

Techniques for Determining Material Properties for Advanced Materials



Greg Doud

RAM V

October 16 – 17 2012

Introduction

- Advances in materials science have revealed a lightweight high strength substance known as carbon fiber.
- Involved in research to develop an Ionic Liquid (IL) processed Rayon carbon fibers (cellulose based) .
- Two types of traditionally processed Carbon fibers currently exist.
- Carbon Polyacrylonitrile (PAN) (petroleum based), and Carbon Viscose Rayon (cellulose based).
- These cellulose based carbon fibers yield a material with low thermal conductivity properties important in applications for rocket nozzles and heat shields.

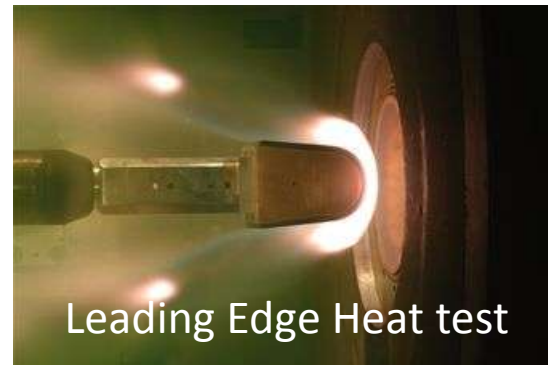


Carbon Fiber Types

- Carbon (PAN) fibers possess high thermal conductivity, electrical conductivity, and strength properties.
- Commercial products include cars, skateboards, airplanes
- Carbon Viscose Rayon produced by North American Rayon Corporation (NARC) is cellulose based, its production is cost prohibitive in the United States.
- Used for heat shielding



McLaren Monocell MP4 12 C



Leading Edge Heat test

Importance

- The production of NARC became cost prohibitive to produce within the U.S. due to environmental regulations in the year 2000.
- The United States supply of NARC will eventually run out and a non-cost prohibitive replacement is needed.



Desired Properties

- Looking for desirable properties of the fibers created by the new IL process.
 - Thermal
 - Strength
- The goal of this research is to produce an IL processed carbon fiber equivalent to Carbon Viscose Rayon (NARC).
- Many challenges are involved in both creating and testing these fibers.



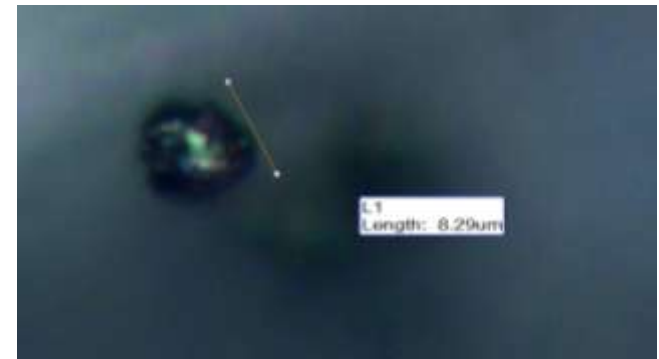
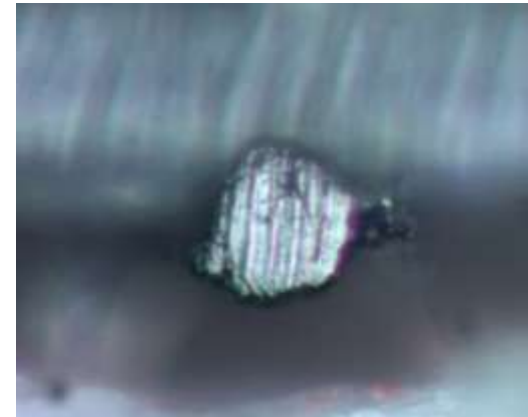
Morphology

- Determination of a materials physical properties i.e. the study of shape, size, texture and phase distribution of physical objects
- Desired fiber diameter of $\sim 20\mu\text{m}$ ($20 \times 10^{-6}\text{m}$)
- The diameter of a human hair is $\sim 120\mu\text{m}$

