Compatibilizers Effect on Recycled Acrylonitrile Butadiene Rubber with Polypropylene and Sugarcane Bagasse Composite for Mechanical Properties

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Abstract. Compatibilizers effect on recycled acrylonitrile butadiene rubber (NBRr) with polypropylene (PP) and sugarcane bagasse (SCB) composite for mechanical properties is evaluated. Trans-Polyoctylene Rubber (TOR) and Bisphenol a Diglycidyl Ether (DGEBA) are used as compatibilizers in this study. Three (3) different composites (80/20/15, 60/40/15, and 40/60/15), with fixed filler (15 phr) and compatibilizers (10 phr) content, were carried out. These composites were arranged via melt mixing technique utilizing a heated two-roll mill at a temperature of 180°C for 9 minutes employing a 15-rpm rotor speed. Tensile and morphological properties were evaluated. The result shown average tensile strength dropped by 48.50% as the recycle NBR content rises 20 phr. Nevertheless, subsequent compatibilization reveals that the composites' tensile properties were all greater than control composites. The morphology discovered validates the tensile properties, indicating a stronger interaction between the PP/SCB and recycle NBR composites with the addition of compatibilizer DGEBA.

1 Introduction

Acrylonitrile butadiene rubber (NBR) is a synthetic rubber which has excellent oil resistant properties over a wide range of temperatures. NBR is also well known for its superior strength, excellent resistance to abrasion, water, alcohols and heat [1]. Acrylonitrile Butadiene (NBR) is use widely variety of application are requiring oil, fuel, and chemical resistance. On the

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industrial side, the NBR find uses in conveyor belting, hydraulic hose, roll cover, oil field packer and seals for all kind of plumbing and appliance application. The nitrile rubber gloves are one of appliance of NBR. Department of Statistics Malaysia have report on June 2022 domestic consumption of rubber gloves is 25 328 tones [2]**.** This can result the waste of the by glove will increase and can cause the environmental problem [3–7].

Therefore, this study focuses on the development of new class of Thermoplastic elastomer (TPE) material by using PP, recycle NBR from the waste nitrile glove generate by nitrile glove industry as matrix in presence of SCB as filler. Recording to Karanjikar and Lakade [8] the combination of PP, synthetic rubber and natural filler are found inherit energy absorbing capacity with good mechanical and thermal properties of composites.

However, the blending of PP and recycle NBR look be very attractive for the fabrication of TPEs due to its excellent mechanical properties and thermal resistance, these composites are found highly incompatible due to the large difference between PP and recycle NBR[9–13]. Aim of this study to o overcome this problem by using Trans-Polyoctylene Rubber (TOR) and Bisphenol a Diglycidyl Ether (DGEBA) as compatibilization techniques.

2 Experimental

2.1 Material and preparation of composites

Polypropylene (PP) provided by TitanPro Polymers (M) Sdn, Bhd, Johor, Malaysia, recycle NBR by Juara One Resources Sdn Bhd, Penang, Malaysia and SCB by Kilang Gula Felda Perlis Sdn Bhd. In this work, recycle NBR with particle sizes ranging from 300 – 150 µm was utilized. While sugarcane bagasse was dried in an oven at 80ºC for 4 hours and crushed into particle sizes of 300 - 150 µm.

In this study, the amount of PP and recycle NBR were manipulated while the SCB was constant 15 phr. The DGEBA compatibilizer and TOR compatibilizer were constant ratio at 10 phr. The PP/recycle NBR/SCB composite composition is illustrated in Table 1.

Table 1. The formulation for PP/recycle NBR/SCB composites

Material	Amount (*phr)								
	Control composites			TOR composites			DGEBA composites		
PP	80	60	40	80	60	40	80	60	40
Recycle NBR	20	40	60	20	40	60	20	40	60
SCB	15	15	15	15	15	15	15	15	15
TOR	-	-	-	10	10	10	-	-	-
DGEBA	-	-	-	-	-	-	10	10	10

*per hundred resin

The composites were produced utilizing a heated two roll mill mixer equipped with a 15-rpm rotor speed and a melt mixing process. Subsequent to the inclusion of recycle NBR and compatibilizer, the mixture was charged with PP for 4 minutes. Next, SCB filler was incorporated at 6-minute periods, in which the procedure was repeated for an additional 3 minutes, which now comprises a total mixing duration of 9 minutes. Then, the compound has been press using electrically-heated hydraulic was preheated to 180°C for 7 minutes, compressed for 2 minutes, and cooled for 2 minutes for a complete preparation time of 11 minutes. The samples are kept at room temperature for 24 hours once they have been cooled. Finally, the samples are prepared to be sliced into dumbbell shapes with a Wallace Die Cutter and tested.

