Catalytic Depolymerization of Lignin (**CDL**) First to Make Chemicals and Materials

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&

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UCSB

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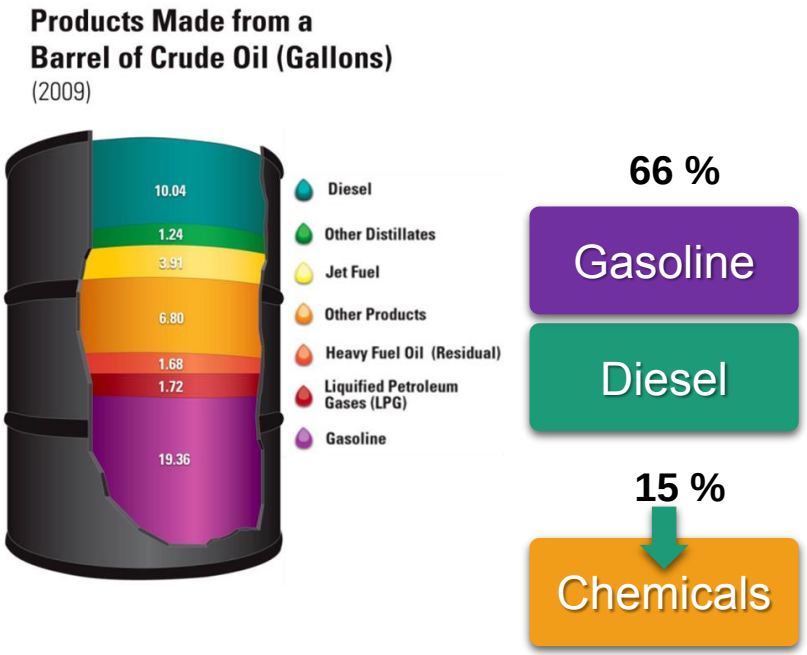
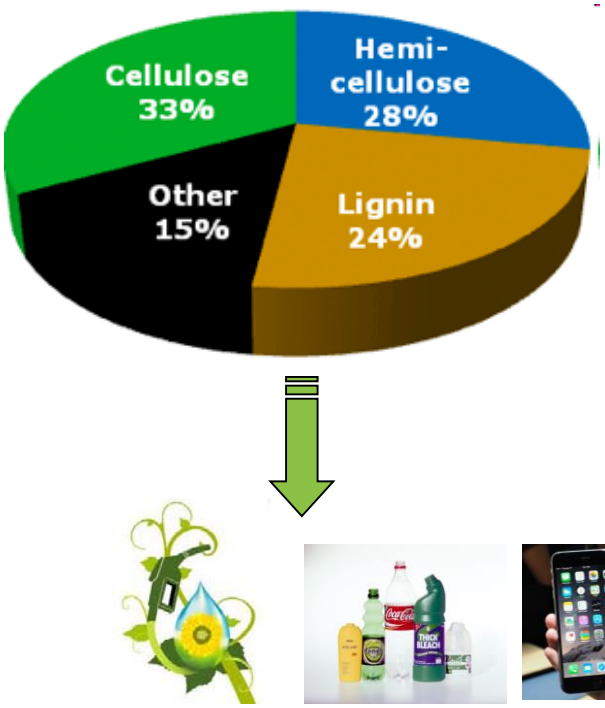
Session title: The Lignin Renaissance: New Approaches to a Century-Old Opportunity

