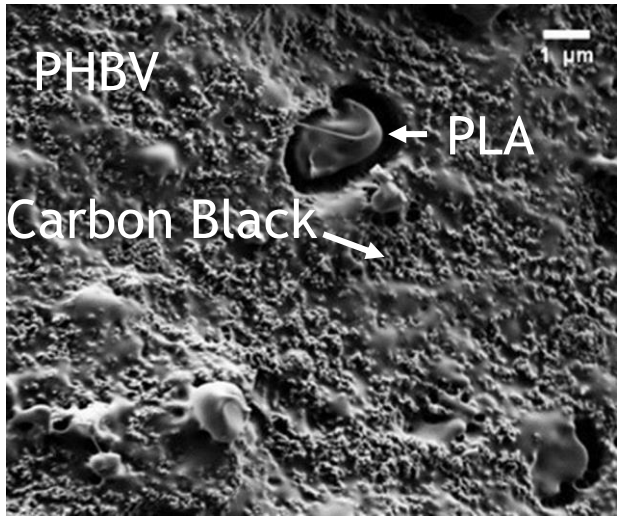
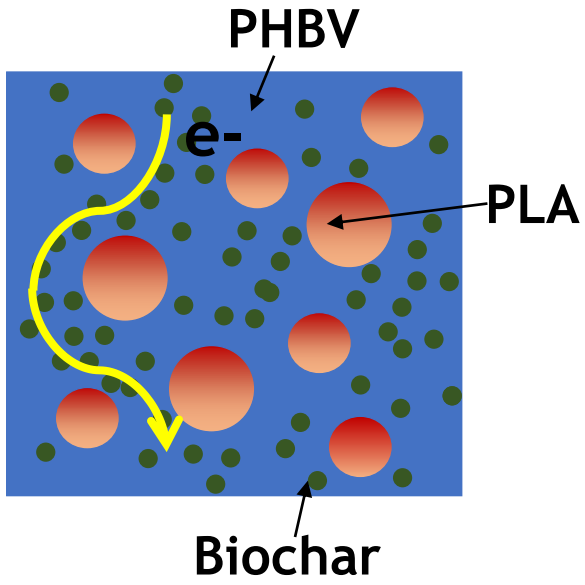
Characterization of Biochar Sourced from Lignin Used to Tune the Electrical and Mechanical Properties of Biodegradable Polymer Blends



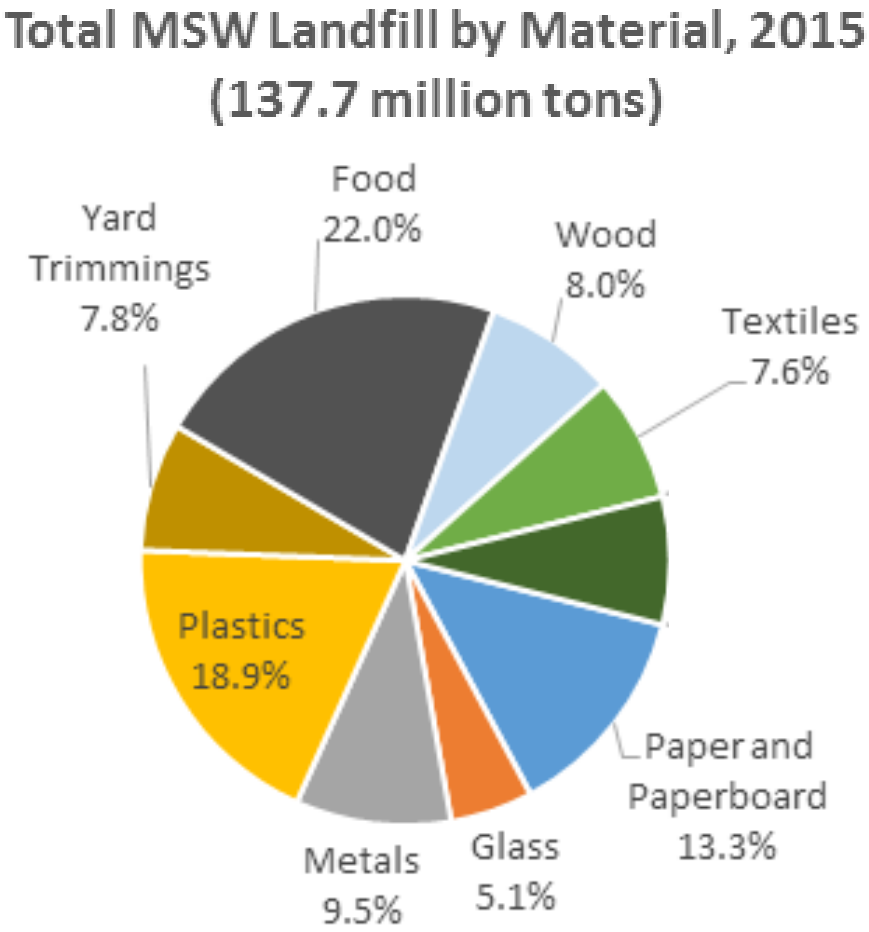
Seth Kane
Jesse Arroyo, Stephan Warnat, Cecily Ryan

