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Adhesives from biomass pyrolysis

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Adhesives from Biomass Pyrolysis

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Outline

- Introduction
- 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 → 30+ MJ/kg (ethanol: 29.7)
- Recovery of organic chemicals: > 90%
- Recovery of total bio-oil energy: > 90%

Preparation of Pyrolysis Bio-oils

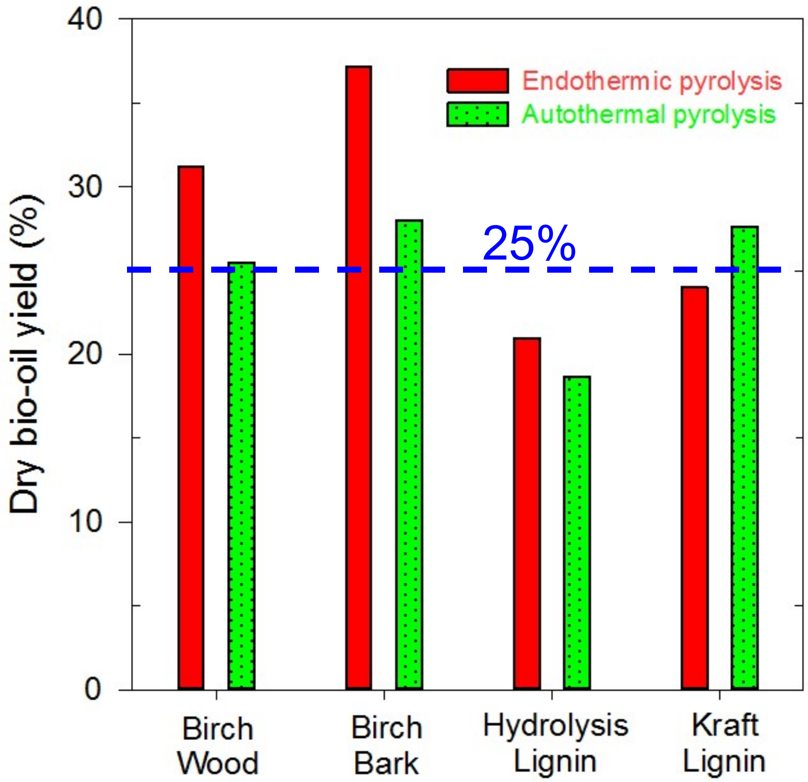
Problem: External heating required (endothermic process)

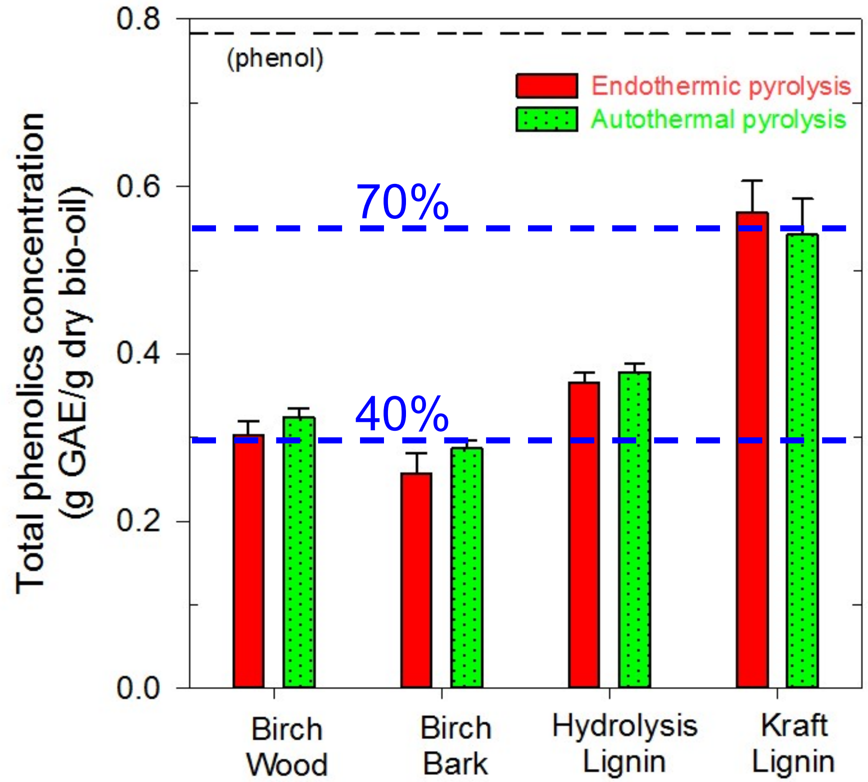
Solution: Autothermal Operation from partial oxidation

Results:

- No need for external heating → 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?

