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Effect of multi-walled carbon nanotubes reinforcement on self-healing performance of natural rubber

Abstract

This work is motivated by the desire to restore the quality of rubber-based product properties with the intention of prolonging the service life period, thus helping create a sustainable environment by proposing effective rubber waste management. This study experimentally investigated an intrinsically self-healing zinc thiolate grafted natural rubber (NRZT) compound filled with multi-walled carbon nanotubes (MWCNT) to assess its influence on mechanical properties and self-healing performance. The MWCNT loading varied to 0, 2, 4, 6, and 8 phr. The Equilibrium swelling test was used to quantify the amount of ionic and covalent crosslinks formed. Fourier Transform Infrared (FTIR) spectra were used to detect the presence of MWCNT in the compound. The mechanical properties computed by the tensile and tear strength tests showed that the incorporation of MWCNT increased both properties up to three and twofold, respectively. However, as expected, the elongation at break (Eb) value was reduced. The unfilled sample showed that it can heal up to ~98 %, measured from the tensile strength. However, the healing efficiency obtained from tensile strength reduces to ~88 % by incorporating 2 phr MWCNT. The Eb and its self-healing efficiency gradually decreased as the MWCNT amount increased. All samples showed outstanding properties under the tearing mode, where the healed samples produced higher tear strength (>100 % healing) than the initial value. Scanning Electron Microscopy (SEM) micrographs revealed a noticeable gap along the healed cut line with increased MWCNT numbers, possibly due to the lower reaction between polymerized zinc thiolate (PZTh) radicals with zinc thiolate (ZT) and rubber molecules. The work aims to investigate the influence of MWCNTs on the mechanical and healing performance of self-healing NR composites by comparing them to their unfilled sample.

Keywords

Advanced materials for environmental protection; Functional polymer; Ionic bonding; Reversible crosslink; Rubber composite; Self-healing rubber