

# Lignin Valorization: Challenges and Opportunities

**Mojgan Nejad**

Assistant Professor, Department of Forestry and Department of Chemical Engineering

Michigan State University

Professor (status only) Mechanical Engineering Department, University of Toronto

NextFor Workshop, September 15<sup>th</sup>, 2021

# *Challenges*



# 1. Lignin Variations

**Different Sources:** Hardwood, Softwood, Annual  
Crops

**Isolation Processes:** Kraft (Lignoboost & Lignoforce),  
Sulfite, Soda, Organosolv, or Enzymatic Hydrolysis



## 2. Characteristic Properties

---

- Dark color
- Unpleasant odor in some cases (Kraft-Softwood)
- Low reactivity toward co-monomers
- Low solubility in most organic solvents (except organosolv lignin)
- Inconsistency



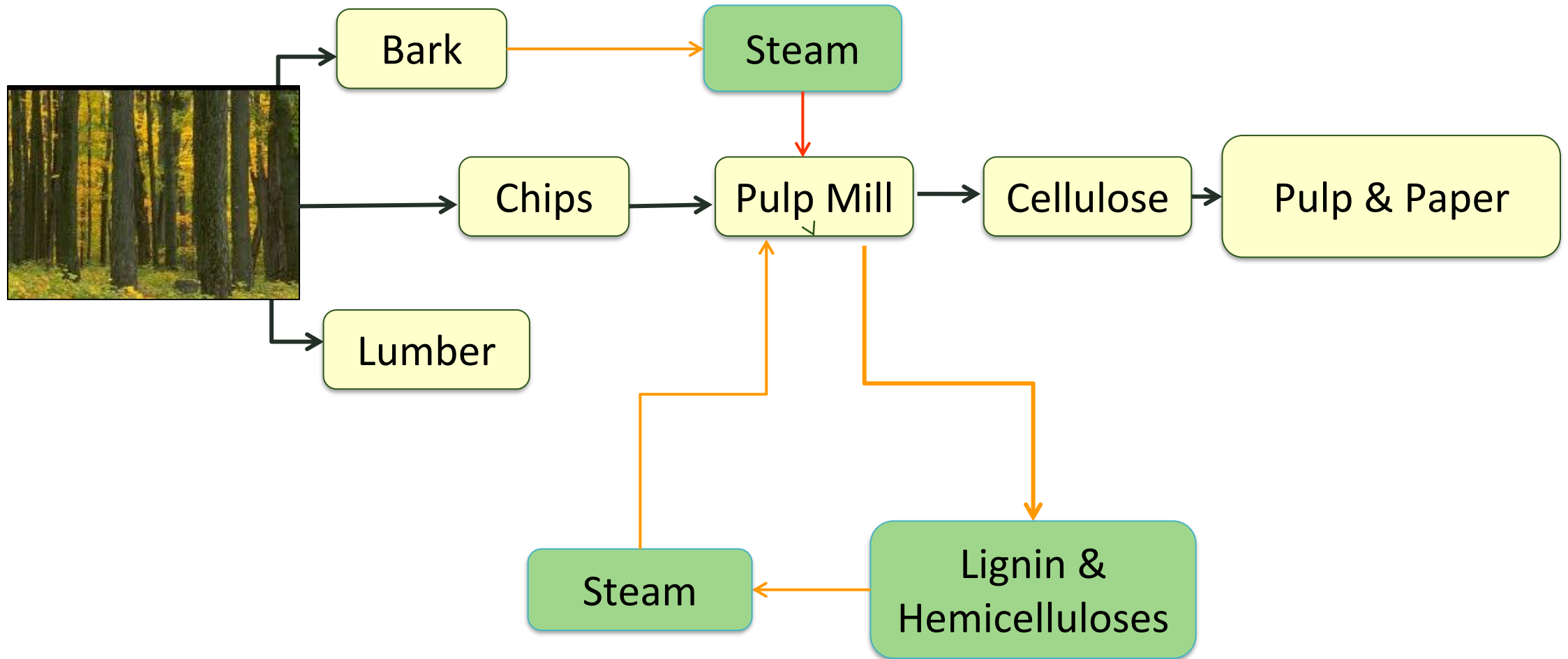
# 3. Byproduct

---

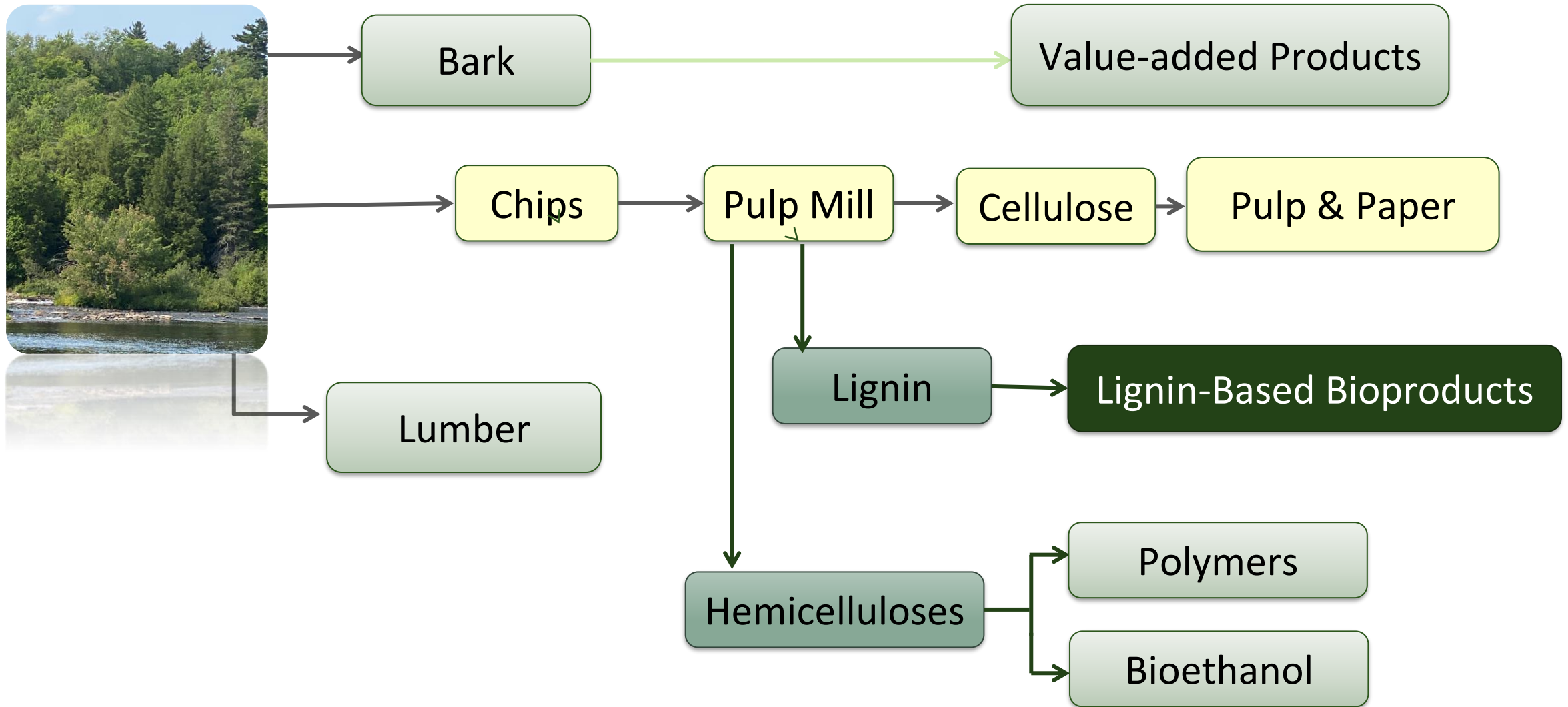
- One major challenge that we lignin is produced as byproduct of pulping and lignocellulosic bioethanol production.
- They are mainly focused in producing high-quality, low-cost paper, ethanol, nanocrystalline cellulose, sugars, and other chemicals.
- The process is not optimized or oriented toward producing high-quality lignin.



