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Flexural Properties of Kenaf Fibre Mat Reinforced PLA Composites

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ABSTRACT

The potential use of natural biopolymer composites in a variety of applications that requires biodegradability and better mechanical properties has renewed many researchers interest on the composites. This research involves the analysis of flexural properties for natural fibers specifically kenaffiber mat in a polylactic acid (PLA) matrix (KM-PLA). The polylactic acid has been chosen as a matrix because it is a biodegradable thermoplastic and is one of the most commercially used. The main objective of this research is to investigate the effect of different temperature condition and pressing time for the kenaf fibre mat reinforced PLA flexural properties. Several samples were prepared for each of the test parameters by mixing PLA with plasticizer and molded with kenaf mat by a hot pressing method. During the fabrication process, triacetate glycerol was used as a plasticizer in order to improve the adhesion between kenaf fibers and matrix. The flexural tests were conducted using Instron Universal Testing Machine. From the result obtained, biopolymer composites samples with pressing temperature of 200^0C for 7 minutes hot pressing time gives a better optimum flexural properties. In conclusion, the flexural properties test indicates that kenaf fiber mat was suitable as reinforcement in PLA composite.
KEYWORDS: Composite, Biopolymer, KenafFiber Mat, PLA.

INTRODUCTION

Recently, naturalfibers have been an attractive alternative reinforcement in composite materials replacing synthetics materials such as glass or carbon fibres. Natural fibres classified into three types namely plant, animal and mineral. Hence, from plant sources been appearance of biopolymers reinforced by plant fibers which is a good combination in mechanical performance with low environment impact[1]. By comparing with synthetic fibers, natural fibers have many advantages [2]because of its biodegradability, low weight, low density, low cost and better mechanical properties. According to the advantages, kenaf been count into consideration as an alternative fiber to jute fiber because of its higher cropping yield. More importantly, in nonwoven materials industry, kenaf fiber presently shown a great potential, yet competing with other types of plant fibres[3]. The performance in mechanical properties of the fiber depends on the fiber matrix [4]. Kenaf fibre consists of mainly cellulose (45-57%) as well as hemicelluloses (21.5%), lignin (8-13 wt%), pectin (3-5 wt%) and waxy substances [5-6]. Figure1 shows the sampling positions and parts of kenaf stems.

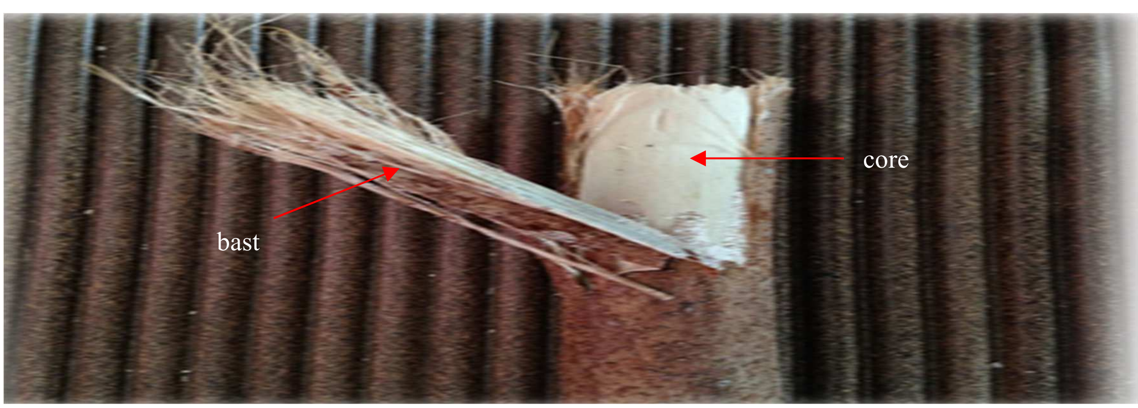

Figure 1:Sampling positions and parts of kenaf stems

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Furthermore, the mechanical properties of natural fiber reinforced polymer matrix composites [7] have been investigated widely and polylactic acid (PLA) polymers have recently been introduced commercially as a biodegradable product and can be used as a matrix for bio composites [8]. PLA can be produced from renewable agricultural sources like corn [9]. Polylactide polymers well known are stiff and brittle [10]. Therefore, its necessary to use plasticizers in terms to improve mechanical properties such as the elongation and impact properties [2]. In addition, PLA has several advantages, such as biodegradability, renewability and its ability to be sealed at low temperatures and low gas emission[11].

