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The Effect of Epoxy Resin Compatibilizer On Polypropylene (PP) / Recycled Acrylonitrile Butadiene Rubber (NBRr) / Banana Skin Powder (BSP) Composites.

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Abstract. Epoxy resin (EP) was use as a compatibilizer on the properties of polypropylene(PP)/ recycled acrylonitrile butadiene rubber (NBRr)/banana skin powder (BSP) composites to determine the characterization of composites with and without compatibilization. The objective of this research was to study the mechanical properties and thermal properties of PP/NBRr/BSP composites with and without epoxy resin compatibilizer. The composites were melt using heated two roll mill at 180°C and speed of 15 rpm with 5 different composition (100/0/10, 80/20/10, 70/30/10, 60/40/10 and 40/60/10 weight %). The effects of epoxy resin on mechanical properties and morphological properties were investigated. The results showed that the incorporation of epoxy resin (EP) has improved the tensile properties of PP/NBRr/BSP-EP composite compared with uncompatibilized composite. The Scanning Electron Microscopy (SEM) study of tensile fracture surfaces of the composite indicates improved adhesion of banana skin (BSP) filler with PP/NBRr/BSP matrices in the presence of epoxy resin.

1. Introduction

In recent years, thermoplastic elastomers (TPEs) have been introduced as a highly demanding class of polymeric materials. It started to replace various conventional materials in many different applications. Thermoplastic elastomers (TPEs) becomes a versatile class of materials because they have dual characteristics of vulcanized elastomer and thermoplastic properties [1].

In addition, thermoplastic elastomers (TPEs) also can adjusting their properties in any way according to its thermoplastic characteristics. The blending of two or more types of polymers is a useful technique for the preparation and development of materials. It is due to the purpose to improve the physical and



chemical properties [2]. Important features of thermoplastic elastomers (TPEs) is, it can be recycled repeatedly without significant losing of its properties. Basically, thermoplastic elastomers (TPEs) is combination of a hard thermoplastic phase and a softer elastomer phase [3]. Therefore, addition of elastomers may serve as an aid in such condition.

Acrylonitrile butadiene rubber (NBR) is an elastomeric material that are that have superior strength, excellent resistance water and alcohols. The blends of acrylonitrile butadiene rubber with polypropylene exhibit excellent oil resistant properties and excellent mechanical due to the presence of PP [3]. They can be successfully used for high temperature and oil resistance applications [4]. Nowadays, the use of lignocellulosic fibers as reinforcement in thermoplastics polymers has gained extra attention to the researchers.

Thermoplastic polymers mix with natural fibers can reduce costs of production, while maintaining their properties. It also environmental friendly materials for application in construction and automotive industries. Studies are ongoing to find ways to use lignocellulosic fibers in place of synthetic fibers as reinforcing fillers [5].

Incorporated into polymer composites, lignocellulosic fibers are of particular interest. It is because they are abundant, renewable, and biodegradable. Furthermore, lignocellulosic fibers are cheaper than inorganic fillers. Recent developments in lignocellulosic fibers such as jute, sisal, coir, flax and banana have shown that it is possible to create well performing materials, using environment friendly reinforcements [6]. It produced composites that offer advantages like environmental friendliness, renewability of the fibers, good sound abatement capability and improved fuel efficiency [7].

Lignocellulosic fibers which are combined with hydrophobic thermoplastics have to be modified because effective wetting of the fibers and strong interfacial adhesion. In order to solve this problem, the interfacial adhesion can be improved by introducing another component that will interact chemically or physically with the other phases. This is because it give an improvement in compatibilization of the composites [1]. Addition of a suitable compatibilizer was found to a development of a finer scale of dimension. Thus, it enhanced interfacial adhesion. Epoxy resin have excellent tensile strength and flexible modulus. They exhibit good adhesion to many substrates, high mechanical strength, resistance to abrasion, heat and chemicals and high electrical resistance [2].

2. Experimental

2.1. Materials

Polypropylene (PP) Grade 6331 was obtained from Titan Pro Polymers (M) Sdn. Bhd. Johor, Malaysia with a melt flow index of 14g/10 min at 230°C and a density of 0.9g/cm³. Recycled Acrylonitrile Butadiene Rubber (NBRr) with 33% acrylonitrile content and a density of 1.015 g/cm³ was obtained from Juara One Resources Sdn. Bhd. Penang, Malaysia. Banana skin was supplied from one banana fritters stall, behind School of Environmental Engineering, Jejawi 3. Diglycidyl ether of bisphenol-A epoxy resin (EP) was obtained from a shop in Kuala Perlis.

2.2. Formulations

Mixing compound for this polymer-fiber composite were prepared based on the formulation table of PP/NBRr/BSP with and without epoxy resin compatibilization as tabulated in table 1. The fiber and PP/NBRr matrix was mixing using the DW 5110 heated two-roll mill machine.

Table 1. Formulations of PP/NBRr/BSP composites with and without epoxy resin compatibilization.