# Current Pulp and Paper Mill



# Future Potential Pathway



# *Opportunities*



# Lignin-Based Polymeric Resins

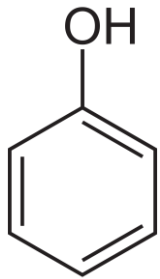
---

- 1. Lignin as Phenol Replacement:** Lignin-Based Phenolic Adhesive for Plywood and OSB application
- 2. Lignin as Polyol Replacement:** Lignin-Based Polyurethanes for Coating, Adhesive, and Foam Applications
- 3. Lignin as Bisphenol-A Replacement:** Lignin-Based Epoxy Resin for Composite, Coating and Adhesive Applications

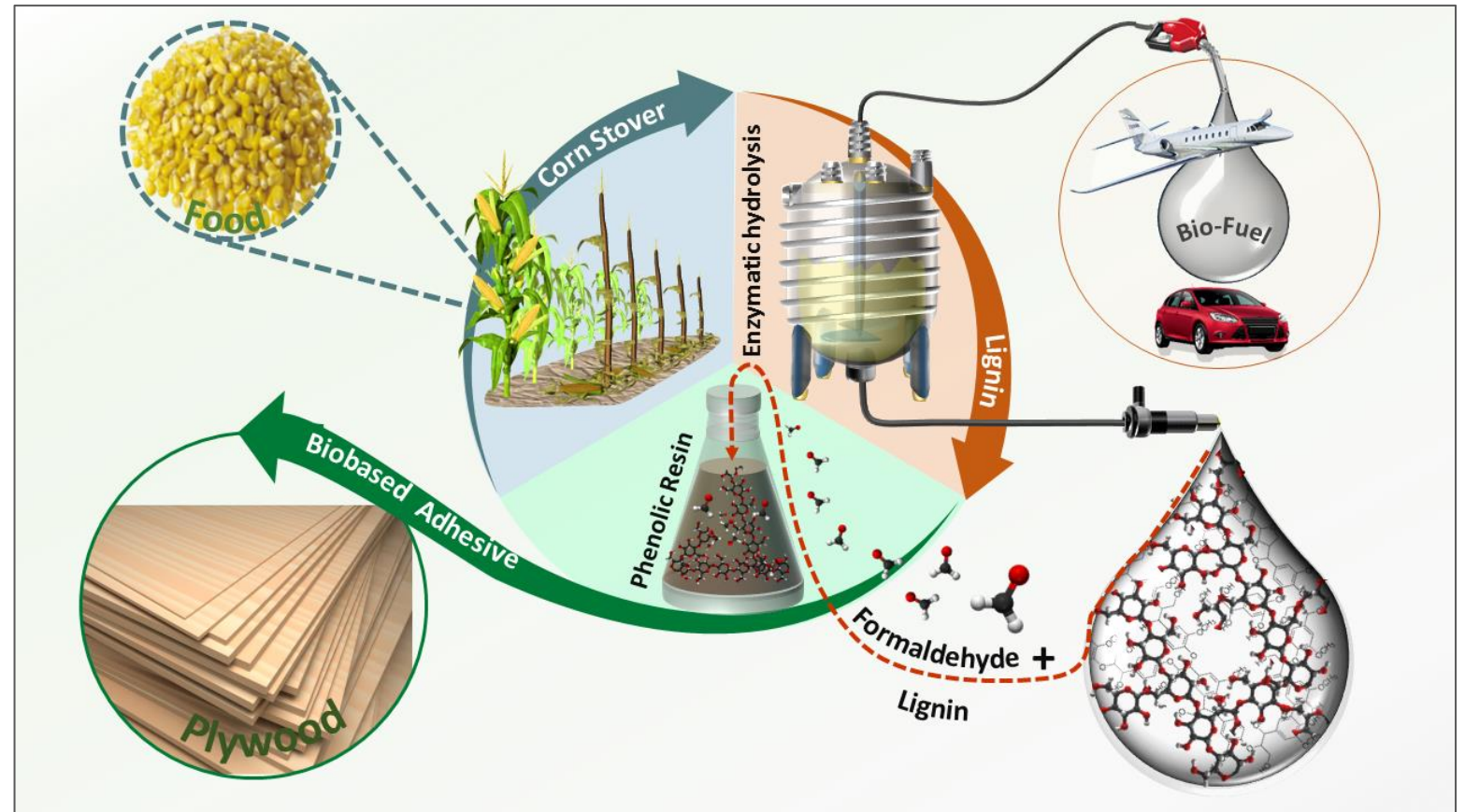
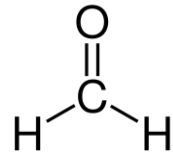


