Study of the Influence of Filler/Polymer Interfacial Characteristics on Bulk Properties of Silicone Nanocomposites

Myriam Paredes, Chitral J. Angammana, and Shesha H. Jayaram
Department of Electrical and Computer Engineering
University of Waterloo, Canada
email: jayaram@uwaterloo.ca

***Abstract*— In comparison to their parent polymer systems, polymer nanocomposites can exhibit superior properties; such as higher strength, greater stiffness, fracture toughness, increased thermal stability, higher chemical resistance, and superior electrical conductivity. The properties of the structure and interface of fillers might have a pronounced effect on the bulk properties of the composite and it is well observed in composite systems with nano fillers having a large surface area. Most importantly, these superior properties can be achieved even at very low filler loading levels, so that the parent polymer matrix does not sacrifice the advantages of low density and high processibility. Chemical bonding between the constituent phases of composite materials is necessary to ensure that the reinforcement of the dispersed phase is transferred to the bulk properties of the composite. In a polymer composite, at microscopic level, the interfacial region is comprised of molecules of the polymer matrix bonded to the surface of the filler particles. These bonds or interactions can be a) chemical bonding between the filler surface and the polymer matrix directly or intermediary coupling agent, b) enthalpic interactions such as London dispersion forces, Columbic interactions, or Hydrogen bonding, and c) entropic effects which are associated with the loss of conformational entropy for a polymer chain due to a nearby impenetrable filler surface. Even though many fundamental studies have been conducted to understand these interactions of micro/nano composites, the mechanisms are still not completely understood. In this work, the filler/polymer surface interactions have been investigated using fumed silica (SiO_2) polymer composites. Polymer composites are made using three different grades of hydrophobic fumed silica with different specific surface areas of 100, 160 and 260 m^2/g in silicone rubber (RTV-615) matrix. The filler/polymer interface characteristics are studied using a variety of in situ methods including atomic force microscopy (AFM), Fourier-transform infrared (FTIR) spectroscopy, and ellipsometry. In addition, ex situ studies were carried out using X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM) to explore the filler composition and morphology.**