Spero

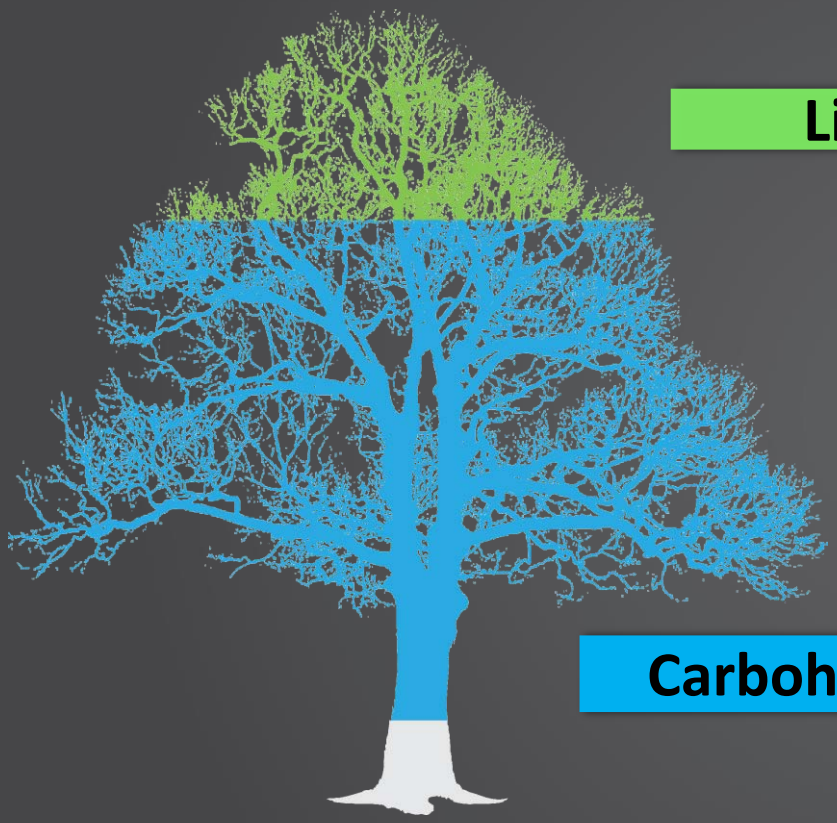
Moving towards a barrel of biomass





Energy Information Administration, “Oil: Crude Oil and Petroleum Products Explained” and Annual Energy Outlook (2016).