2.2 Tensile properties

Tensile testing was performed at room temperature employing an Instron 3366 Universal Testing Machine in compliance with ASTM D412. The tensile tester's initial jaw separation distance was 50 mm, as well as the testing was done at a crosshead speed of 5 mm/min. A Wallace die cutter model S6/1/6. A was employed to shape the 1 mm thick molded samples into dumbbell shapes. Furthermore, the tensile properties of the samples were measured utilizing E_b, Young's modulus, as well as tensile strength.

2.3 Morphological study

A scanning electron microscope (SEM) model Zeiss SUPRA35VP was employed to investigate the composites' morphology. To minimize electrostatic charge and low picture resolution during the inspection, all samples were coated with a thin platinum layer utilizing Sputter Coater Polaron SC 515.

3 Results and discussion

3.1 Tensile properties

The graph bar has been plotted using data of tensile strength (Figure 1), Young's modulus (Figure 2) and E_b (Figure 3). With growing recycle NBR content, both Young's modulus and composites' tensile strength diminish. This is understandable given that the inclusion of recycle NBR reduces the composite's rigidity [14]. PP refers to a strong crystalline polymer in which its mechanical properties are influenced by a variety of elements, including structural parameters and molecular weight, especially crystallinity [3, 15, 16]. Numerous scholars have observed comparable outcomes in their experiments on thermoplastic elastomer blends [17, 18]. In both composites, however, E_b, rises as NBR content rises. The inclusion of NBR lessens the stiffness of the blends, resulting in decreased elongation resistance. The control tensile strength value for difference composite composition (80/20/15, 60/40/15, and 40/60/15), are 11.79, 8.91 and 5.41 MPa respectively.

With the addition of TOR and DGEBA to all composites, nevertheless, both tensile strengths, as well as Young's modulus E_b, enhances. The progressed interfacial adhesion between the recycle NBR and PP phases accounts for the rise in tensile properties [3]. Tensile strength for TOR is 11.98, 8.95 and 5.56 MPa at difference composite composition. Meanwhile, DGABA are 12.46, 9.61 and 6.15 MPa. DGBA is an epoxy resin, and TOR is a coupling agent. These compounds can enhance the adhesion between the hydrophobic polypropylene matrix and the hydrophilic sugarcane bagasse fibers. Epoxy resins are known for their strong adhesive properties, and TOR agents are used to promote adhesion between dissimilar materials. Improved adhesion ensures a better load transfer between the matrix and the fibers, leading to higher tensile strength. As a result, DGEBA composites shown have higher tensile properties compared to TOR composites.

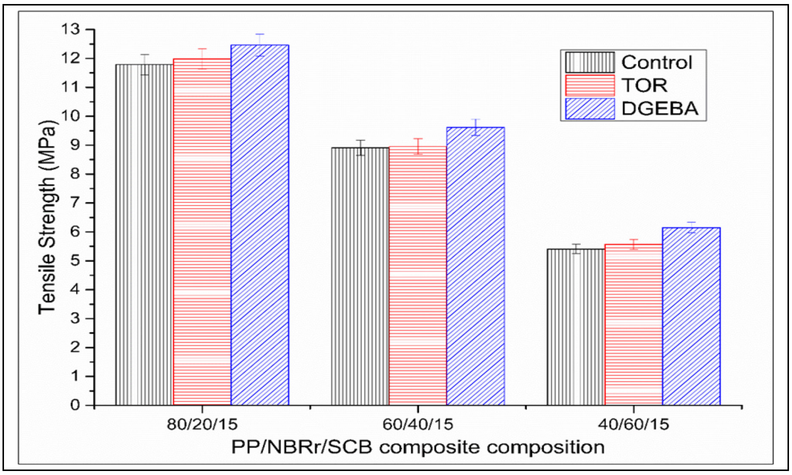

Fig. 1. Tensile strength of PP/Recycle NBR/SCB composites with TOR and DGEBA.

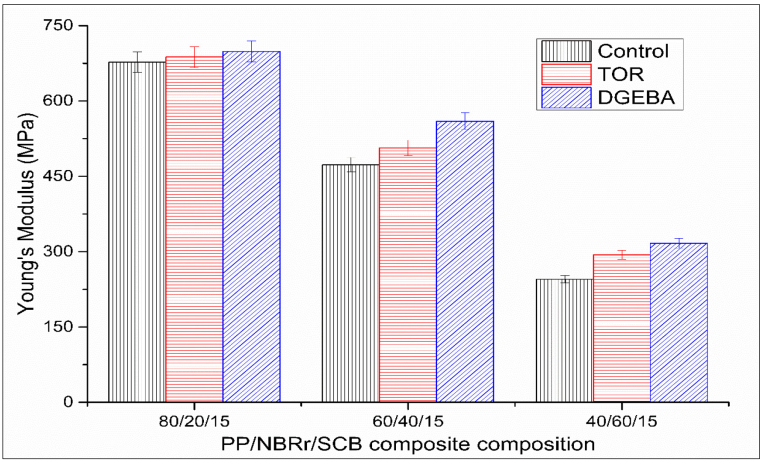

Fig. 2. Young's modulus of PP/Recycle NBR/SCB composites with TOR and DGEBA.