# Lignin as Phenol Substitute in Phenolic Adhesive

Phenol-Formaldehyde Resin



+



# Lignin-Based Phenolic Adhesive

---

CRIBE Funded Project:

❖ Two Lignin Producers



❖ One Phenolic Resin Producer

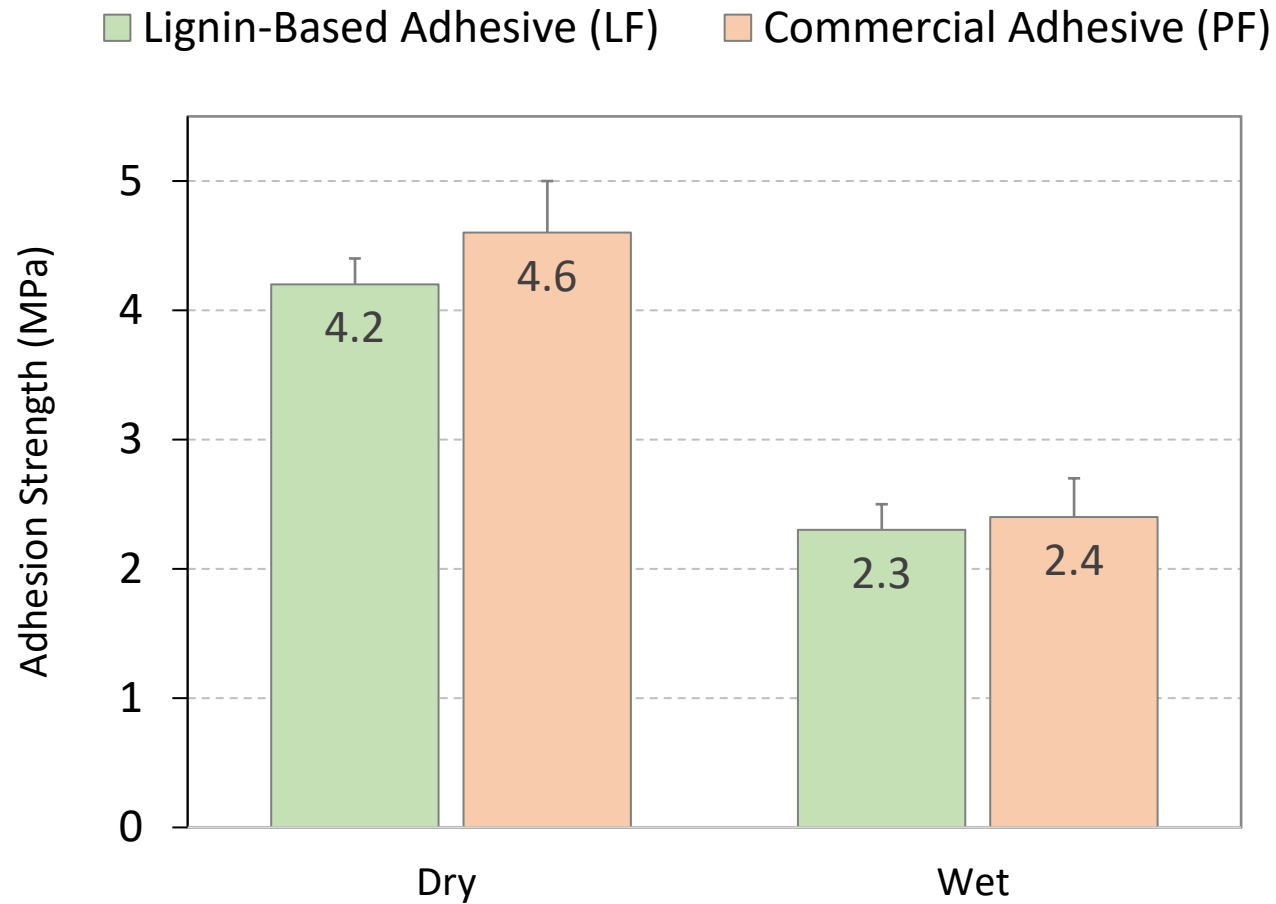


❖ One Plywood Producer



***To Scale up the Production of Lignin-Based Phenolic Resin***

# Lignin-Based Phenolic Resin-CRIBE Project



Lignin-Based (LF) Single-Lap-Joint Sample

