

# Sulfur-Free Nonwood Lignin

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Paptac BCM - Fall 2018

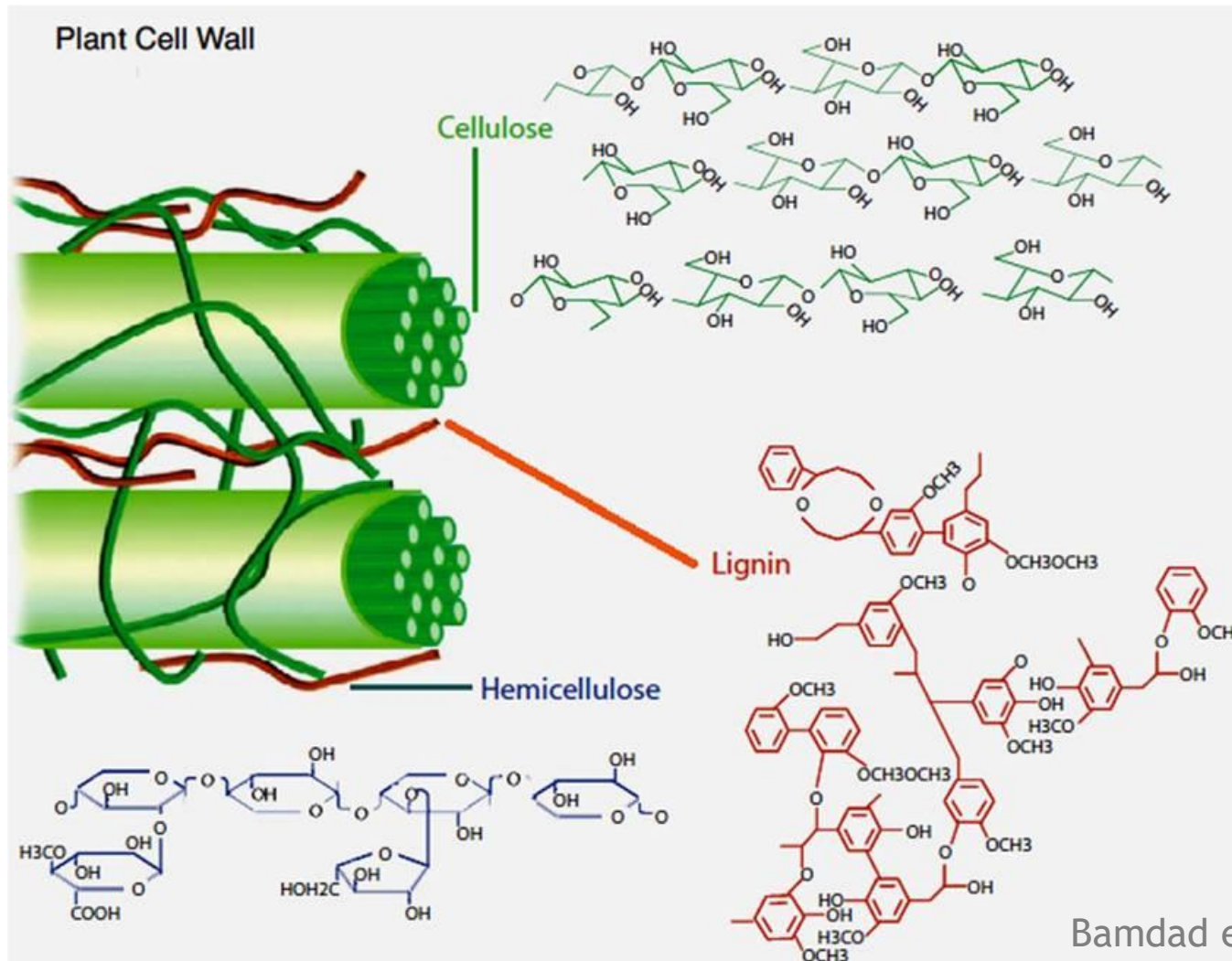


SUSTAINABLE FIBER  
TECHNOLOGIES

# Questions

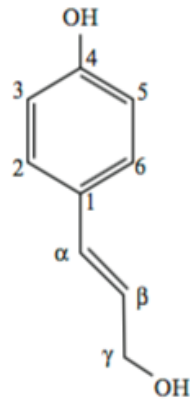
- ▶ What is it?
- ▶ What influences lignin?
- ▶ What do we use lignin for today?
- ▶ Why sulfur-free?
- ▶ Drop-in uses?
- ▶ Future potential?

