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Carbon Fibers Derived From PAN/Bio-based Bicomponent Precursor

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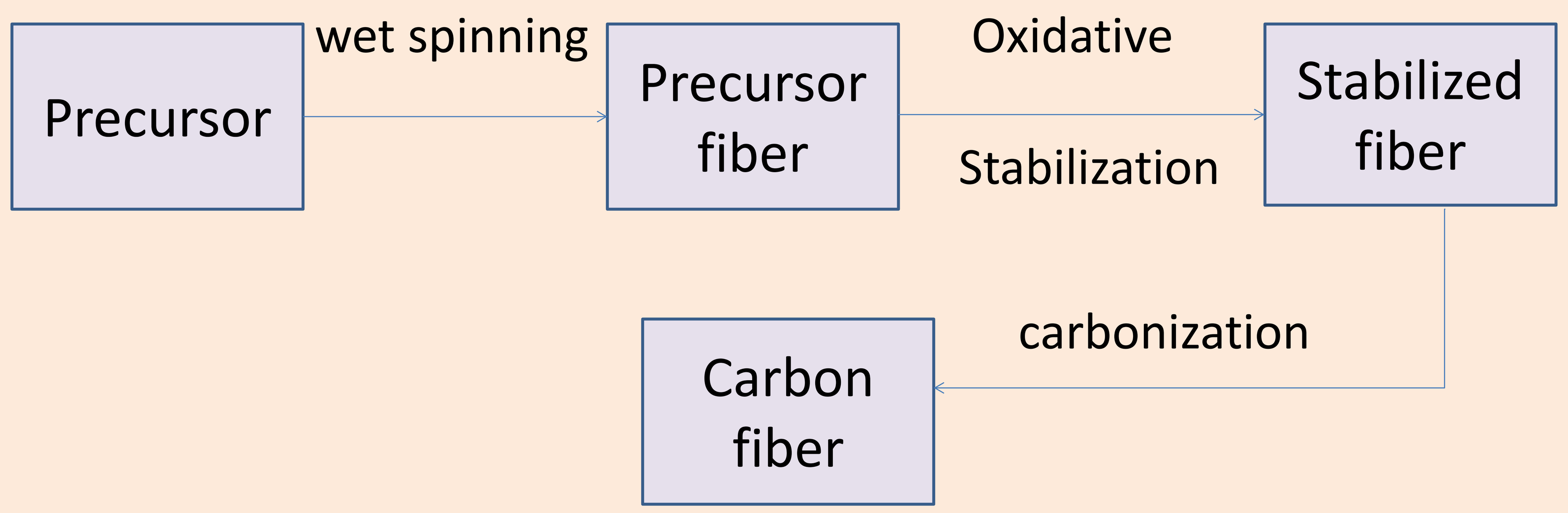
Introduction

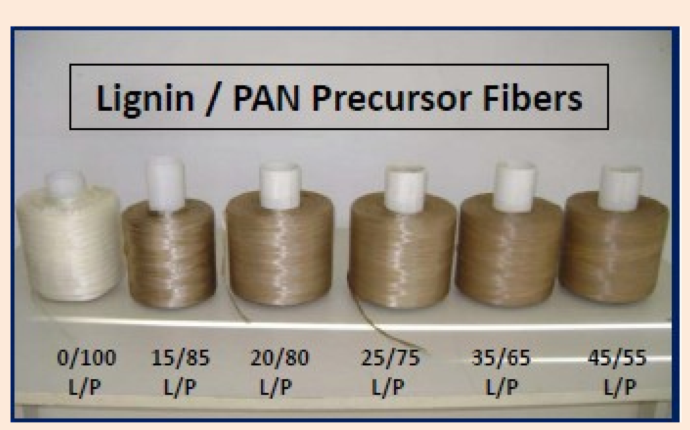
- Poly(acrylonitrile) based carbon fiber dominates over 90% of carbon fiber market due to the high tensile strength

