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Thermo-mechanical behaviors and moisture absorption of silica nanoparticle reinforcement in epoxy resins

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Abstract

An investigation of the thermo-mechanical behavior of silica nanoparticle reinforcement in two epoxy systems consisting of diglycidyl ether of bisphenol F (DGEBF) and cycloaliphatic epoxy resins was conducted. Silica nanoparticles with an average particle size of 20 nm were used. The mechanical and thermal properties, including coefficient of thermal expansion (CTE), modulus (E), thermal stability (T_d), fracture toughness (K_{IC}), and moisture absorption, were measured and compared against theoretical models. It was revealed that the thermal properties of the epoxy resins improved with silica nanoparticles, indicative of a lower CTE due to the much lower CTE of the fillers, and furthermore, DGEBF achieved even lower CTE than the cycloaliphatic system at the same wt.% filler content. Equally as important, the moduli of the epoxy systems were increased by the addition of the fillers due to the large surface contact created by the silica nanoparticles and the much higher modulus of the filler than the bulk polymer. In general, the measured values of CTE and modulus were in good agreement with the theoretical model predictions. With the Kerner and Halpin-Tsai models, however, a slight deviation was observed at high wt.% of fillers. The addition of silica nanoparticles resulted in an undesirable reduction of glass transition temperature (T_g) of approximately 20 ^oC for the DGEBF