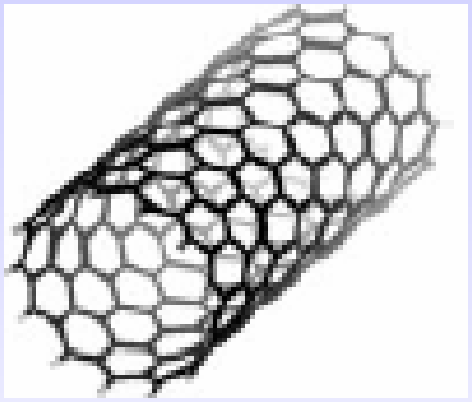
Polymer/carbon nanotubes composite

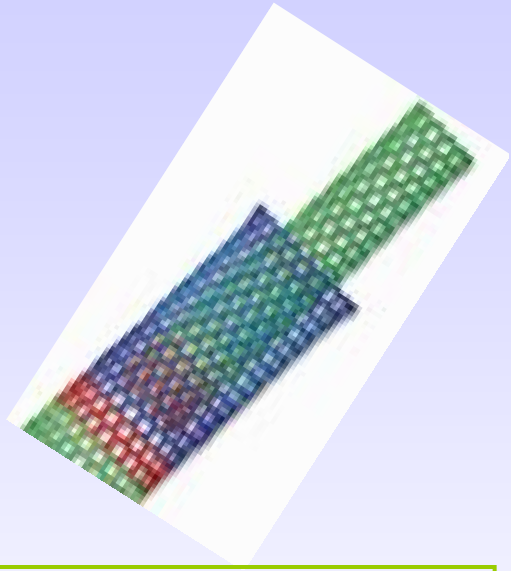
Asif Rasheed
Department of Chemistry
800 West Main Street, Whitewater, WI 53190
University of Wisconsin, Whitewater
rasheeda@uww.edu

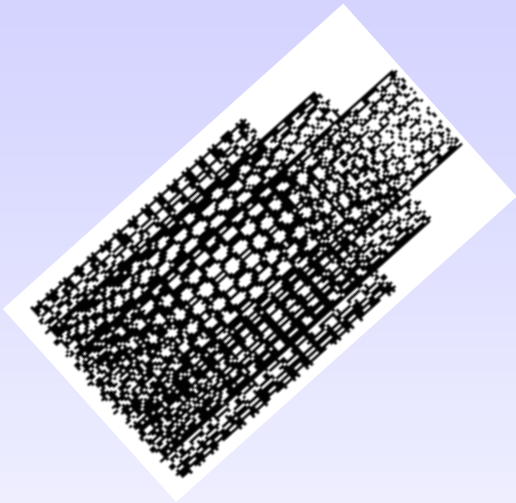
January 8, 2008

Carbon Nanotubes: ~15 years old!

More than 21,000 research publications to date







SWNT first observed in 1993
Diameter: 0.4 to 3 nm

DWNT first observed in 1996
Diameter: 2 to 6 nm

MWNT first observed in 1991
Diameter: 4 to 50 nm

Young's Modulus ~ 1 tera pascal
Electrical Conductivity
Stronger than Steel at $1/6^{th}$ of weight
Thermal Conductivity

Research/Collaborative Interests

- Carbon nanotubes and nanofibers
- Polymer nanocomposites
- Nanocomposites characterization
- Biocompatible/biodegradable polymer blends & composites

- PS, PMMA, PAN, PSVPh
- Cellulose, silk
- SWNT, MWNT, VGCNF
- Films and fibers

- Mechanical, Thermal & Electrical properties
- Morphology/Structure
- State of nano-filler dispersion
- Nano-filler/matrix interaction

Current Research / Potential Outcomes

- Nanocomposites of natural polymers (cellulose, silk) processed from ionic liquid (On-going)
  - Electro active paper (EAPap)
  - Actuator/sensors
  - Fabric for fire barrier application