# What is it?

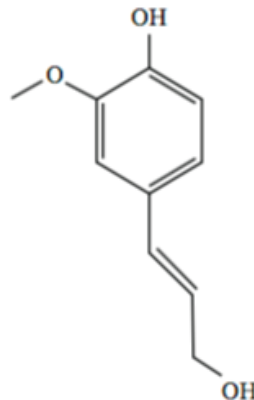


# Wood and Nonwood Monolignols

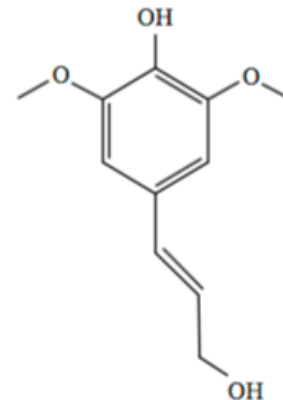
4-hydroxyphenyl (H)



Guaiacyl (G)



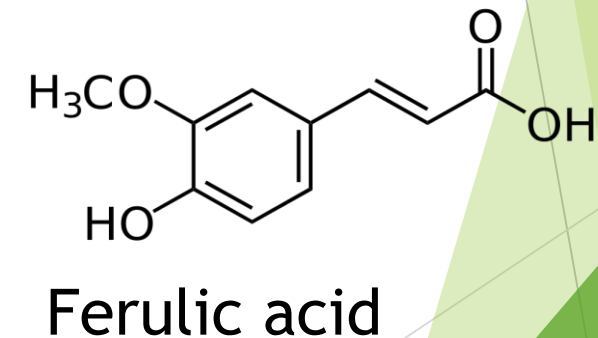
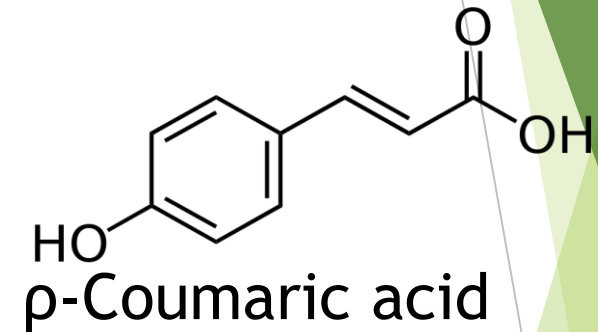
Syringyl (S)



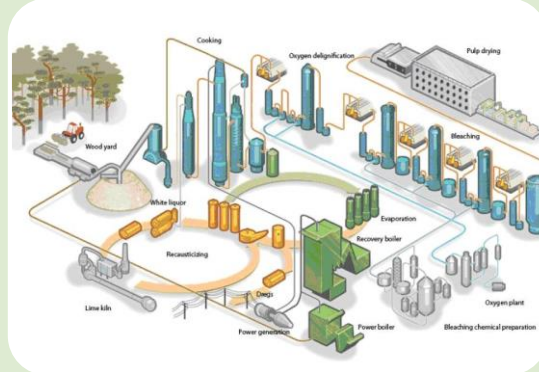
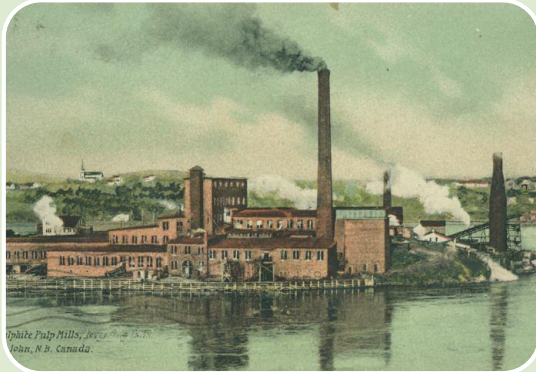
BIOMASS	H	G	S
Hardwood	Trace	25-50%	50-75%
Softwood	0.5-3.5%	90-95%	0-1%
Nonwood	5-25%	25-50%	25-50%

# Lignin in Nonwoods

- ▶ Cereal straw lignin 2-fold higher free phenolic hydroxyl groups
- ▶ Lignin contains up to 10% ferulates and *p*-coumarates
- ▶ Increased LCC bonds when compared to wood
- ▶ Typically lower molecular weight than wood
- ▶ Varied structure species to species



