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A Study on Fibre Length and Composition of Kenaf-Polypropylene (K-PP) Composite for Automobile Interior Parts

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Abstract – *This study was conducted to investigate the relationship between fibre length and the composition of fibre inside the composite. In this study, three different fibre lengths were used (i.e. 1cm, 1.5cm and 2cm); various filling for kenaf fibre/polypropylene (K/PP) composite ratio, with fibre composition ranged from 10% until 50%. 0.3g of maleic anhydride (MA) was added as an additive to improve the bonding between filler and matrix. The properties of composite were measured using hardness and density tests. Dino Lite microscope was used to observe the bonding inside the composite. After testing, it was found that polypropylene affected hardness when mixed with maleic anhydride. Kenaf fibre affected the density of composite when it was submerged in water during testing. Kenaf fibre tends to absorb water if it is not fully covered by polypropylene. Maleic anhydride has been proven to improve the strength of composite after being added to the composite.*

Keywords: Kenaf fibre, Polypropylene, Maleic anhydride, Hardness, Density, Microstructure

1.0 INTRODUCTION

Natural fibre becomes a replacement for synthetic fibre and it is not considered as a new trend anymore. In the early era, humans collect raw and natural materials to make rope and textiles. Next, more of these materials are searched for more applications that suit the properties to produce natural fibres and become replacements for many materials especially synthetic fibre in the automotive sector. Natural fibre has the density in the range from 1.2-1.6 g/cm^3 which is lower than synthetic glass fibre with the density of 2.4 g/cm^3 as discovered by Huda *et al*[1].This is due to the impressive characteristics of natural fibre over synthetic fibre. Many advantages of natural fibres have been outlined by previous researchers, such as: longer tool life, biodegradability, light weight, reproducibility, and lower production cost claimed by Nishino *et al* [2] and Ku *et al* [3].

As mentioned by Zuzana and Eva [4], the application of natural fibre in manufacturing automotive parts contributes 10% weight reduction of vehicle, and this leads to 80% energy production and 5% cost saving. The reduction of vehicle weight can ideally reduce fuel consumption and increase parts strength where natural fibre is used as stated by Jeyanthi *et al* [5]. Moreover, saving on fuel consumption can also lower the amount of CO_2 that contributes to global warming. From the finding of Jeyanthi and Janci Rani [6], the best way to decrease fuel consumption of a vehicle while maintaining it safety factor and reduce production cost is to replace the conventional bumper beam material with natural composite.

In this study, kenaf fibre was used as main material used in producing composites to replace the current material used to manufacture automotive interior. Kenaf (Hibiscus cannabinus L.) is a plant that can adapt to grow under many conditions and grows to height of 3m in 3 months was mentioned by Akil *et al* [7]. Good news is Ibrahim *et al* [8] stated that now Malaysia government had allocated RM35 million to encourage Malaysian farmers to start planting kenaf which will bring great income due to market demand, which means that researchers and industries can obtain material easily. Based on the news released by Toyota Boshoku Corporation in 2012, they had developed lighter weight door trim and seat back board using kenaf in Lexus GS. Polypropylene was added to enhance bonding between kenaf fibres and improve the strength of the door trim. There was 20% weight reduction compared to previous conventional parts [9].

The use of maleic anhydride as an additive inside composites will improve the bonding between hydrophilic natural fibres and hydrophobic thermoplastics matrices, as stated by Tengku Faisal *et al* [10]. Sanadi *et al* [11] stated that the tensile and flexural properties of kenaf-polypropylene composite are well-improved when adding maleic anhydride grafted polypropylene (MAPP) as a coupling agent. Kord [12] Mentioned that the increase of amount of maleic anhydride increased the mechanical properties of composite as observed from his experiment involving tensile, flexural and impact tests.

The aim of this research was to investigate the relationship between fiber length and ratio of composition. Next, the presence of maleic anhydride into composites was examined through hardness test to observe the effect of increasing strength.

2.0 METHODOLOGY

2.1 Raw Material

Kenaf fibre used in this research was obtained from a harvest plant in Kelantan. Meanwhile, polypropylene and maleic anhydride were bought from Polyscientific Enterprise Sdn Bhd.

