

Investigation on the use of coconut shell powder replacing carbon black as filler in natural rubber

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Introduction

Natural rubber is an elastomer which mainly consists of cis-1, 4-polyisoprene. It is used in a wide range of applications, mainly in tire manufacturing. Vulcanizates of natural rubber are reinforced by incorporating fillers such as carbon black and silica.

There is a demand in replacing these fillers by fillers made of natural materials such as coconut shells, since natural filler possesses environment friendly processing, with no wear of tooling and no skin irritation (Bhaskar and Singh, 2013). Coconut shell powder (CSP) is a natural lignocellulosic material which has been used as reinforcing natural filler in a broad range of applications such as building materials, marine cordage, fishing nets, furniture, and other household appliances (Sapuan and Harimi, 2003). The presence of highly polarized hydroxyl groups on the surfaces of the lignocellulosic fillers makes it difficult to achieve strong interfacial bonding with non-polar polymer matrix. As a result, lignocellulosic fillers show poor mechanical properties in polymer composites. However, the interfacial bonding can be improved by employing surface treatments methods including alkaline treatment, esterification and silane treatment (Egwaikhide *et al.*, 2007). In the current research it was expected to improve the properties of natural rubber vulcanizates by incorporating CSP and surface modified CSP replacing carbon black filler.

Methodology

Coconut shells were crushed into powder and it was dried in an oven at 80 °C for 24 hours (Tengkufaisal *et al.*, 2010). The powder having the particle size range of 150 µm to 300 µm was separated by sieving and used for this research (Koayseong chun *et al.*, 2013).

Surface modification of coconut shell powder was achieved by acid treatment. The powder was soaked in an aqueous acetic acid solution with powder to solution ratio of 1g/20 l and the mixture was stirred for 1 hour. The treated powder was separated by filtering. It was washed with distilled water and dried in an oven at 80 °C for 24 hours. Two sets of natural rubber (RSS 1) compounds were prepared according to the tire inner layer compound formulation by milling the ingredients. A series of compounds were prepared by varying the relative amounts of carbon black (N330) and untreated CSP. Another series of compounds were prepared by varying the relative amounts of carbon black and treated CSP. The reference compound was prepared by adding carbon black. Processing characteristics of prepared compounds were investigated by using a Rheometer. Vulcanized samples were prepared using a hydraulic press maintaining the temperature at 150 C for the relevant cure time determined from rheographs. Tensile properties of the samples were determined following ASTM D412 using Intron machine model 2713. Abrasion test was performed on the samples following DIN 53516 using Hampden machine model APH-40 and the hardness test was performed following IRHD using Elastocon machine.

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Result and Discussion

The effect of filler composition on tensile strength of the samples of natural rubber vulcanizates is shown in Figure 01. In the sample designation, the letters C, U and T stand for the type of filler, carbon black, untreated CSP and treated CSP, respectively. In addition, the amount of each type of filler in phr is given by the number following each letter of designation. The sample with only carbon black filler shows the highest tensile strength. As the relative amount of untreated and treated CSP filler is increased the tensile strength decreases. This is due to the weak interfacial adhesion, low wettability, and poor dispersion between hydrophilic CSP and hydrophobic rubber matrix with compared to carbon black. The samples having treated CSP show a higher tensile strength than those having untreated CSP except the sample C90U60. This behaviour attributed to the improved interfacial adhesion and better dispersion between treated CSP and Rubber.

