

Effects of incorporation of silica and zirconia Nanoparticles on the thermal and thermomechanical Properties of polymer nanocomposites

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Hybrid materials of PMMA, Polystyrene & Epoxy consisting of Silica and Zirconia nanoparticles with loadings up to 5 % have been characterized by DSC, TGA, DMA and Nanoindentation techniques. Nanocomposites were prepared via in situ polymerization whereas the dispersibility of the particles in organic media was investigated by dynamic light scattering (DLS), small angle X-ray scattering (SAXS) experiments, and transmission electron microscopy (TEM). We have shown that the size of the nanoparticles has much influence on the properties of the resulting nanocomposite. We were able to synthesize polymer systems filled with small particles (22 nm in size), aggregated at nanometer size only, and well dispersed large particles (66 nm in size). The fillers also formed small primary aggregates of particles, distributed homogeneously in the matrix as shown by SAXS. It was also shown that the hybrid material with high particle contents (over 10 wt %) could not be synthesized due to the formation of agglomerates within the matrix resulting in inhomogeneity. The properties of the resulting nanocomposites were generally superior to the pure polymer matrix. It has also been confirmed that the interface plays an important role in controlling the properties of the hybrid. Composites with strong interface exhibit profound effect on the ultimate properties as clear from the results of high values of damping, glass transition temperature T_g and hardness modulus. The enhanced T_g values observed in the nanocomposites arise from these attractive polymer-nanoparticles interfacial interactions that reduce cooperative segmental mobility. Composites with weak interface showed essentially no change in T_g and damping or even a decline with filler contents. This reduction is ascribed to the free surfaces at the non wetted interfaces of the matrix and nanoparticles that were not well dispersed. The prepared nanocomposite films exhibited somewhat high hardness, better transparency and good thermal stability. On the other hand, incorporation of the particles did not alter the thermal degradation behaviour of PMMA and Epoxy. The uniform dispersion of nanoparticles is critical to the behaviour of the nanocomposites.