- Microwave-Assisted In-situ polymerization to create polymer/CNT nanocomposites
  - High strength/Light weight composite material
  - Electrically conductive
  - Thermal and dimensional stability

Facility/Expertise Needed

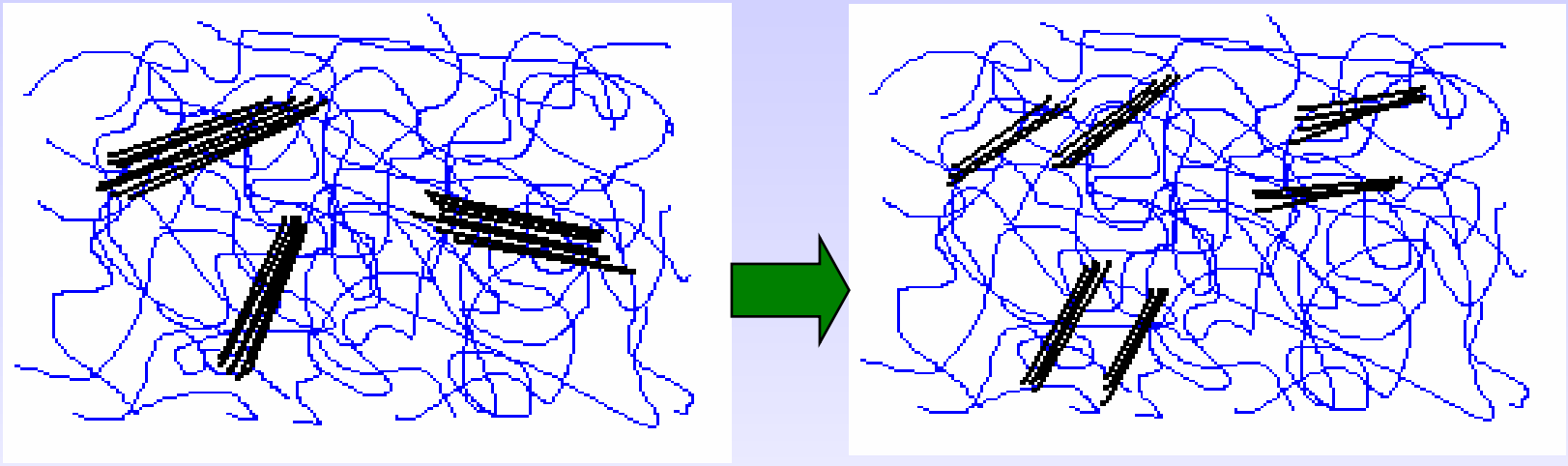
- Mechanical and thermal characterization (tensile testing, DMA etc)
- XRD