Previously, kenaf fibre reinforced polylactic acid (PLA) composites has been found showed a better flexural strength as well as the elastic modules up to 50% of fiber content [12]. Hence, the main objective of this research is to investigate the effect of processing parameters on the flexural properties of kenaf fibre reinforced PLA composites.

MATERIALS AND METHODS

Materials Selection

Kenaf fiber mat were supplied by KEFI (Malaysia) Sdn. Bhd. Density of kenaf mat is approximately 1000 kg/m^3 with size of 1m X 10m. Matrix used Polylactid Acid (PLA) supplied by Nature Works with grade Ingeo biopolymer 2003D. Material properties of PLA are shown in Table1. To remove any moisture content, PLA typical drying conditions for crystalized granules are 2 hours at 90^{0}C before processing. The brittleness of PLA can be modified by triacetate glycerol was used in amount of 0.10 wt % [2].

(a)

(b)

Figue2: Kenaffibers (a) kenafbast (b) kenaf mat

Table 1: Typical properties of PLA

Properties	Details
Specific Gravity	1.24
Melt Flow Rate, MFR g/10min (210^{0}C,2.16kg)	6
Density g/cm^3	1.26
Clarity	Transparent
Tensile Strength @ break (Mpa)	7.7
Tensile Yield Strength (MPa)	8.7
Tensile Modulus (GPa)	500
Tensile Elongation, %	6.0

Composite Sample Fabrication

Composite samples have a ratio of reinforcement and matrix at 20:80. First, kenaffiber mat were cut into the size of mold and were stored in oven for 2 hours at 90^{0}C. PLA is manually mixing and stirred with triacetate glycerol as a plasticizer. Matrix of PLA/triacetate lay-up on top of kenaf mat fibers. Then, the set of fiber and matrix were pressed together with desired temperature and pressing time using hot press method.

(a) **(b)**

Figure 3: Composites sample preparation (a) sample fabrication (b) hot press

Flexural Testing

Three-points bending test, according to ASTM D-790 standard, were performed using a Universal Testing Machineby Instron. The dimensions of the specimens were 115mm length, 20 mm width and 2 mm of thickness. The specimen was placed onto two supports that having 80 mm span distance between support and it were carried out at ambient temperature with cross head speed rate 5 mm/min and load cell of 10 kN. Flexural cyclic tests for the rest samples were also performed using the same set-up. All the results were taken as the average value of 5 samples replication.

Figure 4: Three-points bending test (flexural)

RESULTS AND DISCUSSION

Flexural properties and bio composite morphology will be addressed below. The mechanical properties of kenaf mat reinforced PLA (KM-PLA) composites are shown in Figure-5 and Figure-6. Both showed set of experiments conducted at two different temperatures and three different hot pressing times. In addition, it were indicated that the mechanical properties require higher hot pressing time and temperature respectively. It is obvious flexural modulus and flexural strength increased proportionally with increasing temperature. In Figure-5 for 200^{0}C temperature, the flexural modulus increased 11% and the flexural strength increased 12% by enhancing the hot pressing time from 3 minutes to 7 minutes.

