IOP Conference Series: Earth and Environmental Science

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To cite this article: Ragunathan Santiagoo *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **616** 012040

Tensile Properties of Kenaf Core with Polypropylene and Acrylonitrile Butadiene Rubber Composites

Ragunathan Santiagoo[1,2], Gomesh Nair[3], Husnul Azan Tajarudin[4], Zawawi Daud[5], Mustaffa Zainal[2]

[1]Sustainable Environment Research Group (SERG), Center of Excellence Geopolymer and Green Technology, School of Material Enginering, Universiti Malaysia Perlis, Kompleks Pengajian Jejawi 2, 02600 Arau, Perlis, Malaysia
[2]School of Environmental Engineering, Universiti Malaysia Perlis (UniMAP), Kompleks Pusat Pengajian Jejawi 3, 02600 Arau, Perlis, Malaysia
[3]UOW Malaysia KDU Penang University College, 32, Jalan Anson 10400 Pulau Pinang, Malaysia
[4]Universiti Sains Malaysia, Bahagian Bioproses Teknologi, Pusat Pengajian Teknologi Industri, 11800, USM, Pulau Pinang, Malaysia
[5]Solid Waste Management and Resource Recovery Team, Micropollutant Research Centre, Universiti Tun Hussein Onn Malaysia86400 Parit Raja, Batu Pahat, Johor, Malaysia

E-mail: raguna@unimap.edu.my

Abstract. The reaction of kenaf core powder (KCP)/polypropylene/ acrylonitrile butadiene rubber (NBR) blends with and without a coupling agent, benzoyl chloride is analyzed. The filler loading ranging from 0% to 30% were prepared by using grinding machine and blended with the PP/NBR composites. The increase in only KCP loading in PP/NBR/KCP composites reduced the tensile strength and the elongation at break but increases the tensile modulus. The addition of benzoyl chloride as a coupling agent increased the tensile strength, elongation at break, and modulus of the composites. This investigation proves the enhancement in the adhesion between the filler and polymer matrix. The incorporation of coupling agent also increases the tensile properties of treated composite.

1. Introduction

Composites can be defined as a mixture of different material nature in order to produce a product with new properties as desired. Mechanical properties of composite can be improved by adding fibre or other filler as reinforcement in polymer matrix. However, adding of filler into the polymer matrix may cause brittle nature in resulting composite. Therefore, the problem can be solved by adding treated natural fibre such as kenaf as a reinforcement. Some of the researchers reported that the use of kenaf fibre can upgrade the mechanical strength of composites.

Kenaf is scientifically known as *Hibiscus cannabinus*. The age of kenaf is estimated of 4,000-year-old. The origin of this plant is in ancient Africa. But, kenaf was introduced in Malaysia in the year 2000. The biggest success was in 2007 where the Malaysia National Tobacco Board (MNTB) successfully planted a total of 1000 hectares at Eastern Malaysia for R&D&C. The effect of this success is that they were able to start kenaf processing mills such as KFI Natural Fibre Industries

Sdn.Bhd. Such a big achievement from the introduction of kenaf is because of its unique features. This is because each of its components are very useful from those days. Last time, kenaf is used for the production of twine, rope and sackcloth in which kenaf act as cordage crop. But nowadays, the application of kenaf is huge. Manufacturing involving paper products, building materials, absorbents and animal feed are done from kenaf. On the other hand, when we zoom further on why kenaf is receiving much attention, we can see that the fibres have high specific properties such as the modulus, resistant to impact, flexibility and strength [1].

The latest research done on NBRr is by mixing with thermoplastic compound which is polypropylene and banana skin powder (BSP) as filler. This composite is treated with γ-APS. The treated PP/NBRr/BSP showed an extra enhacement in adhesion when compared to the untreated PP/NBRr/BSP composites as the treated BSP causes the linkage between hydrophilic BSP fiber and the hydrophobic PP/NBRr/BSP composites[2]. Another research is done on tensile strength where the study proves in the reduction of compatibility of the blends during addition of more NBRr. The rubber blend becomes less elastic and firm with the increasing amount of NBRr content[3].

2. Material and Methods

2.1. Filler Preparation

Kenaf core is first cut into small pieces using mortar and pestle. Kenaf core is then dried in an owen at 80ºC for 24 hours. The fibres are separated from kenaf core. After the filler (kenaf core) is dried, they are grinded using grinding machine. The filler are then sieved according to desired size which is about 150µm-300µm for mixing purpose.

