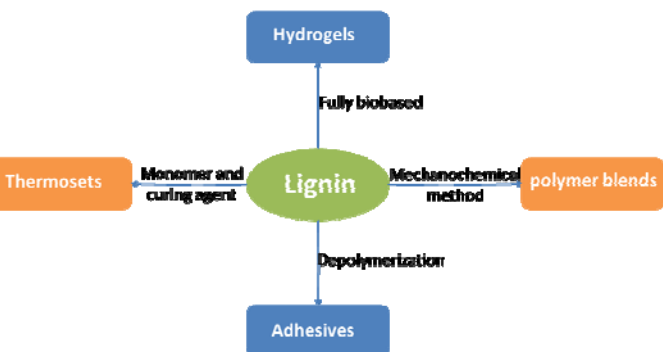


# Application Development of Lignin: thermosets and polymer blends

Junna Xin, Xiaojie Guo, Jinwen Zhang

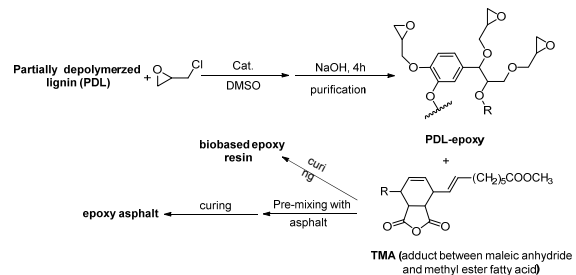
Composite Materials and Engineering Center, Washington State University, Pullman, WA 99164, USA (jwzhang@wsu.edu)

## 1. Outline



## 2. Epoxy resin based on depolymerized lignin

### Approach 1: Preparation of epoxy monomer from PDL<sup>1</sup>



Scheme 1. synthesis route of epoxy monomer from PDL and curing.

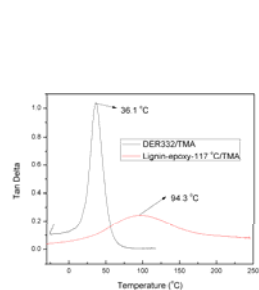


Figure 1. Tan  $\delta$  versus temp. for DER332 and PDL-epoxy-170 °C.

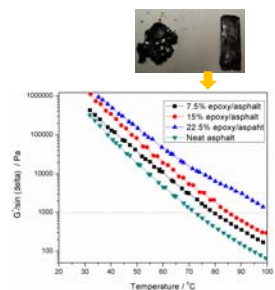
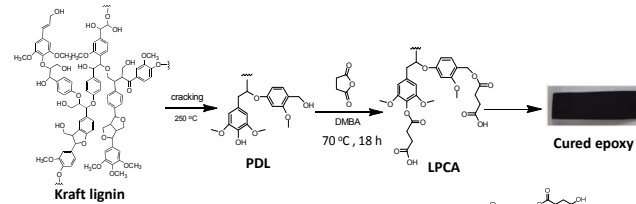


Figure 2. Effects of epoxy resin contents on the rheological properties

### Approach 2: Preparation of curing agent based on PDL (BCD)<sup>2</sup>



#### DMA characterization

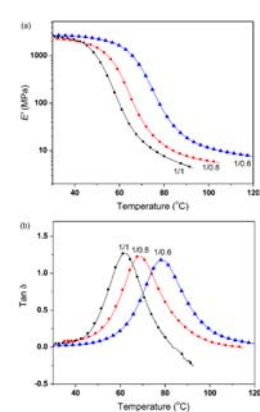


Figure 3. DER 353 cured by various equivalent of LPCA.

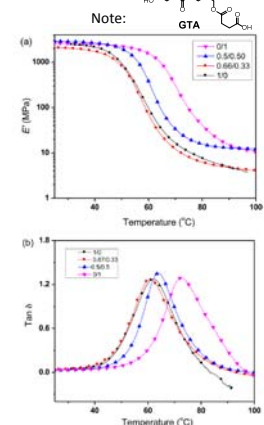


Figure 4. DER 353 co-cured with LPCA/GTA at various ratios .

## 3. Thermoplastic applications of lignin

### Mechanochemical synthesis of oleated lignin and its blends with PLA

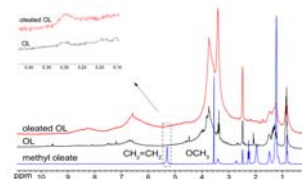
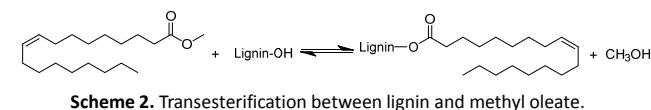


Figure 5. <sup>1</sup>H NMR spectra of methyl oleate, OL and oleated OL..

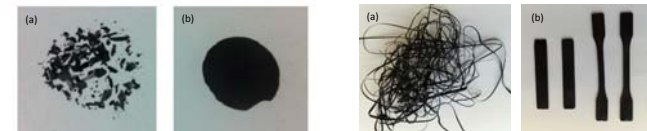


Figure 6. Photographs of (a) OL and (b) oleated OL after hot-pressing at 180 °C.

Figure 7. PLA/oleated OL blends (a) melt extrusion; (b) melt molding.

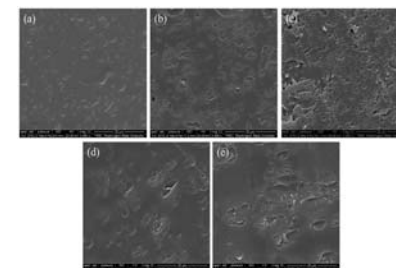
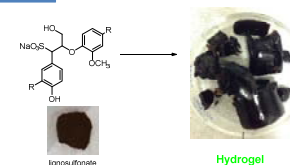


Figure 8. SEM micrograph of cross-section surface of PLA/lignin blends: (a) oleatedOL30, (b) oleatedOL50, (c) oleatedOL70, (d) OL30 and (e) OL50.

### Adhesives



### Hydrogel



## 4. Conclusion

- Epoxy monomers based on partially depolymerized lignin (PDL) were prepared and used together with a biobased curing agent to modify the performance of asphalt.
- A polyacid-type curing agent based on PDL was prepared used together with other liquid curing agents for epoxy curing.
- Chemical modification of lignin was effectively achieved via the solvent-free ball milling process. The compatibility between oleated lignin and PLA in the polymer blends is greatly increased.
- Hydrogels based on modified lignosulfonate was successfully prepared.
- Lignin was successfully used as a major ingredient for adhesive application.

### Acknowledgements

This work was supported by the Northwest Advanced Renewables Alliance (NARA), was funded by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.