415b Measurements of Particle Orientation in Simple Shear and Channel Flows of Polypropylene/Clay Nanocomposites

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Flow-induced changes in the orientation of dispersed clay particles is expected to have a significant effect on the properties of polymer/clay nanocomposite materials. Here we report studies of flow-induced orientation in dispersions of organically modified montmorillonite clay in polypropylene. The nanocomposite samples were prepared using two methods. Melt blending in a twin-screw extruder led to intercalated samples in which the layered structure of the clay remains intact. An additional step of solid-state shear pulverization leads to samples with a much higher degree of exfoliation of individual clay sheets. In situ x-ray scattering was used to probe particle orientation in steady shear using an annular cone and plate shear cell which provides information about particle orientation in the flow-gradient plane. The more highly exfoliated pulverized sample shows significantly lower orientation than the intercalated melt-blended sample. Both samples were also studied in extrusion-fed channel flows. In slit-channel geometries, the dominant shear rate direction is parallel to the x-ray beam, allowing information about orientation in the flow-vorticity plane to be acquired. In fact, little scattering was observed in these configurations, indicating the tendency of clay particles to 'lie down' in the shear flow. Superposition of extension via contractions or expansions in slit-channel flows did not reorient particles sufficiently to bring them 'into view' in these geometries. Extrusion experiments using a nominally two-dimensional slit flow, in which the beam passes along the vorticity direction, provided the means to obtain orientation data in these samples at higher shear rates than the annular cone and plate shear cell.