Two different formulation were used in order to differentiate the strength and morphological studies of the material produced. First, PP/NBR/Kenaf core composite is used based on the formulation as a control. Then, the same formulation is used but this time the kenaf core was treated with benzoyl chloride after pre-treatment with sodium hydroxide. The formulation is showed in table 1.

Table 1. Formulation of composite material.

Material	Amount (weight %)										
	Control						Treated				
PP	70						70				
NBR	30						30				
Kenaf core	0	5	10	15	20	30	5	10	15	20	30
Benzyl Chloride (ml)	0						50				

2.2. Treatment of Filler

For the preparation of treated kenaf core powder, about 200.00 gram of kenaf powder is soaked with sodium hydroxide (NaOH) solution at 6%. The process duration took about 1 hour and it is held at room temperature. The powder was then filtered and washed with distilled water. Suspension of treated kenaf core powder were done again with 10% NaOH solution before being agitated vigorously with 50.00 ml of benzoyl chloride. The purpose of this step is to ensure complete ionization of hydroxyl group. The mixture was then allowed to stand for 15 minutes. The powder was then filtered and washed in order to isolate the kenaf core powder solely. Final step of the treatment was the washing and drying of the isolated powder in an open air for few days and in oven at 60 °C for about 24 hours to get rid of the hydrochloric smell.

2.3. Preparation of Acrylonitrile butadiene rubber (NBR)

Then, for the preparation of nitrile butadiene rubber, it was cut using saw into big pieces. The big pieces are then cut into small pieces and sealed.

2.4. Mixing Process
The kenaf core powder (filler), polypropylene and NBR are then mixed through two roll mill. The ratio of the materials has been used as guideline during the mixing process. The temperature of the roll mill is set to 180ºC. The roll mills were let to rotate slow and at steady speed and the Polypropylene were put later slowly between the rolls for 4 minutes. Then, NBR is added to the roll mill containing PP at 4th to 7th minute. The filler is added to the mixture from 7th minute to 9th minute. The compound were taken out during the 9th minute and put aside to cool for 2 minutes.

2.5. Sample Preparation
After the cooling took place, it undergoes the hot press timing into plate of 22gram at approximately 11 minutes with the pre-heat of 7 minutes and pressed for 2 minutes and another 2 minutes later were for the samples to cool. As final step, the samples were undergoes cutting process which is been cut into a dumbell shape for testing.

2.6. Tensile Properties
Universal Testing Machine WA-300 is used to analyse the mechanical properties of the sample through tensile, young modulus and elongation at break. The sample is characterised using scanning electron microscopy (SEM) after testing. The results obtained is used to compare sample with raw material and the treated sample.

3. Results and Discussion

3.1. Tensile Properties
Figure 1 depicts the tensile strength for treated and untreated PP/NBR/KCP composites. It can be seen that the tensile strength decreases for both composites. In overall, the treated PP/NBR/KCP composite has higher tensile strength compared to the untreated one. This indicates that the benzoyl chloride which act as coupling agent has improved the fiber-matrix interaction by forming new linkage between fibre and matrix part of the compound. The pre-treatment done by using sodium hydroxide causes the ionization of the hydroxyl group to the alkoxide. This process increases the surface roughness and therefore enable good mechanical interlocking. This alkaline treatment enhances long lasting mechanical properties especially of flax fibres particularly in the fiber strength and stiffness. The benzoyl chloride that is used after the filler is pre-treated promotes a better filler- matrix adhesion as well as encourages the strength of composites. Furthermore, this facilitates the stress transfer due to the ester bond formed between the hydroxyl group of KCP and the ester group of benzoyl chloride [4].

Figure 2 portrays the elongation at break of both treated and untreated PP/NBR/KCP composite. Based on the graph drawn, the elongation at break showed decreasing pattern with increasing KCP content. But then the treated filler proved that it enables better adhesion and good filler dispersion between filler and matrix. Hence, the elongation at break of treated composite is higher when compared with untreated composite. The agglomeration still occurs at highest filler content leading to obstruction of stress transfer from matrix to filler phase.

The presentation of tensile modulus for both the treated and untreated PP/NBR/KCP can be seen as figure 3. The increase in Young’s Modulus especially for treated composites implies that there is improvement in interfacial adhesion which causes the tendency for filler to agglomerate is less. This enhances toughness of the respective composite. Therefore, the possibility of sudden failure to occur is less.

