508b Supercritical Carbon Dioxide Exfoliated Polymer Nanocomposites

Steven E. Horsch, Gulay K. Serhatkulu, Rangaramanujam M. Kannan, and Esin Gulari

Achieving a high degree of dispersion of nano-scale fillers in a polymer matrix can lead to significantly improved mechanical and barrier properties, thermal stability, and flame retardancy of a polymer nanocomposite as compared to the pure polymer. A major technical challenge is to significantly exfoliate and evenly disperse naturally layered fillers, such as clays, graphite and carbon nanotubes, in a host polymer matrix. We employ several strategies to delaminate and separate the layers and disperse nano-scale fillers in polymers using supercritical carbon dioxide (scCO2) processing.

The first strategy involves subjecting the nano-scale filler, clay or graphite, to scCO2 for a period and then rapidly depressurizing the system. The processed nano-filler exhibits a volume expansion of approximately 60% when compared with the as-received material and this expansion remains after exposing the processed filler to vacuum and sonication. Wide angle X-ray diffraction of the processed filler reveals a significant reduction in the intensity of the basal-spacing peaks and in some cases the peaks disappear entirely. The second strategy exploits scCO2's ability to swell and plasticize a polymer and facilitate its mixing with the fillers. The polymer and the processed filler are mixed thoroughly and processed in scCO2 at a temperature and pressure suitable for the given polymer/filler system. The degree of filler dispersion is a function of the processing temperature, pressure, and time.

We have investigated high molecular weight polydimethylsiloxane(PDMS)/clay, polystyrene(PS)/clay, thermoplastic polyurethane(TPU)/graphite nanocomposites. The microstrucrture of the nanocomposites are characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM) and rheology. Some benefits of scCO2 processing include 1) use of natural clay instead of chemically modified organoclays, 2) lower processing temperatures avoiding thermal degradation, 3) elimination of organic solvents in processing. Furthermore, these strategies are applicable to a large number of polymer/filler systems.