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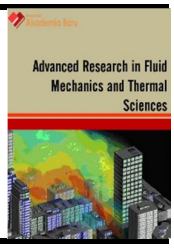

A Proposed Compatibilizer Materials on Banana Skin Powder (BSP) Composites Using Different Temperature

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ABSTRACT

In recent years, there has been an increasing interest in materials treatment in order to improve the properties. In this study, the effect of recycled acrylonitrile butadiene rubber (NBRr) loadings and compatibilization of polypropylene maleic anhydride (PPMAH) in the polypropylene (PP) / recycled acrylonitrile butadiene rubber (NBRr) / banana skin powder (BSP) composites was analysed. The proposed material involved a few steps such as the Polypropylene (PP) was melt at optimum temperature which is 230 ^{o}C. Next, the composites for both uncompatibilized and polypropylene maleic anhydride (PPMAH) compatibilized were mixed using heated two roll mill at specific temperature (180°C) with six different NBRr loadings rate. A few analysis techniques such as tensile properties and Scanning Electron Micrograph (SEM) were conducted. The SEM micrographs show good attachment and better distribution of filler in the compatibilizer composite.

1. Introduction

Fibres reinforced polymer composites have many application as class of structure materials because of their ease of fabrication, relatively low cost and superior mechanical properties compared to the polymer resins [1]. The type of nature fiber commonly incorporated into polymer composites includes rice husk, bagasse, rice straw, coconuts, banana skin, sisal, pineapple skin, rubber wood, palm oil fruit bunch, sago, short silk fiber, rubber wood, hemp, cotton stalk, kenaf, and cellulose [2]. Nature fiber composites are used as filler in polyolefin matrix. It is supposed to reduce the cost production of the composites and also lead to the eco-friendly biodegradable plastic composites [3,4].

Sugarcane is one of the world's largest crops [5]. In 2010, Food and Agricultural Organization of United States estimates it was cultivated on about 23.8 million hectares, in more than 90 countries, with worldwide harvest of 1.69 billion tons [6]. Brazil was the major producers, in decreasing

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amounts of production, were India, China, Thailand, Pakistan and Mexico [7]. In Malaysia, northern area especially Perlis known for their sugar production and wide area with sugarcane crop. The fibrous residue of sugarcane stalks is left over after crushing and extracting juice. SCB content is mainly cellulose, hemicellulose lignin, and pectin with a relatively high amount of modulus, often found as a fibrillar component of the lignocellulose materials [8,9]. The use of this waste material as fillers in thermoplastic elastomer has not been well exploited because of its incompatibility of a hydrophilic nature and the hydrophobic characteristic of polyolefin. Various types of binder have been used such as silane, alkoxysilane, maleic-anhydride grafted polypropylene (MAPP), and others. MAPP is widely used as it functions by enhancing the interactions between reinforcement and matrix [10].

In this research, a blending of PP and SCB are used for the fabrication of composite due to its excellent mechanical properties. However, these composite are found highly incompatible due to the large difference between PP and SCB. To overcome this problem, the PPMAH as compatibilizer are use.

2. Material and Method

2.1 Material

Isotatic Polypropylene (PP) was supplied by TitanPro Polymers (M) Sdn, Bhd, Johor, Malaysia (code 6331). The PP having a melt flow index and density is 14 g/10 minutes at 230 ^{o}C and 0.9 g/cm^{3} respectively. The Sugarcane bagasse collected from Kilang Gula Felda Perlis Sdn. Bhd which contains 46.6 % of cellulose, 25.2 % of hemicellulose and 20.7 % of lignin per weight. The sugarcane bagasse was dried at 80 ^{o}C for 4 hours in oven in order to remove the moisture. The SCB was grinded using pulverizing machine (Rong Tsong Precision Technology Co. Product Id: RT-34) with speed of 2850 rpm into 300 - 150 µm particle size. Polypropylene maleic anhydride was supplied by sigma Aldrich chemical with the percentage of grafting is 8-10 % and melt flow index of 11.5 g/min. The amount of PPMAH used as compitilizer was fixed at constant 5 wt%.

2.2 Preparation of the PP/SCB Composite

Table 1 shows the formulation of PP/SCB composite. The different content of SCB in PP/SCB composite was used in this experiment. PPMAH as a compatibilizer was also kept at 5 wt% constantly for compatibilized composite.

