Dynamically Vulcanized Rubber/Plastic Blends: Influence of Network Structure on Static and Dynamic Properties

Abstract

Thermoplastic vulcanizates (TPVs) based on poly[styrene-b-(ethylene-co-butylene)-b-styrene] triblock copolymer (S-EB-S)/solution polymerized styrene butadiene rubber (S-SBR) and ethylene octene copolymer (EOC)/natural rubber (NR) have been prepared as potential alternative to conventional S-SBR and NR vulcanizates. The processing parameters have initially been optimized through design of experiment for the binary blends with special reference to the ultimate performance properties. Subsequently, sulphur vulcanization technique has been adopted in order to fabricate the aforesaid TPVs by utilizing the optimized processing conditions through selective cross-linking of the rubber phase. The formation of microstructures and its associated morphological changes during the reprocessing of aforementioned TPVs have been monitored through scanning electron microscopy, transmission electron microscopy and atomic force microscopy. It has further been attempted to envisage the most influential parameters that distinguishes the ultimate performance properties of the designated TPVs. The thorough analyses have confirmed that the formation of disintegrated and agglomerated rubber nano-particles, having average particle size between 80 and 85 nm, has the major influence upon the final performance properties of the respective TPVs. In the TPV composites, the filler particles (carbon black) have depicted phase selective migration tendency toward the less viscous thermoplastic phase at the elevated mixing temperature, leading to the deterioration of performance properties through the reduction in total crystallinity of the thermoplastic phase. This has been theoretically evaluated through thermodynamic calculations, and substantiated by different spectroscopic, microscopic and gravimetric techniques. Finally, a novel characterization method has been developed to evaluate the rubber-like behavior and viscoelastic properties, as reported for the rubber-like materials. Conventional dynamic mechanical analyzer has been utilized in order to characterize the rubber elasticity and dynamic viscoelasticity of the TPV composites. Two independent theoretical approaches *viz*. rubber index and damage parameter, have been adopted in order to evaluate the same. It has been found that the reduced interconnectivity between the rubber domains, which has been obtained as a result of uneven filler dispersion into the rubber phase, has resulted in reduced elasticity in the rubber networks.

Keywords: Thermoplastic vulcanizate, design of experiment, nano-particle, thermodynamic calculation, rubber index.