Materials	PP NBRr/BSP Composite (weight %)				PP/NBRr/BSP-EP Composite (weight %)			
PP	80	70	60	40	80	70	60	40
NBRr	20	30	40	60	20	30	40	60
BSP	10	10	10	10	10	10	10	10
Epoxy Resin	-	-	-	-	5	5	5	5

2.3. Preparation of The Composites

Mixing compound for this polymer-fiber composite are prepared based on the formulation table of uncompatibilized PP/NBRr/BSP composite and compatibilized PP/NBRr/BSP-EP composite (weight %). The compounds for uncompatibilized PP/NBRr/BSP composite were prepared by means of heated two-roll mill, at a temperature of 180°C. It is above the melting point of the thermoplastic matrix, for 8 minutes, which mean PP was melted for the first 4 minutes and then was followed by NBRr for the next 4 minutes. Banana skin powder were previously sieve to 150 µm to 300 µm and dried in an oven at 180°C for 24 hours. Once the PP/NBRr were melted, the constant percentage weight of BSP was added to the polymer and heated for 3 minutes. Immediately after mixing, the material was dumbbed at 11 minutes to avoid thermal degradation on the compound.

The compounds for compatibilized PP/NBRr/BSP-EP composite were prepared by means of heated two-roll mill, at a temperature of 180°C. It is above the melting point of the thermoplastic matrix which mean PP was melted with the injection of epoxy resin. Epoxy resin was injected first to every composition of PP before they were melted together. PP was melted for the first 4 minutes and then was followed by heated NBRr for the next 4 minutes. Banana skin powder were previously sieve to 150 µm to 300 µm and dried in an oven at 180°C for 24 hours. Once the PP/NBRr were melted, the constant percentage weight of BSP was added to the polymer and heated for 3 minutes. Immediately after mixing, the material was dumbbed at 11 minutes to avoid thermal degradation on the compound.

2.4. Compression Moulding

All the compounds obtained from the heated two roll mill were compressed using a hot press at 180°C for a total preparation time of 16 minutes. Firstly, 1mm thickness mould together with steel plates were heated for 3 minutes, prior the hot press procedure. The HDPE/NBR/RHP mixture were weighed for 28 grams and placed in between the steel plates for preheat of 7 minutes followed by compressing of 1000psi for 3 minutes. Eventually, heated 1mm sheet was allowed for cooling for 3 minutes. The 1mm sheet sample obtained was cut into dumbbell shape by using Wallace Die Cutter model S6/1/6.A.

2.5. Tensile Properties

The samples were prepared according to ASTM 421 method. Initial jaw separation distance of the tensile tester was 40mm and the testing was carried out a cross head speed of 50 mm/min. The mechanical properties for instance tensile strength, Young's Modulus and elongation at break (EB) were recorded for each of the samples.

2.6. Morphological Properties

Scanning Electron Microscopy (SEM) were carried out using SEM machine model SUPRA36VP-24-58 Field Emmission Scanning Electron Microscope (FESEM). The morphological of the 1 mm dumbell tensile fractured surfaces at failure mode of the samples was examined and analysed SEM micrographs were taken at various magnifications for morphological evaluation. Prior to the SEM observations, the fractured ends of the specimens were mounted on aluminium stubs and sputter-coated with a thin layer of platinum to avoid electrostatic charging during examination.

3. Results and Discussion

3.1. Tensile Properties

Figure 1 shows the tensile strength of PP/NBRr/BSP composites with and without epoxy resin compatibilization. With regard to the tensile strength, the difference between tensile strength of control PP/NBRr/BSP composites and compatibilized PP/NBRr/BSP composites decreases as NBRr loading increases. For example, at 80/20/10, 70/30/10, 60/40/10 and 40/60/10 composites composition, the tensile strength of control PP/NBRr/BSP composites and compatibilized PP/NBRr/BSP composites were 12.116/14.328, 11.833/13.291, 9.945/10.380 and 5.980/6.387 MPa, respectively. This may due to addition of NBRr to the composite which leads to decrease in rigidity. This also could be due to poor

adhesion between polar BSP and non-polar PP matrix [4]. This postulates that the existence of copolymers between the PP/NBRr matrix and BSP as a result of the presence of epoxy resin played a greater role in the transfer of stress. That is to say, higher content of epoxy resin provides greater interactions between PP/NBRr matrix and BSP to form more copolymers, and hence, further improves the interfacial interaction in the PNBrr/BSP composites [8].

Figure 2 show the Young's Modulus of PP/NBRr/BSP composites with and without epoxy resin compatibilization. The difference in Young's Modulus between both composites also shows a similar trend as NBRr loading increases. At composites compositions of 80/20/10, 70/30/10, 60/40/10 and 40/60/10, the Young's Modulus of control PP/NBRr/BSP composites and compatibilized PP/NBRr/BSP composites were 672.59/701.90, 606.20/587.40, 449.6/492.1, 306.7/307.7 MPa, respectively. The copolymers formed with the presence of epoxy resin played a pivotal role in restricting the mobility of the polymer chain, and hence, resulted in stiffer composites [8]. On the other hand, it also can be noticed that Young's Modulus graph trend for composite with epoxy resin were found to be higher than uncompatibilized composite. Incorporation of epoxy resin improved the adhesion at the fibre-matrix interface, as shown later in the morphological properties. The better stress distribution which results in good tensile strength of PP/NBRr/BSP composites is due to the strong interfacial bonding, and hence, improved the mechanical properties of the composites [4].

