THE EFFECT OF LIGNIN ON MECHANICAL PROPERTIES OF AESO-BASED POLYMERS

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OBJECTIVE/APPROACH

Overview of Research

Creating composites using base resin consisting of 70/30 AESO/Styrene

Varying the amount of lignin added to the resin

The resin is infused into different types of fibers using the Vacuum Assisted Resin Transfer Molding (VARTM)

Test mechanical properties of composites

Objectives

Determine the weight percentage of lignin needed in order to optimize mechanical properties

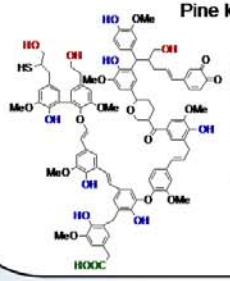
Determine the surface interactions between the resin and fiber interface through the addition of lignin

MATERIAL MODELING

Why Use Lignin?

- Lignin is one of three most abundant renewable resources on planet amid cellulose and natural oils
- Most industrial lignin is obtained as a waste product during paper pulping process (100 million tons/year)
- Despite widespread availability, industrial applications of lignin are rather limited

Pine kraft lignin (Indulin AT)

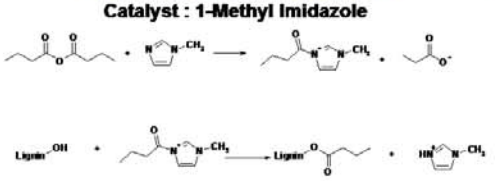


Functionality
Alcohol groups
5.85 moles/k
*Carboxyl
0.9 moles/kg
* Carbonyl
0.8 moles/kg

(McCarthy et al., 2000)

BUTYRATION REACTION

Catalyst : 1-Methyl Imidazole

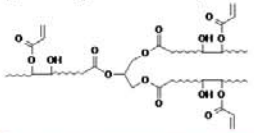


Water/Ether extraction to separate 1MI out

Sedimentation of lignin-BA out of ether with Cyclohexane

Plant-Oil Based Resin

Acrylated Epoxidized Soybean Oil



+ Styrene

AESO/STYRENE/LIGNIN-BA POLYMERS

Initiator: **tert-Butyl Peroxybenzoate**

Curing: **2 hr at 110°C**

Post Cure: **2 hr at 160°C**

Lignin/AESO/Styrene*

Lignin-BA/AESO/Styrene

*Thielemans *et al.*, Journal of Applied Polymer Science, 2002

POLYMERIZATION

- Methods investigated:
  - Resin Transfer Molding (RTM): not successful, very messy, excessive cleaning
  - Vacuum Assisted Resin Transfer Molding (VARTM): straight-forward, easy to clean, good results
- VARTM
  - Initiator: 3wt% Trigonex
  - Activator : 0.8wt% Cobalt-Naphtanate
  - Polymerize overnight

APPROACHES

Fiber treatment:

Dissolve lignin in PH 10 aqueous solution

Soak fiber mat in solution for 1hr

Dry fiber mats at 55°C under vacuum for 24 hrs

Lignin amount varied with solution concentration

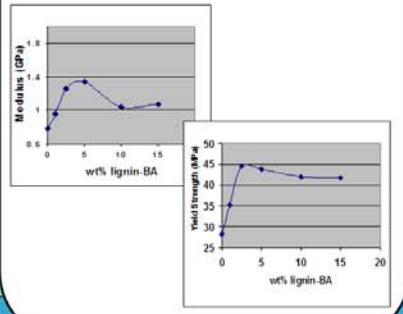
Filler

Modify lignin with butyric anhydride (BA)

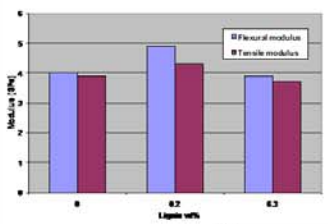
Dissolve lignin-BA in AESO/styrene resin

Inject and cure Lignin/AESO/styrene as normal

FLEXURAL MODULUS AND YIELD STRENGTH

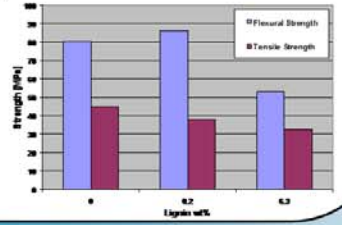


HEMP TREATED WITH UNMODIFIED LIGNIN

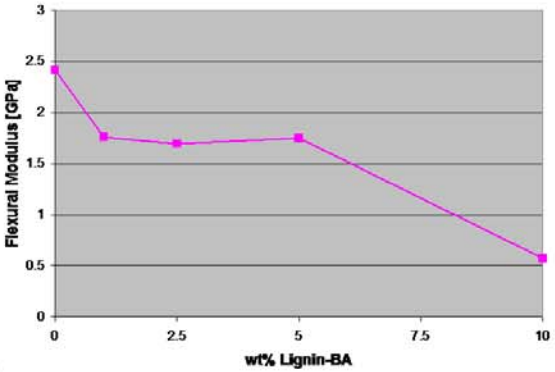


20 wt% Hemp in composite

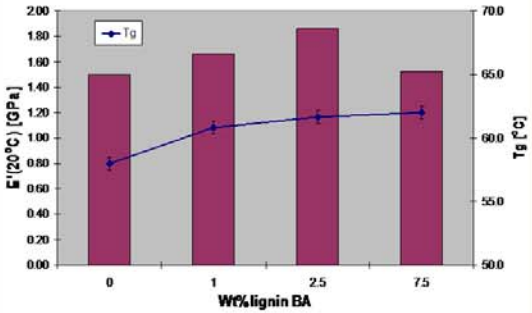
Composite postcured at 160ºC



FILLER APPROACH



THERMO-MECHANICAL PROPERTIES



CONCLUSIONS

- Maximum in property improvement around 5 wt%
  - Lignin increases mechanical properties (up to 70%)
  - Cross-link density drops with lignin addition
- AESO/styrene/lignin properties still lower than commercial unsaturated thermosets

RESULTS

- Filler approach
  - Tensile samples need to have more homogeneous thickness
    - VARTM with Plexiglass on top
  - Viscosity increases with lignin amount
    - Fiber wetting worsens
    - Decrease in flexural modulus with lignin addition

FUTURE WORK

- Use of partially methacrylated/partially butyrated lignin mixed with AESO/Styrene mixture
  - Inverse or limit crosslink density decrease
- Further Analysis of fractured samples using Transmission Electron Microscope (TEM)

THE NEAR FUTURE

- Analysis of broken samples using Scanning Electron Microscopy
- Analysis of tensile strength and modulus through tensile testing of filler samples
- Use different lignin (Hardwood)

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