2.2 Preparation of Material

Kenaf fibre was cut into the desired length using scissors into the sizes of 1cm, 1.5cm and 2cm.These sizes were selected based on the mould size, which has the diameter of 2.5cm as indicated in Fig. 1. Therefore, if the fibre is longer than mould diameter, then the fibre cannot be stacked but it will fold to fit inside mould. This will definitely give impact on the experimental result. First, polypropylene was subjected to hot press to break the molecule bond inside the polypropylene, crushed and then blended to produce powder form of polypropylene. The purpose of using powder form of polypropylene is to obtain fully melted polypropylene during compression to merge and bond polypropylenestrongly with fibre.

Figure 1: Aluminium mould used to produces sample.

Next, kenaf fibre, polypropylene and maleic anhydride were weighed before they were placed inside mould. The total weight of composition was 3g excluding the weight of 0.3g of maleic anhydride. The weight percentages of kenaf fibre were 10wt%, 20wt%, 30wt%, 40wt% and 50wt%. The amount of each material and their respective names are shown in Table 1. The material was placed inside the mould and stacked alternately with one another. For example, polypropylene powder was sprinkled at the base of the mould, and then kenaf fibre was placed slightly on top of it, followed by polypropylene powder again. This alternating sequence was repeated after all materials were placed inside the mould. This method also known as hand lay-up method. The average samples' thickness was obtained in the range between 3mm to 4mm.

Table 1: Sample Naming

Kenaf (wt%)	Polypropylene(wt%)	1cm	1.5cm	2cm
10	90	A1	B1	C1
20	80	A2	B2	C2
30	70	A3	B3	C3
40	60	A4	B4	C4
50	50	A5	B5	C5

The parameters for producing samples are as follows: temperature 190°C, preheated for two min, pressurize at 25kg/cm^2, hot pressed for one min and cooled at cooling platform for 20 min. Tengku Faisal Z.H et al used hot press stage involving preheat at 180ºC and 150kg/cm^2 for six min, continued by compression for three min at the same temperature and followed by cooling for two min [6]. Different parameters were chosen by the authors due to the mould material and hot press machine after conducting the trials before producing actual samples for test. Density test was carried out first using densitometer. Next, hardness test was performed using analogue shore hardness tester. Finally, the structure of the samples was examined using Dino-Lite.

3.0 RESULTS AND DISCUSSION

Shore hardness and density of specimens are discussed in this section. Based on Figure 2, it shows that at the ratio 10/90 and 20/80, the density of composites is about the same. This is because at lower weight percentage of fibre, polypropylene is able to cover fibre and hence less water is absorbed by fibre. Therefore, the density is lower at these two ratios. At ratio 30/70, 40/60 and 50/50, as fibre length increases, the density also increases. This means that for longer fibre, fibre absorbs more water inside the composites. From Fig. 2, the highest density is shown by the ratio 50/50 with fibre length of 2cm. From the density test, the authors can summarize that fibre has the ability to absorb water and will increase in the density of composites. Longer fibre tends to absorb more water compared to shorter fibre. The coverage of polypropylene is affects the result of density test. If polypropylene can cover fibre in larger area, then there will be less contact of water with fibre.

According to Fig. 2, the hardness is highest at 10% fibre with 2cm fibre length. At lower fiber percentage, polypropylene has higher percentage and gives more coverage on fibre. Therefore, when shore hardness device is placed on the composite surface, polypropylene reacts well with additive and becomes harder compared to other fibre. However, according to the trend of the graph, the authors perceived that more compact composite will help to improve the hardness value of the composite. This means that as the percentage of kenaf fibre in the composite increases, the hardness value also increases due to the effect of fibre length. Therefore, more compact state inside the composite will help to enhance its hardness.