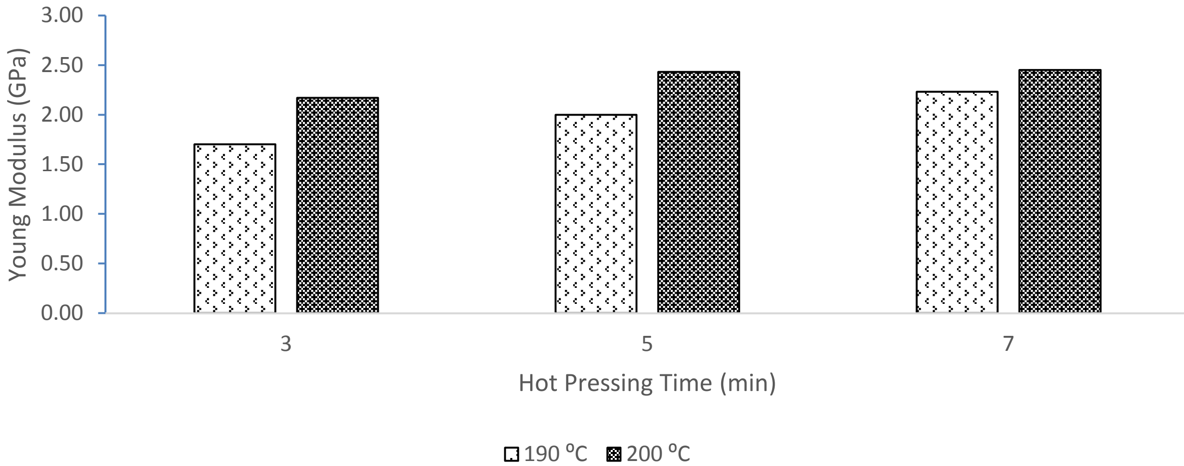

Figure 5: Graph flexural young modulus vs time

Figure 6 shows when the heating time is increased flexural strength increases respectively. By comparing between temperatures of 190^{0}C with minimum of 3 minutes pressing time and at a temperature of 200^{0}C, a maximum of 7 minutes pressing time, it showed a flexural strength enhanced by 36%. This proves that a good flexural strength performance occurred with increasing time and temperature. To explain this thought, Figure 7 shows at 200^{0}C and 7 minutes, the PLA was able enter the kenaffiber mat compared to 190^{0}C;3 minutes pressing time.

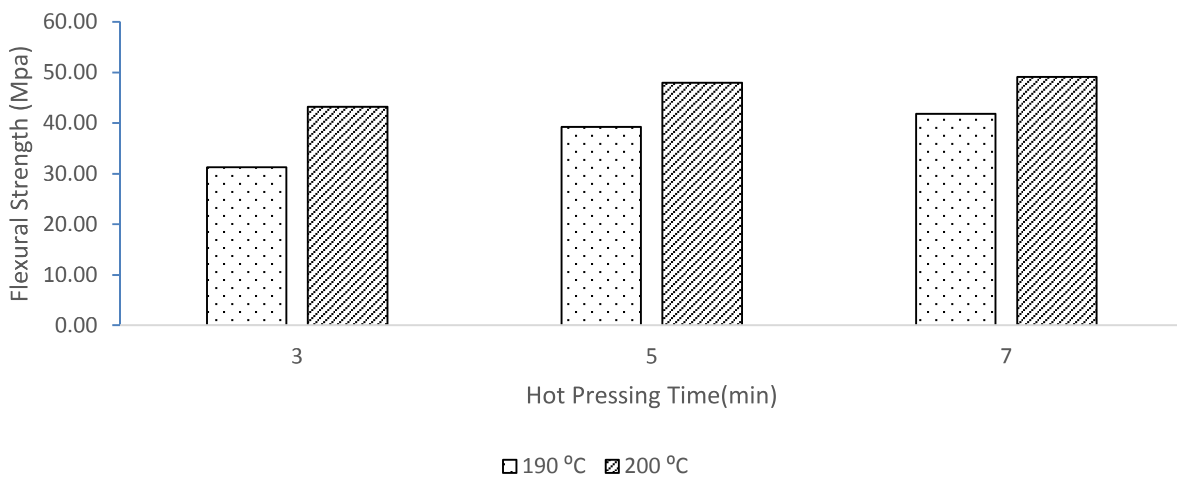

Figure 6: Graph flexural strength vs time

Scanning electron microscopy (SEM) was used to analysis by observing the adhesion between KM-PLA composite. Generally, there is very clear seen that weak interfacial adhesion for the less hot pressing time. This could be due to granules PLA had been used rather than emulsion type of PLA. This affected the penetration of PLA into the kenaf mat during the fabrication process. In contrast, by adding more hot pressing time with higher temperature, this could be enhances the penetration interfacial adhesion of kenaf fiber mat and the matrix by allowing the PLA granules melt and diffuse into kenaf mat during the fabrication process. The depth among kenaf mat and PLA increased more than 60 % also can see in Figure-7(f). In this stage, fiber-matrix starts to bond together because the PLA started to penetrate into kenaf mat. Result showed in Figure-7(a) and 7(d) for 3 minutes hot pressed heating time the PLA has not yet been fully absorbed into the mat. This scenario occurred because in the first 3 minutes the PLA has just melted. Fiber debris can be seen in Figure-3(d) which is due to the brittleness of PLA. Figure-7(a) clearly showed a very weak interfacial adhesion which is shown that the matrix was unable to penetrate into the kenaf mat.