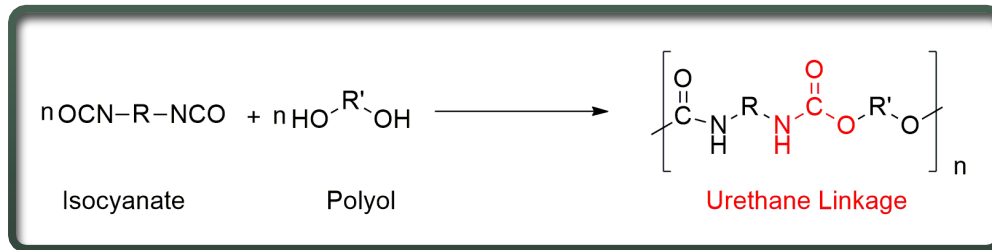
# Lignin-Based Polymeric Resins

---

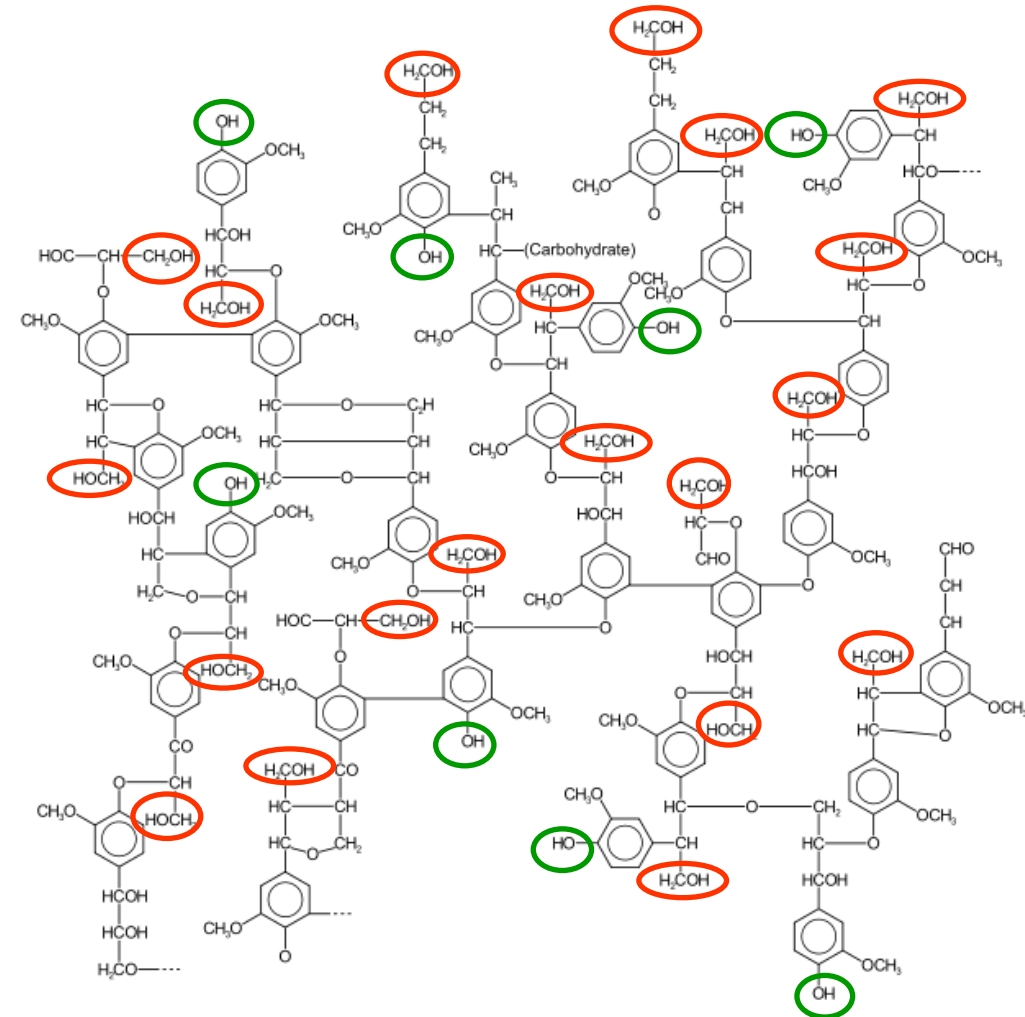
- 1. Lignin as Phenol Replacement:** Lignin-Based Phenolic Adhesive for Plywood and OSB application
- 2. Lignin as Polyol Replacement:** Lignin-Based Polyurethanes for Coating, Adhesive, and Foam Applications
- 3. Lignin as Bisphenol-A Replacement:** Lignin-Based Epoxy Resin for Composite, Coating and Adhesive Applications