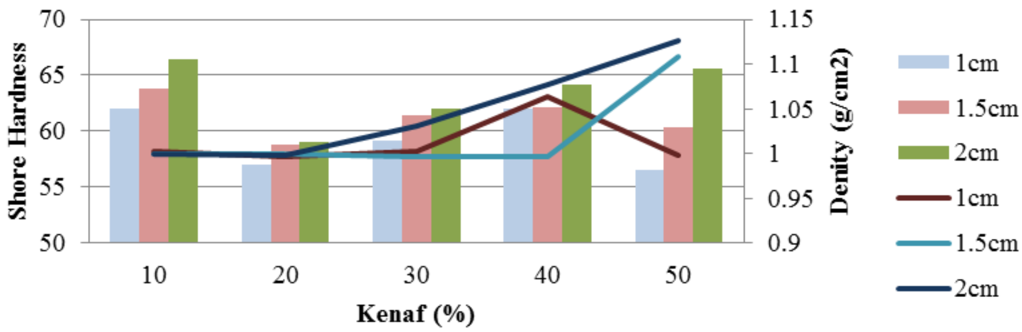

Figure 2: Graph of shore hardness and density (g/cm^2) versus kenaf (wt%)

Dino-Lite was used to capture images on samples, which can show the surface of samples in more vivid visual. Sharp and brief images can be captured and the analysis can be done when the images are observed under different magnification. From the result below, sample A1 is less affected by the density test and obtains higher hardness value compared to other samples. As shown in Fig. 3**,** polypropylene presents more than kenaf fibre and gives more coverage. Hence, when these samples are placed inside water during density test, polypropylene stops the fibre to absorb water. Similar assumption can be applied to sample C5 in Fig. 4. Fibre content is same with polypropylene and shows the highest result of water absorbed, as well as the highest density sample.

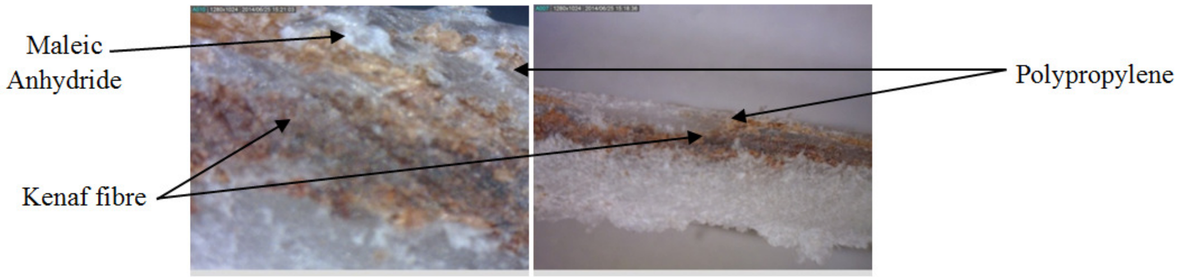

Figure 3: Sample A1 under 200x and 50x magnification

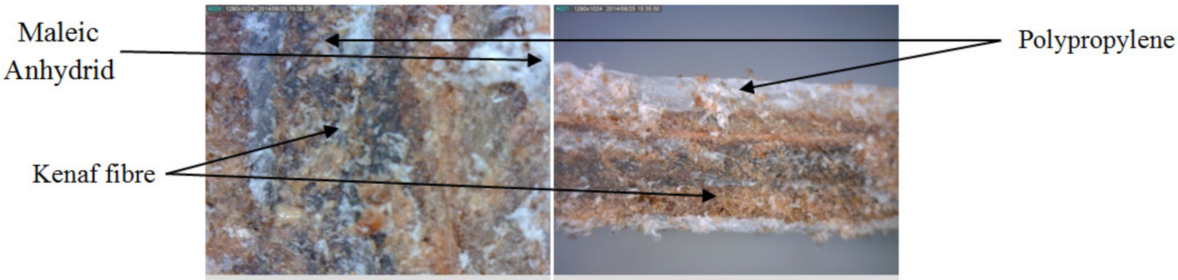

Figure 4: Sample C5 under 200x and 50x magnification

4.0 CONCLUSSION

Through all the testing mentioned above, the authors concluded that the coverage of polypropylene on composite surface can prevent water absorption of kenaf fibre. The hardness of composite is affected by two main factors, namely the addition of maleic anhydride and the compact level inside composite due to fibre composition. Therefore, the best sample is selected based on the application of composite. For the automotive sector, composite is used in various parts; therefore the best sample that suits the profile is those with lightweight and safety properties. By combining both factors, the authors selected the sample with lower density and higher hardness value which is sample C1 with 10/90 ratio and length of 2cm.

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