Large Scale Production and Mechanical Properties of Mechanochemically Fibrillated Nanocellulose (CNF) Films

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Project Goal
The project goal is to develop a method for large scale production of high strength and high stiffness CNF films which satisfies the following constraints:
1. Short lead time (<1 hr)
2. Solvent free process
To evaluate the efficacy of the developed method, the tensile properties of the produced CNF films will be measured as a function of various experiment parameters: pressing time, temperature, and pressure.

Introduction
Cellulose is an abundant biosynthesized material which can be harvested from many sources. Due to its renewability and outstanding mechanical properties, there is a strong desire to process it into usable forms like films and membranes [1][2]. Yet current industrial and laboratory efforts to produce CNF films suffer from the following problems:
- Prolonged lead times (few hours to weeks)
- Hazardous (heavy solvent dependency)
- Expensive (solvent removal and recycling)

Materials
CNF (batch#44) was obtained from University of Maine. The CNF slurry had a 3wt% concentration in water. There was no surface modification or acid treatment performed on the cellulose.

Making CNF Films
The technique developed to produce CNF films consists of three main steps: filtration, mechanically-assisted water removal, and pressure-assisted hot drying.

Filtration
The initial dilute CNF solution was poured into a house-made 1 ft² dewatering frame. The first step utilized capillary suction to remove 69% of the water.

Mechanical Dewatering
The second step involved the use of a 12 inch width slip roller. The watered down film and transfer mesh was passed several times through the rollers which removed an additional 8% of the water by mechanical pressing.

Pressure-assisted Hot Drying
The third step involved the use of a hot press to remove the remaining water and fully consolidate the CNF web.

Results
Time-Temperature Study
For each case 24 samples were tested, pressure was kept constant at 30psi (211KPa).

Summary
- CNF films have been produced with lead times of 45±15 min and no solvents.
- Mechanical testing shows ultimate strengths of 165±14.93 MPa and a tensile modulus of 15.17±1.23 GPa (211% greater than casted films).
- It was found that pressing times or temperatures do not affect the ultimate strength or tensile modulus.
- Pressure studies (not shown) show that higher pressing pressures lead to higher properties.

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References
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