OAI Progress Report for the project (CCRP 2002-03)

NANOCOMPOSITE MATERIALS

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TASK 1: NANOTUBE SYNTHESIS (6% effort)
ESEM showing possible nanotube ribbons grown at UC that could be used to reinforce composites
AFM image of UC nanotubes
(image by FirstNano for information, not done as part of OAI project)
TASK 2. COATING AND DISPERSION OF NANOTUBES (47% effort)
Plasma Processing Parameters

- Basic pressure: < 40 mTorr
- Monomer used: C6F14
- Monomer pressure: 200 ~ 250 mTorr
- System total pressure: < 300 mTorr
- RF frequency: 13.56 MHz
- Input power: 5-30 Watt
- Treatment time: 5-30 minutes
- Per batch: 0.2-1 grams
SEM micrograph showing uncoated CNT clusters

SEM micrograph showing well dispersed coated CNT's in the polymer matrix

Results using Polystyrene Composite
(D. Shi and T. He)
TASK 3: FABRICATION & CHARACTERIZATION OF NANOCOMPOSITES (47% effort)
MWCNT Polystyrene Nanocomposite Tensile Test Samples
MWCNT Polystyrene Nanocomposite Tensile Test Samples
(D. Shi and T. He)

Strength of the coated and uncoated polystyrene CNT composite
(maximum increase in strength is ~25%)
MWCNT Polystyrene Nanocomposite Tensile Test Samples
(D. Shi and T. He)

Elastic modulus of the coated and uncoated polystyrene CNT composite
(maximum increase in modulus is ~10%)
MWCNT Polystyrene Nanocomposite Tensile Test Samples (D. Shi and T. He)

Failure surface showing holes from fiber pullout for uncoated MWCNT
MWCNT Polystyrene Nanocomposite Tensile Test Samples

Failure surface and fiber pullout with uncoated MWCNT
MWCNT Polystyrene Nanocomposite Tensile Test Samples

Failure surface with coated well dispersed MWCNT
Reinforcement of Polymers

- **Functionalization of MWCNT different ways:**
  - Acrylic acid plasma coating, results presented in figures
  - Water plasma coating, worse than acrylic acid
  - Solvent-free functionalization, one test no improvement, still developing process
  - Dispersion in surfactant (soap water), to test sample

- **Initial Results:** Strength/modulus far below predictions, retained strain to failure, trying to improve processing

- **Epoxy- 15% MWCNT**
  - 23% inc. comp. modulus
  - 25% inc. comp. strength

- **Polystyrene- 3% MWCNT**
  - 10% inc. tens. modulus
  - 25% inc. tens. strength

Previous results of compressive elastic modulus and strength of MWCNT Epoxy coated with acrylic acid
Mold being developed to align nanotubes in epoxy
Solvent free functionalization approach in work
(after J.M. Tour, Rice University)
CONCLUSIONS

1. Nanocomposite properties far below predictions
   • Plasma coating improves dispersion but agglomeration occurs at higher percentages of loading of nanotubes

2. Processing and properties improving
   • Gradual improvement in elastic properties
   • Good electrical conductivity

3. Continuing Work
   • Functionalization by different methods
   • Molds being modified/developed
   • Alignment of nanotubes will be attempted by two methods to tailor thermal conductivity and improve elastic properties
     • Magnetic alignment
     • Ultrasound during polymerization for dispersion and alignment
   • More SEM and TEM studies