Imparting Dimensional Stability on Cellulosic Material with Electron Beam

By Sean Woods
Graduate Student
UV/ EB Tech Center SUNY ESF

Acknowledgements

- **Project Team**

  Dr. Jennifer Smith, PhD, PE
  Project Director

  Dr. Mark Driscoll, PhD
  UV/EB Tech Center Director

  Kenneth J. Tiss, AIC, CPC
  Major Professor

Acknowledgements cont.

- Major Contributions

  Dr. Scott Larsen, PhD

  Project Manager

  NYSERDA

  Robert Smith

  Microscopy Specialist

Outline

1. Natural Fibers and Their Properties
    a) Hygroscopicity
    b) Internal Stresses
2. Literature Review
3. Objective Statement and Experimental Procedure
    a) Design of Experiment
    b) Sampling Method
4. Future Work

Natural Fibers

- Jute
- Sisal
- Hemp
- Coconut
- Wood Excelsior

Sustainability

"Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.“

-US EPA

Problem Statement

Hygroscopicity

Dimensional Change

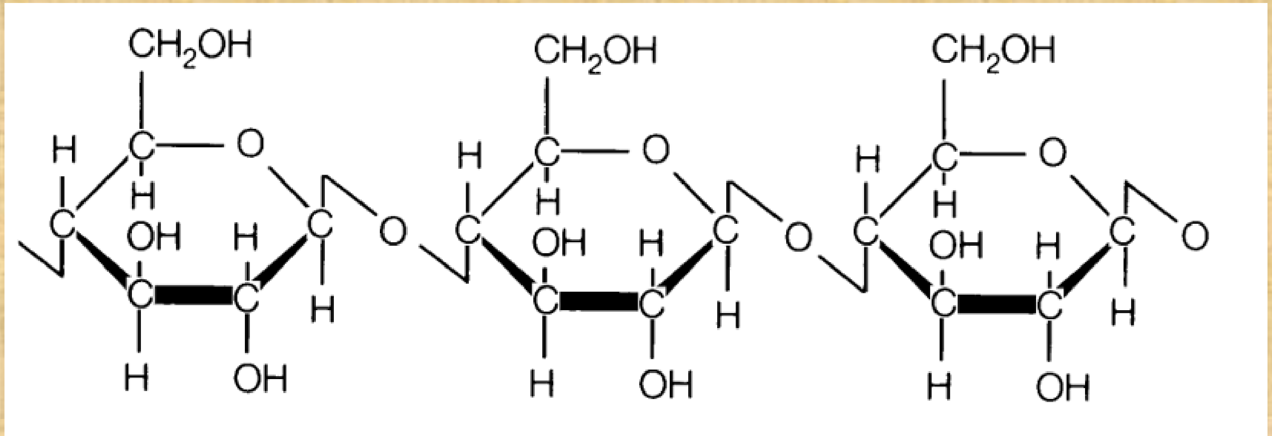
Internal Stresses/
Failure

Hygroscopicity

hy·gro·scop·ic (hgr-skpk)

adj.

Readily absorbing moisture, as from the atmosphere.



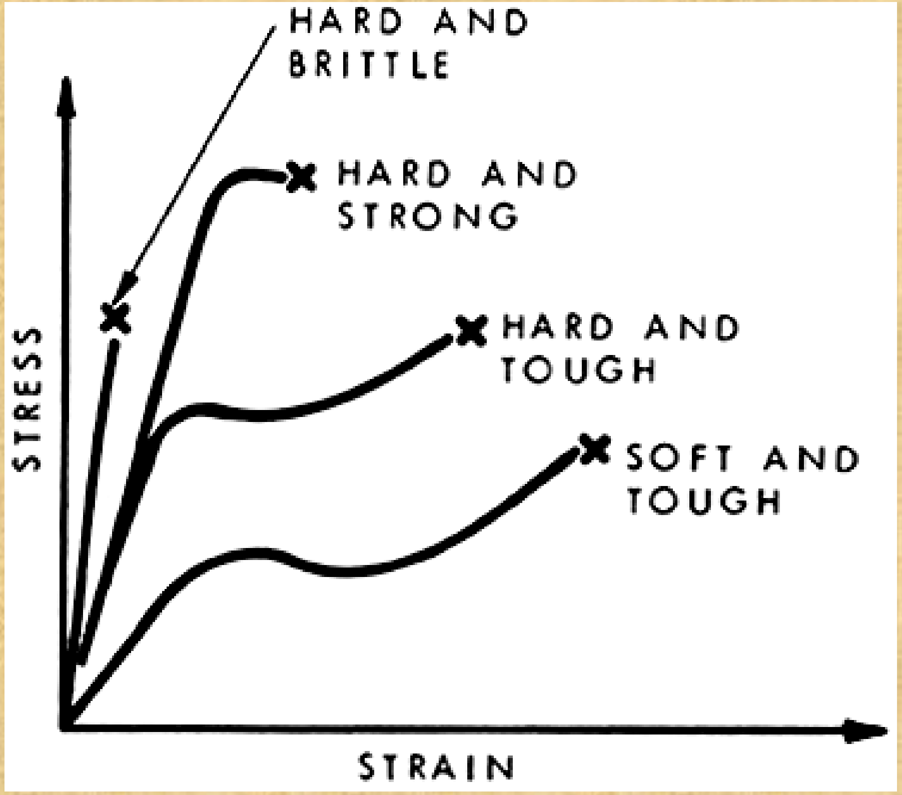
Internal Stresses

- **Hooke's Law of purely elastic materials**

$$\sigma = E\varepsilon$$

σ = stress

ε = strain



Sampling of Solutions

- Treatment of Fast-Growing Poplar with Monomers Using In Situ Polymerization

  Wen He, Tetsuya Nakao, Masahiro Yoshinobu, Qisheng Zhang
- A Study of the Effects of Bi-Functional Sizing Agents on the Mechanical Properties of Jute-Bisphenol F Composite Systems