# Lignin-Based Polyurethanes

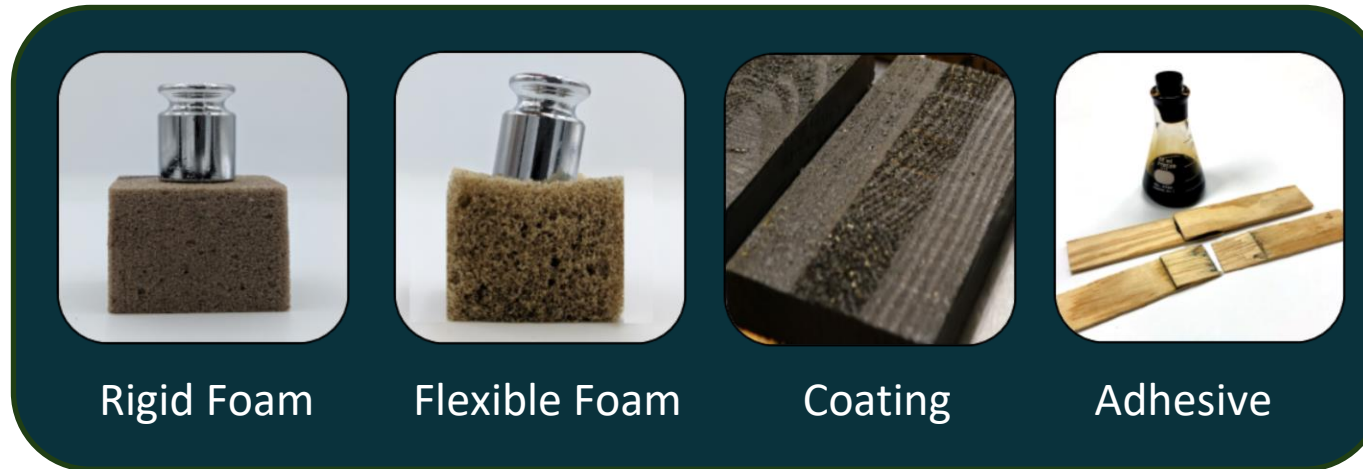


Lignin is a Natural Polyol



Glazer, A. W., and Nikaido, H. (1995)

# Lignin-Based Polyurethanes





# Lignin-Based Polyurethane Adhesive: CRIBE Project

---

CRIBE Funded Project:

- ❖ Two Lignin Producers
- ❖ One Polyurethane Adhesive Producer
- ❖ One Cross-Laminated Timber (CLT) Producer

