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Experimental studies on mechanical and morphological property of the natural and SBR/BR hybrid rubber

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ABSTRACT

There is an increasing concern over the quality of incoming recycled material for the manufacturing of tyre tread compounds. Often, the recycled material is a blend of different tyre segments. The parts and segments of tyre generally contain varying composition of rubber constituents. Because of the similar physical appearance, the source and composition of this material are somewhat complicated to be differentiated, hence compromising the quality of the tyre treads produced. In the manufacturing of tyre treads especially for heavy vehicles such as buses and trucks, the recycled material of sufficient quality should be used. They were investigated with regard to the mechanical properties and morphological studies. Tensile modulus and hardness appreciably increased with WTR loading. Tear strength increased with increasing GTP. The dispersion of hybrid composites in the matrix was confirmed by Scanning Electron Microscopy. However use GTP in partial NR-SBR compounds, suitable for low potential application which leads to significant solution of environmental contamination.
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1. Introduction

The tread is normally composed of natural rubber and polybutadiene rubber with the right proportion, as these two constituents offer high resistance to an abrasion, resistance to the cracking and low heat buildup. Failure to attain the correct rubber composition would definitely lead to the inferior quality of tyre tread that may as well compromise the tyre safety [1–3]. In the present practice, the readily formed tyre tread compound of unknown composition is tested for physicochemical and mechanical characteristics to ascertain its quality and suitability for heavy vehicles. This trial-and-error approach is time-consuming and expensive, and commonly leads to unsatisfactorily outcomes. Consequently, the compound may end-up be rejected because of the quality and safety issues [4,5].

1.1. Need for composite materials

Conventional materials have a wide array of disadvantages ranging from strength to resistance. The need for composite materials has always been there, since conventional materials fail unprecedently [6–9]. Natural rubber composites are advantageous over conventional metals since they have favorable mechanical and chemical properties induce by the addition of fillers [10,11]. The composite materials also offer to reduce environmental impacts of material that are non-biodegradable but can be used as fillers to produce the composite, for e.g. Waste Tire Rubber (Fig. 1).

1.2. Waste tyre rubber

In a study on non-biodegradable wastes worldwide, it was observed that every year 119 tons of Waste Tyre Rubber was dumped into waste lands [12]. After stipulated time period of their use, tyres get worn out and do not have any application left. They

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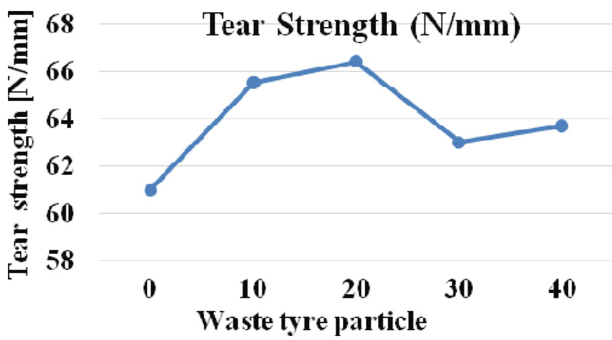

Fig. 1. WTR Vs TEAR.

have to be thrown out. But if these can be reused or recycled, their imprint on the environment can be greatly reduced. Waste tyre rubber can be powered by mechanical process called as pulverization [13–15]. It can also be obtain in different grain size using sieve analysis techniques, thereby increasing their applicability. Pulverizing waste rubber than the chemical processes. The chemical process is expensive and also the natural properties of the material are lost due to chemical reaction [16–19]. Thus, the RRP (Recycled rubber powder) can be use as filler material in natural rubber compound to produce composites [20–22]. Waste tyre rubbers were being used as fillers here has a favorable influence on theme chemical properties of the composite. In this study, the waste tyre rubber was pulverized (150–250 µm) and was used as fillers in the proportion ranging the percentage of Waste Tyre Rubber was kept constant at 5% (Fig. 2).

2. Rubber compounding using two – Roll mill

The spacing between the two rollers is can be adjust by operator using nip adjustments that are present in the outside of the roller mills [23]. The speed of two rolls are frequently different and often back roller moving speed than the front roller. Also, sometimes both the rollers can be rotated at the same speed, depending upon the application and the use. A temperature of 50 °C is maintained in the rolls to aid the compounding process. The natural rubber sheet is added to mill nip and band, as continuous sheet, on to front roll. The rolls rotate at about 40RPM simultaneously. Fillers are added incrementally one after another – Waste tyre rubber, Nylon-6, Silica, EPDM and Carbon black. The rubber composite in now allowed to go through the two rollers of the rollers of the roller mills in order for the fillers to blend in with the natural rubber so as to produce a rubber composite. After each addition of fillers, the rubber is allowed to go through the rollers for about 30 s and then the compound is flipped on the other side so as for the fillers to blend in well with the natural rubber composite [24,25]. Now the fillers blend in with the natural rubber latex. In order for the compound to turn into a composite, it is essential that the fillers and natural rubber has a cross link between them. Sulphur and accelerators are added incrementally to aid the cross-linking reaction. The cross- linking helps in holding the fillers in the composite together. Also, it is important to a have a equal distribution of the filler throughout composite. Now Aromatic oil is added in steps to aid the composite forming process. Finally, curatives such as MBT and TMTD were added. The rolling process is continued for about 5 min and the composite material is obtained as a sheet. Now the material is allowed to cool down to the room temperature [26].

The material obtained is in the form of a latex sheet. It has to be then either put through a hydraulic jack or other die presses in order to obtain it in the form of our choice. In industries, the rubber composite is allowed to cool down using a vacuum of cold air that passes over the composite. This fastens the cooling down process and helps in more optimum delivery [27,28].

