Abstract

Transformation of fresh fly ash (FFA) into Nanostructured fly ash (NFA) has been carried out by mechanical activation process using a ball mill, the ‘top-down’ process for the development of nano materials. NFA has been characterized for its particle size, surface area, surface free energy, crystallinity and morphology by using sophisticated analytical tools. A significant reduction in particle size by 1/430 times and crystallinity by 16% observed for NFA in conjunction with an improvement in surface area by 102 times. Particle size measurement by Transmission Electron Microscopy (TEM) revealed that NFA has a particle diameter of approximately 100 nm. Composites prepared from NFA and Styrene Butadiene Rubber (SBR) exhibit higher state of cure and higher tensile strength as compared to those with carbon black, precipitated silica and FFA filled SBR composites at equivalent dosages varying from 1 phr to 60 phr. Tear strength and abrasion resistance of the NFA-SBR nanocomposites are superior to those of FFA and silica filled SBR composites, but are inferior to that of HAF filled SBR composites. TEM study reveals that the NFA particles are evenly distributed in the SBR matrix and the dispersion is homogeneous. Surface modification of NFA by sodium hydroxide (NaOH) treatment and hydrochloric acid (HCl) etching cause dissolution of specific domains on the fly ash surface generating micropores and thereby enhancing surface asperity and the specific surface area. The nanocomposites containing either NaOH treated or HCl treated NFA show invariably higher bound rubber content, greater rubber-filler interaction and higher mechanical strength properties as compared to that of the unmodified NFA filled SBR nanocomposites. The surface activation of the NFA by stearic acid and organosilane (trimethoxy propyl silane) carried out separately improve the organophilic nature of the nanofiller surface. Consequently, dispersion of the surface activated NFA in SBR matrix is enhanced and the technical properties of the SBR nanocomposites improved significantly. Chemical modification of NFA surface by grafting styrene and then polymerizing it by conventional radical polymerization technique yields polystyrene grafted NFA which has been fully characterized by using FT-IR, TGA, SEM and TEM. Polystyrene grafted NFA in SBR matrix improved the rubber-filler interaction by increasing rubber bound filler and enhanced physico-mechanical properties of the NFA-SBR nanocomposites. Surface pre-treatment of NFA by RF oxygen plasma resulted in improvement of surface polarity and adhesion characteristics of the NFA surface. Enhanced technical properties of SBR composites filled with plasma treated fly ash are a proof of its higher compatibility with the rubber matrix. Electron beam irradiation of NFA surface generates free radicals as well as micro porosity on the surface, resulting in improved adhesion between fly ash and SBR matrix which ultimately improve the technical properties. Thus nanostructured fly ash can be used as a non-black reinforcing filler in rubber industries paving the way for its large scale utilization. This, on the other hand, shall lead to easing the problem of waste disposal, making the earth ecofriendly.

Keywords: *Fly Ash, Nanocomposite, Surface Modification, Physico-Mechanical Properties, Nanostructured Fly Ash*