IOWA STATE UNIVERSITY

Materials Science & Engineering Department

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Preliminary Oral Examination
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"Fabrication and Characterization of Novel Epoxy Matrix Nanocomposites"

Reducing the cost of the production of polymer matrix composites that contain nano-scale additives is important for expanding the application of nanocomposites today. Understanding the principles that underlie the controlled structure in nanocomposites is also critical in guiding the design of innovative materials with desired properties. In this research, both of these aspects are addressed.

Carbon fiber reinforced polymer matrix (CFRP) composites are attracting a growing demand from automotive and wind turbine blade industries in recent decades because of their light weight and excellent mechanical properties. The high cost of conventional precursors, to produce carbon fibers, prevents the wide use of CFRP composites in non-aerospace structural applications. Lignin is an aromatic-structured biopolymer obtained from wood. It is inexpensive, renewable and already oxidized, and therefore considered a promising precursor for low-cost carbon fibers. In this work, electrospun carbon nanofiber mats have been produced from lignin/polyacrylonitrile (PAN) blends. The increased surface-to-volume ratio of fibers as their cross-section is scaled down to the nanometer range is expected to give better interaction between the fibers and a polymer matrix, leading to better reinforcement than from conventional carbon microfibers. In this research, lignin/PAN-based carbon nanofiber mats have been fabricated and characterized with an emphasis on understanding their processing-structure-property relation. The mechanical properties of CFRP nanocomposites formed by embedding the nanofiber mats within an epoxy matrix will be optimized in proposed work, by tailoring the diameter and alignment of the carbon nanofibers.

Polycyclic aromatic hydrocarbons (PAHs) epoxy nanocomposites, in another aspect, are of increasing interest in various applications because not only do they offer multifunctional properties but also the fundamental physical properties of the host polymer are typically improved by incorporation of the nanofillers. In this research, PAH epoxy nanocomposites will be investigated using broadband dielectric spectroscopy, a powerful tool to analyze molecular dynamics in polymer systems. Parametric model fitting using the Havriliak-Negami approach will be applied to characterize the dielectric relaxation processes as a function of frequency and temperature, for various loadings of nanofiller, in order to understand the mechanism of the reinforcement of epoxy containing PAH nanofillers.