Instrumentation Available

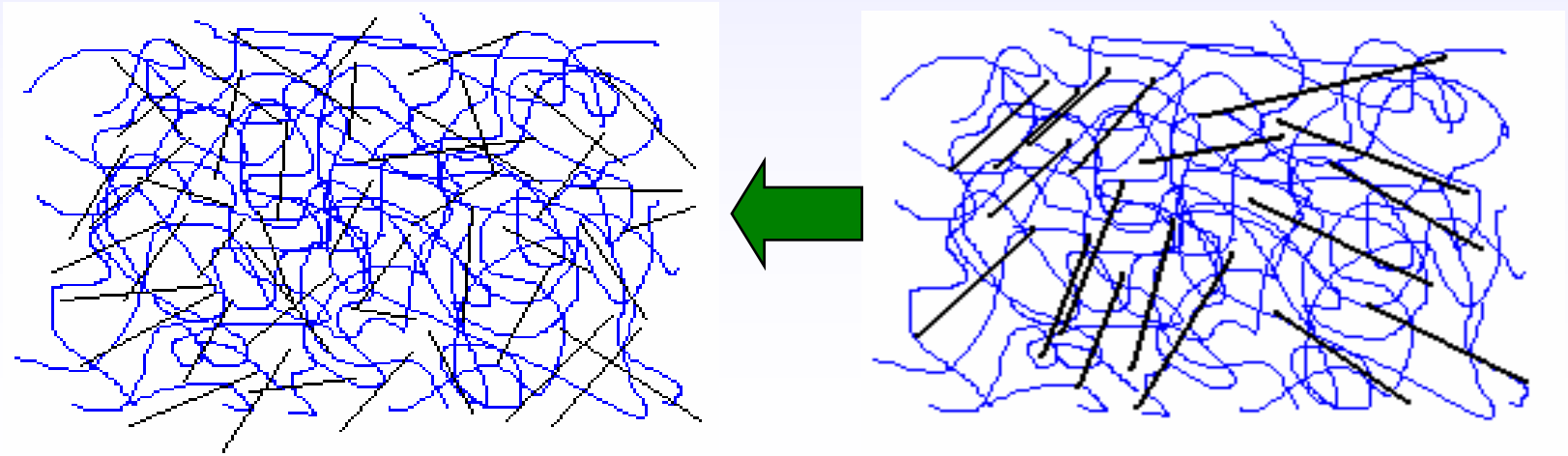
- Electron Spin Resonance (Bruker EMX)
- SEM (Joel JSM-6390)
- Spectroscopy (FTIR, UV-Vis, Florescence, AA)

Bruker EMX ESR

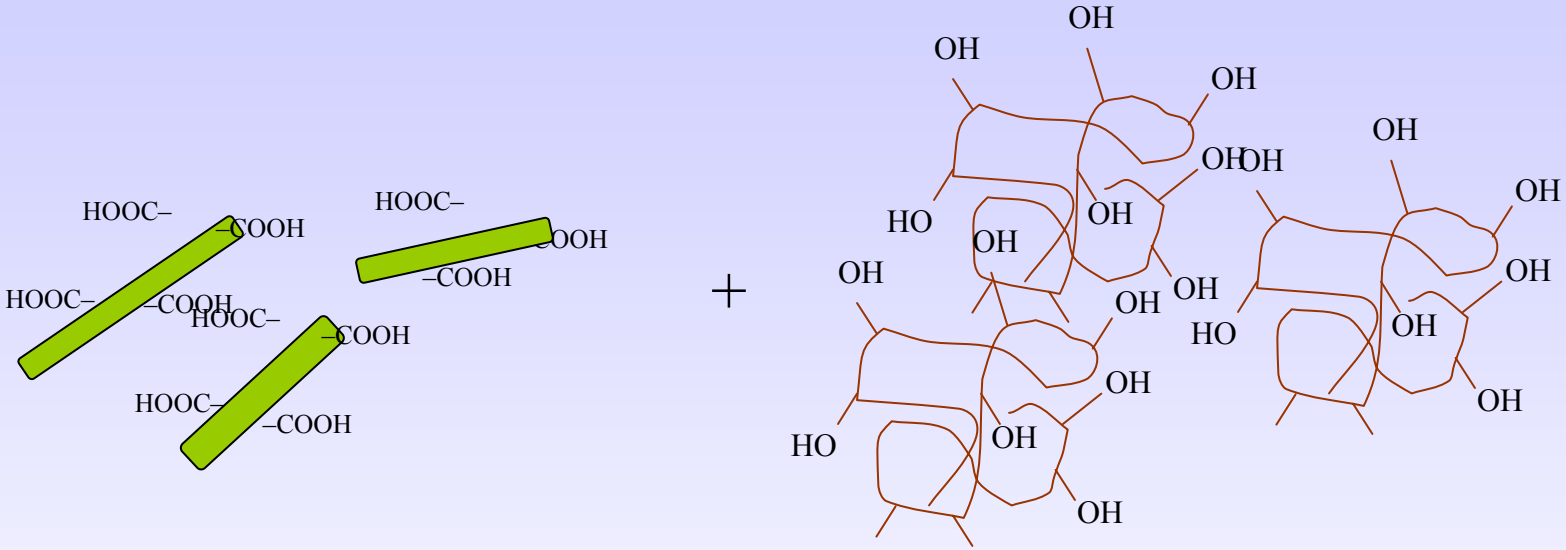
Polymer-CNT Composites



Challenge: Dispersion!!

