Monthly Progress Report

For the project (CCRP 2002-03):

Nanocomposite Materials

By

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MONTHLY UPDATE REPORTING THE RECENT WORK UP TO AUGUST 10, 2003

ACCOMPLISHMENTS
In the month of July we have continued to develop and test different methods for functionalizing nanotubes. We have also cast and tested nanocomposite samples. We have also grown nanotubes. The progress is explained below.

Overall, it appears that for cases of functionalized MWCNT that are up to 5% by weight of the epoxy nanocomposite, we now show a modest improvement in properties. Previously we had shown a decrease in properties for lower % loading in epoxy. In polystyrene we have improvement up to about 5% loading. The improved results are due to improved dispersion of the nanotubes and other changes in processing. Continued improvement is expected and improvement is also expected with SWCNT nanocomposites.

Task 1: Nanotube Synthesis (~6% effort)
We grew SWCNT using our nanofurnace. ESEM images confirmed the quality of the nanotubes. A few ribbon like structures also appeared which are interesting. We are going to purify the nanotubes and use in our experiments so that we do not have to purchase the SWCNT. The students Sachin and Atul are working on nanotube synthesis with help from Tony. (Note that this work on the nanofurnace is supported by other means including a UC summer student fellowship and a $5,000 grant from the UC to develop nanotube synthesis at the UC.)

Task 2: Coating and Dispersion of Nanotubes (~47% effort)
We are continuing to develop several methods to functionalize nanotubes. The progress is summarized next.

Solvent free functionalization. We ran three experiments and collected enough MWCNT to make a 0.5% sample using epoxy in the thin plate mold. The sample has some variations in thickness and surface porosity. The sample will be electrically and mechanically tested for experience and the process will be repeated. This is the first time epoxy was cast in this mold. We will try with clear epoxy before trying with nanotubes again. The student Suhasini is leading this work with help from Tony.

Plasma treatment with no monomer. This experiment is to see if there is any effect of the plasma alone. This experiment was done by the student Tony using MWCNT which were cast in polystyrene. These are being tested for elastic modulus and strength.

Nanotube Alignment. Dr. Shi has returned from France and has nanotubes aligned magnetically transverse to the plane of the composite. The degree of alignment is to be characterized.

Task 3: Fabrication and Characterization of Nanocomposites (~47% effort)
We have been testing samples and making several changes in our procedure. The main results are discussed below.

Alignment of nanotubes. After several not successful but learning experiments, the students Phil and Nicole are making further changes to the thin film alignment mold, mainly to pressurize the mold so that it is completely filled. Thus far, the mold is not completely filling. Doug Hurd has machined most of the mold with help from Phil.

MWCNT Epoxy Testing. A number of CNT epoxy cylindrical samples were cast and the mechanical properties determined. The MWCNT coated with acrylic acid showed a 17% increase in elastic modulus for 1% by weight of randomly aligned nanotubes in epoxy. The improvement is due to better dispersion.
of the nanotubes by sonicating at elevated temperature for a longer time. Also, the nanotubes were pressurized up to 6,000 psi in the mold at room temperature and then cast with no pressure. This improvement in processing was done by the student Nicole. Once the new procedure is finalized, a set of 0%, 1%, 3%, 5%, and 10% samples will be made to verify the improvement.

**SWCNT Epoxy Testing.** Functionalization and testing of samples is underway by the student Srilaxmi.

**Other progress.** We will be receiving funds for instrumentation to build a reconfigurable furnace with a floating catalyst to grow long nanotubes as part of a Hayes Investment Fund award to Dr. Jim Boerio of the UC. Mark Schulz was one of the Co-PI’s on this proposal. Don Bailey gave us suggestions on our presentation to the OBR which helped us get the grant.

**Continuing work.**
We have been reviewing the literature and are making changes to our processing based on results in the literature and based on our experiments. Some of the changes we are working on are below.
1. Building an experiment to use sonication during curing, the equipment has been ordered from other funds to try this experiment,
2. use longer times for dispersion using sonication and mechanical mixing at elevated temperature,
3. improving the three functionalization methods that we are focusing on (i.e. the plasma coating, solvent-free, and surfactant methods) by processing, casting, mechanical testing, evaluation, modification and repetition, and
4. making more Environmental Scanning Electron Microscopy (ESEM) images of the nanocomposites.

It should be noted that Dr. Jim Boerio and his student Jennifer are also helping us with the functionalization.

Please send any questions or corrections that should be made to this monthly update to me. Thank you.
Mark Schulz.