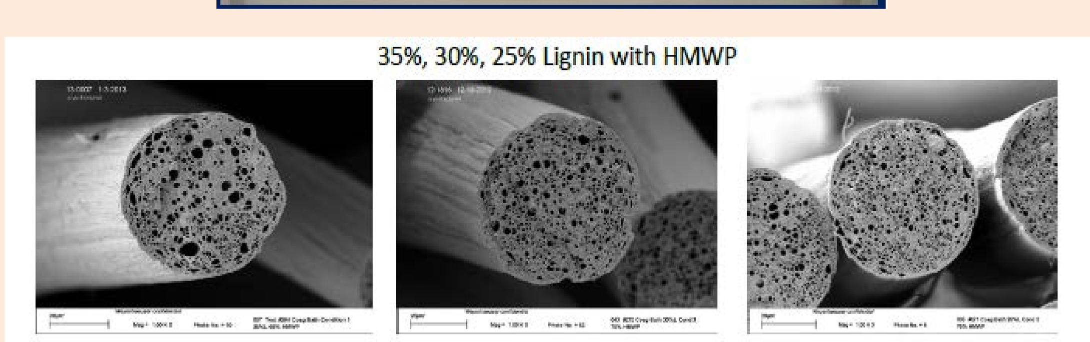


- However, the high price of PAN limits the widespread use of carbon fiber
- To reduce the cost of precursor , bicomponent precursor (PAN with bio-based material, such as lignin) is studied in this project

Partially Bio-based PAN-lignin Blend as Carbon Fiber Precursor [1]

- Zoltek and Weyerhaeuser has developed lignin/PAN polymer blend precursor for carbon fiber by wet spinning





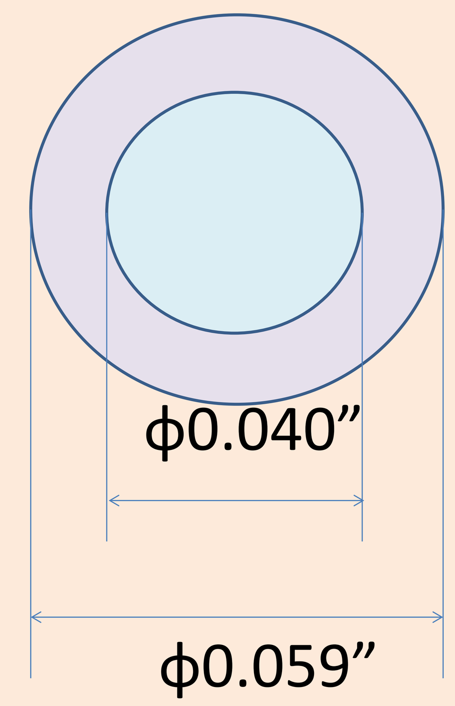
- 35% lignin/PAN precursor resulted in the highest and most uniform tensile property of 1.7Gpa
- Limitation: Lignin particles result in morphologies with macro-voids; these were not successful for converting to carbon fiber

$$\frac{tensile\ strength\ of\ 35\%L/P fiber}{tensile\ strength\ of\ 100\%\ PAN\ fiber} \approx 0.61 \approx PAN\ content$$