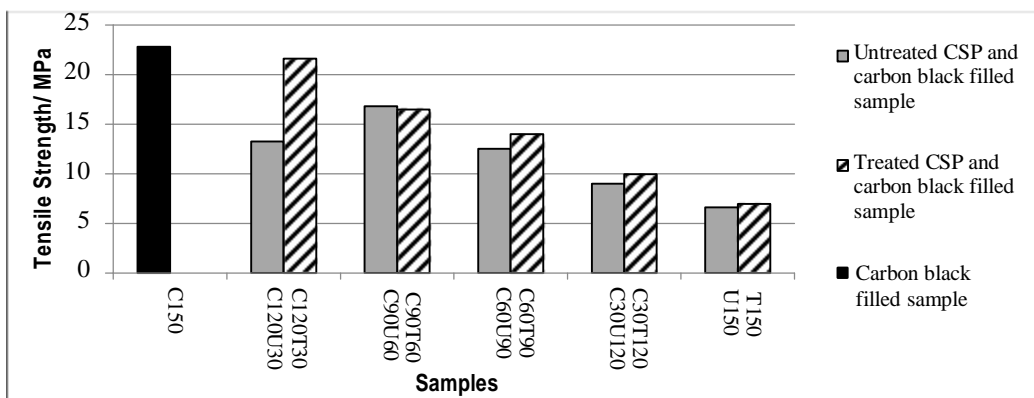


Figure 01: Variation of tensile strength of samples with different filler compositions

The samples with treated CSP show higher elongation at break than those with untreated CSP. In addition, the sample with only carbon black filler shows the lowest elongation at break. Resilience of treated CSP filled samples also higher than the untreated CSP filled samples and reference sample. Tear strength is essentially measure of resistance to the propagation of a crack under tension. As shown in Figure 02, all the samples except C120T30 show lower tear strength than the reference sample.

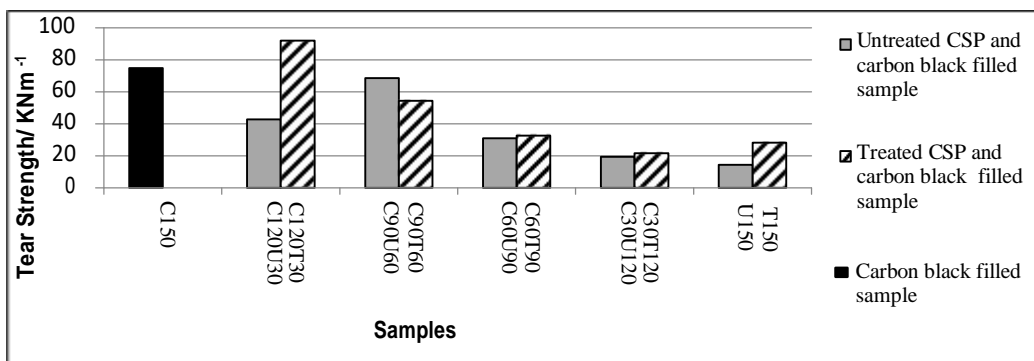


Figure 02: Variation of tear strength of samples with different filler compositions

As the untreated and treated CSP amount is increased, there is a trend decreasing the tear strength of samples. However, tear strength of samples having treated CSP is higher than that of the samples having untreated CSP at each corresponding relative CSP composition except the sample C90U60. It

may be due to the fact that treated CSP filler particles act as a barrier to the propagation of micro cracks.

Hardness values of treated CSP filled samples are higher than those of untreated CSP filled samples at each corresponding relative CSP composition. This is also due to the improved interfacial bonding of treated CSP filler and rubber. Volume loss values in abrasion of all the samples are higher than that of reference sample. In addition, volume loss values in abrasion of treated CSP filled samples are lower than those of untreated CSP filled samples at each corresponding relative CSP composition. In other words, untreated CSP filled samples show higher abrasion resistance than treated CSP filled samples.

Conclusion

Mechanical properties such as tensile strength, tear strength, resilience, hardness and abrasion resistance of samples containing CSP are lower than those of the reference sample. However, for many properties the sample having 120 phr of carbon black and 30 phr of treated CSP shows higher values or values in an acceptable range with compared to the reference sample. At many relative compositions, treated CSP filled samples show higher properties than untreated CSP filled samples. This confirms the improved interfacial bonding of CSP filler and rubber by the surface treatment method used. It can be concluded that carbon black can be replaced by treated CSP as a reinforcing filler for natural rubber vulcanizates.

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