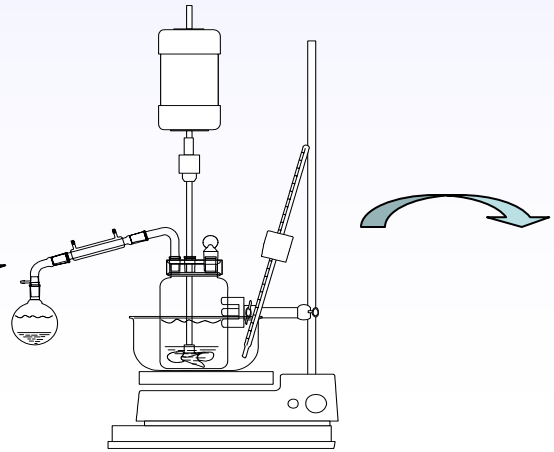


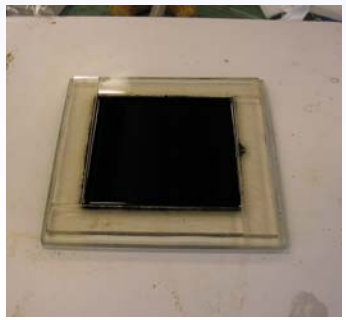
Intermolecular Hydrogen Bonding between CNTs and PSVPh



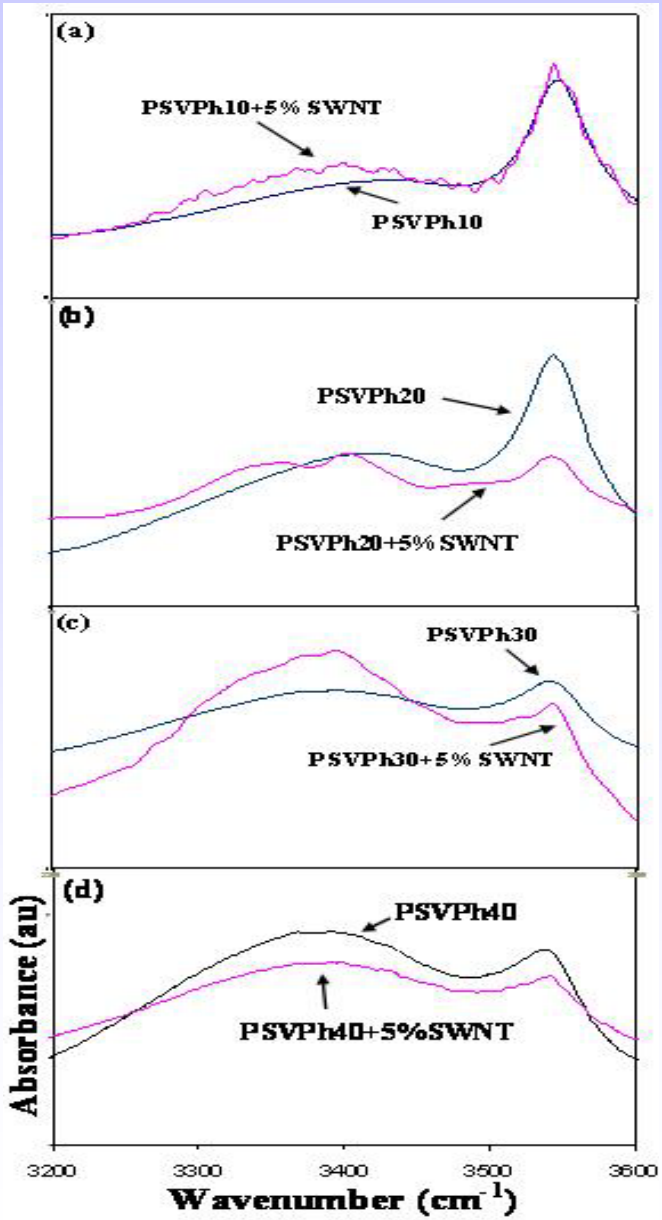
5 wt% SWNT composites with PSVPh (varying amounts of vinyl phenol)