- Lignin dose not provide any strength in resulting carbon fiber

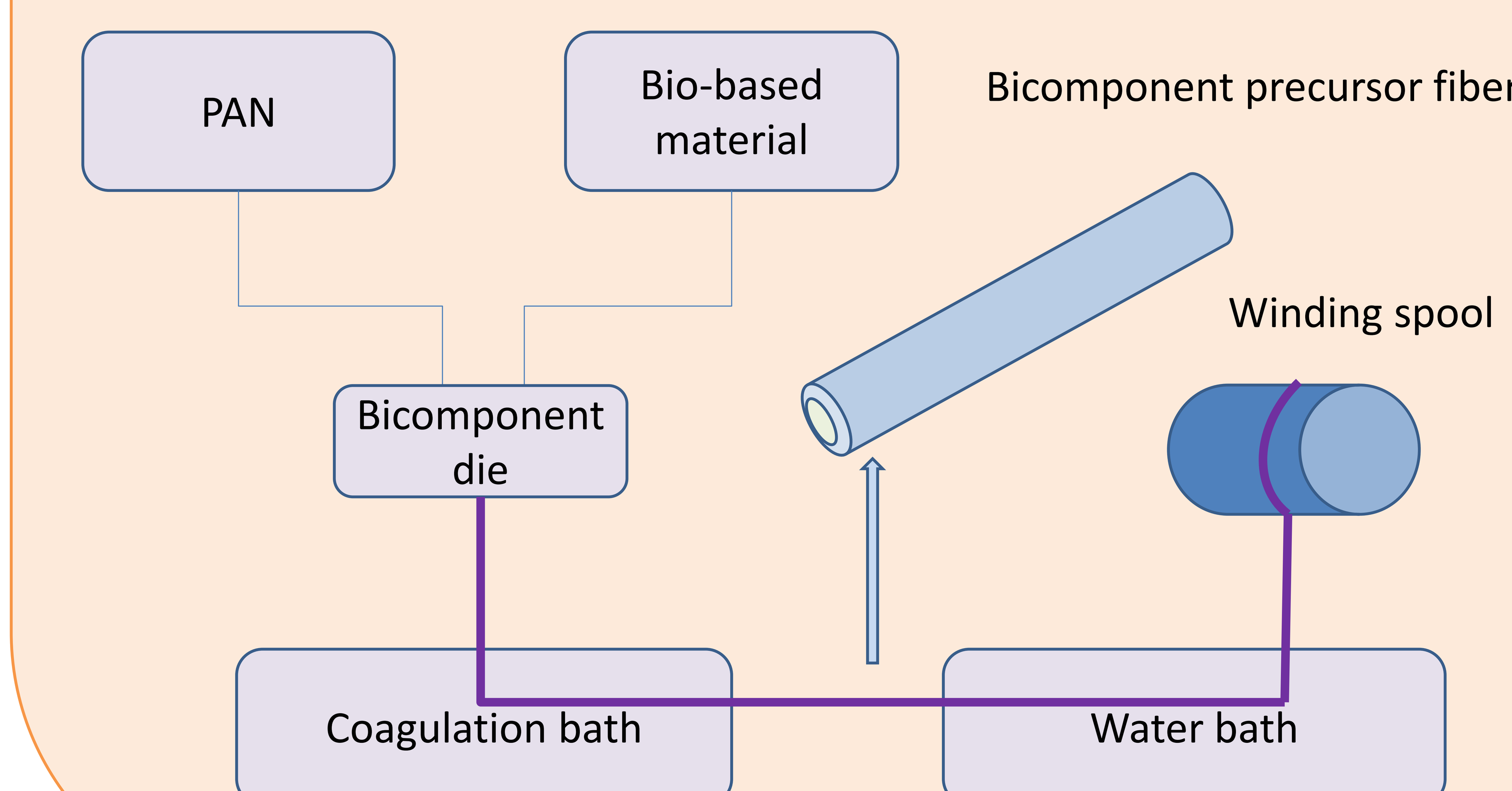
Wet Spinning

- Polymers are dissolved in solvent to form solution
- Fiber is formed by using coagulant to extract solvent from polymer
- PAN--sheath, Bio-based material--core