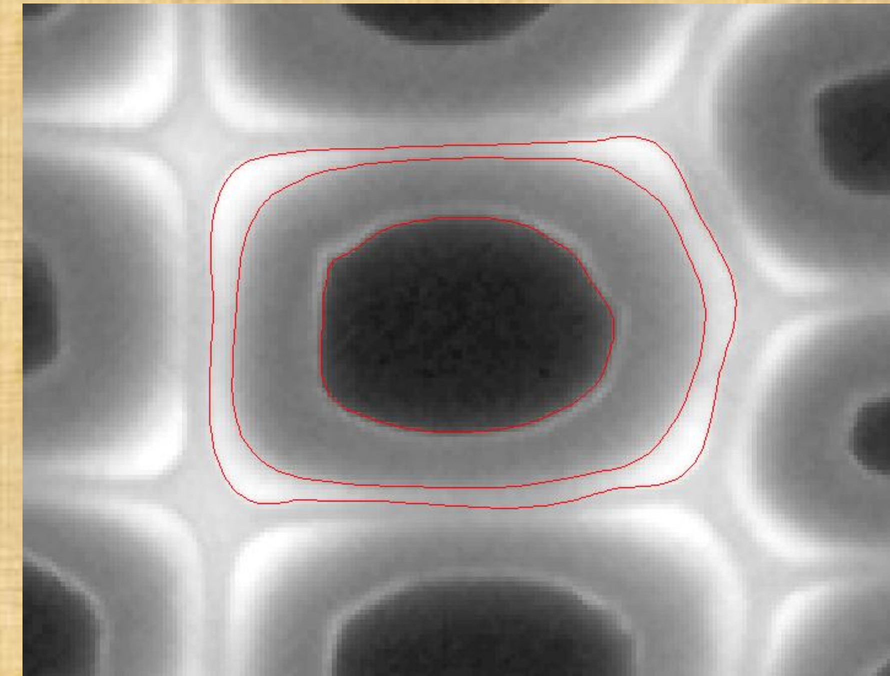
  Arun Sampath
- The Development of Wood Polymer Penetrant and In-Situ Polymerization with Electron Beam and X-Radiation

  L.S. Larsen

Treatment of Fast-Growing Poplar with Monomers Using In Situ Polymerization

- Polymer matrix injected into poplar was styrene
- Styrene unable to bond with cellulose substrate
  - Glycidyl Methacrylate

(Axelsson et. al., Image Analysis of Internal Structure)



*Glycidyl side reacts with hyrdoxyl groups
In the cell lumens

*Methacrylate side reacts with styrene

A Study of the Effects of Bi-Functional Sizing Agents on the Mechanical Properties of Jute-Bisphenol F Composite Systems

- Problem
  - Traditional Epoxy Matrix has poor wettability to cellulose substrate
    - Hydrophilic vs. Hydrophobic
- Solution
  - Surface modifying amines change the properties of the substrate to promote bond with matrix
    - Fiber matrix interaction improved
    - Fiber tensile strength decreased due to treatment

The Development of Wood Polymer Penetrant and In-Situ Polymerization with Electron Beam and X-Radiation

- Reactive monomer mixtures vacuum impregnated into maple blocks and polymerized by electron beam

$$ASE = \left[1 - \frac{\textit{Percent Shrinkage Treated Specimen}}{\textit{Percent Shrinkage Control Specimen}}\right] \times 100$$

Untreated maple control samples had an average tangential shrinkage of 4.59%.

WPP Treatment	Shrinkage (%)	Anti-Shrink Efficiency	Weight Gain (%)
HEMA	0.34	92.54	81.74
CD-570	2.17	52.66	72.88
SR-603	2.16	52.90	40.77
HEMA BA	0.12	97.28	82.49
HEMA/SR-395	0.44	90.41	67.81
HEMA/MPEG 550	-0.03	100.67	78.95
HEMA/MPEG 550 BA	-0.28	106.13	73.51
HEMA BA H_2O	3.81	16.93	N/A

Table 8: Antishrink Efficiencies and percent weight gain for various WPP treatments between 60° F and 78% RH to 70° F and 30% RH.

Objective Statement

- Control dimensional change of natural fibers utilizing low molecular weight monomer polymerized by electron beam radiation resulting in a wood polymer composite.

Procedure

- Design of Experiment
  - 5 fibers (glass fiber as positive control)
  - 2 pretreatment monomers
- Determination of Anti-Shrink Efficiency
  - Individual fibers will be analyzed under a light microscope in tandem with image analysis software ImagePro Plus
  - 5 points of measurement along fiber

Procedure cont.

Condition to 9% MC

Submerge in DI Water

Condition to 9% MC

Vacuum Impregnation and Polymerization

Submerge in DI Water

Future Work

- Form treated natural fibers into laminated composites
  - Test for strength and serviceability properties against glass fiber composites
- Investigate economically viable applications
  - Building Materials
  - Automotive
  - Etc.

Questions?

Contact Information:

Sean Woods

UV/EB Tech Center SUNY ESF

1 Forestry Drive Syracuse, NY 13210

srwoods@syr.edu