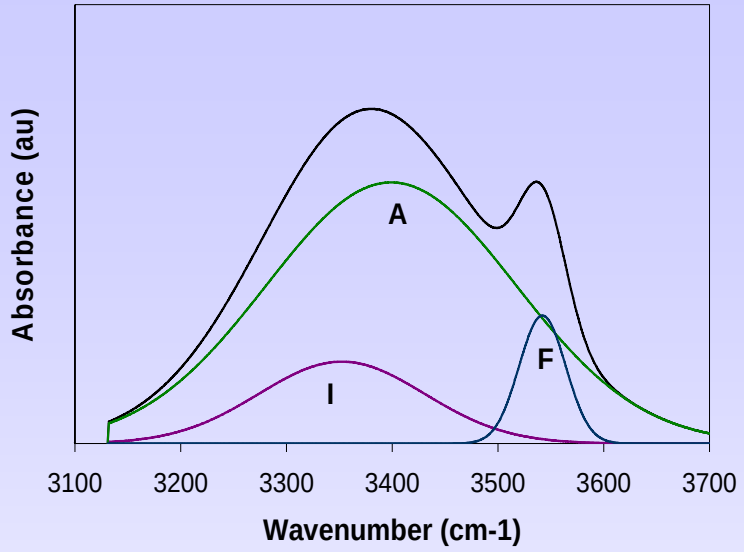
CNT Sonication

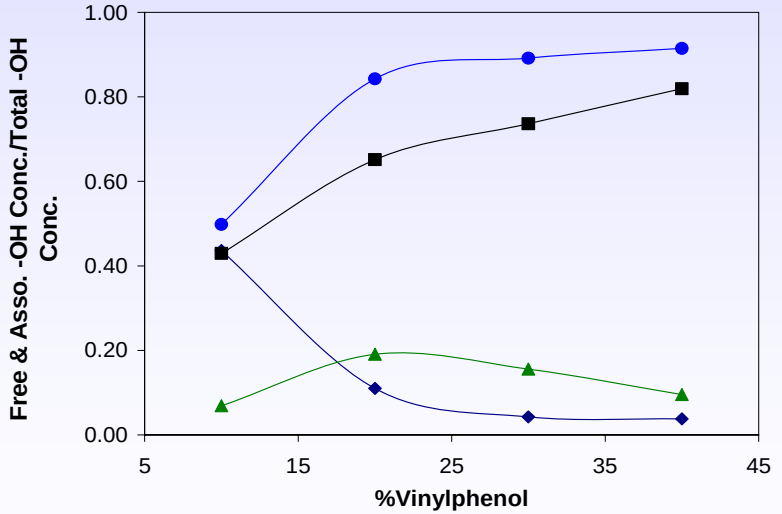




FTIR Spectroscopy of PSVPh-SWNT Nanocomposites





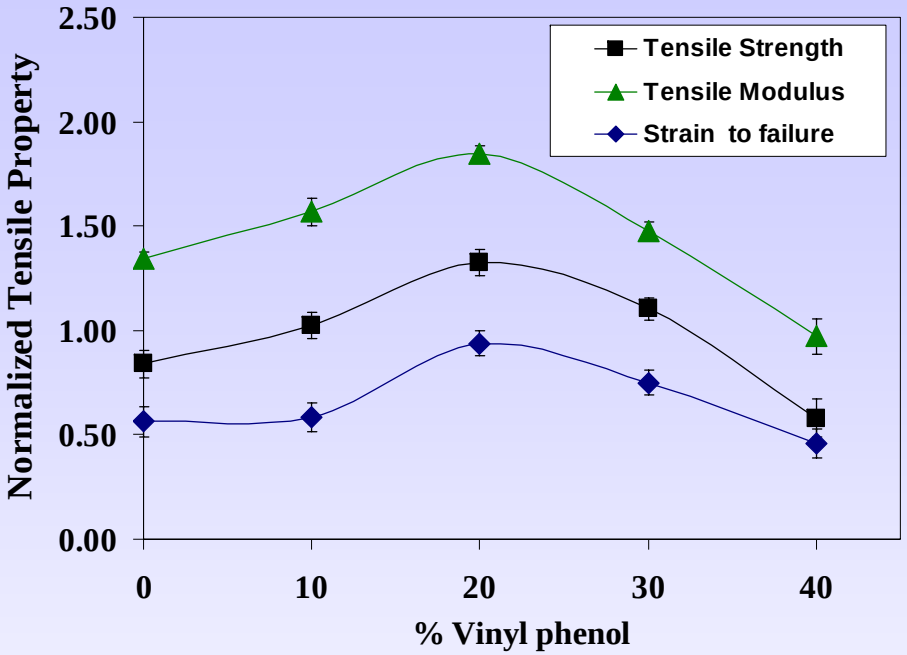


$C_{F,\text{-OH}}/C_{T,\text{-OH}}$ (♦), $C_{asso,\text{-OH}}/C_{T,\text{-OH}}$ (●)

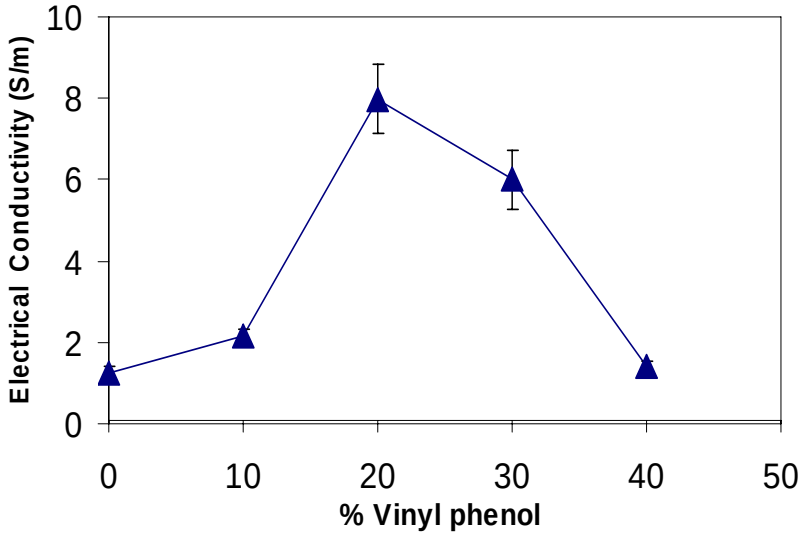
$C_{A,\text{-OH}}/C_{T,\text{-OH}}$ (■), $C_{I,\text{-OH}}/C_{T,\text{-OH}}$ (▲)

Rasheed et al, Polymer (2006), 47(13), 4734-4741

Tensile Test



Electrical Conductivity



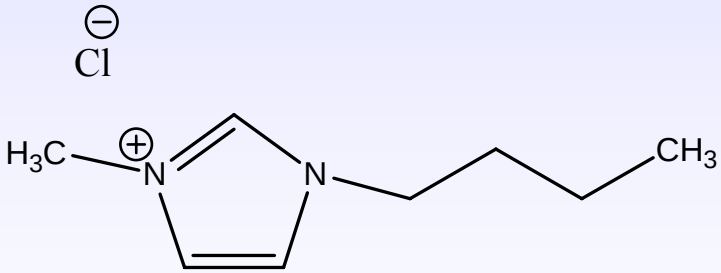
Conclusions

- Optimization of interaction does enhance dispersion of nanotubes in polymer matrix
- Optimized interaction correlates to the property enhancement in the nanocomposite

