Abstract

The present thesis encompasses with the dispersion and distribution behaviour of various carbon fillers in elastomer and elastomer blend matrices for the development of electrically conductive with good mechanical and thermal properties composites. These composites have been prepared through the incorporation of various carbon fillers like particulate carbon black (N300, Vulcan XC-72), multiwalled carbon nanotubes (MWCNT) and graphene nanoplatelets (GNP) or their combination in elastomer blends or in single elastomer matrix. Theses composites were prepared by different mixing procedures involving the melt mixing, solution mixing, and solution cum melt mixing. The distribution behaviour of single filler was checked in 50/50 wt/wt polar/polar (compatible) blend of NBR/EVA and 50/50 wt/wt polar/non-polar (incompatible) blend NBR/EPDM. The distribution behaviour of hybrid fillers (GNP+CB & GNP+MWCNT) was checked in single elastomer matrix. In melt mixing method of composite preparation, different modes of carbon fillers addition in the phases of elastomer blends were carried out and their effects on mechanical and electrical properties have been investigated. The different modes of filler addition significantly affect the electrical conductivity (both AC and DC) of the blend composites. The formation of conductive networks in the blend matrix is significantly affected by the viscosity of the constituent elastomer. The relatively much less variation in mechanical properties are observed due to change in modes of filler addition reveals that even after preferential addition of fillers in particular phase, there is redistribution of fillers during successive stages of mixing. The dynamic mechanical analysis (DMA) and results of surface energy measurement revealed that carbon black and GNP have higher affinity towards the less viscous elastomer phase of both compatible/ incompatible blend. The dispersion of GNP in elastomer matrix strongly depends on the mixing procedure and two-step mixing method (solution cum melt mixing) was adopted for better dispersion of grapheme in elastomer. The addition of GNP in elastomer matrix exhibits good reinforcing effect. The incorporation of only 7 phr of GNP significantly improves the scorch safety, tensile strength (improvement of ~260%) and thermal conductivity (0.83 W/mK from 0.21 W/mK) for the incompatible EPDM-NBR blend. The morphological analysis revealed that solvent assisted dispersion of GNP exhibits better improvements in cure characteristics as well as mechanical properties compared to the dry mixing accomplished in two-roll. The combination of GNP and other carbon fillers like carbon black (CB) and MWCNT significantly improves the mechanical, electrical and thermal stability properties of elastomer composites compared to individual single filler used in hybrid fillers. The dispersion of GNP in matrix polymer is strongly influenced by the presence of other member of hybrid filler system. Different morphological analyses revealed that CB helps in better delamination of stacked GNP layers, whereas the presence of MWCNT does not improve the dispersion of GNP in the elastomer matrix. Morphological analysis also reveals the formation of some networks of GNP-CB-GNP which accounts for significant improvement in tensile strength and elongation at break compared to that of GNP-MWCNT hybrid system. The improved dispersion of GNP due to delamination of stacked GNP layers in presence of CB generates more new surfaces and increase in surface area for bonding with polymer chains, which accounts for its better dispersion and improvement in polymer-filler interaction and also improvement in mechanical and thermal properties.

Keywords: Dispersion, distribution, elastomer composites, electrical conductivity, mechanical properties, thermal properties, morphology.