DISPERSING LAYERED SILICATES IN POLYMER MELTS: USING MELT RHEOLOGY TO DETERMINE DISPERSION

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Abstract

Polymer nanocomposites have been a keen area of research interest for the past decade. In place of traditional fillers, nanocomposites use significantly smaller amounts of reinforcing material with very high surface area per unit volume. The promise of polymer nanocomposites ranges from improved mechanical strength, reduced thermal expansion, improved barrier properties, decreased flammability, to electrical conductivity, but all of these potential improvements depend on good dispersion of the nanocomposite filler. The goal of this research has been twofold: first, to develop an effective technique in which melt rheology can be used to characterize exfoliation of nanoclay in this important class of materials and to determine the effect that applied stresses have on such polymer nanocomposite systems. To date, the use of melt rheology in characterizing exfoliation in polymer nanocomposites has been limited to qualitative assessment of a solid-like plateau that evolves in the elastic modulus due to the dispersing nanoclay particles forming and acting as a reinforcing network structure typically known as a "house of cards" morphology. By applying scaling laws from fractal gel rheology to linear rheology for polypropylene and polystyrene nanocomposite systems, melt rheology has been used effectively to determine the fractal dimension of the clay network structure in nanocomposites. These scaling laws have also allowed for percolation behavior to be determined for the nanocomposite systems and with it aspect ratios for the particles have been determined. These rheological predictions have shown to prove accurate when compared to direct measurements from X-ray scattering and TEM microscopy analyses.

High shear stress mixing regimens have shown to be successful in creating well dispersed polystyrene nanocomposites. For polypropylene nanocomposites, a new blend creation mechanism, multilayer coextrusion has been employed to make thin films of nanocomposite materials. Characterizing the mechanical and thermal properties of these films suggests multilayer coextrusion can be used to create dispersed nanoclay morphologies in polymer melts. This thesis has provided a new and reliable rheological tool for quickly assessing dispersion and has suggested a new multilayer coextrusion technique to make tailored nanomaterials.