Fortum  
**Bio2X**<sup>®</sup>

  
**West Fraser**

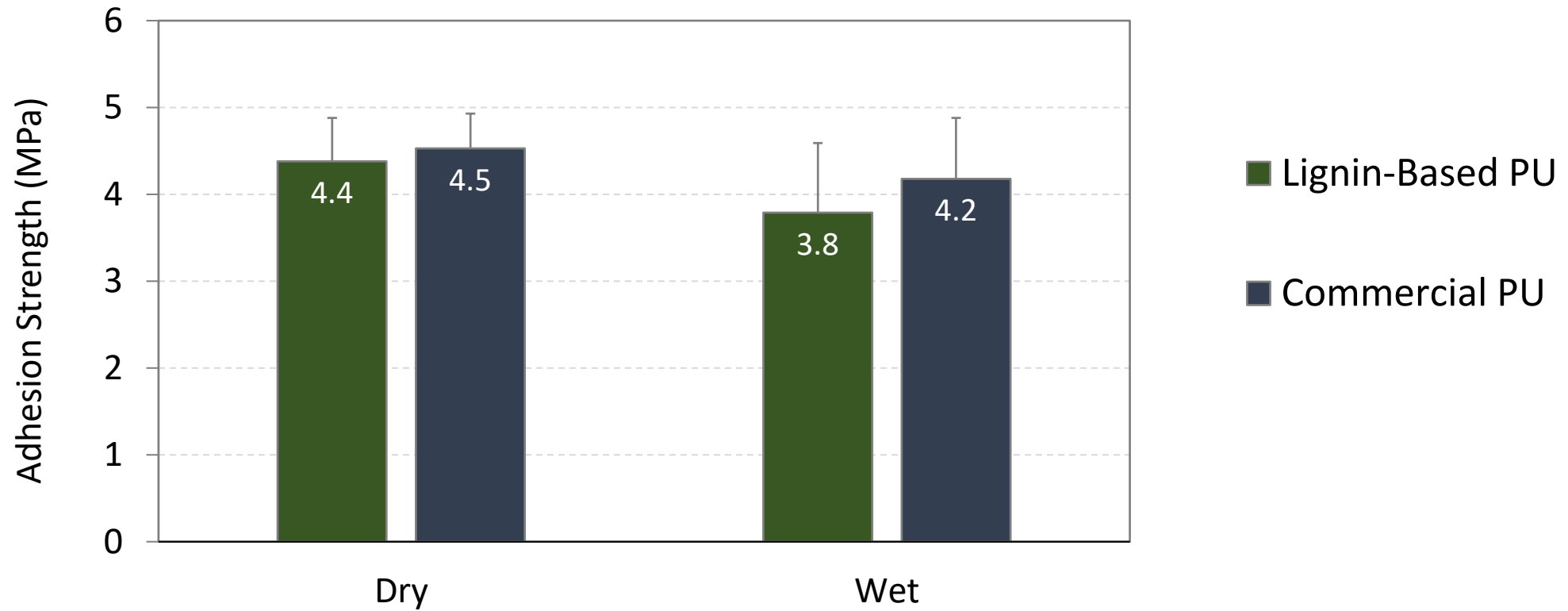
  
**Henkel**

  
**ELEMENT5**  
MODERN TIMBER BUILDINGS

***To Scale up the Production of Lignin-Based PU Adhesive***



# Lignin-Based Polyurethane Adhesive-CRIBE Project



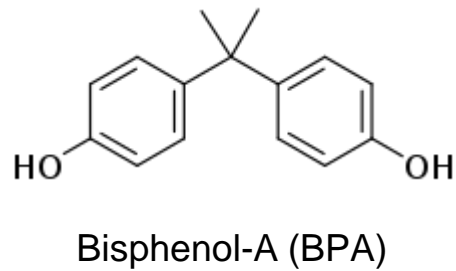
# Lignin-Based Polymeric Resins

---

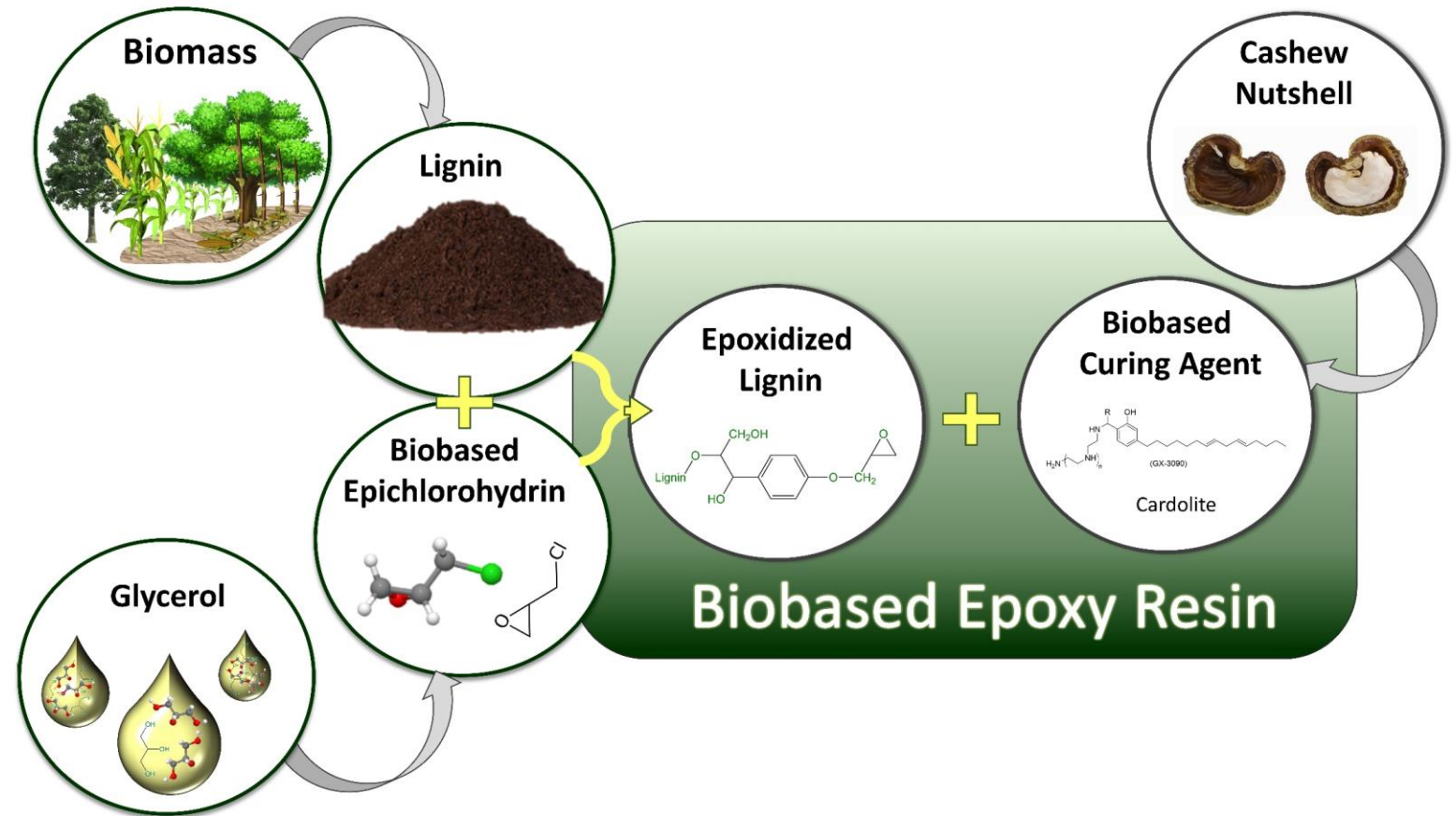
- 1. Lignin as Phenol Replacement:** Lignin-Based Phenolic Adhesive for Plywood and OSB application
- 2. Lignin as Polyol Replacement:** Lignin-Based Polyurethanes for Coating, Adhesive, and Foam Applications
- 3. Lignin as Bisphenol-A Replacement:** Lignin-Based Epoxy Resin for Composite, Coating and Adhesive Applications



# Lignin-Based Epoxy



Biobased  
Epichlorohydrin



# Acknowledgements



United States Department of Agriculture  
National Institute of Food and Agriculture



West Fraser



SHERWIN-WILLIAMS.



***I Appreciate Your Attention!***

[Nejad@msu.edu](mailto:Nejad@msu.edu)