

**Commercialization of Cellulose Nanomaterials
Toward Tree Fruit Frost Protection and
Thermal-insulation Packaging Applications**

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Outline

- Plant Based Dispersion (PBD) for Tree Fruit Frost Protection
- Cellulose Based Foams for Thermal-insulation Packaging Applications



PBD for Tree Fruit Frost Protection

- Cold damage causes the greatest crop loss worldwide (FAO)
- Spring frost and fall freeze events predicted to increase
- Current protective measures insufficient/unsustainable



Existing frost protection methods



Wind machine:

- Breaks inversion layers in field level microclimate
- 1-3 °C Increase
- High Cost
- Not effective when wind > 5 mph



Heating (propane or diesel):

- Warms plant level microclimate
- Requires many heaters
- Not very efficient wind > 5mph
- Pollution concerns



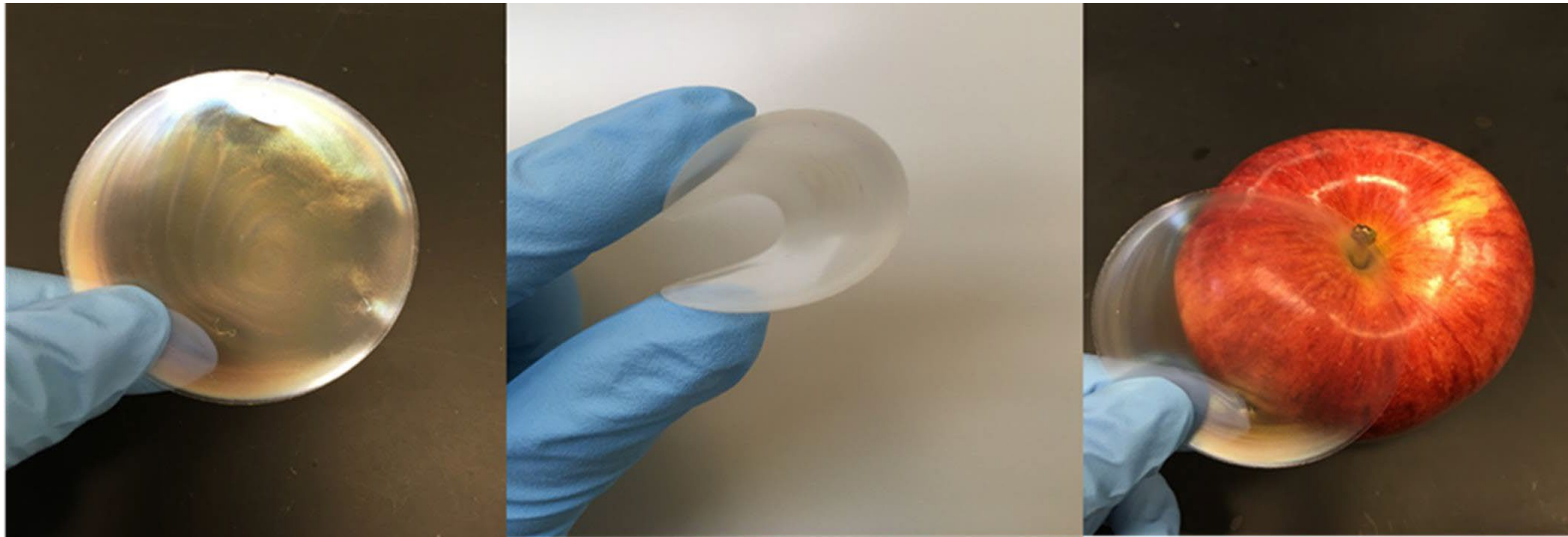
Frost irrigation:

- Keeps plant 1-2 °C above freezing through heat of fusion
- Can damage plant
- Inefficient use of water
- Water availability?

