IOWA STATE UNIVERSITY

Materials Science & Engineering Department

Danny Vennerberg

Final Oral Examination
PhD Student with Michael Kessler

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"Development of scalable methods for the utilization of multi-walled carbon nanotubes in polymer and metal matrix composites"

Multi-walled carbon nanotubes (MWCNTs) have received considerable attention as reinforcement for composites due to their high tensile strength, stiffness, electrical conductivity and thermal conductivity as well as their low coefficient of thermal expansion. However, despite the availability of huge quantities of low-cost, commercially synthesized nanotubes, the utilization of MWCNTs in engineering composites is extremely limited due to difficulties in achieving uniform dispersion and strong interfacial bonding with the matrix. A proven method of enhancing the nanotube-polymer interface and degree of MWCNT dispersion involves functionalizing the MWCNTs through oxidation with strong acids. While effective at laboratory scales, this technique is not well-suited for large-scale operations due to long processing times, poor yield, safety hazards, and environmental concerns.

This work aims to find scalable solutions to several of the challenges associated with the fabrication of MWCNT-reinforced composites. A rapid, dry, and cost-effective method of oxidizing MWCNTs with O_3 in a fluidized bed was developed as an alternative to acid oxidation. Oxidized MWCNTs were further functionalized with silane coupling agents using water and supercritical carbon dioxide as solvents in order to endow the MWCNTs with matrix-specific functionalities. The effect of silanization on the cure kinetics, rheological behavior, and thermo-mechanical properties of a model epoxy nanocomposites were investigated.

In order to achieve composite properties approaching those of individual nanotubes, new approaches are needed to allow for high loadings of MWCNTs. One strategy involves making macroscopic mats of nanotubes called buckypaper (BP) and subsequently infiltrating the mats with resin in processes familiar to traditional fiber-reinforced composites. The latter part of this talk will outline a new method of producing BP comprised of oriented nanotubes through the use of a modified Taylor-Couette setup capable of simultaneously shearing and filtering an aqueous MWCNT dispersion. BP produced with this setup exhibited anisotropic electrical and mechanical properties as a result of the nanotube alignment.