Functionalization of Carbon Nanofibers Followed by In-Situ Polymerization to Form Nanocomposites

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There is an increasing interest in developing composite materials that combine the desirable properties of inorganic materials (e.g. high strength, electrical conductivity, thermal stability) with the advantages of polymers (processing ease, corrosion resistance, flexibility). While nanocomposite materials based on polymeric matrices and inorganic fibers have tremendous potential for advances in material performance, they have yet to achieve expected properties based on pure component properties. This has been attributed to a mismatch between surface of fiber and polymer matrix that leads to a poor adhesion at matrix-filler interface. In addition, poor distribution of nanofibers within the matrix results from combination of structure mismatch and processing of composites using bulk mixing techniques.[1,2] This presentation will focus on efforts to use fiber functionalization followed by in-situ polymerization as a method to improve compatibility and dispersion of carbon nanofibers within specific polymer matrices.

Results for two very different polymeric systems (i) a typical commercial thermoplastic polyimide (6FDA-PDA) and (ii) thermosetting vinyl ester resin will be presented. In both cases, oxidized carbon nanofibers supplied by Applied Sciences Inc. were functionalized with monomers that can participate in the polymerization reaction. The functionalized nanofibers were added to the polymerization mixture and polymerization proceeded using well-established techniques[3-7]. This paper will focus on functionalization chemistry and polymerization for each of these polymer systems. In addition, the mechanical and thermal degradation properties of resulting nanocomposite materials for different functionalization chemistries and fiber loading will be presented.

For the polyimide system, Raman and thermal gravimetric analysis indicate that the carbon nanofibers were functionalized with the diamine, PDA, via intermediate reaction with thionyl chloride. In-situ polymerization of the polyimide 6FDA-PDA in the presence of either oxidized or functionalized fiber resulted in formation of high molecular weight polymer. Preliminary dynamic mechanical data indicates that polymer was formed was formed on the surface of the functionalized fiber but not the oxidized fiber. Nanocomposites based on polymers synthesized in presence of functionalized fibers exhibited improved mechanical properties relative to the base polymer matrices.

References

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