Wasted Carbon Value



Lignin

$40 per ton

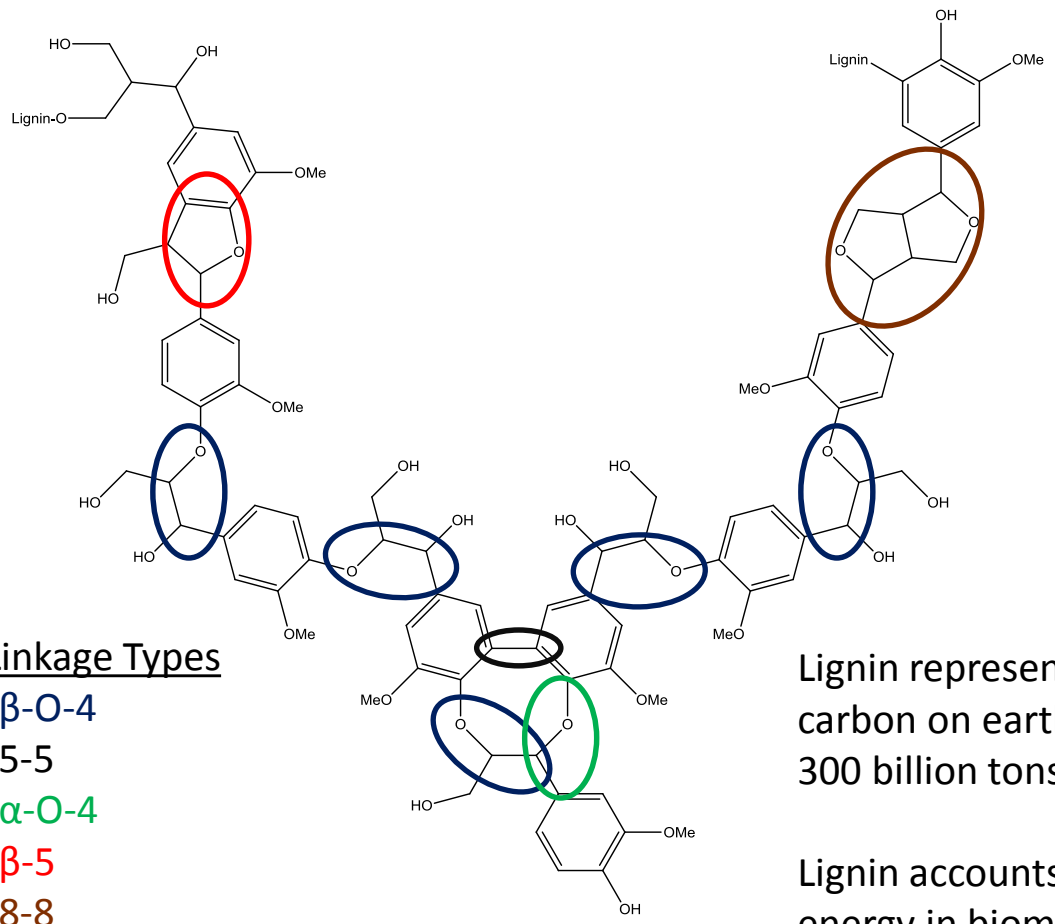
Biomass2energy.com

Carbohydrates

Petrixo.com

Spero™

Lignin: abundant & rich in energy



Linkage Types

- β-O-4
- 5-5
- α-O-4
- β-5
- 8-8

Lignin represents 30% of non-fossil carbon on earth
300 billion tons (3×10^{14} kg)

Lignin accounts for 37% of the energy in biomass

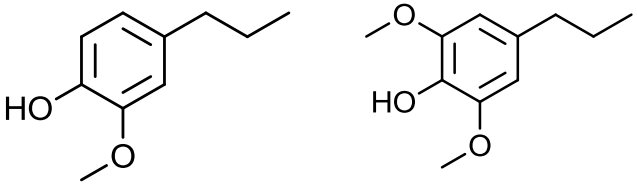
Catalytic depolymerization of lignin (**CDL**)

