Enhancement of physical properties of natural rubber vulcanizates by incorporating rice husk ash with carbon black as a filler

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Introduction

There is a higher demand for carbon black and silica as reinforcing fillers in manufacturing of various rubber products which enhance the properties such as modulus, tensile strength, resilience and hardness of vulcanized rubber. Because of their increased prices, it has become a major concern for finding new fillers replacing carbon black and silica. One of the possible candidates in this regard is rice husk ash (RHA) which is an agricultural waste causing environmental pollution (Chuayjuljit, *et al.*, 2001). RHA mainly consists of silica and carbon. Two types of RHA, white rice husk ash (WRHA) and black rice husk ash (BRHA) can be produced by controlled burning of rice husk (Sarkawi, *et al.*, 2003, Ramasamy, *et al.*, 2013). In this research the use of WRHA and BRHA as fillers in enhancing the properties of natural rubber vulcanizates replacing carbon black was investigated.

Methodology

Two cylindrical metal baskets, one is smaller than the other, were placed coaxially and space between the cylinders was filled with dried rice husk. Ignition was done inside the small basket which contained small holes. It formed a little smolders which slowly spread into the rice husk facilitating controlled burning (Allen, 2004). The burning was continued for a day and obtained WRHA. In order to produce BRHA the dried rice husk was burnt in an open place for an hour. Both WRHA and BRHA were sieved to obtain particles with a size range from 150 μm to 300 μm.

Rubber compounding formula for tire side wall was used to prepare the natural rubber (RSS 1) compounds with different amounts of fillers. A series of rubber compounds having varying amounts of carbon black (N 330) and BRHA filler. Mixing of the ingredients was carried out in an internal mixture followed by mixing on a two-roll mill for 5 minutes at 80 °C. Two rubber compounds were prepared varying the amounts of carbon black (N 330) and WRHA filler employing the same mixing process. Investigating the processing characteristics of the resulting compounds using a Rheometer, optimum curing time for each sample at 150 °C was determined. The rubber samples were prepared by curing the compounds in a hydraulic press at 150 °C for relevant curing time periods.

The tensile properties of resulting vulcanizates were determined following ASTM D412 standard using Instron machine model 2713. For tear testing the same machine was used following ASTM D-638 standard. Hardness test was performed using Elastocon machine following IRHD standard.

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Result and Discussion

The samples were designated according to the types of fillers and the amounts of fillers in grams incorporated. In the designation the letters C, B and W represent the presence of carbon black, WRHA and BRHA, respectively. Each number following the each letter in the sample designation represents the amount filler in grams present in each sample. Variation of the tensile strength upon the filler composition in samples is shown in Figure 01. Values of tensile strength of all the rice husk ash containing samples are considerably higher than that of the reference sample which contains only carbon black. The samples C81B54, C27B108 and C67.5B67.5 show tensile strength values greater than 20 MPa. Tensile strength of C67.5B67.5 is little less than the doubled value of the tensile strength of reference sample. The improvement of tensile strength of RHA containing rubber samples can be attributed to enhanced rubber-filler interaction and good filler dispersion in the rubber matrix. This is resulted by relatively high surface area of small RHA particles enabling better wetting of the particles by the rubber matrix (Onyeagoro, 2012).

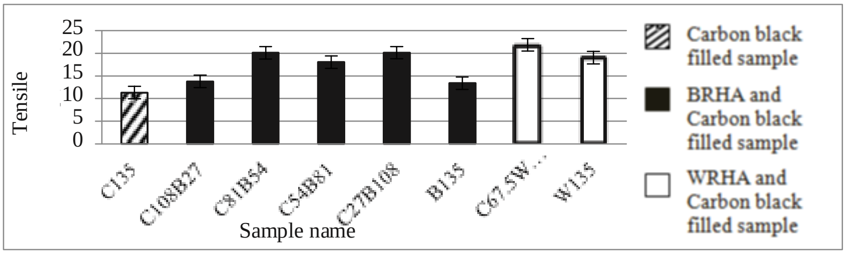

Figure 01: Variation of tensile strength of samples with different filler compositions

The variation of tear strength on the filler composition of the samples is shown in Figure 02. The highest tear strength is attained by the sample containing only carbon black (C135). The samples C81B54 and C27B108 show tensile strength values which are nearly three fourth of the value of tensile strength of C135. The samples W135 and B135 show law values tear strength.

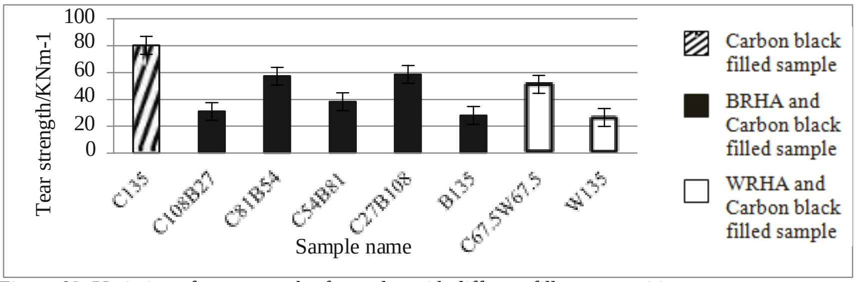

Figure 02: Variation of tear strength of samples with different filler compositions

In the case of investigation on hardness of the filled rubber vulcanizates, the reference sample showed the highest hardness value and the samples B135 and W135 showed very close and considerably high hardness values. Considering the samples containing BRHA and carbon black mixed filler systems, it was observed that the hardness of samples decreases with increasing the amount of BRHA filler and with decreasing the amount of carbon black incorporated. This may be due to relatively large particle size of carbon black filler which obstruct the movement of the rubber matrix when the matrix is subjected to indentation (Rahman, *et al.*, 2009).

Resilience is a measure of rubber-like elasticity of vulcanizates. It can be observed that the resilience of the filled rubber samples increases as the amount of RHA increases. The sample W135 shows the highest resilience (72.67 %) whereas the reference sample shows a low resilience value (58.33%).

Conclusion

The incorporation of RHA as a filler replacing carbon black into natural rubber vulcanizates has improved some of the mechanical properties of the resulting vulcanizates. Especially, the RHA and carbon black mixed filler systems and WRHA alone as a filler can considerably improve the tensile strength of the vulcanizates. Although the tear strength of RHA containing vulcanizates are lower than that of only carbon black filled sample, tear strength values of samples C81B54, C28B108 and C67.5W67.5 show promising values. It has been proved that RHA as a filler can better improve the resilience of rubber vulcanizates than carbon black. However, the mixed filler systems of RHA and carbon black cannot considerably contribute to the hardness of the vulcanizates. The results of this investigation confirm that the carbon black can be partly replaced by RHA filler maintaining the required mechanical properties of natural rubber vulcanizates resulting in reduced cost and environmentally friendly processing.

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