Often a combination of these methods, high cost, unreliable results

Innovation

Plant based dispersions (PBD) formulated using cellulose nanomaterials (CNM) for frost protection



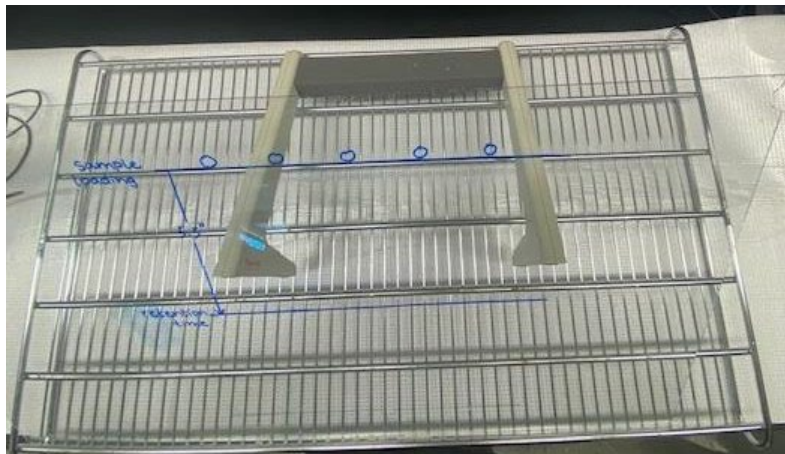
US Patent # 11,122,751; Issue on 9/21/21, X. Zhang et al.,

Updates

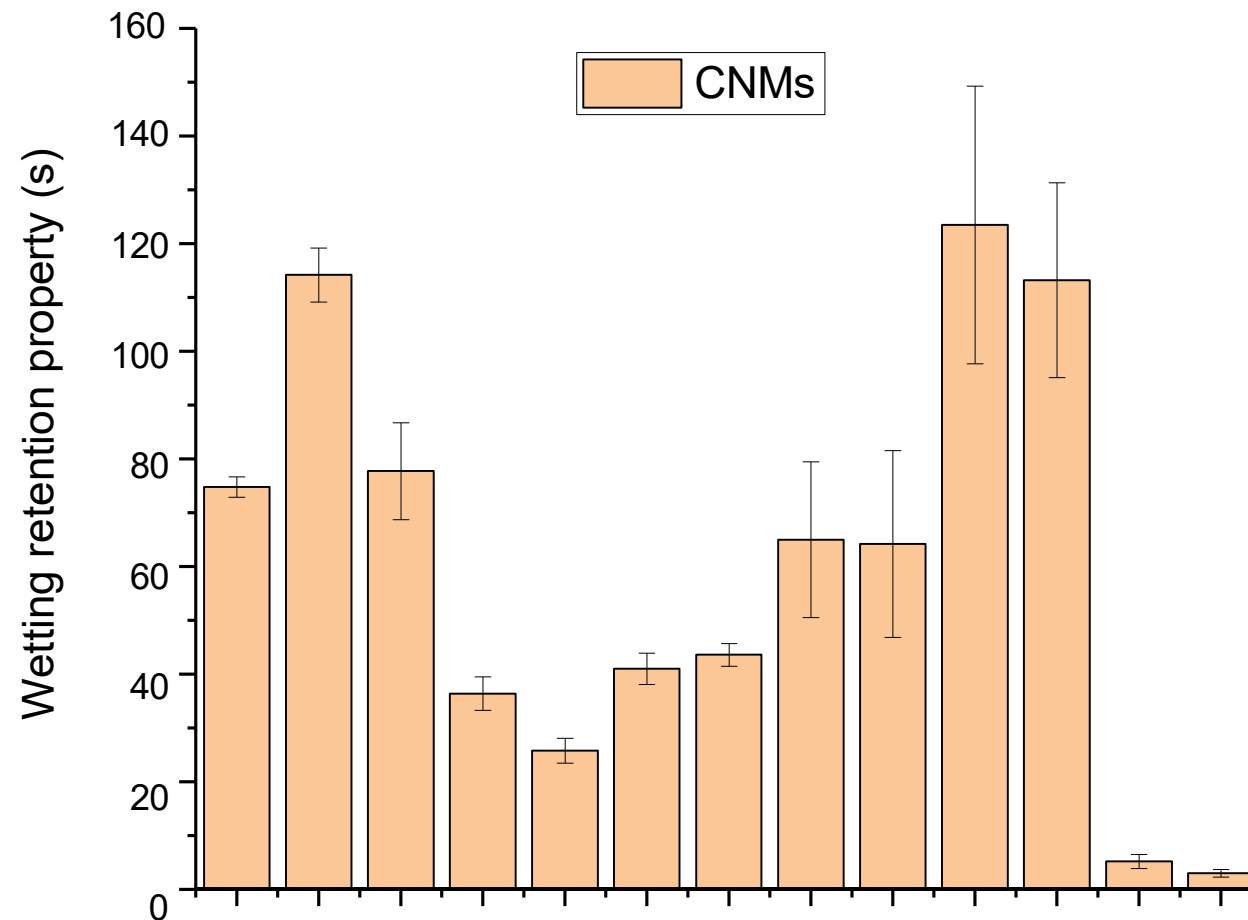
- Using existing equipment available to the growers
- PBD treatment improved yield by up to 9,000 lbs./acre (sweet cherry)
- No adverse effect on floral development, pollination, fruit development, fruit set etc.
- Technology licensed to Sappi Biotech in 2022
- A pre-commercialization trial conducted in spring 2023 led by Sappi and assisted by an Ag-supplier and WSU