1-20 g biomass

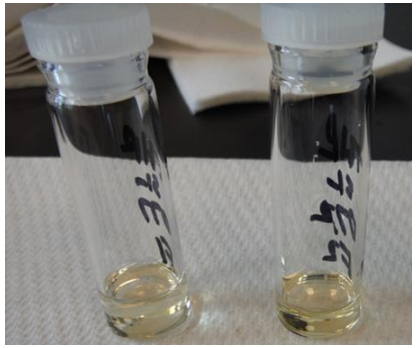
5 wt% Cat. Zn-Pd/C

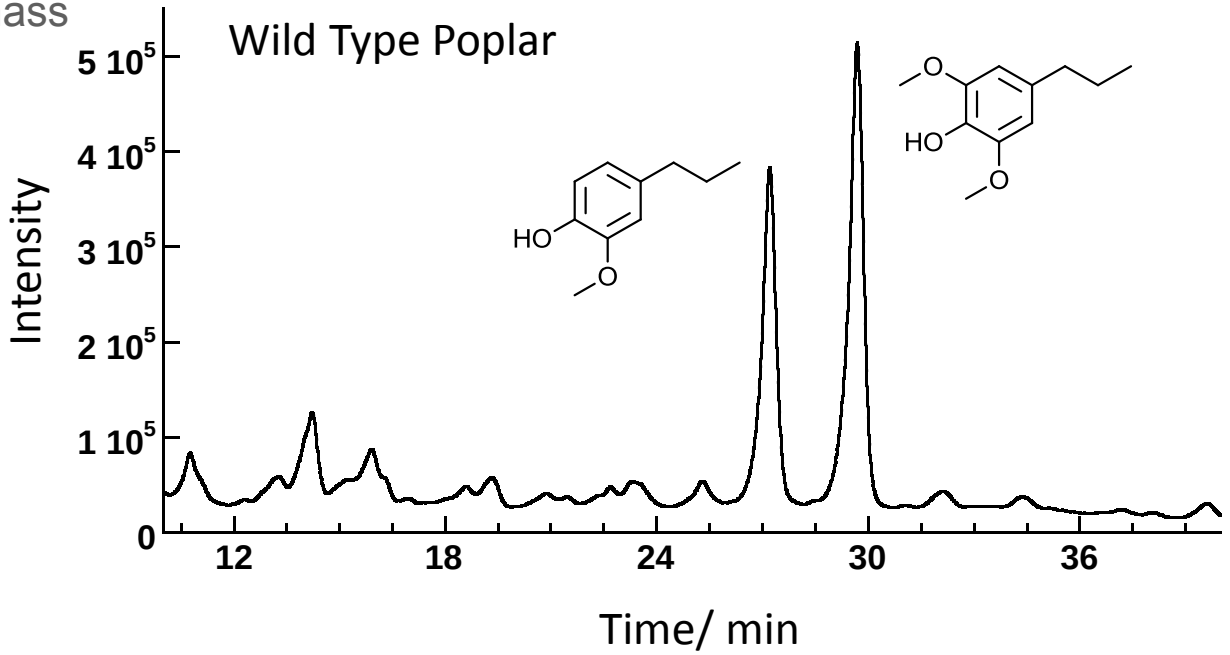
50 bar H_2, 200 °C

MeOH



Yield 54%





PCT/US14/62471, filed **2014**.

Parsell *et al. Green Chem.* **2015,** *17*, 1492-1499.

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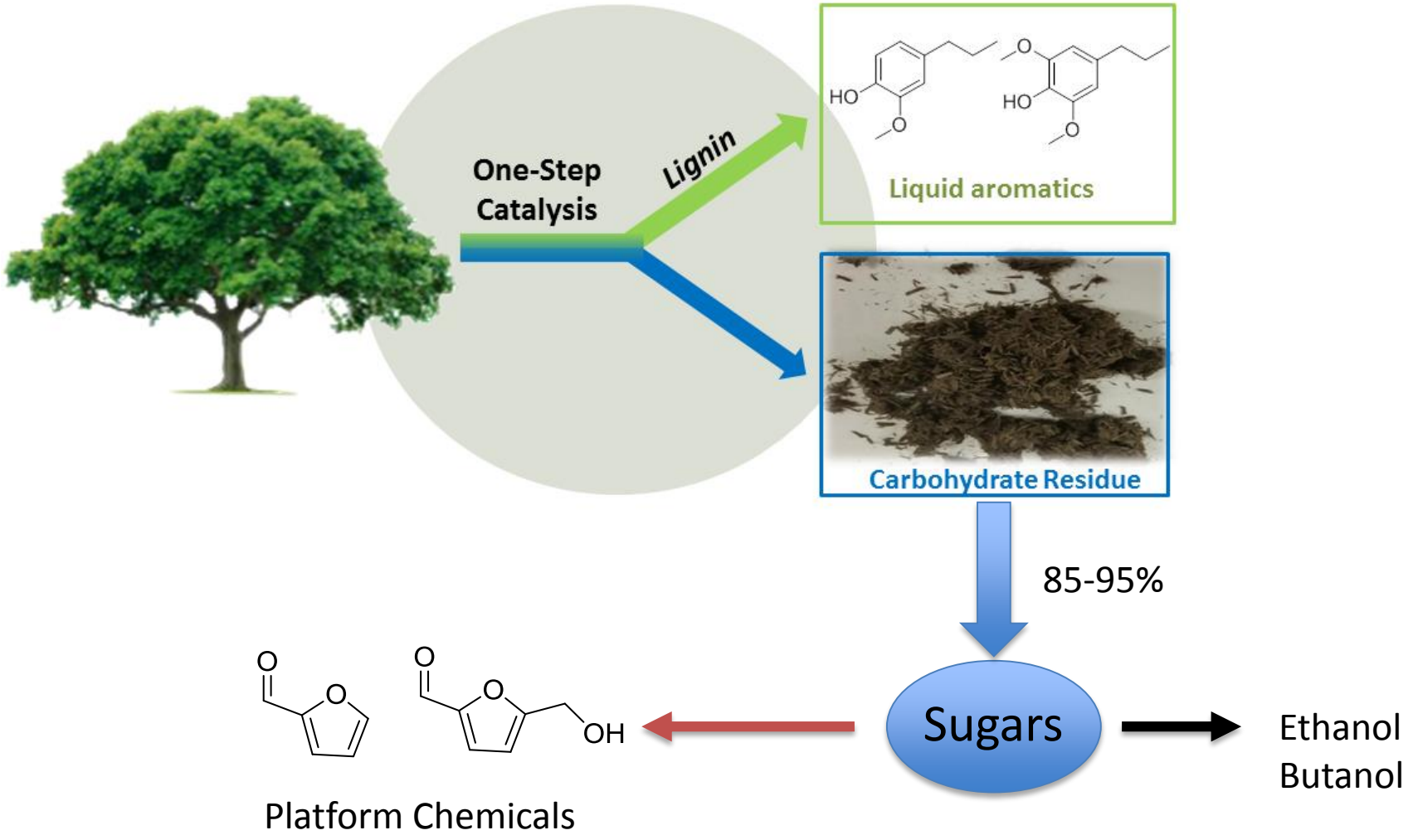
Carbohydrate value retained