# Pulping and extraction processes



## Sulfite

- 130-160C,  
1.5-5pH
- 4-8% sulfur
- up to 20%  
carbohydrate
- Soluble

## Kraft

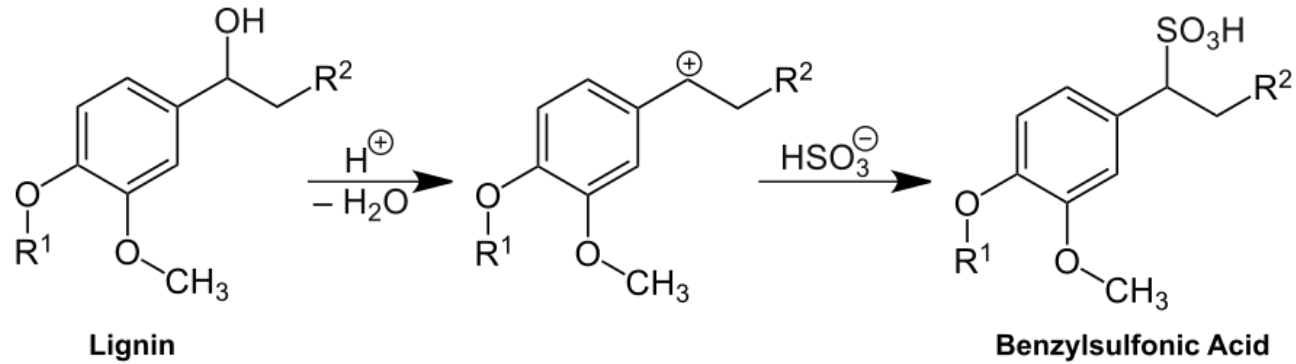
- 160-180C,  
13+pH
- acid  
precipitated
- ~3% sulfur
- Insoluble

## Phoenix

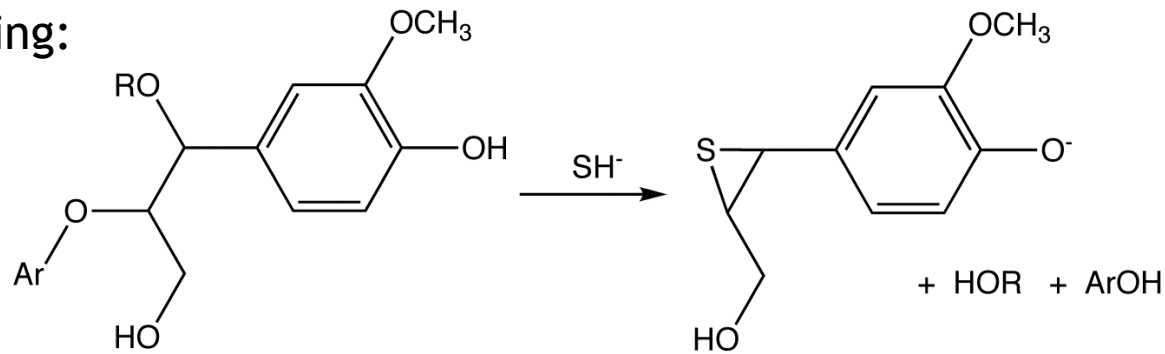
- <100C, <12pH
- sulfur and  
AQ-free
- up to 20%  
carbohydrate
- Soluble

# Reactions occurring during pulping

Sulfite pulping:



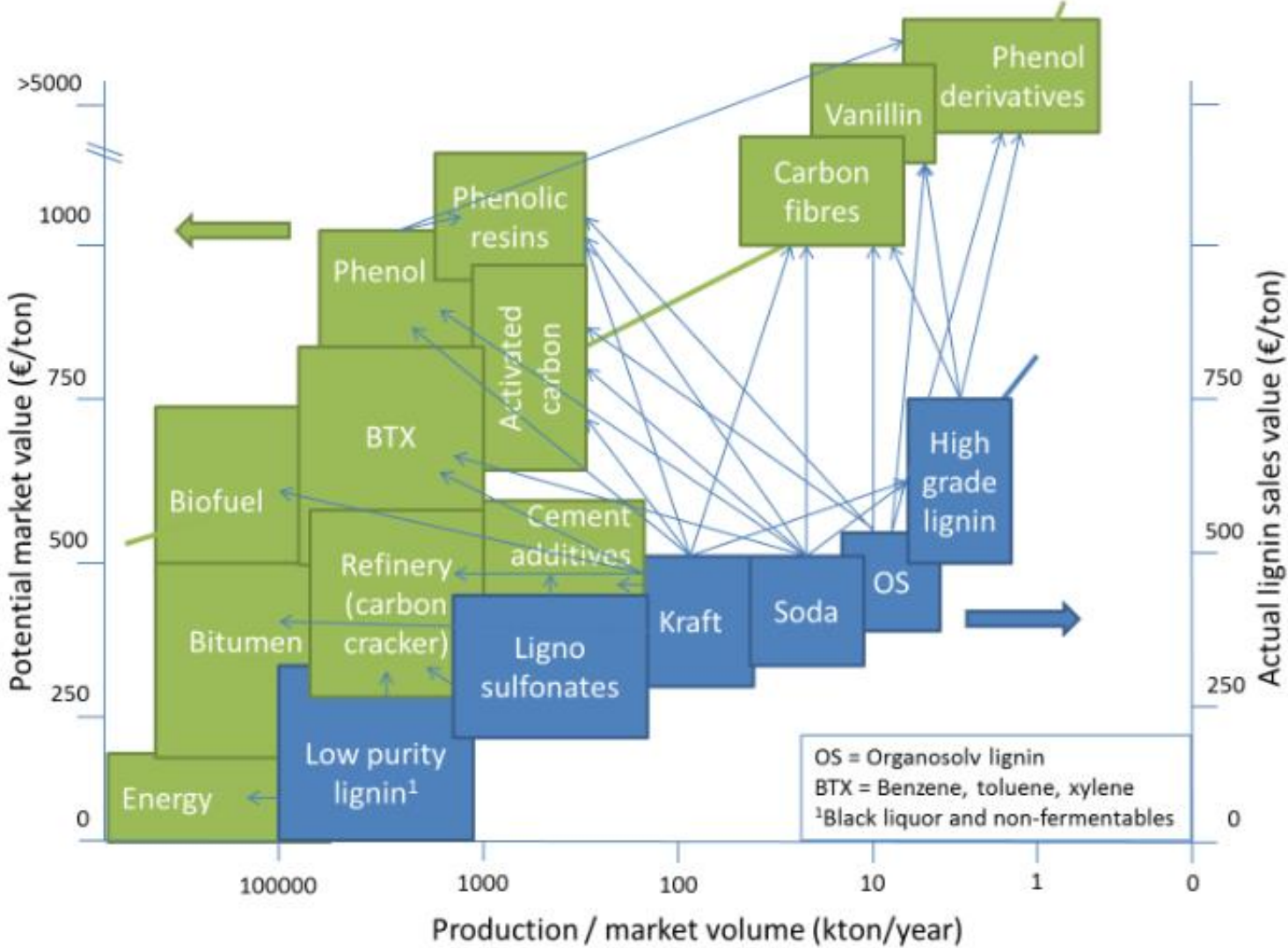
Kraft pulping:



# Lignosulfonates



# Lignin production vs utilization



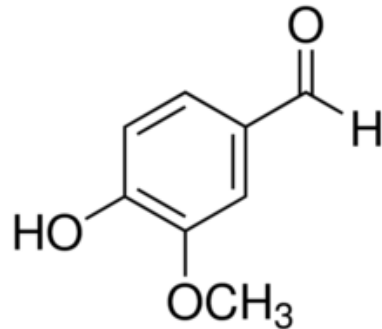
# Why Sulfur-free?

- ▶ Odor
- ▶ Toxicity
- ▶ Catalyst inhibition



# Characteristics of Phoenix lignin

- ▶ MW: 400-2000 Da, PD: 2-3.5
  - ▶ Kraft: 800-2500 Da
  - ▶ LS: 5000-200,000 Da
  - ▶ Nonwood soda: 7000-8500 Da
- ▶ Increased carboxylic acid and aldehyde groups
- ▶ Reduced C-C bonds and methoxyl groups
- ▶ Monomeric profile intermediate between soda and liginosulfonates
  - ▶ High in Vanillin
- ▶ Sulfur <500ppm



# Drop-in: Dust control on dirt roads



# Drop-in: Deicer corrosion inhibitor

- ▶ Corrosion inhibitor
- ▶ Prewetting agent
- ▶ Ice crystal reformation inhibitor
- ▶ Reduce chloride content