Lab Evaluation of Different PBD Formulations

- The performance on frost protection differs significantly among different CNM (cellulose nanomaterials, e.g. CNC and CNF):
- Spreading, wetting and retention tests to screening CNM based PBD for frost protection



Efficacy/performance of Different Cellulose Nanomaterials

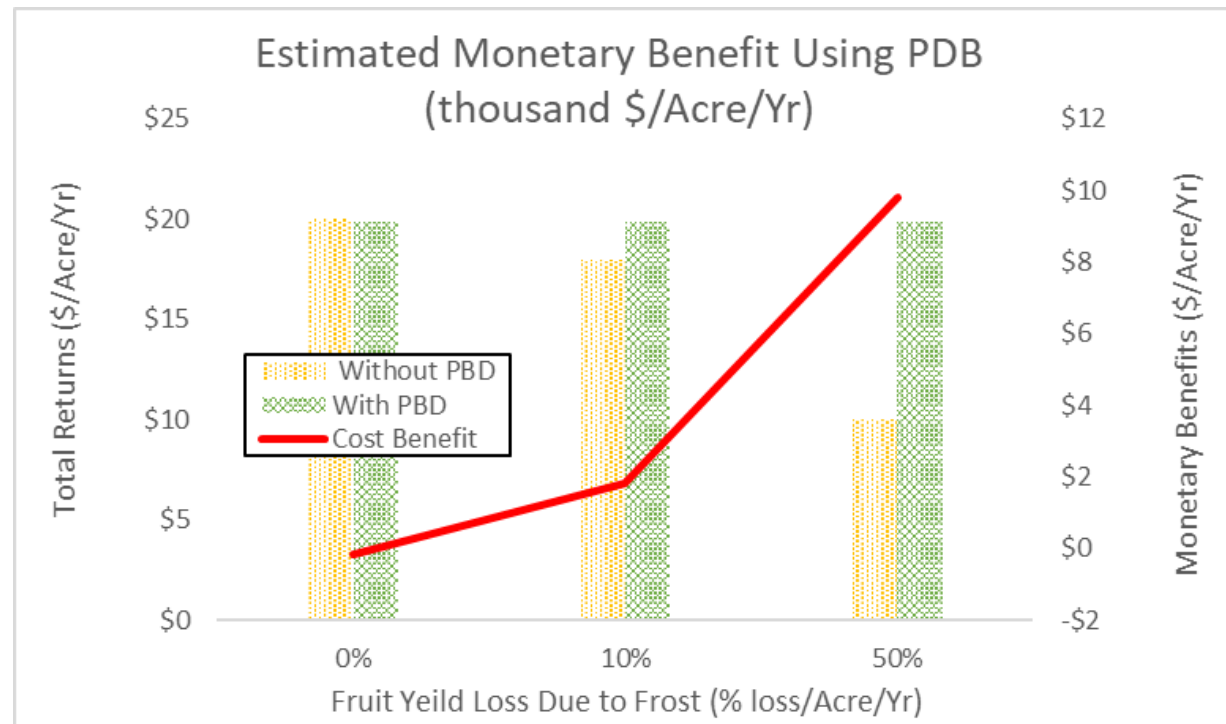


US Market

- WA: > 200,000 acres of tree fruit (apples, cherry, pear)
- U.S.: 290,000 apples, 120,000 cherry, 110,000 peaches/pear, 900,000 grape
- Cold damage not a U.S. problem – global
- Impact of climate change: weather patterns indicative of increasing pressure from variable spring temps
- > 800 metric tons (dry weight basis) annual demand for CNC or CNF in Washington State (based on *one application of 2% PBD per acre*).