Luo, Abu-Omar *et al. ACS Sustainable Chem. & Eng.* **2016**, *4*, 2316-2322.

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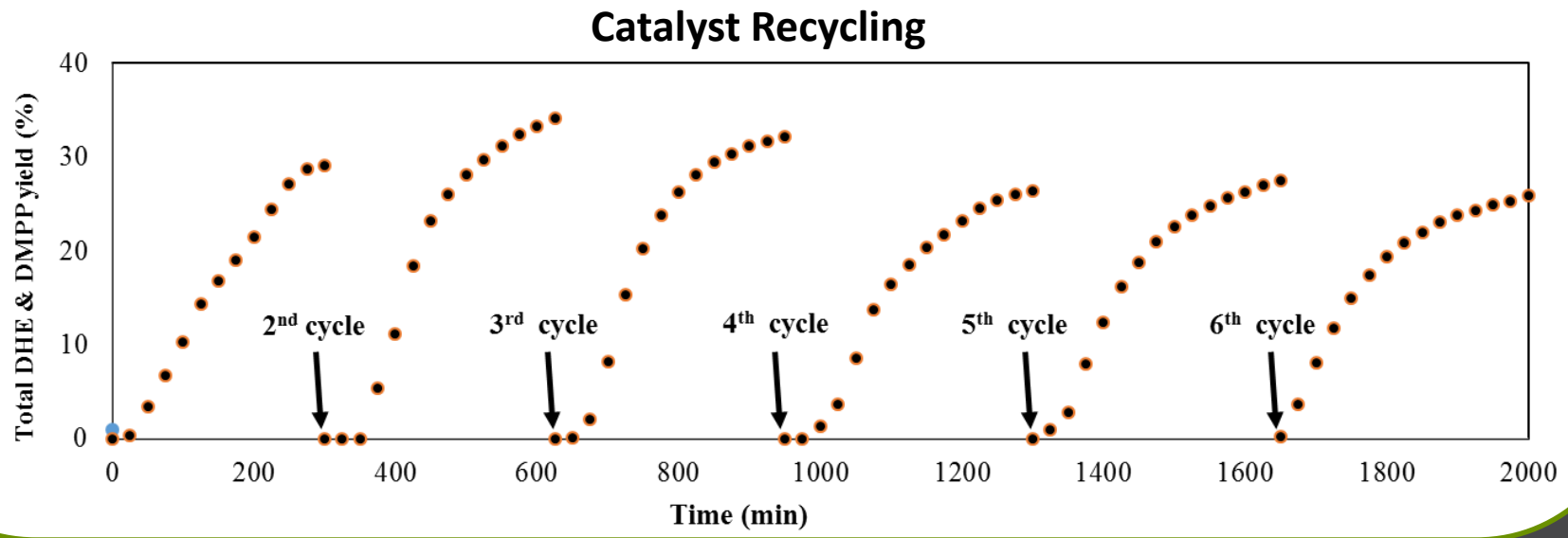
SPERO Catalyst

