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Effects of Styrene Butadiene Rubber on Physical and Mechanical Properties of Kenaf Core Fiber Reinforced Polypropylene Composites

Siti Hajar Mohd[1], Mohamad Bashree Abu Bakar[1*], Nik Aida Hamizah Nik Rosdi[1], Intan Najihah Sabri[1], Mohamad Hazim Mohd Amini[1], Razif Muhammed Nordin[2] and Jutharat Intapun[3]

[1]Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan, Jeli Campus, 17600 Jeli, Kelantan Malaysia.
[2]Faculty of Applied Science, Universiti Teknologi Mara, Arau Campus 02060 Arau, Perlis Malaysia.
[3]Faculty of Science and Industrial Technology, Prince Songkhla University, Surat Thani Campus, Makham Tia, Mueang Surat Thani District, Surat Thani 84000, Thailand.

Email: bashree.ab@umk.edu.my

Abstract. In this research, the kenaf core fiber (KCF) reinforced polypropylene (PP) in the presence of styrene butadiene rubber (SBR) were melted blending with PP using Brabender internal mixer. The composites then fabricated using compression molding to form a sheet of PP and KCF reinforced PP (KCFPP) composites. Pure polypropylene (PP) matrix was used to serve as control whilst SBR was functionalized as impact modifier to improve the toughness properties of PP. The mechanical properties were determined by tensile test using Universal Testing Machine (UTM) according to ASTM D5803. The results show that the increment in SBR content has given an improvement in impact related properties (elongation at break) but at the expenses of strength and modulus properties.

1. Introduction

Polymer matrix composites (PMCs) are from variety of short or continuous fibres that are bind together by an organic polymer matrix. PMCs consist of a polymer matrix which is known as matrix and fibres as the reinforcement method. Since a few decades ago, many researchers have used natural fibre reinforced polymer composites in their researches because they are renewable, cheap and also low density [1]. Besides, natural fibres such as abaca, jute, kenaf and coir are good reinforcement in thermoplastic and thermoset matrices. Natural fibres also have been used in many applications such as automotive, building, industries and aerospace industry [2].

To reduce cost and avoid harmful destruction of the environment, *Hibiscus cannabinus* L or known as kenaf fiber has been chosen in this research. It is because of their environmentally friendly and biodegradable [3]. Next, polypropylene (PP) also was used as a matrix in the composites. PP has many advantages due to its good properties for composite fabrication. In addition, PP also can be used for reinforcing, blending and filling [4]. However, since PP has low toughness, especially below room temperature, the addition of kenaf core fiber (KCF) into PP had further reduced the impact properties of the composite due to ductile to brittle transition.

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To overcome this problem, this research had used synthetic rubber. Synthetic rubber has good dimensional stability and strength. The synthetic rubber usually has been applied in automobiles, footwear and civil construction. Hence, styrene butadiene rubber (SBR) was chosen. SBR is copolymers of styrene and butadiene and also known as Buma-S. Usually, this rubber used by mix it with other materials such as natural rubber to improve its mechanical properties [5]. Besides, SBR mostly used to produce car tires and parts of the automotive industry. This is because SBR has high abrasive, good resistance against thermal degradation, high crack resistance and lower rolling resistance [6]. Furthermore, SBR has been known for its high impact strength which enhances the toughness of PP when blending with it. The present paper reports the effect of SBR as an impact modifier on the physical and mechanical properties of KCF reinforced PP composites.

2. Experimental Method

Kenaf core fiber (KCF) acts as reinforcement fibres were supplied by Lembaga Kenaf dan Tembakau (LKTN) and polypropylene (PP) as a matrix was manufactured by Lotte Chemical Titan Sdn.Bhd. Besides that, styrene butadiene rubber (SBR) also was used as an impact modifier to enhance the toughness properties of PP composites. All these materials were melt-blending using Brabender internal mixer according to formulation in Table 1.

The compression molding was used to prepare the composite's specimen, and tensile properties were conducted by a universal testing machine (UTM) model Testometric M500-50T. Next, water absorption also was conducted to characterize the physical properties of the samples.

Table 1. Formulation of composites

Samples	KCF (wt%)	PP (wt%)	SBR (wt%)
S0	0	100	0
S1	30	70	0
S2	30	68	2
S3	30	66	4
S4	30	64	6
S5	30	62	8
S6	30	60	10

The formula of Water Absorption:

$$Water\ Absorption = \frac{Wf-Wi}{Wi} \times 100\% \qquad (1)$$

3. Results and Discussions

3.1. Tensile Properties

Figure 1 to 3 shows the tensile properties of KCF/PP with and without SBR by different volume of SBR. S0 which is pure PP acts as a control in this research. For Figure 1, the highest tensile strength is S1 due to low interfacial adhesion, poor dispersion of reinforcement and high interfacial tension between components of the polymer blend. As a result, a lower tensile strength of blends than pure PP is expected.

The highest tensile strength observed among the blends of KCF/PP/SBR was 7.463 MPa at S2, then followed by 6.649 MPa, 6.315 MPa, 6.614 MPa, and 4.940 MPa at S6, S5, S3 and S4 composition respectively. The patterns show that the increase of tensile strength when 2% of SBR was added. But it starts decreasing the tensile strength when 4% of SBR was added. Then, the value of strength keeps decreasing when 6% of SBR was added. However, the value had increased again when 8% and 10% of SBR was added.