Table 1
Formulation of PP/SCB composite

Material	Amount (wt%)										
	Without PPMAH						With PPMAH				
PP (Matrix)	100	95	90	85	80	70	95	90	85	80	70
SCB (Filler)	-	5	10	15	20	30	5	10	15	20	30
PPMAH (Compatibilizer)	-	-	-	-	-	-	5	5	5	5	5

The composite were prepared by melt mixing using a heated two roll mill mixer at 180 ^{o}C with the rotor speed of 15 rpm. PP was charged into the mixing roll and melted for 4 minutes. At the 4 minute the SCB was added and the mixing was continued for 3 minutes for a total mixing time of 7 minutes. Then, the mixtures were dried for 24 hours at the 80 ^{o}C under the vacuum.

The mixtures were preheated for 6 minutes at 180 ^{o}C and were compressed for 4 minutes at

the same temperature using 1000 psi hydraulic press. The pressed composites were allowed to cool at the same pressure for another 4 minutes before it can be removed from the hot press.

3. Experiment

3.1 Tensile Properties

Tensile test was carried out according to ASTM D638 using an Instron tensile machine Model No. 3366. Dumbbell tensile specimens with 1 mm thickness were cut from the molded sheets with a Wallace die cutter. Tensile strength, Young's modulus, and elongation at break were measured at a crosshead speed 50 mm/min, and tensile tests were performed at room temperature (25 ± 3) ^{o}C.

3.2 Morphological Study

The morphology of the tensile fracture surface at failure mode was examined using a Scanning Electron Microscopy (SEM), model JOEL JSM-6460LA. The tensile fracture ends of the specimen were mounted on aluminium stubs and sputtered-coated with a thin layer of gold to avoid electrostatic charging prior to examination.

4. Results and Discussion

4.1 Tensile Properties

Figure 1 shows the tensile strength of the PP/SCB composite with and without PPMAH as compatibilizer. The tensile strength of the PP/SCB composite was decreased with the increasing amount of SCB. This due to poor stress transfer from the filler to the matrix in higher filler content. However, in the presence of PPMAH as compatibilizer, higher tensile strength was resulted. The even distribution of SCB filler and better bonding with PP matrix may due to the esterification bonding in the composite. The use of PPMAH as compatibilizer agent promotes the interaction between SCB filler and PP matrix at the interface thus improving the fibers-matrix compatibility. The proposed compatibilizer mechanism is hydrogen bonding and covalent ester linkage generated by the chemical reaction of the anhydride group of the PPMAH and the hydroxyl group of the filler surface [11]. Tajvidi *et al.*, have reported similar findings on anhydride moity on polypropylene/nature fiber composites [12].

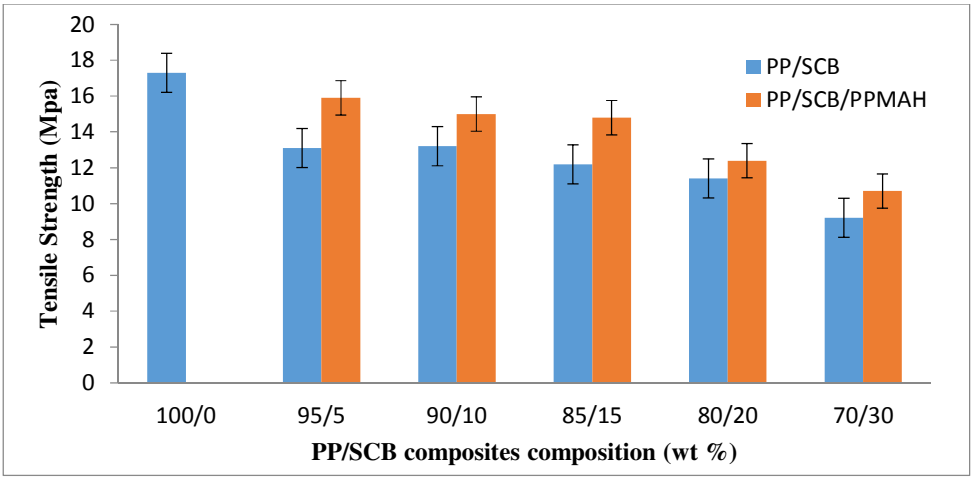

Fig. 1. Tensile strength of the PP/SCB composite with and without PPMAH as compatibilizer

Figure 2 shows the elongation at break of the PP/SCB composite with and without PPMAH as compatibilizer. The elongation at break was decreased with the increasing of filler content. This due to the brittle behaviour of SCB filler in the composite besides poor mixing of the compound during processing. The agglomeration may also result due to strong hydrogen bond between the fillers at higher filler content. This is in agreement with H.S. Yang et al. in rice husk flour filled polypropylene composites [13]. However, the elongation at break of PP/SCB composite with PPMAH was found to be further reduced. This may due to better enhanced matrix-filler bonding in the presence of PPMAH. The PPMAH have improved the adhesion of the SCB filler with the PP matrix that resulted in lower result compared to the one without PPMAH. This due to restricted mobility of polymer chain due to the entanglement of the anhydride group with the PP plane [14]. According to Razavi *et al*., it has been reported that the composite has undergone a stiffening process which lead to higher rigidity [15].