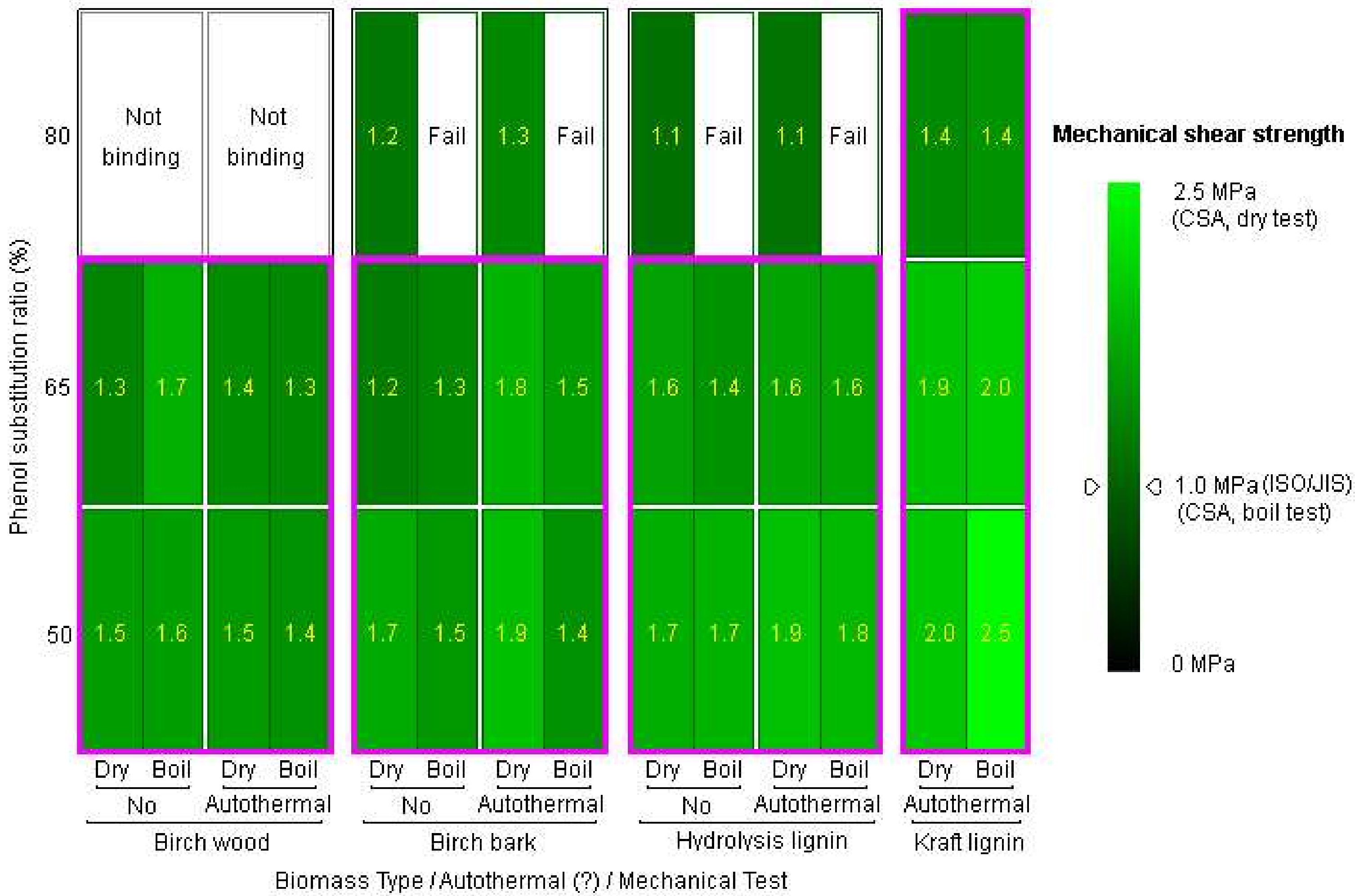
Preparation of Bio-phenol Resins for Wood Adhesives

