583b Rheology of Carbon Nanofiber/Polystyrene and Nanoclay/Polystyrene Melt Composites

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Rod-like and plate-like nanoparticles (namely carbon nanofibers and nanoclays) were incorporated into a polystyrene (PS) matrix by means of melt blending and solvent casting. The morphology of the nanocomposites was characterized using SEM, TEM and X-ray diffraction. Melt blending by a twin screw extruder was able to disperse the carbon nanofibers (CNFs) uniformly, but at the cost of fiber breakage due to the high shear stress generated by extrusion process. The solvent casting method, utilizing ultrasound waves to disperse CNFs, could disperse the CNFs satisfactorily while preserving the CNG lengths. The nanoclay composites produced by melt blending contain intercalated clay particles.

Our experimental measurements revealed that the aspect ratio of CNFs has profound effect on the rheology of the CNF/PS composites in the melt phase. The elastic modulus G' of the melt blended composites (shorter CNFs) and solvent cast composites (longer CNFs) both increases with higher CNF concentration. G' is found larger for solvent cast composites. Also, at low frequencies, a plateau in G' occurs for SC composites at high CNF concentrations. This solid like behavior indicates that network nanostructure exists in these composites. Solid like behavior is more pronounced in clay/PS composites due to the larger propensity to form network structure for plate-like particles than for rod-like particles. The plateau of G' occurs at a lower particle concentration in clay/PS composites than in CNF/PS composites.

CNF and nanoclay orientation developed in melt processing dictates the properties of the end state, such as modulus and conductivities. Orientation of the carbon nanofibers in shear and extensional flow is characterized using TEM micrographs in two mutually orthogonal planes. The results show that the shear viscosity is able to align the CNFs to the flow direction even at low to moderate shear rates (0.1 to 10 s-1).

A full 3-dimensional thermo-mechanical model based on rigid particles suspended in a viscoelastic matrix has been constructed. This model successfully predicts the measured rheological properties and particle orientation discussed above.