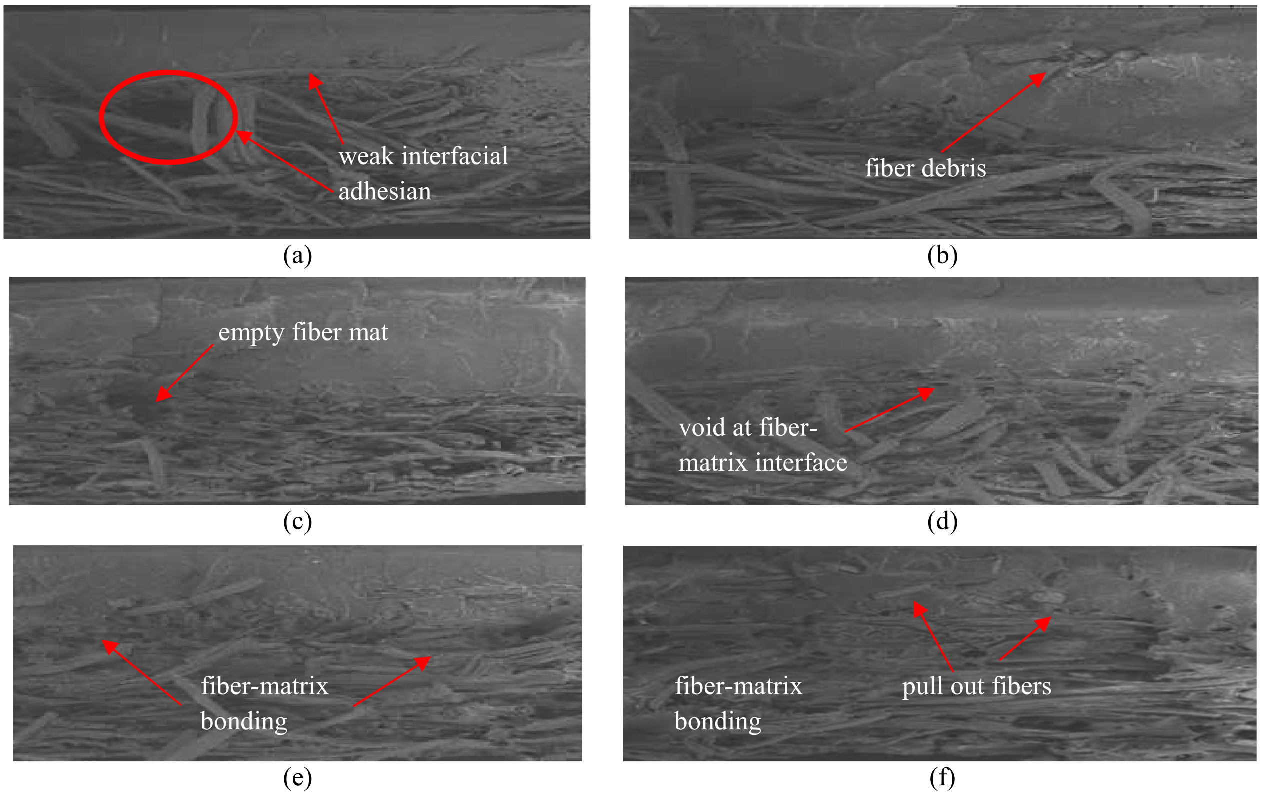

Figure 7: SEM microphotographs of the kenaf mat/PLA biocomposite with three different heating times and temperature (a) 3 minutes, 190^0C(b) 3 minutes,200^0C (c) 5 minutes, 190^0C and (d) 5 minutes, 200^0C(e) 7 minutes,190^0C (f) 7 minutes, 200^0C

CONCLUSION

Thus, flexural properties for KM-PLA composites are identified influenced with two factors. Certainly, temperature and pressing time. Higher temperature enhanced and suitable to give the interfacial adhesion of the KM-PLA and leading to a better mechanical properties highlight in flexural properties compared with the less temperature. Kenaf fiber have good potential reinforcement for polymeric composite in order to replacing the synthetic fiber. In addition, PLA also showed a good performance as a biopolymer matrix by adding a plasticizer. From the analysis, can be summarized, composite sample's produced at temperature 200^0C for 7 minutes hot pressed gives an excellent mechanical properties. These reveal that kenaf fiber mat was suitable for flexural applications and as reinforcement in PLA composite and flexural properties test.

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