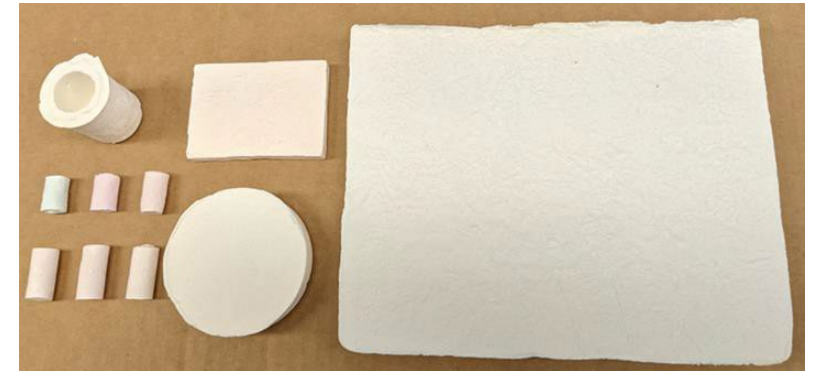
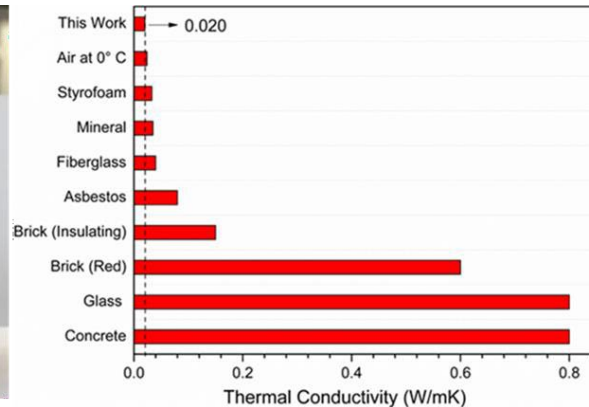
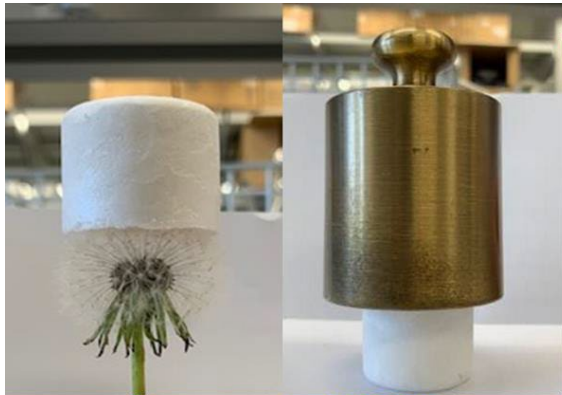
Cost and Benefit Analysis

- 10,000 pound per acre fruit yield, \$2.00 per pound bulk price
- Cost: materials, production, application, fuel, labor etc.



Cellulose Based Biofoams for Thermal-insulation Packaging Applications

- Cellulose (CNF and CF) Based Biofoams can readily replace EPS based packaging foam
- Cost the CNF and CF is a key economic factor
- Conducted over a dozen pilot trial toward scaling up manufacture process with licensee and a commercial freeze-drying company.



Updates

- Most CNF and CF are suitable for foams preparation
- The properties of CNF and CF affect mechanical properties of the foams
- Technology licensed to a global packaging company
- Foam performance verified by ISTA Testing Standard 7E
“Thermal Transport Packaging Used In Parcel Delivery System Shipment”



Updates

- Identified low-cost CNM feedstock.
- Produced large size panels (~ 2' by 2') by 24-hour drying cycle
- Working toward further increasing process efficiency and developing an integrated cellulose foam manufacturing process.



Acknowledgments

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- P. Wang, Junxia Wang, R. Nanda, M. Whiting, A. Ameli, B. Arnoldussen, Q. Zhang, CK Mo, J. Alhamid