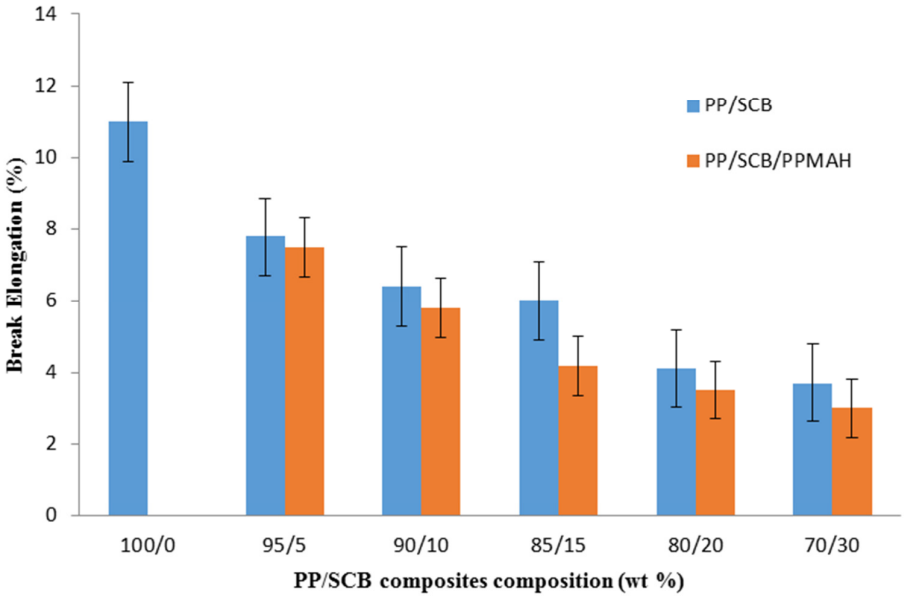

Fig. 2. Elongation at break of the PP/SCB composite with and without PPMAH as compatibilizer

Figure 3 shows the Young's modulus of the PP/SCB composite with and without PPMAH as compatibilizer. It can be seen that, Young's modulus was increased with the increasing filler content. However, the PPMAH compatibilizer on the composite shows even higher Young's modulus than the one without compatibilizer. These findings are in agreement with the elongation at break decreasing trend in Figure 2. The same trend is reported by Hazwani *et al.*, [16]. The enhanced adhesion and dispersion of filler in the presence of esterification bond may be responsible for this. According to Ismail et al., the use of PPMAH as a compatibilizer agent provides the composite with good compatibility in a hydrophobic matrix of PP [17].

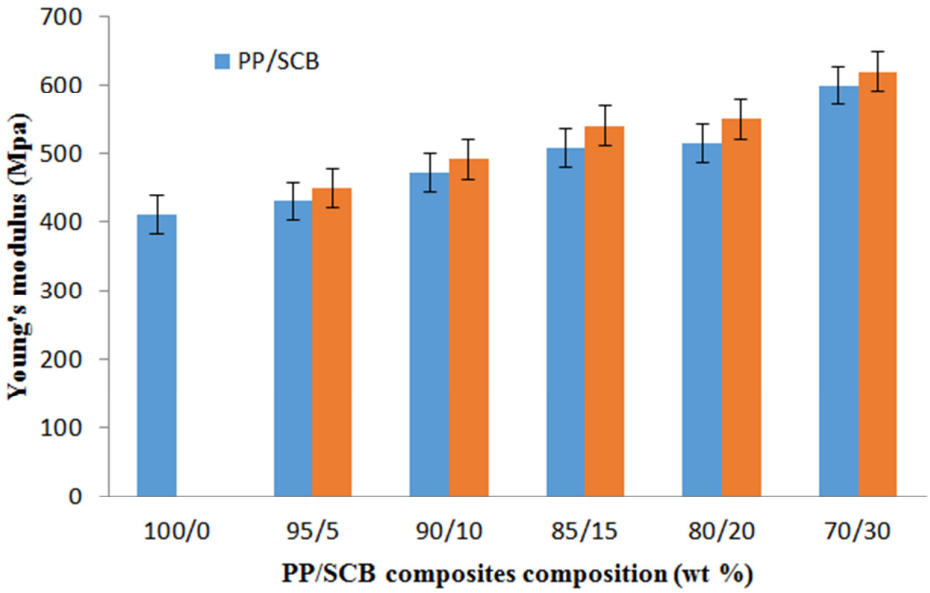

Fig. 3. Young's modulus of the PP/SCB composite with and without PPMAH as compatibilizer

