Engineered Nanocomposite Materials Properties through Embedding of Smaller Nanoparticles in a Polymer Matrix

Abstract

Polymer nanocomposites are significant for modern and future technologies due to their tailored properties, lightweight and low cost. However, 'forward' engineered polymer (host matrix) composites with smaller size nanoparticles (guest) providing desired properties targeting specific applications remains a challenging task as they depend largely on nanoparticles size, shape and loading (volume fraction). This study develops polymer nanocomposites impregnated with 'organic-inorganic' silsesquioxane nanoparticles and graphene nanoribbons, and investigates microscopic structure and dynamics of interfacial layer to predict macroscale properties. The nanocomposites consist of poly(2-vinylpyridine) (P2VP) polymer (segment ~5nm) with spherical silsesquioxane nanoparticles (diameter ~2-5nm) and planar nitrogenated graphene nanoribbons (lateral dimension ~5-10 nm), both with attractive (hydrogen bonding and electrostatic) interactions. This approach reinforces the role of molecular parameters controlling the structure and dynamics of interfacial layer in predicting properties. The transmission electron microscopy will reveal microscopic structure and the lattice bonding, interfacial stress transfer and conjugation length are determined from micro-Raman spectroscopy. The glass transition temperature, T_g, obtained using differential scanning calorimetry reveals positive shift in T_g values with nanoparticles loadings. We used temperature dependent broadband dielectric spectroscopy to gain fundamental insights into the interfacial layer and diffusion dynamics above and below T_g and to establish quantitative *microstructure-property* correlations.