Nano-particle dispersion technique improves polymers

August 29 2005

Supercritical fluid carbon dioxide used; melt properties provide monitor

There is a lot of excitement about incorporating nano particles into polymers because of the ability to improve various properties with only a small percent of the particles. "You can improve the barrier to gases, such as hydrogen, carbon dioxide, and oxygen. You can increase material strength with little increase in weight," said Don Baird, professor of chemical engineering at Virginia Tech.

But there are problems. "While 1 percent by weight of nano particles will change a material's properties dramatically, 2 or 3 percent provides hardly any additional enhancement," he said. "The particles just clump together, and thereby reduce the advantages associated with the surface area of single particles."

Another problem is that the incorporation of nano particles changes a polymer's flow properties leading to potential processing problems.

Baird's research group at Virginia Tech has developed a method for improving the dispersion, or exfoliation, of individual nano particles into polymers. He will present his research at the 230th American Chemical Society National Meeting, held in Washington, D.C., Aug. 28-Sept. 1. "The paper will present how we are dispersing nano particles and how we are using flow properties to monitor dispersion," he said.

Using supercritical carbon dioxide, the researchers are able to exfoliate nano particles at higher concentrations, leading to further enhancement of mechanical properties than presently possible using just mechanical mixing. "Carbon dioxide is soluble in a lot of polymers. It attaches to the particles so they don't attach to each other, and helps disperse the particles throughout the polymer. It is a benign, natural substance," Baird said.

The rheological properties including the normal stresses (elastic properties) and the stress relaxation response are used to monitor particle dispersion.

The researchers also have discovered that the changed flow behavior is good news – an indication that the material will exhibit improved mechanical properties.

Baird's team observed that nano clay particles well dispersed in polypropylene and polycarbonate plastics tend to promote polymer chain orientation, or alignment, and then retard relaxation or loss of orientation. "The result is they make the polymer chains act like longer or higher molecular weight chains. The material is stronger than one would expect given the size of a polymer chain."

Pointing to a bobbin of fiber, Baird said, "If that contained nano particles and was stretched, it is possible that the fiber could be woven into a vest that would stop a bullet. An ordinary polymer material with well dispersed high levels (8 wt%) of nano particles could have exceptional mechanical properties."

He will present the paper, "Effects of nano clay particles on non-linear rheology of polymer melts (Poly 248)" at 11:20 a.m. Monday, Aug. 29, in the Grand Hyatt Constitution room D-E, as part of the Herman Mark Award program honoring Don Paul.

Learn more about Baird's research at www.che.vt.edu/baird/baird.htm

Source: Virginia Tech