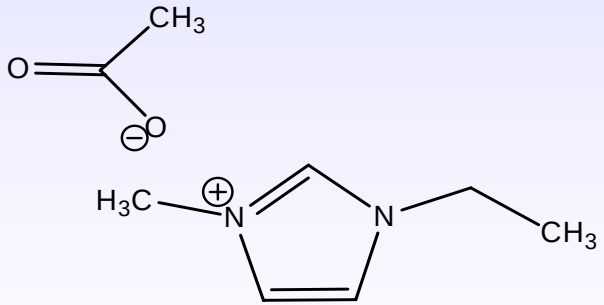
Rasheed et al, Polymer (2006), 47(13), 4734-4741

Current Work: Cellulose/CNT Composites Processing via "Green Route"

- Cellulose, most abundant natural polymer, has estimated 1.5 * 10^{12} tonnes per annum production world wide*
- Approx. 80% wood pulp processed by Kraft process
- Kraft process utilizes NaOH and Na_2S to digest the wood and generates H_2S, CH_3SH, CH_3SCH_3
- Ionic liquids have low volatility, hence considered as environmental friendly or "green" solvents
- Ionic liquids are known to assist CNT dispersion
- Recent studies show solubility of cellulose in ionic liquids**



1-butyl-3-methylimidazolium chloride (BMI Chloride)



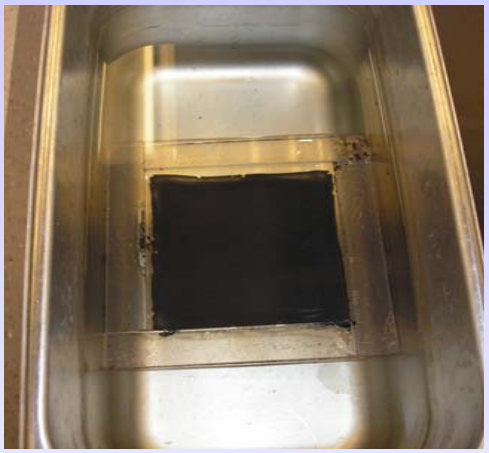
1-ethyl-3-methylimidazolium acetate (EMI acetate)

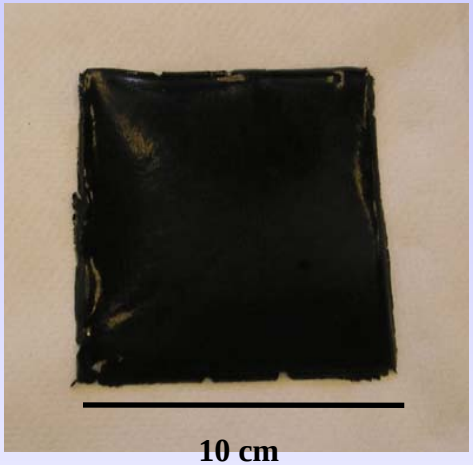
Shigeru Deguchi, Kaoru Tsujii and Koki Horikoshi Chem Commun., **2006, 3293 - 3295*

***Swatloski et al, J. Am. Chem. Soc. 2002, 124, 4974-4975*

***Gupta et al, Langmuir 2007, 23(3) 1325-1319*

Cellulose+1%MWNT Composite Paper





From ~ 3 wt % Cellulose/MWNT in EMI acetate solution dispersed by mechanical stirring

Coagulated in ethanol bath

Further/On going Work

- Process conducting paper of cellulose/MWNT using varying loadings of MWNT
- Processing conducting paper of cellulose using SWNT and VGCNF at varying NT loadings
- Characterization: Mechanical strength, electrical conductivity, state of CNT dispersion

Thanks

WiSys, UW Platteville & Sponsors