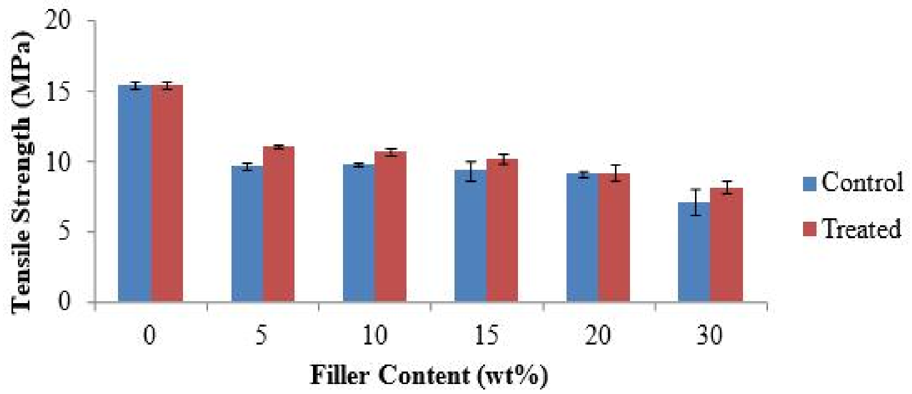

Figure 1. The tensile strength for treated and untreated PP/NBR/KCP composites.

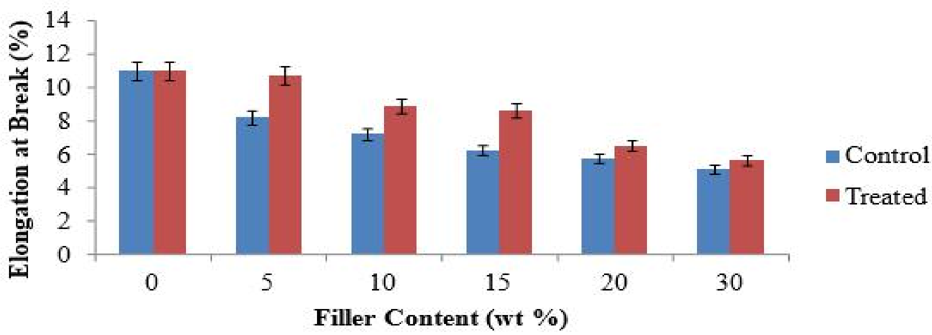

Figure 2. The elongation at break of both treated and untreated PP/NBR/KCP composite.

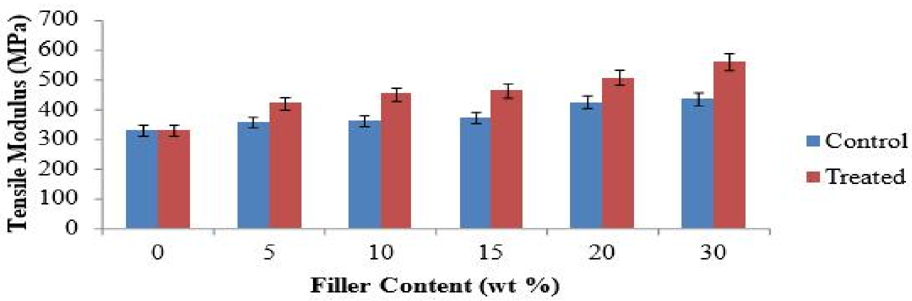

Figure 3. Tensile modulus for both the treated and untreated PP/NBR/KCP composite.

4. Conclusion

Based on the study done, it can be seen that the filler adding reduces the tensile strength and elongation at break of PP/NBR/KCP. However, the tensile modulus increases with increasing filler content. Two contrasting results were obtained from the experiment conducted where the study is divided into two; one with untreated composites and the other is treated with benzoyl chloride. The coupling agent modified PP/NBR/KCP composite portrays higher tensile properties in terms of tensile strength, elongation at break and Young's modulus. This is because benzoyl chloride which act as coupling agent causes changes in the linkages between fibre and matrix part of the compound. The pre-treatment of sodium hydroxide ionizes the hydroxyl group to the alkoxide, thus increases the surface roughness in addition to mechanical interlocking. This reaction can be seen through morphology study. The enhancement in interfacial adhesion ended in less agglomeration. This can be proven from the Young's Modulus results especially for the treated composites. Therefore, the stiffness of the respective composite boosted. The effect of a morphological study conveys that the

IOP Conf. Series: Earth and Environmental Science **616** (2020) 012040 doi:10.1088/1755-1315/616/1/012040

positive effect of coupling agent on interfacial bonding of cellulose and polymer that improved their abilities.

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