AMINO FUNCTIONALIZATION OF MWNT AND ITS EFFECT ON ILSS OF HYBRID NANOCOMPOSITES

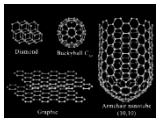
Chandrasekaran, V.C.S., Santare M.H., Krishnan P., Advani S.G.

University of Delaware . Center for Composite Materials . Department of Mechanical Engineering

INTERLAMINAR SHEAR STRENGTH (ILSS)

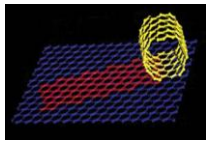
- ILSS - limiting factor in structural applications of laminated composites
- In plane properties depend on fibers
- Out of plane/through thickness properties depend on matrix between laminas
- ILSS – Matrix dominated
- Matrix becomes the weakest link
- Reinforcing the Matrix helps increase ILSS
- Nanofillers due to their high specific surface area, help in load transfer and reinforce the matrix

WHY CARBON NANOTUBES?



The Carbon nanotube (CNT)

Iijima S.1991



The CNT can be deemed as a rolling cylinder from graphite sheet. (Berkeley research review)

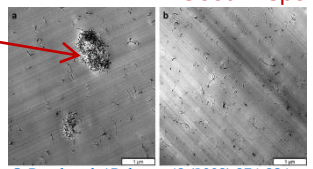
	CNT	Comments
Tensile modulus	270GPa~1 TPa *Lu JP. et al. 1997*	10-100 times higher than the strongest steel
Maximum tensile strength	11~200GPa *Li F. el. 2000*	4 times higher
Thermal Conductivity	~ 2000 W/m/K *J. Hone et al. 1999*	Twice as high as diamond
Maximum Current Density	10^{13} A/m2 *Stefan Frank et al. 1998*	1000times higher than copper wires
Aspect radio	~1000	

Unique Properties of CNT

Critical aspects for effective reinforcement

Good Dispersion

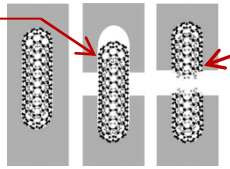
Agglomerates Can act as Stress raisers



S. Pegel et al. / Polymer 49 (2008) 974-984

Interfacial Stress Transfer/Interfacial bonding

Poor adhesion Leads to debonding Of CNT

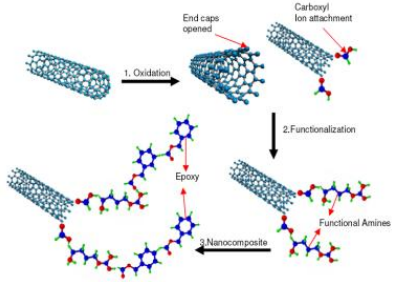


Good Adhesion Results in effective reinforcement

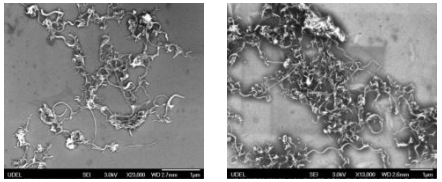
F.H. Gojny et al. / Composites Science and Technology 65 (2005) 2300–2313

FUNCTIONALIZATION

- Addition of Amino Functional groups to CNT helps in dispersion of CNT due to steric repulsion of functional groups
- Amino functionalgroups provides a strong interfacial adhesion due to their compatibility with both epoxy and CNT,



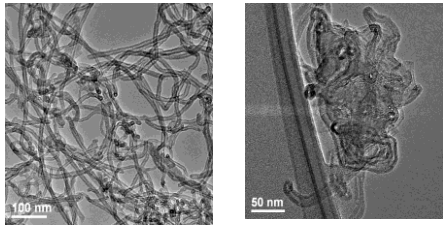
SEM



Functionalized Nanotubes — Pristine Nanotubes

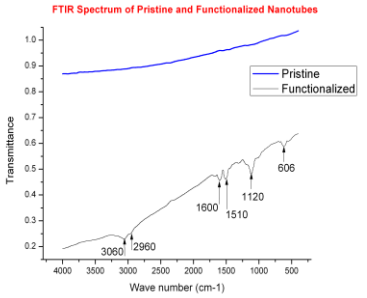
Functionalized CNTs dispersed well compared with unfunctionalized CNTs