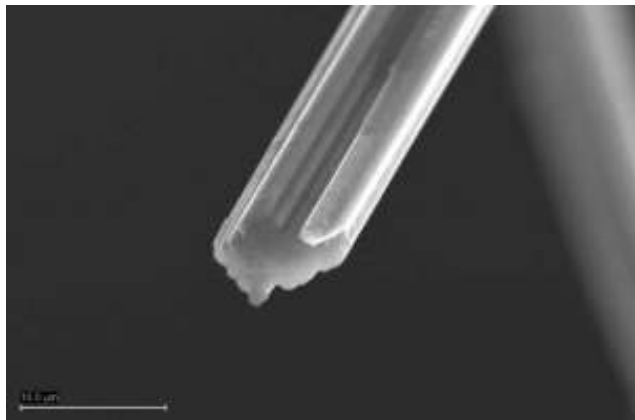
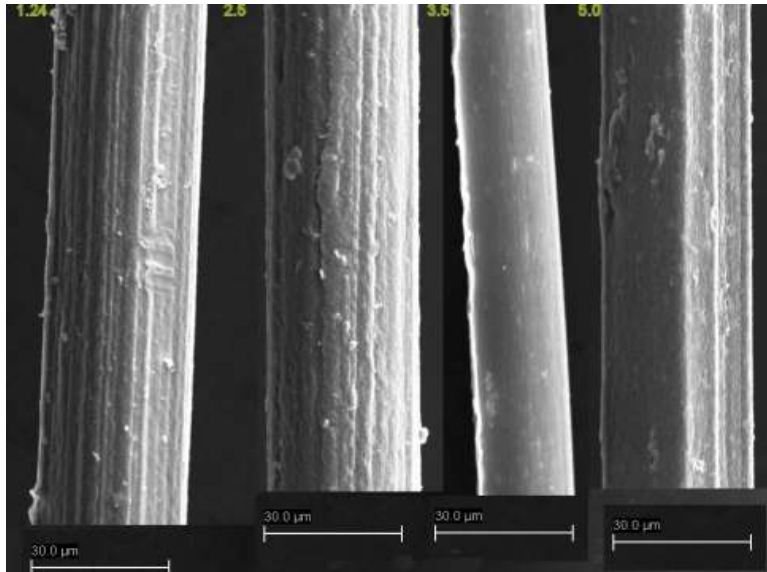


Optical Microscopy

- Pot fibers in a casting resin
- Typically an epoxy or polyester
- Potted sample is polished and mounted
- Cross sectional analysis performed in Microscope



Scanning Electron Microscopy (SEM)



- Involves applying a conductive coating to specimens of interest
- Highly detailed images can be achieved of small objects
- Imperfections/quality of experimental fibers
- Specimens bombarded with electrons
- No significant effect on surface

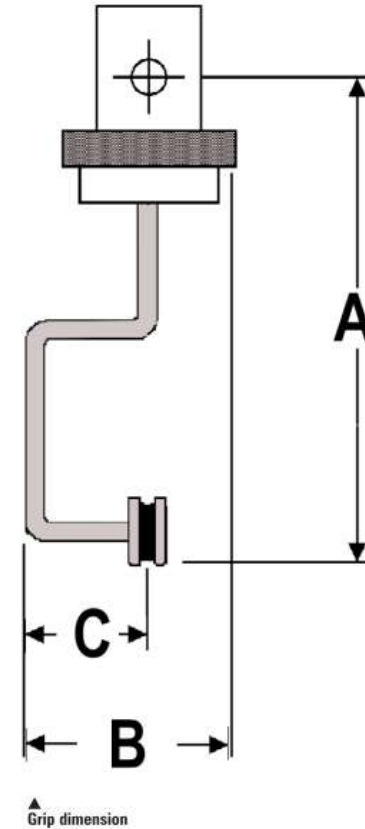
Strength

- Review applicable standards for single fiber testing
- Small loads ~ 2lb range
- Requires a custom test fixture
- Specialized bench top electromechanical test machine
- Resolution must be $\sim 1 \times 10^{-4}$ lbf (.0001)