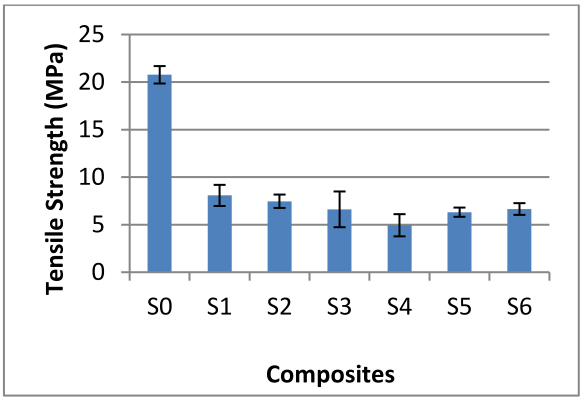

Figure 1. The tensile strength of KCF/PP/SBR composites

For Figure 2, according to [7] the addition of KCF/PP at S1 results the higher Young's modulus than pure PP which 612MPa and 593MPa respectively due to addition of fiber or filler into the matrix, so the stiffness of the composites increases. Besides, pure PP has lower Young's modulus because PP does not have any fiber or filler that acts as a load bearing component in the composites [8].

However, when added SBR, Young's Modulus become decrease at 2% and start to increase again at 6%. Overall, from general observation, the addition of SBR has reduced Young's modulus of KCF/PP composites since rubber generally enhances flexibility of polymer chain [9].

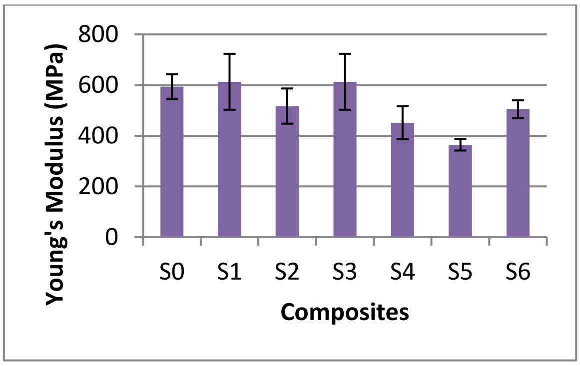

Figure 2. The Young's Modulus of KCF/PP/SBR composites

Figure 3 shows the results of elongation at break of S1, 3.09% which KCF/PP composites are lower than pure PP, due to crack transmit through the lack of interfacial adhesion and it causes S1 to become brittle. Besides, the formation of agglomeration also might cause the lower in elongation at break. However, when 2 % was of SBR was added into the composite elongation at break increases which 6.56 %. This might due to the SBR acts as an impact modifier to enhance the properties of PP. Then, the elongation at break starts slightly to decreases again when 4% of SBR was added. Overall, the results, can observe the addition of SBR decrease the strength and modulus but increase the toughness related properties like elongation at break. The increase in the SBR composition allowed more impact force to be absorbed through stress distribution by rubber particles present in the composites.

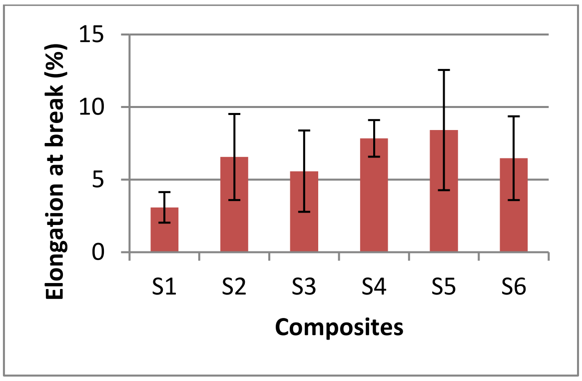

Figure 3. The elongation at break of KCF/PP/SBR composites

3.2 Water Absorption Properties

Based on the results, the lowest water absorption was observed in Figure 4 was pure PP. PP is hydrophobic which does not absorb water [10]. For S1, KCF/PP there was a substantial increase in water absorption due to KCF was hydrophilic. Furthermore, KCF contains cellulose, hemicellulose and lignin, then, cellulose is a hydrophilic polymer that consists of a hydroxyl group. As a result,, high water absorption in the composites because the hydrogen bond of water molecules reacts with the hydroxyl group.

When SBR is added into KCFPP, the water absorption becomes increases. This is due to PP and SBR are miscible and separate the homogenous phase at low temperatures. The bond between PP and SBR is then lost, leading to the formation of vacuoles in the structures. [11]. Overall, as shown in Figure 4, the addition of SBR has failed to reduce the water absorption because it is only functioning as an impact modifier instead of fiber matrix interfacial adhesion promoter.

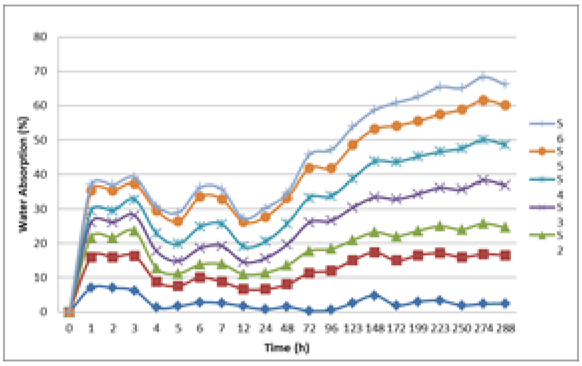

Figure 4. Water absorption for pure PP and KCF/PP composites

4. Conclusion

KCF reinforced PP composite with the presence of SBR was successfully melt blending using Brabender internal mixer and fabricated through the compression molding method. Based on the results of the characterization test and analysis that have been carried out, the KCF can be used to reinforce the PP matrix. Overall, it can be concluded that the increment in SBR content has given an improvement in toughness related properties like elongation at break at the expense of strength, modulus, and water absorption properties.

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