TEM



Functionalized Nanotubes — Pristine Nanotubes

Less agglomerates in functionalized CNTs when compared with unfunctionalized CNTs



3060, 2960 ----- NH Stretching in CONH, NH_2, NH
1600 ---------- C=0 Stretching
1510, 606--------- N-H distortion
1120---------- C-N Stretching

FTIR confirms the presence of amino functional groups

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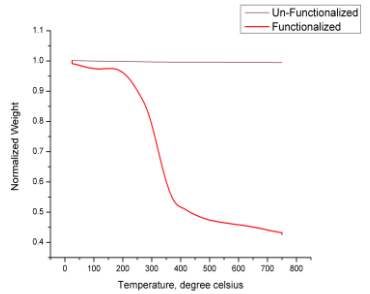
(Continued)

THERMO GRAVIMETRIC ANALYSIS (TGA)



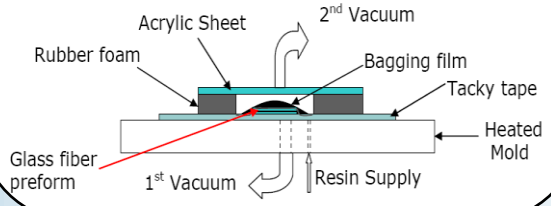
53% of weight loss in functionalized CNT around 200 – 400^0 C when Compared with un-functionalized CNT indicates the presence of organic Groups and the extent of functionalization

MANUFACTURING

Dispersion of CNTs in resin by tip sonication method

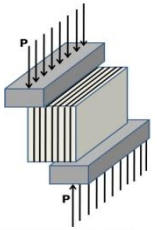
Infusion of CNT modified resin into glass fiber mats using Flow flooded chamber (FFC), a modified VARTM Process

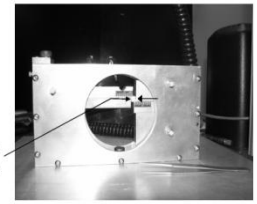
FFC



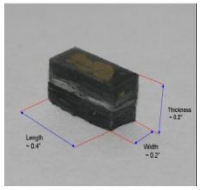
COMPRESSION SHEAR TEST (CST)

CST gives a simpler and more well defined shear stress distribution compared to short beam shear Test

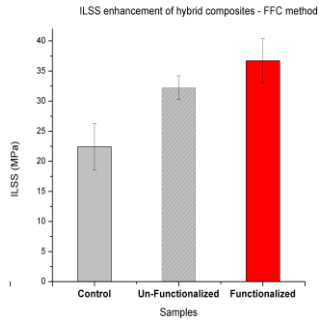




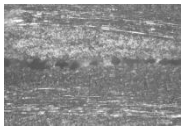
CST fixture



Test Specimen

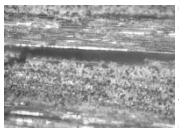


FRACTURE SAMPLES



Un-Functionalized

Functionalized



Control

Control sample :
Crack propagates along interface
Functionalized & Unfunctionalized sample :
Crack propagates through glass fiber Tows, possibly indicating a better adhesion

All images taken @ 10 X

CONCLUSION

- Functionalized MWNT shows 61% improvement in ILSS compared to unmodified epoxy
- Functionalized MWNTs shows 14% improvement in ILSS compared to Unfunctionalized MWNT
- Better dispersion due to repulsion between functional groups on the surface of nanotubes
- Better adhesion evident from fracture samples

ACKNOWLEDGEMENTS

Dr.Giriprasath Gururajan, Dept. of Materials Science & Eng., UD
Carl Giller, Dept. of Materials Science & Eng., UD
Dr.Chaoying Ni, Dept. of Materials Science & Eng., UD
Jennifer Mueller, Dept. of Materials Science & Eng., UD
Hassnein Ghulam Jaffari, Dept. of Physics and Astronomy, UD
Levent Colak, Dept .of Physics and Astronomy, UD
Srinivasan Balakrishnan, Dept. of Physics and Astronomy, UD
Dr. Molly Jean O' Hagan, Chemistry and Biochemistry, UD
Dr. Dennis Kissounko, Center for Composite Materials, UD
Center for Composite Materials, UD
Mid Atlantic Industrial Assessment Centre, UD

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