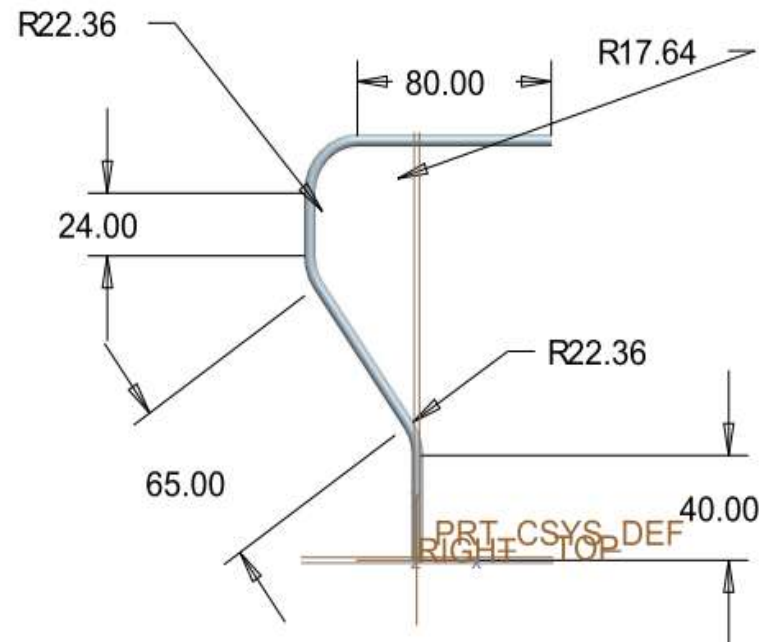
Single Fiber Testing

- ASTM standard C1557-03
- Individual fibers that are between 8-20 μm Diameter become difficult to test
- Standard Test Method for Tensile Strength and Young's Modulus of Fibers.
- Appropriate load cell requires the manufacture of a custom fixture.



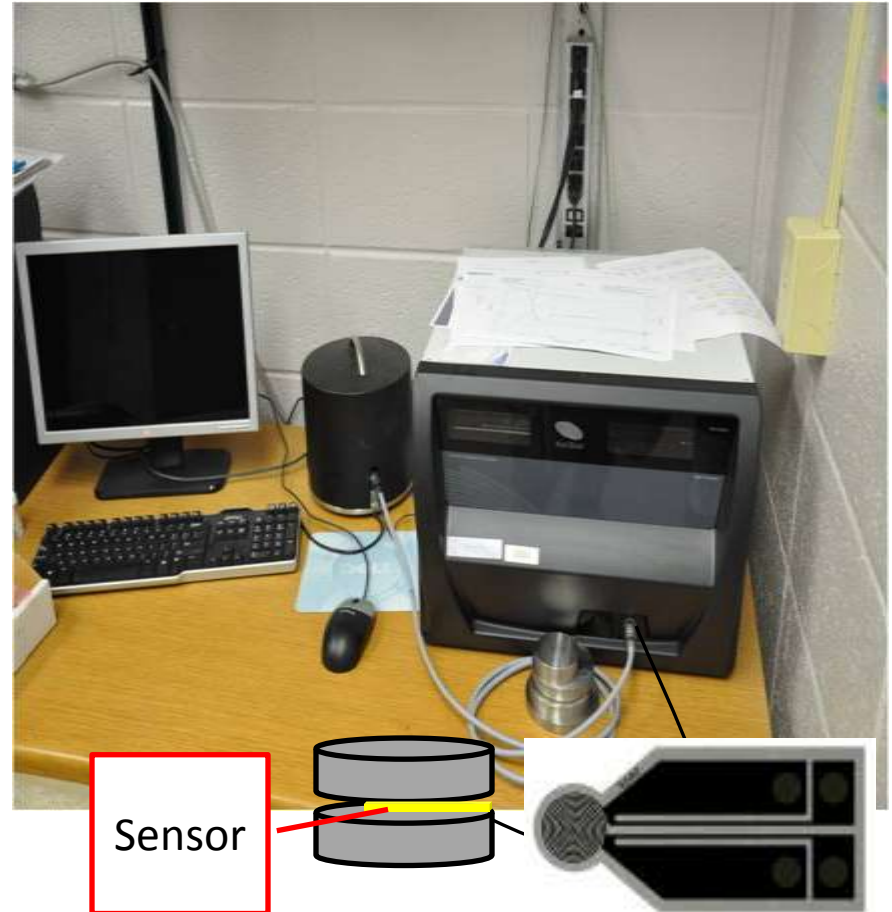
Fixture Design

- Lessons learned from previous testing lead to current fixture design
- This design was chosen for its light weight characteristics
- Designed for simple production and repeatability/simplicity of test set-up



Thermal Conductivity

- Used to determine the thermal conductivity of materials
- Requires flat specimens to sandwich a heating element
- Developing a method to test groups of fiber for thermal conductivity comparison with Carbon Viscose rayon



Conclusion

- Demonstrated a few examples of how to perform some basic materials testing.
- Problems with testing involved creating custom fixtures.
- Further study is being performed to compare the properties between IL Carbon Fiber and the traditional Carbon Viscose Rayon (NARC).



Questions?

Greg Doud

doudg@uah.edu

[http:// rfal.uah.edu](http://rfal.uah.edu)