- Highly Selective
- Easily separated from product stream
- Recyclable with good lifetime



Spero™

Business Opportunity

Flavor & Fragrance

Fragrance $10 B

- 4.3% growth

Flavor $10.6 B

- 6% growth
- Natural flavors 12%

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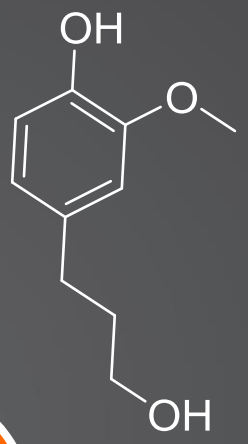
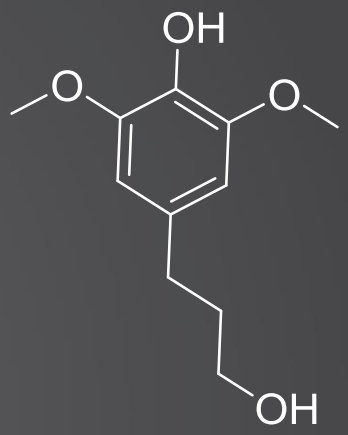
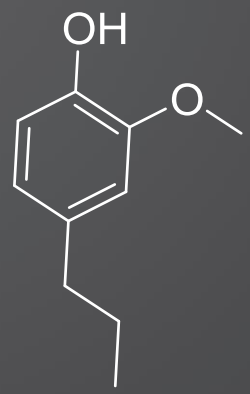
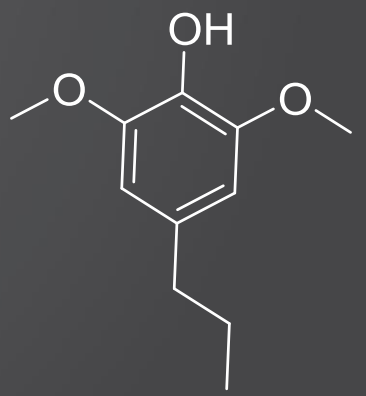
Lignin Monomer

Solvent Conditions









Yield: 70-100 g
from 1 kg of biomass

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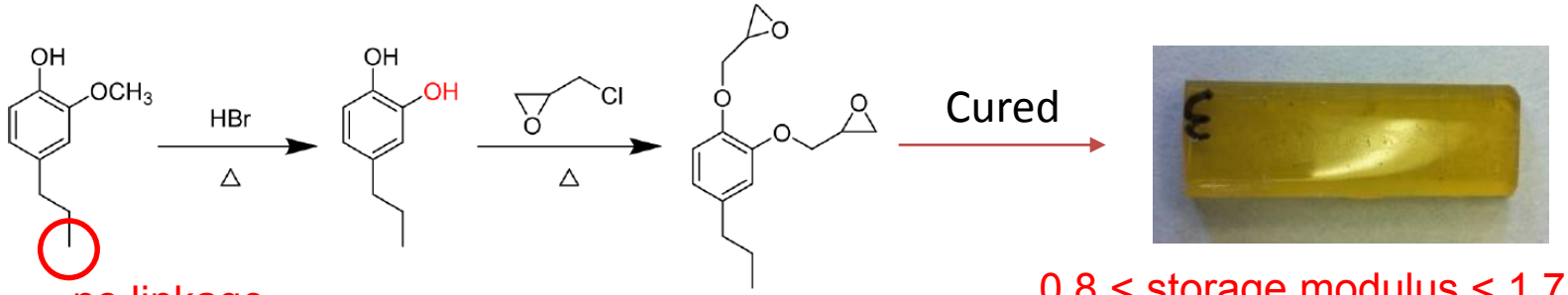
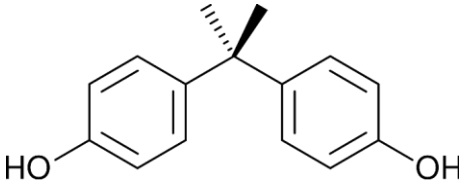
Lignin monomers for bio-based epoxy resins



no linkage

0.8 < storage modulus < 1.7 GPa

T_g up to 90 °C



Bisphenol A (BPA)