# Animal Feed

- ▶ Cattle and pet
- ▶ Binder
- ▶ Nutrients
  - ▶ 5% crude protein
  - ▶ 2.5% crude fat



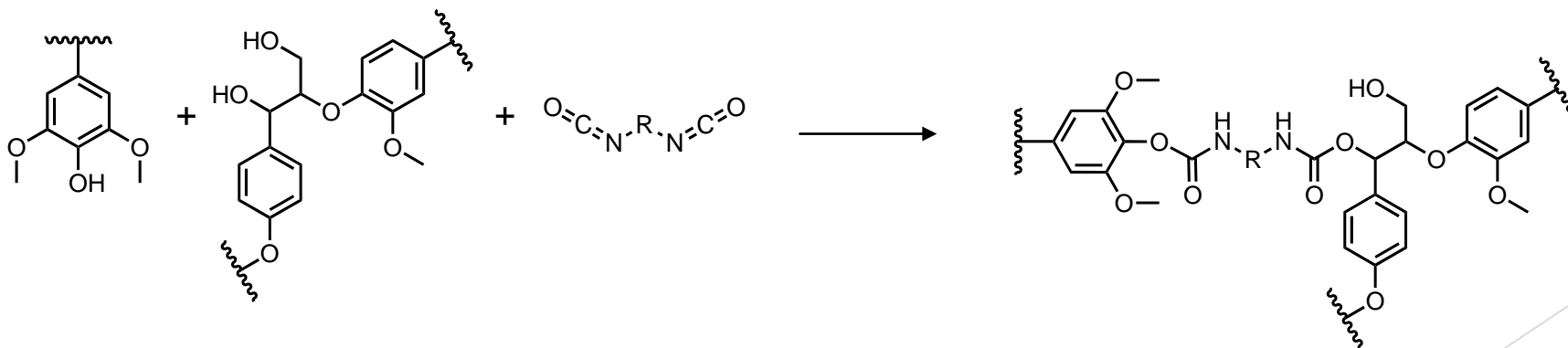
# Polyurethanes

- ▶ Rigid and flexible
- ▶ LEED building



Highly Characterized Lignin Isocyanates

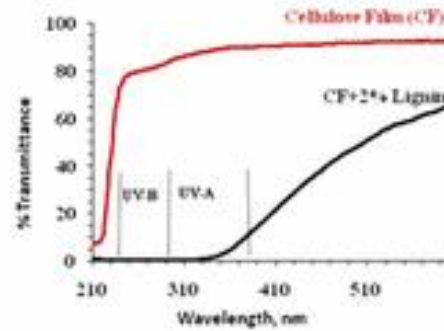
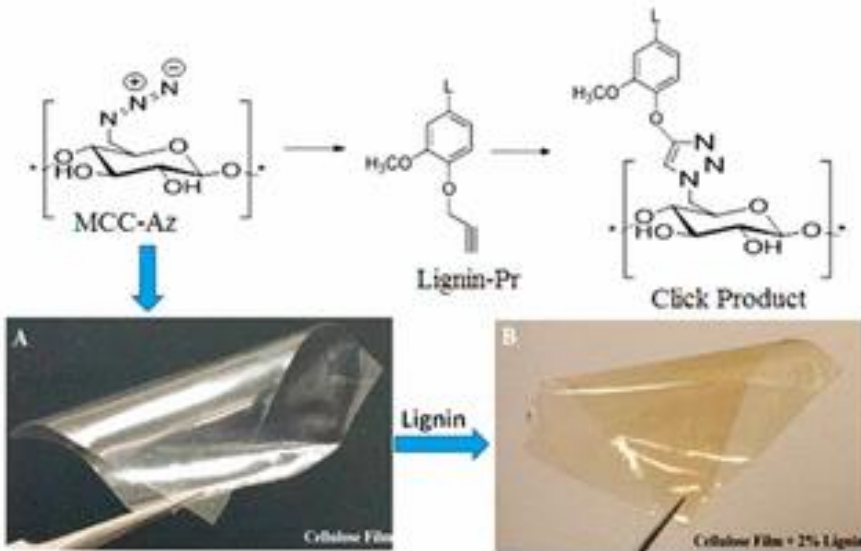
Highly Crosslinked Lignin Polyurethane