In respect to both tensile properties which are tensile strength and Young's Modulus, same graph trending on tensile strength and Young's Modulus result has reported by Santiago et al. (2011) on his research which is PP/NBRr/RHP biocomposites with and without coupling agent, γ -aminopropyltrimethoxysilane (APS). This is due to the NBRr characterization that leads to decrease in rigidity of the composite and also the reducing of crystallinity of PP in the composites. It is very sensitive for interface of polymer blends because there is a poor interface behaves as a flaw. It initiates failure which resulted in low tensile strength and elongation at break [1].

Figure 3 shows the elongation at break of PP/NBRr/BSP composites with and without epoxy resin compatibilization. It is noted that the difference of elongation at break value between both composites increases as the loading of NBRr increases. For instance, at 80/20/10, 70/30/10, 60/40/10, 40/60/10 composites composition, the elongation at break of control PP/NBRr/BSP composites and compatibilized PP/NBRr/BSP composites were 5.60/5.40, 6.20/6.86, 6.60/7.00 and 6.80/7.50 %, respectively. The elongation at break increase with increasing NBRr loading in both composites. Addition of NBRr reduces the stiffness of the composites which resulted in lower resistance to elongation. However, it can be observed that the incorporation of epoxy resin promotes better interaction between PP/NBRr and BSP in this tensile property, which is elongation at break. Similar finding has been reported by Ismail et al. (2009). Elongation at break increases with increasing NBRr loading in both composites. Addition of NBRr reduces the composites stiffness which resulted elongation to be lower resistance.

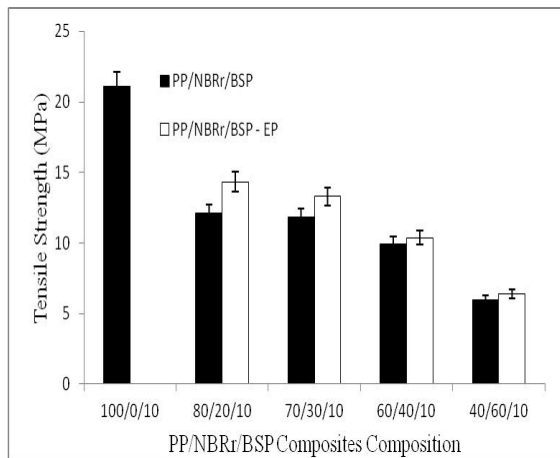


Figure 1. Tensile strength of PP/NBRr/BSP composites with and without epoxy resin compatibilization.

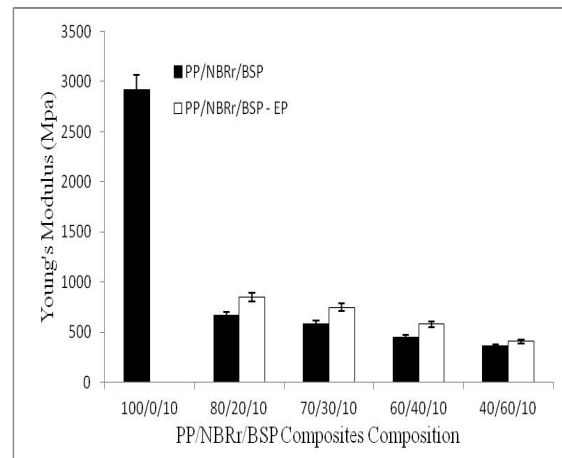


Figure 2. Young's Modulus of PP/NBRr/BSP composites with and without epoxy resin compatibilization.

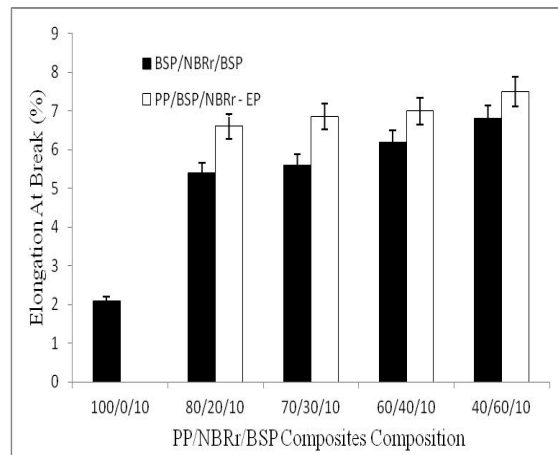


Figure 3. Elongation at break of PP/NBRr/BSP composites with and without epoxy resin compatibilization.

4. Conclusion

According to objectives of this research which are to study the mechanical properties, thermal properties and the chemical interaction and morphological properties of PP/NBRr/BSP composites with and without epoxy resin compatibilizer. it can be conclude that PP/NBRr/BSP composites were succesfully prepared using epoxy resin as a compatibilizer. The mechanical properties of the composites have been improved by addition of compatibilizer. Scanning electron microscopy showed improved adhesion of BSP filler with PP/NBRr matrices.

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