ABSTRACT

The use of hybrid filler systems that combine the outstanding properties of nanofillers with other conventional fillers like carbon black (CB) that are of lower cost are of very high technical relevance, especially with reference to application in tire compositions. Due to their specific structure and distinct properties one dimensional nanostructures have emerged as the major players in the current era. Since the reinforcing potential of carbon black is well understood, new generation fibrous nanofillers such as carbon nanotubes (CNT), silicon carbide nanofibers (SiC), aramid nanofibers (ANF) and graphite nanofibers (GNF) were chosen as the sole reinforcement in natural rubber (NR) to understand the dependence of properties of elastomers on dimensionality of fillers. NR nanocomposites were then developed using these fibrous nanofillers, and their rheometric, mechanical, dynamic mechanical, and thermal properties were studied. The synergistic reinforcement of new generation nanofibers when used along with carbon black, a conventional reinforcing agent, in a typical tire tread composition was investigated. Reinforcement in these composites was analyzed using the properties of the unvulcanized compounds, which were then correlated with those of the vulcanized compounds. The processability of the uncured composites was characterized using Mooney viscometer, capillary rheometer, and parallel plate rheometer. The molecular aspects of reinforcement were elucidated from theoretical calculations using Mooney–Rivlin plots. The unique synergism developed using CB-nanofiber hybrid filler was reflected in the enhanced failure resistance and dynamic mechanical properties of the composites. Tribological characteristics were studied using DIN abrader as well as a Laboratory Abrasion Tester (LAT 100), and the abrasion loss of the samples was correlated with energy dissipation occurring during the process. The study also established a correlation between the wear loss and fatigue properties of the hybrid nanocomposites containing different fibrous nanofillers. Tire innerliner compositions using NR were developed and the competency of nanofiber-CB dual filler system in enhancing the barrier properties was investigated. The increase in tortuosity created by the presence of the hybrid filler system was studied using permeability models and crack growth properties were investigated using tear fatigue analyzer (TFA). A comprehensive characterization of the electrical conduction and strain sensing behavior of a natural rubber based commercial tire tread and innerliner composition combining the reinforcement of a carbon black-conductive nanofiber dual filler system was carried out. The gauge factor observed was way higher than the value reported for metallic or polyvinylidene difluoride (PVDF) based strain sensors developed for this application. A 25 % enhancement in thermal conductivity was also observed. Thus, the developed composites have the potential to be used as durable in-situ strain sensors for next generation intelligent tires so that the problems of debonding and heating differences in the sensor-rubber interfaces in tires could be avoided in the future.

Keywords: *Natural rubber, nanofiber, nanocomposite, hybrid filler, tire tread, tire innerliner*