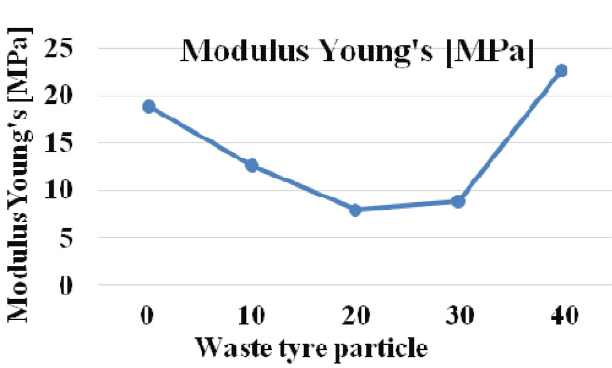

Fig. 2. WTR Vs Youngs Modulus.

3. Results & discussion

3.1. Mechanical testing

3.1.1. Tensile strength test

The test consists of a universal testing machine that has provisions to load the material for tensile testing. The specimen is cut the shape of a dumb bell or ring from a flat sheet. The specimen is placed between the tensile grips and locked using ports present in the grips (Fig. 3).

A standard rate of about 20 in. per minutes. As the tensile grips move away from each other, the sample is subjected to tensile force. The testing is stopped once the sample rupture or breaks in the middle part the test is repeated if the rupture does not happen in the middle and happen at the end of the sample since that does not exactly the tensile strength of the sample material (Table 1).

From the above graph, The tensile strength over the addition of WTR gradually decreases and increases at an 30% of WTR and the minimum and maximum tensile strength is found to be 19.0 Mpa and 16.5 Mpa. The addition of WTR on NR gradually increases the tear strength and decreases over the ratio 20% WTR and the maximum and minimum tear strength is found to be 65.52 N/mm and 60.98 N/mm composites.

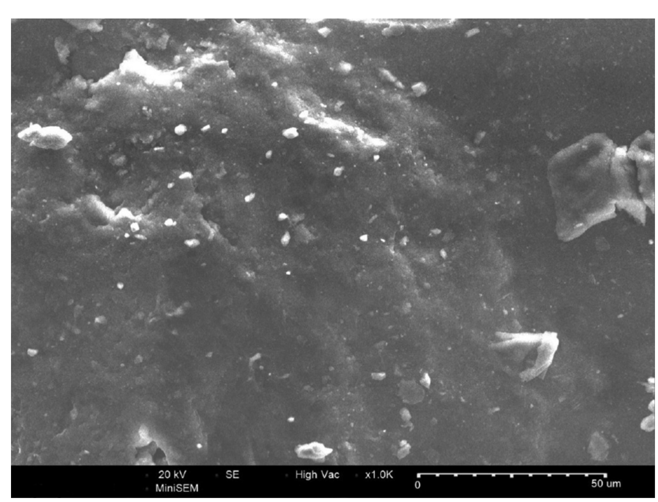

Fig. 3. Composites in 50 µ resolution.

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Table 1
Blending Formulation.

Compostion	NR	SBR/BR	CB	WTR
C	70	5/25	25	
C1	70	5/25	25	10
C2	70	5/25	25	20
C3	70	5/25	25	30
C4	70	5/25	25	40
D	70	10/20	25	–
D1	70	10/20	25	10
D2	70	10/20	25	20
D3	70	10/20	25	30
D4	70	10/20	25	40

The difference between Tensile strength and Waste tyre particle was shown in graph. Tensile strength slightly increases up to 10% and decrease up to 20% of WTR again gradually increase up to 40% of WTR in the composites. Tear strength gradually increase up to 10% and decrease up to 20% of WTR again suddenly increase up to 40% of WTR in the composites. The difference between Tear strength and Waste tyre particle was shown in the graph.

3.1.2. Hardness test

The hardness test is done by using the ASTM D2240. This test is based on penetration of specific type of indentor when forced into the material under the specified conditions. The specimen to be tested is cut into a pile of thickness 6.4 mm. The hardness is examined after a firm contact with the specimen. The main important mechanical properties in rubber industry are hardness. The level of the hardness value is increased with increase in the nylon percentage as well as modulus is initially increase than gradually decrease that is shown in Fig.

The difference between Hardness Shore vs. WTR was shown in the graph. Hardness shore A increase up to 10% of WTR and decrease up to 30%of WTR and suddenly increase up to 40% of the WTR in the composites. Modulus Young's decrease gradually up to 30% of WTR and increase up to 40% of the WTR in the composites. The difference Modulus Young's vs WTR was shown in the graph fig. The difference between hardness shore vs WTR was shown in the graph fig. Hardness shoreA increase up to 10% and decrease up to 40% of WTR in the composites. Modulus Young's increase gradually up to 10% and decrease up to 20% again increase up to 40% of WTR in the composites.

3.2. SEM test on sample 'C 4'

The following image is the result of the SEM test carried on the sample C 4 and that shows the surface of the composite in 50 μm respectively. The morphology of the samples revealed that the fillers are blends effectively with the natural rubber. The results obtained through the mechanical testing indicates that the developed natural rubber hybrid composite filled with these additives showed better mechanical properties than that of the natural rubber.

4. Conclusion

The mechanical properties of hybrid GTP/Si filled partial natural rubber compounds were investigated with an emphasis on the tensile and tear properties. The following conclusion can be drawn since this research work:

- The tensile strength and the elongation at break decreased with raising GTP loading.
- The tensile modulus and hardness appreciably increased by GTP loading and tear strength decreased with increasing GTP loading.
- The dispersion of hybrid composites in the matrix was confirmed by Scanning Electron Microscopy.
- However use GTP in partial NR-SBR compounds, suitable for low potential application which leads to significant solution of environmental contamination.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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