Advantages of Spero's resin technology

Properties

Mechanical properties (storage modulus and T_g) competitive with DGEBA or BADGE, which are made with Bisphenol A.

Naturally sourced from renewable lignin or wood.

No emissions.

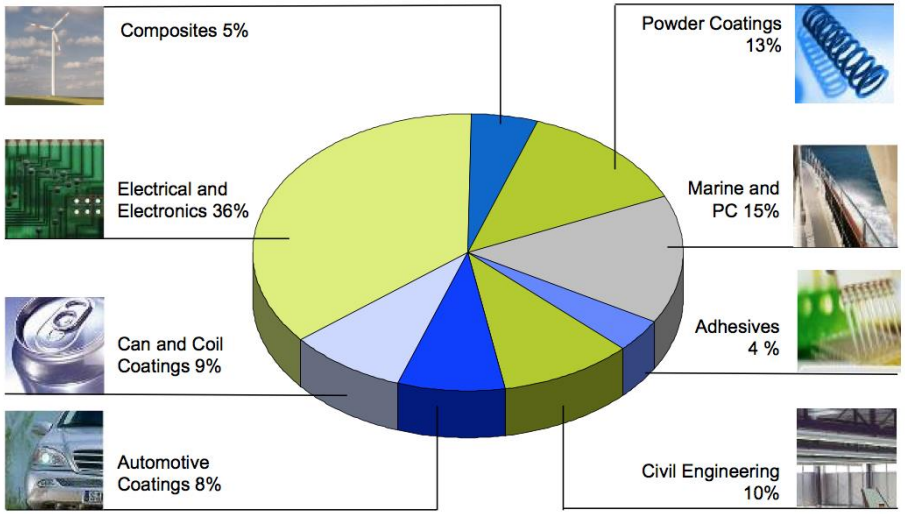
Opportunity

Huge markets > $\$10^{10}$

In flooring laminates alone

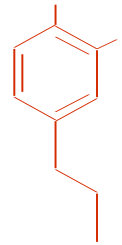
- A typical plant makes 600 M ft^2/year. Each ft^2 is ~ 1 lb., of which 15-20% is resin binder.

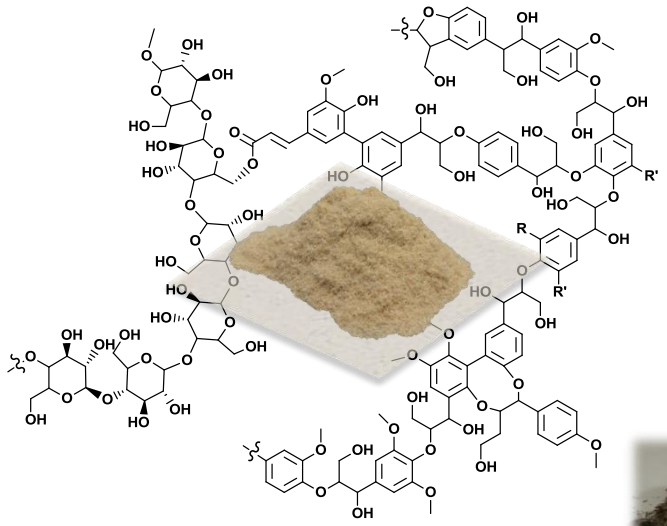
Meets CARB (Cal. Air Resource Board) limits



Lignin first biorefinery

Flavor &
Fragrance
Chemicals





CDL

Cellulose
Solid Residue