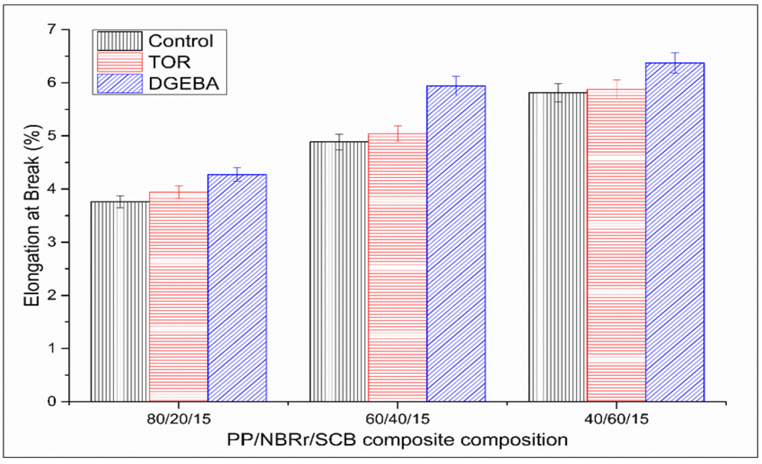

Fig. 3. Elongation at break (Eb) of PP/Recycle NBR/SCB composites with TOR and DGEBA.

3.2 Morphological properties

At X150 μm magnification, Figure 4 depicts an SEM micrograph of the tensile fractured surface of the PP/Recycle NBR/SCB (a) 80/20/15 as well as (b) 40/60/15 phr. Figure 4 (a) demonstrates that SCB and recycle NBR have weak adherence to PP. Additional, multiple pullouts of recycle NBR and SCB can be seen in Figure 4 (b). This could be accounted to poor interaction between the PP/Recycle NBR matrices and SCB filler. The reduced tensile values in the composites might be attributed to poor adhesion between the SCB filler and the PP/Recycle NBR matrices [19], hence justifying the poor stress transfer across the plane. Sugarcane bagasse contains cellulose, hemicellulose, lignin, and other components that may not readily bond with propylene lead to poor adhesion.

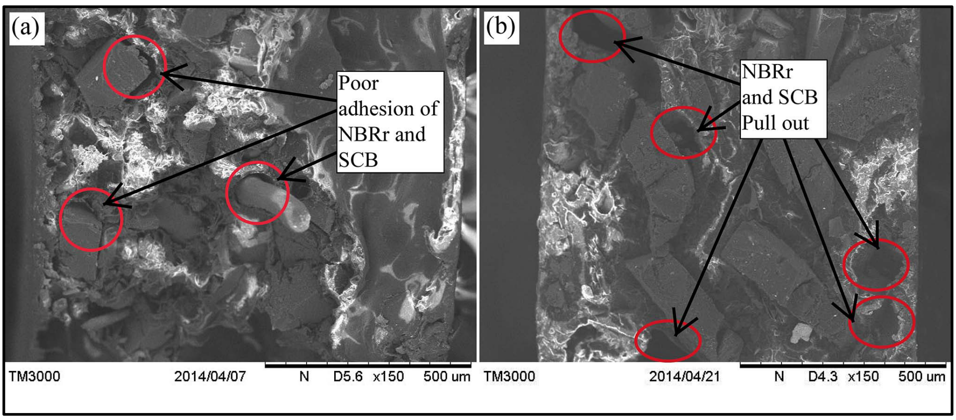

Fig. 4 SEM micrographs of the tensile fractured surface of the PP/Recycle NBR/SCB (a) 80/20/15 and (b) 40/60/15 phr at X150 μm magnification

Figure 5 illustrates the SEM micrograph with respect to the tensile fractured surface of the PP/Recycle NBR/SCB/TOR (a) 80/20/15 and (b) 40/60/15 phr at X150 μm magnification. Besides, good attachment of recycle NBR and SCB with PP was observed. Furthermore, minimal pull out may be viewed in Figure 5 (b) compared to the control composite. This proves that the addition of TOR as compatibilisation in the composite has to improve the adhesion of SCB and recycle NBR filler.