NREL 2018

# UV Barrier

- ▶ Rigid plastics and flexible films
- ▶ Antioxidant properties

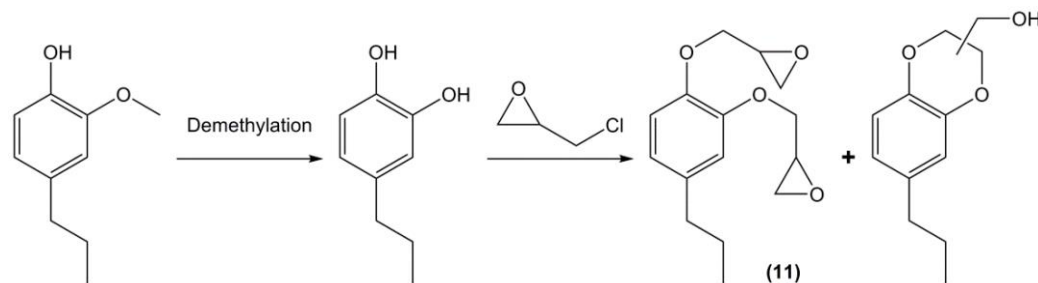


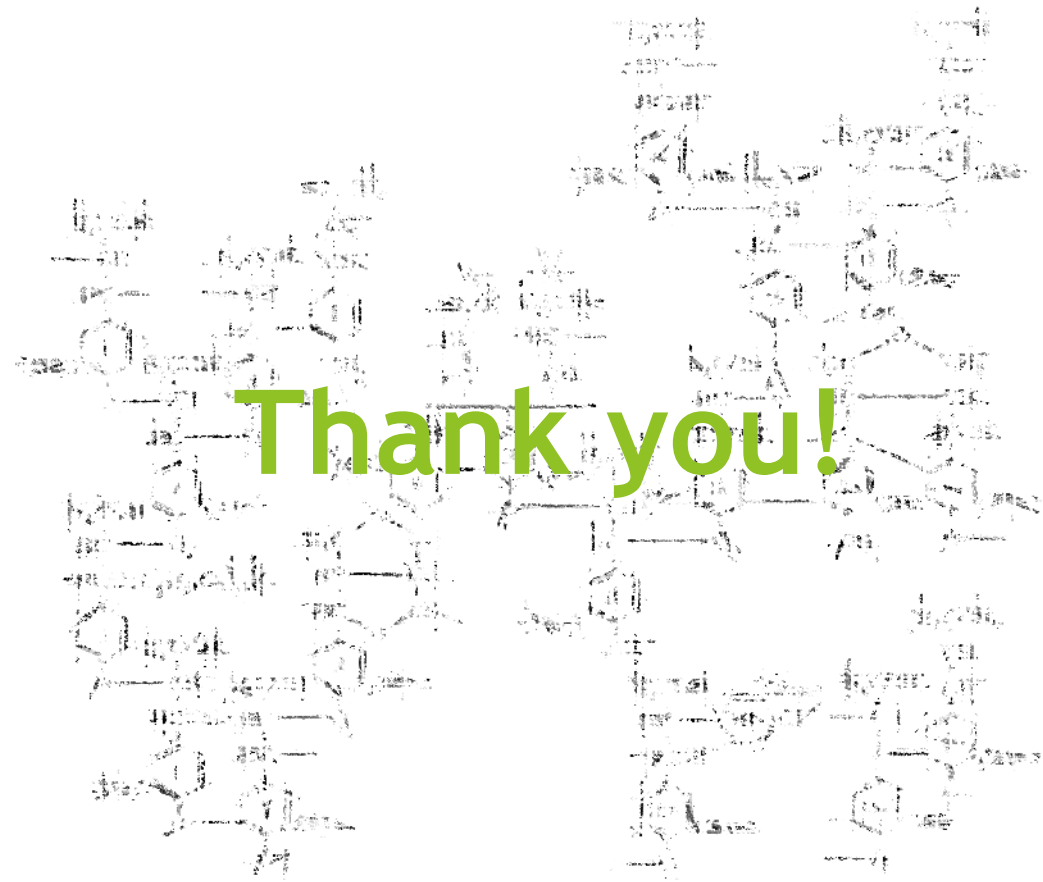
UV Protection

Sadeghifar et al 2017; Quian et al 2017

# Epoxy resin

- ▶ Printed Circuit Board
- ▶ Epoxylated lignin monomers and polymers
- ▶ High purity or chemical modifications
- ▶ Flame-resistant properties





**Thank you!**