4.2 Morphological Properties

Figure 4 shows the scanning electron micrograph of the tensile fractured surfaces of PP/SCB composite composition 70/30 (300X magnification). Poor adhesion was observed as the presence of multiple pull out SCB holes. The weak adhesion between PP matrices and SCB give rise to poor stress transfer across the plane which resulted to lower tensile strength for without compatibilizer composite [18].

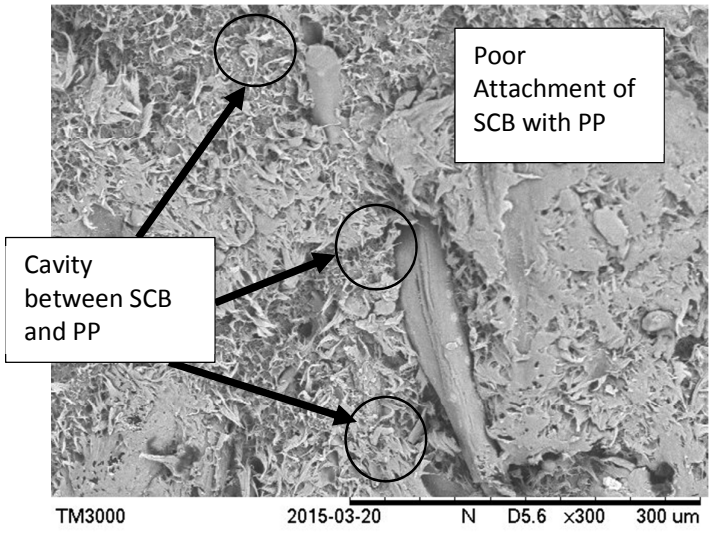

Fig. 4. Scanning electron micrograph of the tensile fractured surfaces of PP/SCB composite composition 70/30 (300X magnification)

Figure 5 shows the scanning electron micrograph of the tensile fractured surfaces of PP/SCB/PPMAH composite at composition 70/30/5 (300X magnification). Better dispersion and good adhesion between SCB and PP matric can be observed. There are less SCB pull out cavity as they were well bonded with matric in the composite. The presences of PPMAH in composite rises of attachment between SCB and PP.

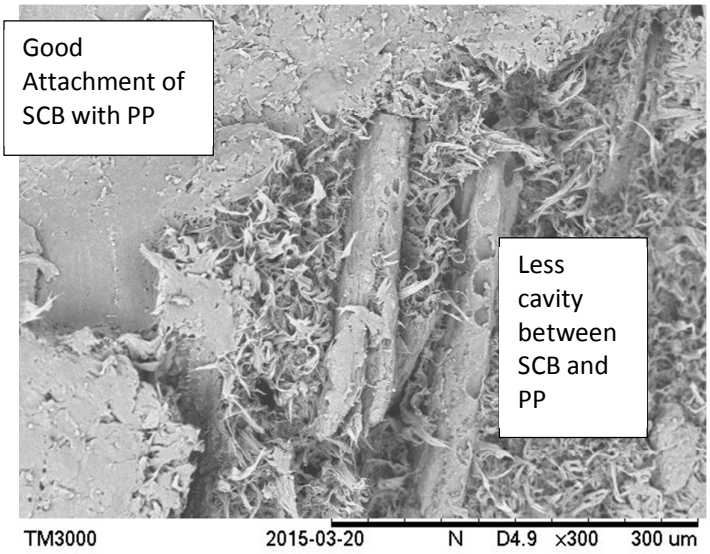

Fig. 5. Scanning electron micrograph of the tensile fractured surfaces of PP/SCB/PPMAH composite at composition 70/30/5 (300X magnification)

4. Conclusion

Tensile strength and elongation at break of the PP/SCB composite decreased with increasing of SCB filler content. This is due to poor adhesion of filler with matrices in higher SCB the filler content. However, higher tensile strength and Young's modulus for PP/SCB composite with PPMAH as compatibilizer. This due to the strength attachment of SCB filler with PP matrix. The SEM micrographs show good attachment and better distribution of filler in the compatibilizer composite. Good adhesion between the phases gives rise to good stress transfer across the PP/SCB interface.

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