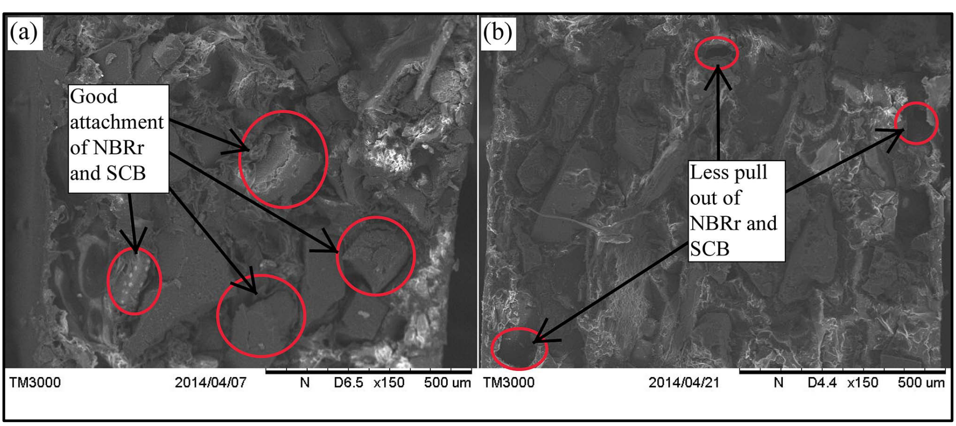

Fig. 5 SEM micrograph of the tensile fractured surface of the PP/Recycle NBR/SCB/TOR (a) 80/20/15 and (b) 40/60/15 phr at X150 μm magnification

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Moreover, the addition of TOR to different polymer blends has been shown to minimize phase morphology scale, resulting in improved mechanical properties. This finding supported a study by Fatin et al. [20] in terms of SEM results. Figure 6 depicts the SEM micrograph of the tensile fractured surface with respect to the PP/Recycle NBR/SCB/DGEBA (a) 80/20/15 and (b) 40/60/15 phr at X150 μm magnification. The SCB filler dispersed better in the PP/Recycle NBR matrices, as well as the PP/Recycle NBR and SCB particles adhered effectively. There were fewer recycle NBR pullouts and fewer gaps between SCB and recycle NBR with PP. This is owing to the high interaction between SCB filler and PP/Recycle NBR matrices when DGEBA compatibilizer is present [21]. Furthermore, owing to the encapsulation of SCB and recycle NBR with PP in the existence of DGEBA predominantly throughout the mixing process, greater recycle NBR content composites have a closer arrangement of recycle NBR particles [22].

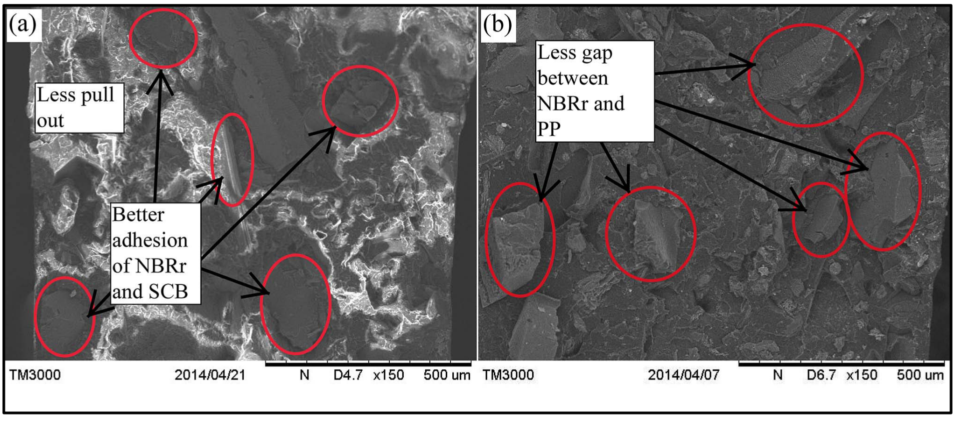

Fig. 6 SEM micrograph of the tensile fractured surface of the PP/Recycle NBR/SCB/DGEBA (a) 80/20/15 as well as (b) 40/60/15 phr at X150 μm magnification.

4 Conclusion

The tensile strength of the material reduced as the recycle NBR content raised. Nevertheless, subsequent compatibilization reveals that the composites' E_b, Young's modulus, and tensile strength are greater than control composites. The morphology findings back up the tensile properties, signifying that the addition of a compatibilizer improves the interaction between the PP/SCB and recycle NBR composites. In conclusion compatibilizer DGEBA was found to be better than TOR in term of thermal, chemical and mechanical properties on PP/Recycle NBR/SCB composite.

Acknowledgments

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