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#### Adhesives from biomass pyrolysis

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## **Adhesives from Biomass Pyrolysis**

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GPE, Mont Tremblant

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# Outline





- Preparation of pyrolysis bio-oils
- Fractional condensation
- Autothermal operation



Bio-phenol resins for wood adhesives



Conclusions



## Introduction

Bio-phenol resins for wood adhesives:

- Biomass fast pyrolysis can produce phenolic chemicals in the form of "Bio-Oil"
- PF resins are widely used for wood adhesives
- Prior studies with whole bio-oil or a solvent-extracted oil fraction provide 20-50% phenol substitution
- Research objective
- Develop an inexpensive pyrolysis process to produce better bio-oil for phenol substitution in PF resins



# **Preparation of Pyrolysis Bio-oils**

Problem: Bio-oil contains ~35% water, and volatile acids

Solution: Fractional Condensation of Pyrolytic Vapors

**Results:** 

- Two fractions: dry bio-oi (<1%), aqueous condensate
- Dry bio-oil HHV:  $20 \rightarrow 30 + MJ/kg$  (ethanol: 29.7)
- Recovery of organic chemicals: > 90%
- Recovery of total bio-oil energy: > 90%



# **Preparation of Pyrolysis Bio-oils**

Problem: External heating required (endothermic process)

Solution: Autothermal Operation from partial oxidation

**Results:** 

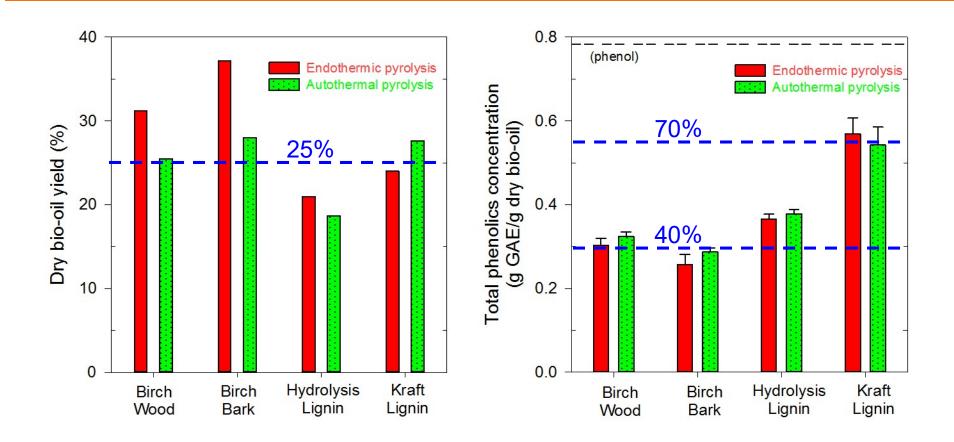
• No need for external heating  $\rightarrow$  simplified reactor design,

less expensive process

- Better dry bio-oil quality:
  - reduced acidity
  - reduced amount of heavy sugars and pyrolytic lignin
  - enriched concentration of simple phenolics



## **Dry Bio-oil for Bio-Phenol Applications**





Problem: High-value application for dry bio-oil?

# Preparation of Bio-phenol Resins for Wood Adhesives



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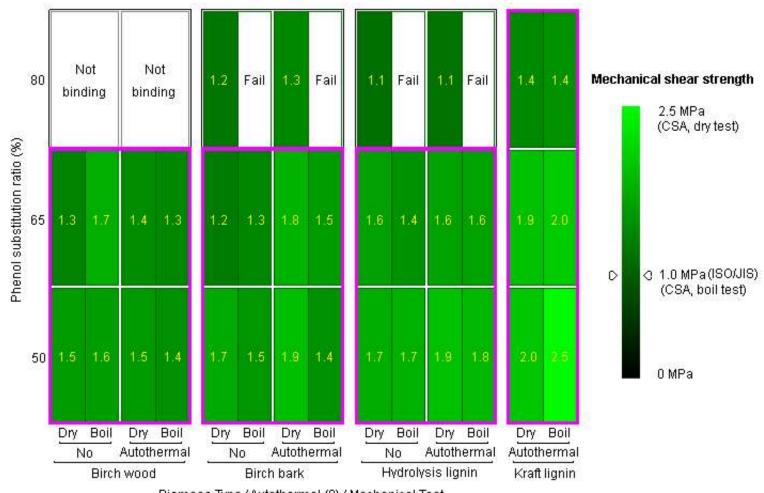
## **Adhesive Characterization**

➤ Tests → Bio-phenol resins can be made in existing plants with no reduction in production capacity

- Regulatory requirements for plywood panels are met:
- Mechanical shear strength (dry test, and boil test – 28 h cycle)
- Formaldehyde emissions



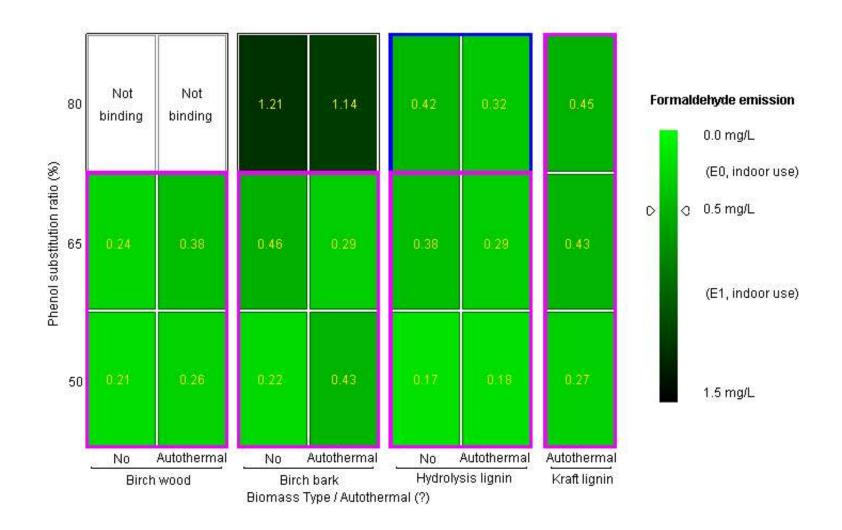
## Meeting ISO/JIS Specifications: Mechanical Strength



Biomass Type / Autothermal (?) / Mechanical Test



## Meeting ISO/JIS Specifications: Formaldehyde Emission





## Low-Cost Waste Biomass: Digestate?

- > Digestate  $\rightarrow$  Low cost, high lignin content, and high ash
- Dry bio-oil (500 °C): Two types of digestates
- Total phenolics: > birch bark
- Viscosity (MW): > birch bark
- Phenol substitution: 50%, < birch bark (65%)
- ➤ Future work:
- For better bio-oil quality and phenol substitution ratio:
  - Higher pyrolysis temperature
  - Longer vapor residence time



## Conclusions

#### High bio-phenol substitution ratio was achieved:

- 50 wt. % 80 wt. % phenol substituted by pyrolysis bio-oil
- Fractional condensation and autothermal operation are beneficial

## Bio-PF wood adhesive is attractive:

• Cost savings: expensive, fossil-sourced phenol

 $\rightarrow$  inexpensive, sustainable bio-oil

(cost < 50% of phenol from benzene)



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- ICFAR colleagues
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