Nanocellulose reinforcement for bio-based phenolic thermo-responsive resins

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Introduction

Petroleum reserves are depleting and the push for an efficient low cost alternative has led to extensive research in the area of cellulosic-based biofuels. Waste or non-fuel components of biofuel platforms such as pyrolysis need to find a value-added market. Methods to separate the phenolic rich fraction from pyrolysis bio-oils have been used to develop resins. This work has evaluated the use of nanocellulose as a reinforcing element to increase the resins mechanical properties. Nanocellulose compositions would assist us with designs of new kinds of materials. Comparison of the effect of different concentrations of nanocellulose and the PRF resin on the properties helps us find the optimum composition..

Raw Material (Wood Pellets) ➔ Pyrolysis (Bio-Oil) ➔ Fractionation (Isolate Lignin) ➔ PRF (Resin) ➔ Mechanical Properties

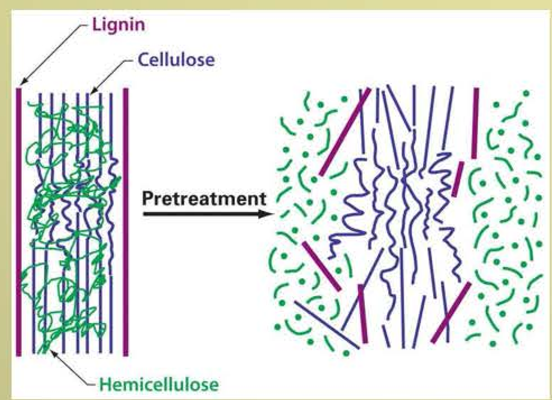
Objectives

- Examine Nanocellulose Reinforcement For Bio-Based PhenolicThermo-Responsive Resins
  - Determine and enhanced mechanical properties of nanocellulose, Phenolic Rich Fraction (PRF), and polycarprolactone (PCL) compositions by modified concentration.
  - Devise a scheme of integrating nanocellulose into the PRF composition.
  - Perform Dynamic Mechanical Analysis (DMA) on composition to study the rheological response of the materials.

Materials

- Chemical Laboratory and Equipment
  - Bio-Oil, Ethyl Acetate, Sodium Bi-Carbonates, Water, and Nanocellulose, Branson Ultrasonication Equipment, Fisher Scientific Isotemp Oven, and the DMA Machine.

Applications for fractionation and purification.



Schematic of goals of pretreatment on lignocellulosic material (Mosier et al. 2005).