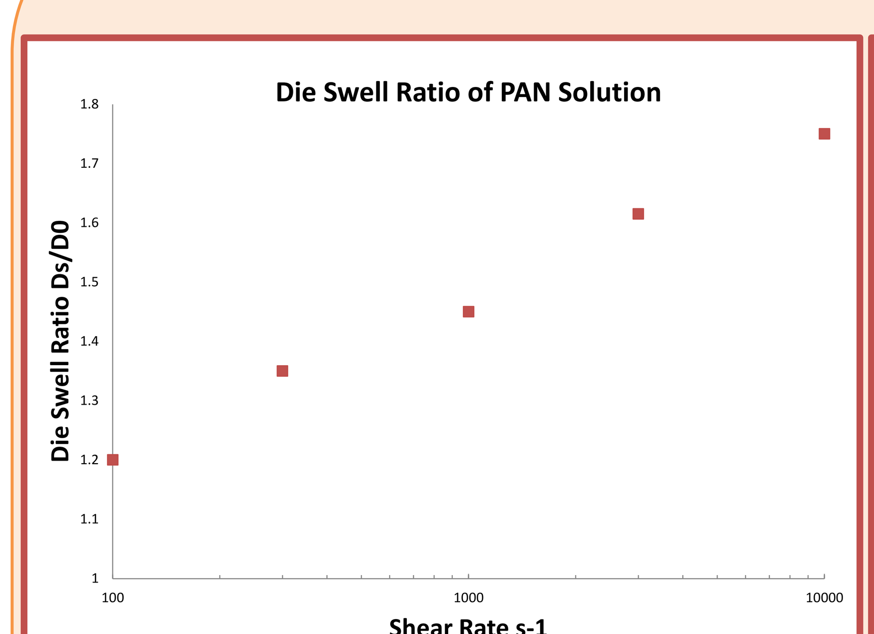


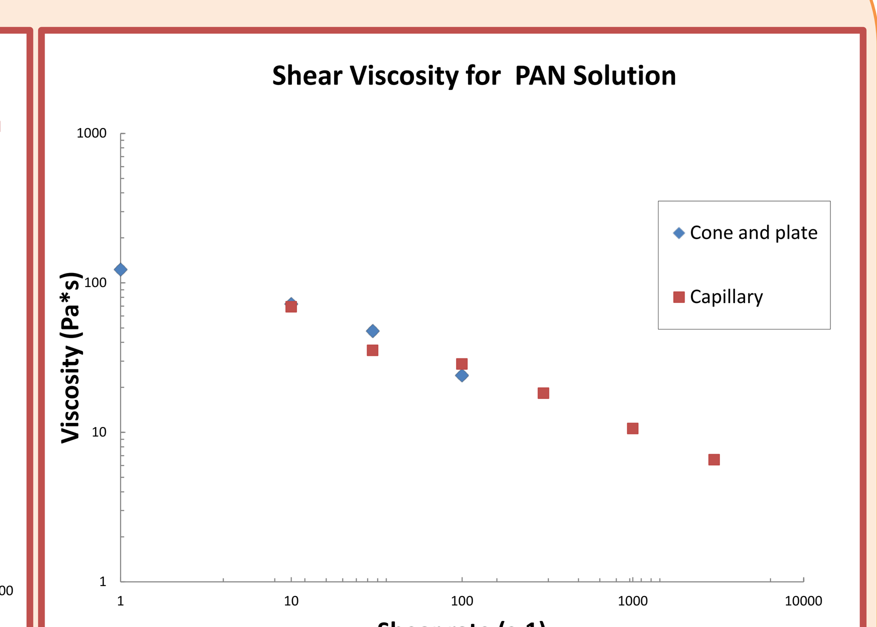
Cross section of bicomponent capillary

Bicomponent die



Viscoelasticity of PAN Solution





Stabilization and Carbonization

- Thermal oxidative stabilization is accomplished by heating precursor fibers in air at 200 to 400 °C
- Tension must be applied to keep molecular orientation during stabilization
- Carbonization occurs at temperature over 1000 °C in an inert environment
- Stabilized fibers are hung on a graphite rack with tungsten weight hooked below

Stabilization furnace

High temperature furnace

Future Work

- Test spinnability of lignin
  - Rheology study
- Produce bicomponent carbon fiber
- Characterization of resulting carbon fiber
  - Mechanical properties (tensile strength and Young's modulus)
  - Physical properties (cross sectional shape with SEM and crystallite structure with WAXD)
- Property modification
  - UV assisted stabilization

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[1]. Husman, G. Development and commercialization of a novel low-cost carbon fiber. Presentation at 2013 DOE Hydrogen and Fuel Cells Program And Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting. May 15,2013

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