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



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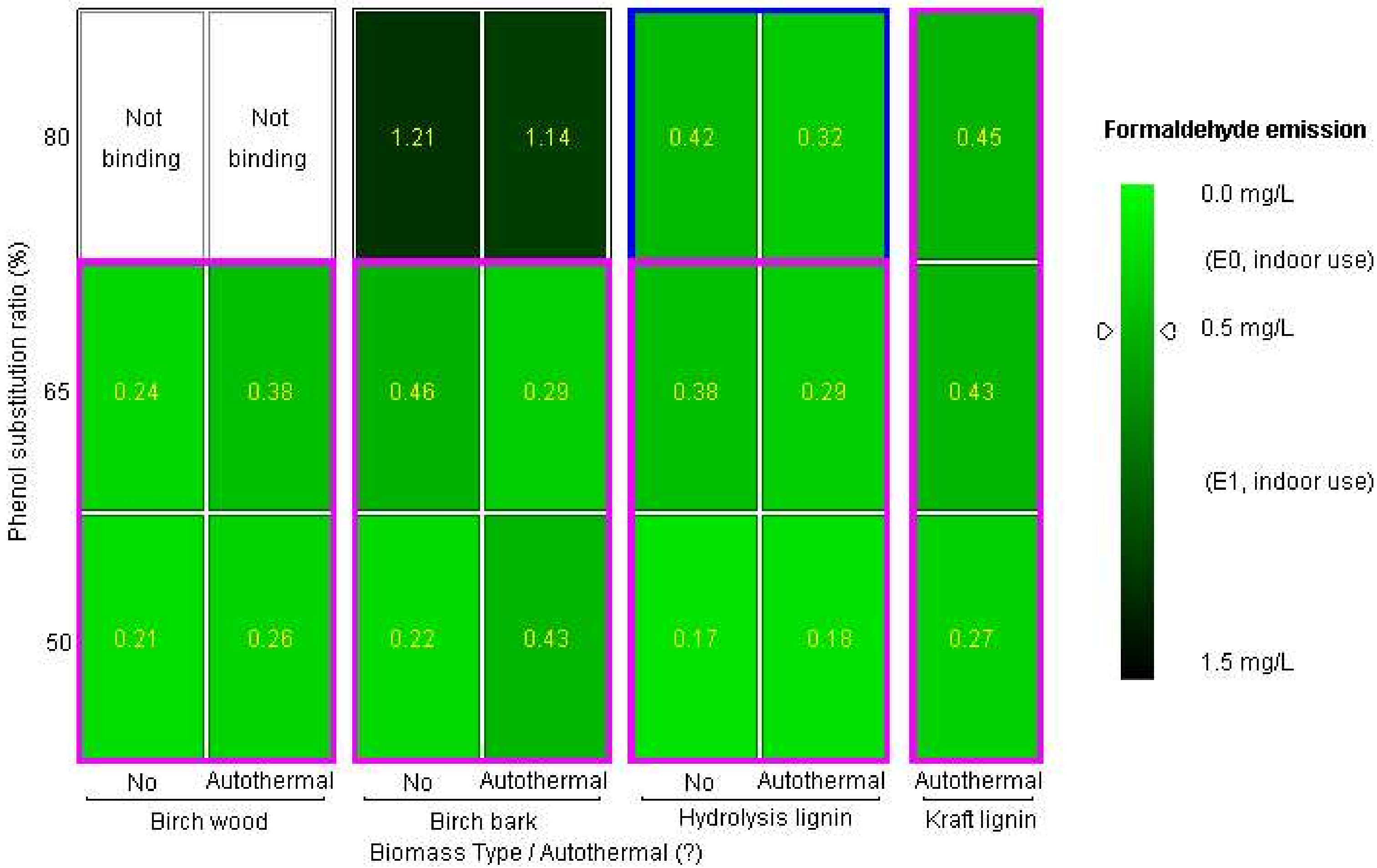
Meeting ISO/JIS Specifications: Formaldehyde Emission



Low-Cost Waste Biomass: Digestate?

- Digestate → 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
  → inexpensive, sustainable bio-oil
  (cost < 50% of phenol from benzene)

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