Ultra sonication equipment

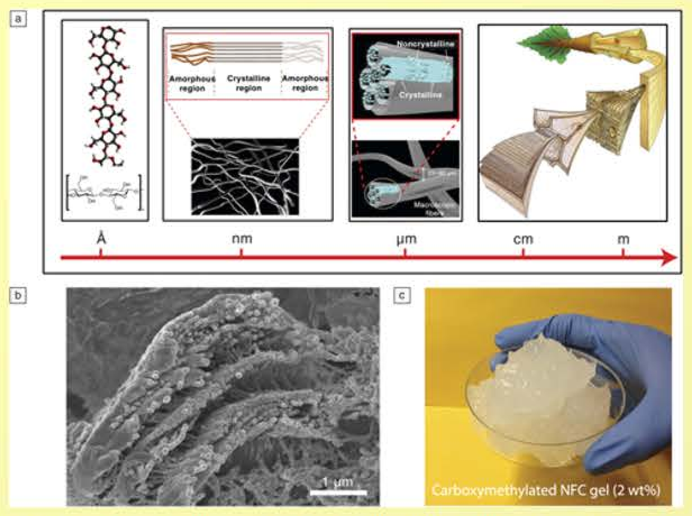
Heat Treatment Oven

Dynamic Mechanical Analysis Machine

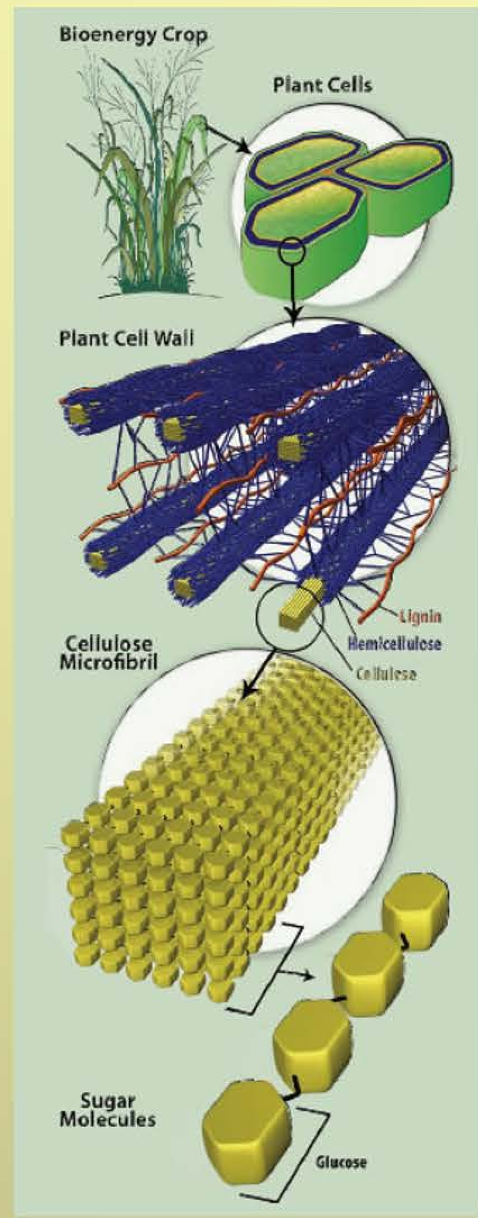
Methodology

- The application of different chemical concentration to obtain a PRF to be inserted into the nanocellulose matrices to acquire a mechanical solid property
- The Pyrolysis Process of Bio-Oil
  - Lignocellulose breakdown on the cell wall structure to separate each component (cellulose, hemicelluloses and lignin).
- The Fractionation Process of the Biomass
  - Equal amounts of biomass and ethyl acetate for extraction of lignin oil.
- The Purification Process is to cleanse the PRF obtained from the lignin fractions
  - To remove at acidy from the PRF which will be put in in the nanocellulose and PRF mixture.
- The Heat Treatment Process
  - To extract all existing water and ethyl acetate.
- Dynamic Mechanical Analysis (DMA)
  - Study and characterize the composite material of the nanocellulose, PCL, and PRF.

1.) Getting Samples of Nano cellulose



Structure of cellulose from the wood cell wall to microfibrillated fiber to nanofibrillated fiber to a cellulose molecule. Image courtesy of Mark Harrington. © 1996 University of Canterbury.



Schematic of plant cell wall utilization of lignin, hemicellulose and cellulose. Adapted from (Sannigrahi et al. 2010).

1.) Concentrations of the biomass and ethyl acetate for fractionation

2.) Concentration of lignin, ethyl acetate, water and sodium bi-carbonates for purification

