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A study on a natural rubber and coconut coir-based carbon black composite

H. S. R. R. Fernando[1] and V. A. Seneviratne[1*]

[1]Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka
varunis@sci.pdn.ac.lk*

Carbon black (CB) is extensively employed as a reinforcing filler in various industrial applications. Widely available polymer-filler composites are synthetic. A main motive of this research was to synthesise and characterise an eco-friendly polymer composite for applications in bicycle tyre and tube industry. The study utilised coconut coir to produce CB and used it as the filler in natural rubber (NR). The coconut coir-based carbon black (CCCB) was prepared by the combustion of coconut coir at 200 ^{0}C in a nitrogen atmosphere. Instead of sulphur, pentane-1,5-diylidenediamine (PDD) with equal amounts of ammonia and glutaraldehyde was employed as a cross-linking agent at a low temperature to process NR. The NR and CCCB composites (NR-CCCB) were synthesised incorporating 50 mL of NR latex, 6 ml of PDD solution, and different amounts of CCCB. The mixture was stirred at 45 ^{0}C for 3 hours, casted into the moulds and made NR-CCCB composites having different weight percentages of CCCB (0, 2, 4, and 6%). The structural properties and mechanical properties, including Young's modulus, tensile strength, and elongation at break, were assessed to evaluate the influence of CCCB on the composite material. X-ray diffraction was conducted on CCCB, and scanning electron microscopy was conducted on both the composites and CCCB to understand the structural changes and morphological characteristics. The X-ray diffraction analysis indicated that the CCCB is inexhibit an amorphous phase. Morphological analysis revealed a uniform dispersion of CCCB within the rubber composite, which contributed to the enhanced mechanical properties observed in the composites. The particle size of CCCB was estimated to be 70-80 μm. The density of NR-CCCB increased from 887 kg m^{-3} to 1241 kg m^{-3} by 40% with the increase in filler loading. Universal testing machine was used to study the mechanical properties of NR-CCCB and the reference bicycle tube. The results demonstrate the increase of tensile strength and Young's modulus of NR-CCCB 0.75×10^6 N m^{-2} to 1.32×10^6 N m^{-2} and from 0.72×10^6 N m^{-2} to 1.25×10^6 N m^{-2} respectively, with increasing filler content, resulting in increased hardness, stiffness, and strength of the rubber. However, the elongation at break of NR-CCCB decreased from 476% to 422% with increasing filler content, indicating a decrease in the flexibility of the NR composites. The density and Young's modulus of the reference bicycle tube were measured as 1262 kg m^{-3} and 5.67×10^6 N m^{-2} respectively.

Keywords: Carbon black, Coconut coir, Natural rubber, Natural rubber, Tensile strength, Vulcanisation