Malaysia to use for particleboard manufacturing as an alternative solution to balance shortage of rubberwood (RW) supply. In this study, particleboard manufactured from kenaf stem (KS) and RW particle blends at different RW loading (0%, 50%, 70%, 100%) and resin levels (6%, 8%, 10%). Urea formaldehyde resin is used as a binder. The effects of RW:KS ratio and resin content on mechanical and dimensional stability properties of hybrid particleboard were determined. The results indicated that particleboards bonded with 10% resin level and 50:50 (RW:KS) had the highest strength (19.08 MPa) while particleboards made of 70:30 (RW:KS) display better stiffness (2.23 GPa). Statistical analysis using ANOVA and LSD were conducted on the obtained results. The results show that RW:KS ratio has greater influence over thickness swelling (TS) and water absorption (WA) of particleboard than the level of resin content. The relationship between internal bonding (IB) and TS of particleboards were also examined and obtained strong inverse relationship between IB and TS. Hybrid particleboards made from 70% RW and 30% KS with 10% resin content display over all good properties and comparable with 100% RW (control) samples. It concluded that kenaf stem can replace rubberwood particles up to 50% but the resin level must be kept at 10% or more because lower resin level (⩽8%) significantly decrease strength of the particleboard.

1. Introduction

Kenaf (*Hibiscus cannabinus* L.) is a non-wood plant belongs to the hibiscus family (*Malvaceace*) and is related to cotton and okra. Kenaf believed to be a 4000 year old crop with roots in ancient Africa (western Sudan). It is a common wild plant of tropical and subtropical Africa and Asia. Since the interest in kenaf has fluctuated, Malaysia takes part in researching of this non-wood since 1999 [1]. Kenaf was first introduced in Malaysia in the early 1970s but it officially recognized as potential crop after rubber, oil palm, cocoa, pepper, and sago in the late 1990s [2]. Kenaf has great potential as a source of raw material for the commercial production of timber and fiber-based products. Kenaf plant has fast growth rate with short rotation of two cycle plant mature between 4 and 5 months. Due to the shortage and increasing price of

* Corresponding author at: Department of Biocomposite Technology, Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia. Tel.: +603 89466960; fax: +603 89471896.

E-mail addresses: parida@upm.edu.my (M.T. Paridah), jawaid@upm.edu.my, jawaid_md@yahoo.co.in (M. Jawaid).

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rubberwood, an alternative or complimentary raw material of particleboard manufacture needs to be explored and commercialized in order to substitute rubberwood (RW). Kenaf characteristics are similar to those of wood, while other fibers such as hemp, jute and flax fibers are substantially different [3]. Kenaf as a renewable plant has the potential to be a good alternative to wood which needs 25 years to be harvested. The whole kenaf stem can be either directly processed into chips-sized particles or separated into long bast fibers and fine core particles. However, since the ratio of bast to core is low in weight (30:70), and bast fiber is long and straight in which it provides better strength, while core fiber is light. So, it is more economical to use both the bast and core fiber for kenaf board manufacture. Board prepared from bast and core able to optimize both features in which a strong and light board can be obtained for the final product. If this material is to be used in the particleboard industry, the evaluation of the strength of particleboard made from kenaf stem material has to be carried out.

The wood composite industry is one of the most rapidly developed industries in Malaysia. In wood-based industries, the shortage of wood as a raw material has recently become a great concern and many industries close down due to shortage of raw materials [4]. Wood based industry of Malaysia is one of main revenue earners and generates export income of RM21.7bil/year from 2006 until 2010 and creating 300,000 job opportunities [5]. Particleboard is a wood based panel composite manufactured by compressing small wood particles while simultaneously bonding them with an adhesive. It is used in furniture, desks and counter tops, cabinets, floor, wall, ceiling panels, and office dividers [6]. Particleboard is manufactured by mixing wood particles, sawmill shavings, flakes, or even sawdust together with a resin and forming the mix into a sheet.

Generally, types of particleboards may be defined according to their structure and method of manufacture. Single-layer particleboard is produced, three or five layers particleboard also commonly manufactured. In single-layered, the board consists of homogeneous mass of particles evenly distributed throughout the thickness of the mat. For three-layered or also known as sandwich board, the two outer layers particles are fine and contain more adhesive and moisture than the inner layer particles. The surface or outside layers of the boards are higher density than the core when pressed. Multiple-layer particleboard is manufacture similar to three-layer except for an increase in the number of layers added. Previous study reported the development and characterization of hybrid medium density fiberboard by using rubberwood (RW) and empty fruit bunch (EFB) based on oven-dried weight [7]. Hybridization can define as the act of mixing different species of plants to produce hybrids. A single layer panel made from mixed species of 50% kenaf-50% aspen and 25% kenaf-75% aspen has modulus of rupture (MOR) and modulus of elasticity (MOE) values of 0.16, 0.15, 0.14, and 0.23 MPa, respectively [8]. In their study, the admixture panel had higher strength as compared to those made from 100% kenaf and 100% aspen. Other study reported that a single layer particleboard made from pure kenaf stem (100% KS) and 10% UF resin has slightly lower MOR, MOE, and IB compared to particleboard made from pure rubberwood (100% RW) with decrement of 23.5%, 42.5%, and 66.5%, respectively [9]. Production of binderless kenaf particleboard with steam-injection pressing gives relatively higher mechanical and physical properties than particleboard made from normal hot-pressing [10].

Recently published work evaluated physical and mechanical properties of experimental particleboard panels made from rubberwood using modified starch as binder [11]. In an interesting work, researchers evaluate relationship between chemical properties of chips, UF-resin amount and physical, mechanical properties of particleboard manufactured from vine pruning's [12]. In this study, we evaluate technical feasibility to produce particleboard by hybridization of kenaf stem and rubberwood particles. Mechanical and physical properties of particleboard made from kenaf and rubberwood were characterized. We also determine effect of kenaf and rubberwood ratio and resin level on modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), board density, and dimensional stability of particleboard.

2. Materials and method

2.1. Materials

Kenaf stem (V36) which is the most suitable variety for Malaysian condition used in this study. The kenaf whole stems (KS) were collected at kenaf farm of National Kenaf and Tobacco Board, Kelantan. Rubberwood (RW) chips with the type of PB260 (commercial) supplied by Dongwha Fiberboard Sdn. Bhd., Nilai, Negeri Sembilan. Commercial grade for particleboard, urea formaldehyde (UF) resin with 40% solid content purchased from Malaysian Adhesives Chemicals Sdn. Bhd., Shah Alam, Selangor was used as a binder. Hardener (ammonium chloride) and wax were added to accelerate curing of UF.

2.2. Experimental parameters

In this study, there were three types of UF resin level used: 6%, 8% and 10% and ten types of particleboard were produced. There were four types of board made from 6% resin which were 100% of RW, 70% RW:30% KS, 50% RW:50% KS and 100% of KS. Each of the 6% and 8% resin level have their board with ratio 70% RW:30% KS, 50% RW:50% KS and 100% of KS, respectively. Three boards were replicated for each type of board. Table 1 shows the

Table 1
Target board properties.

Properties	Values
Density	700 kg/m^3
Board size	530 mm × 530 mm × 12 mm
UF resin content (65% solid content)	6%, 8%, 10%
Wax (50% solid content)	1%
Hardener (ammonium chloride)	1%
EMC of board	10%
RW particles size	0.5–2.0 mm
Kenaf particles size	0.5–2.0 mm