3.) The fractionation and purification process, a 4-5 hours

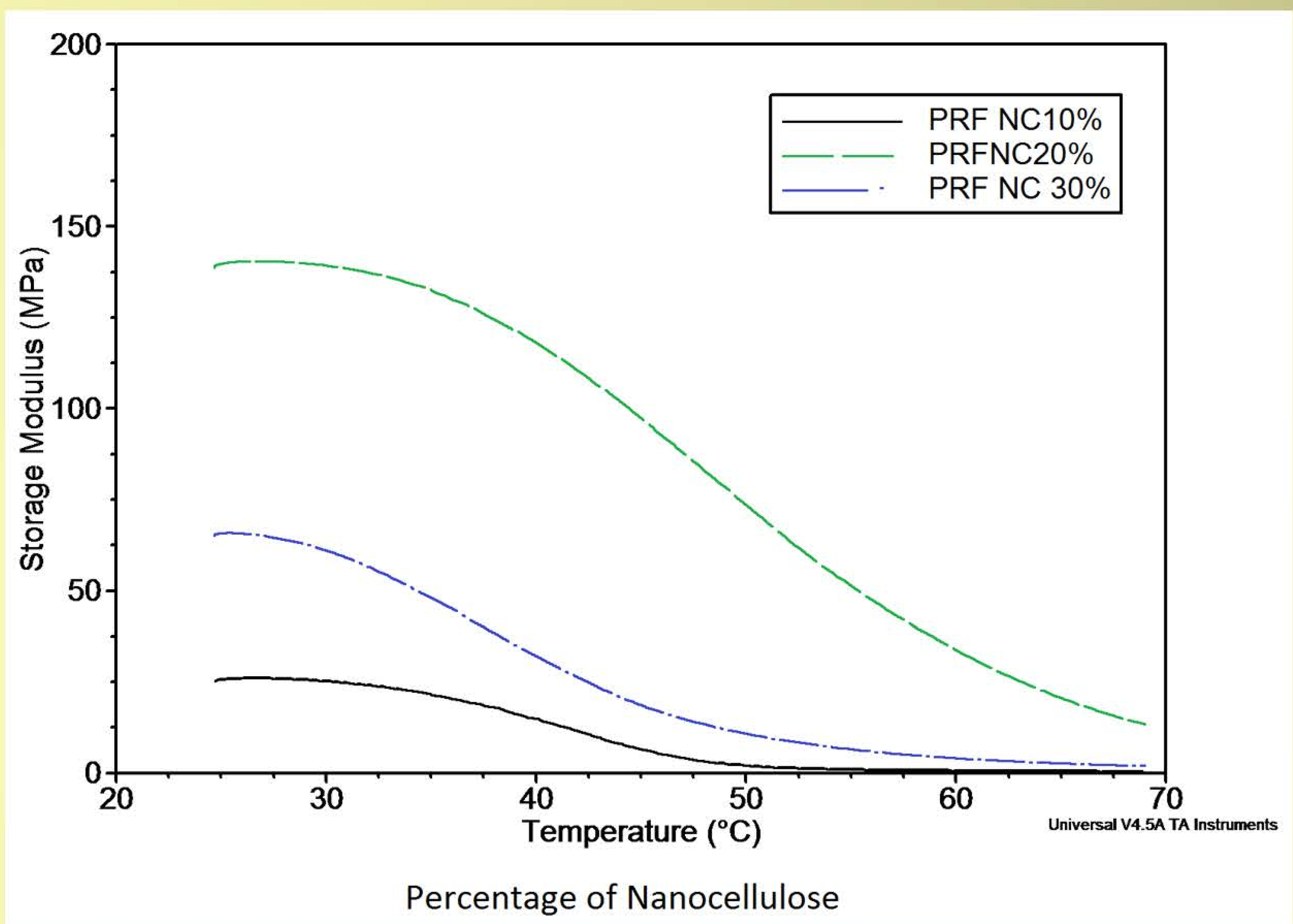
4.) Mixtures of the PRF and Nanocellulose

Results

1.) Heat treament at 100 degrees C.

2.) Nanocellulose in grams calculated to per liter

50ml of nanocellulose and 50ml of water concentration with heat treatment resulted: 3.7 per liter of nanocellulose. A 100ml of PRF to the same concentration of nano/water resulted: 3.8 per liter



Dynamic Mechanical Analysis of nanocellulose composites

Conclusions

- Performance of Lignin Base Phenolic Resin
  - Separation of the nanocellulose and PRF was observed. This may likely be in part due to the hydrophilic nature of the nanocellulose.
    - Separation likely meant a lower actual concentration of nanocellulose in the composite.
  - DMA results concluded that a 20% nanocellulose solution had the highest modulus.
    - 30% saw a decrease in modulus which may result from agglomerated nanocellulose
  - This approach could be a sustainable option for co-products in bioenergy production.

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