sethkane@montana.edu

Biochar & Bioenergy
July 3, 2019



Motivation



https://www.epa.gov/smm/sustainable-materials-management-basics

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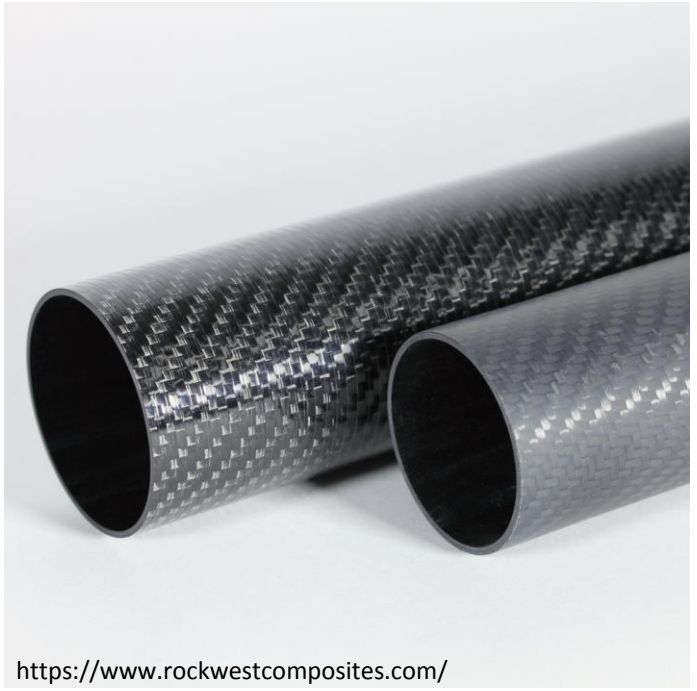
Motivation

Composite materials allow for the tuning of material properties to the desired application

Composite materials are not commonly recycled

Nanofilled composites enable the creation of electrically semi-conductive materials



https://www.rockwestcomposites.com/

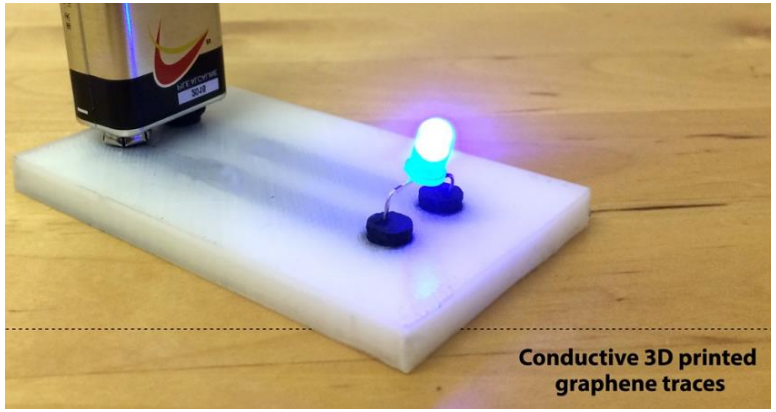
Ryan Lab Group, Unpublished 2019

Why add biochar to bioplastics?

3D printable, biodegradable, electrically semi-conductive plastics!

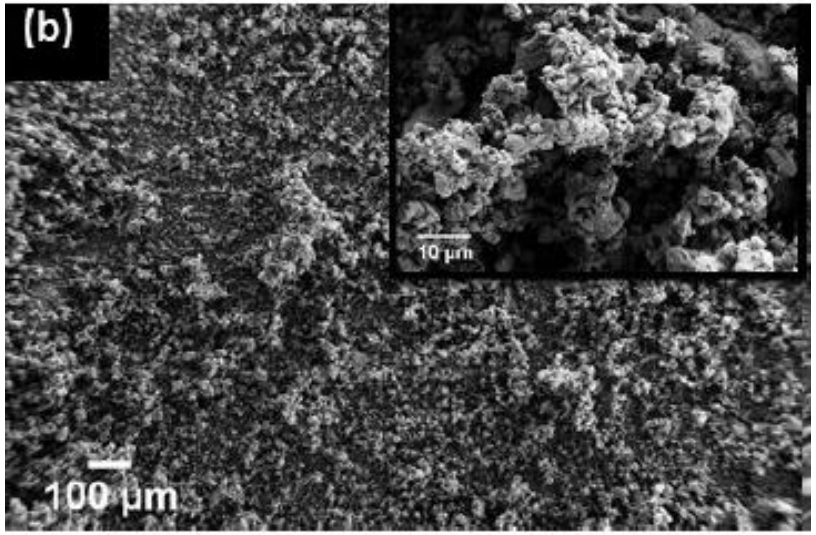
Promising alternative to carbon black

Beneficial at end of life

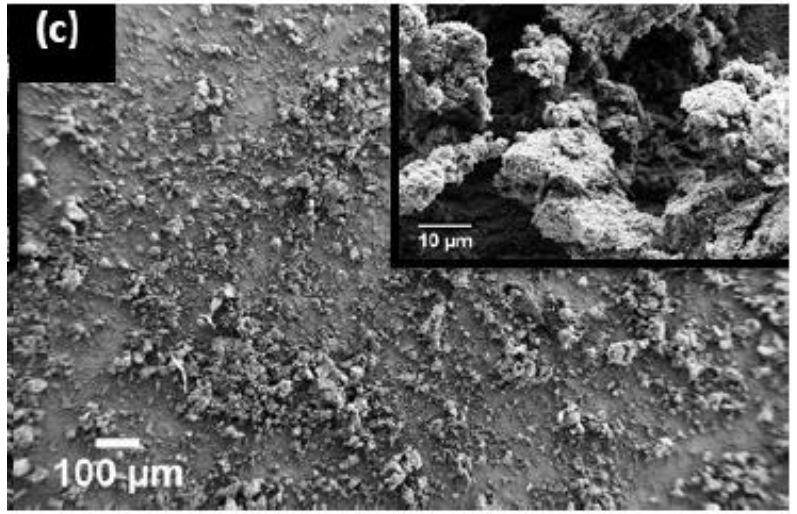


https://www.blackmagic3d.com/

Biochar from lignin



Carbon black Vulcan XCMAX22



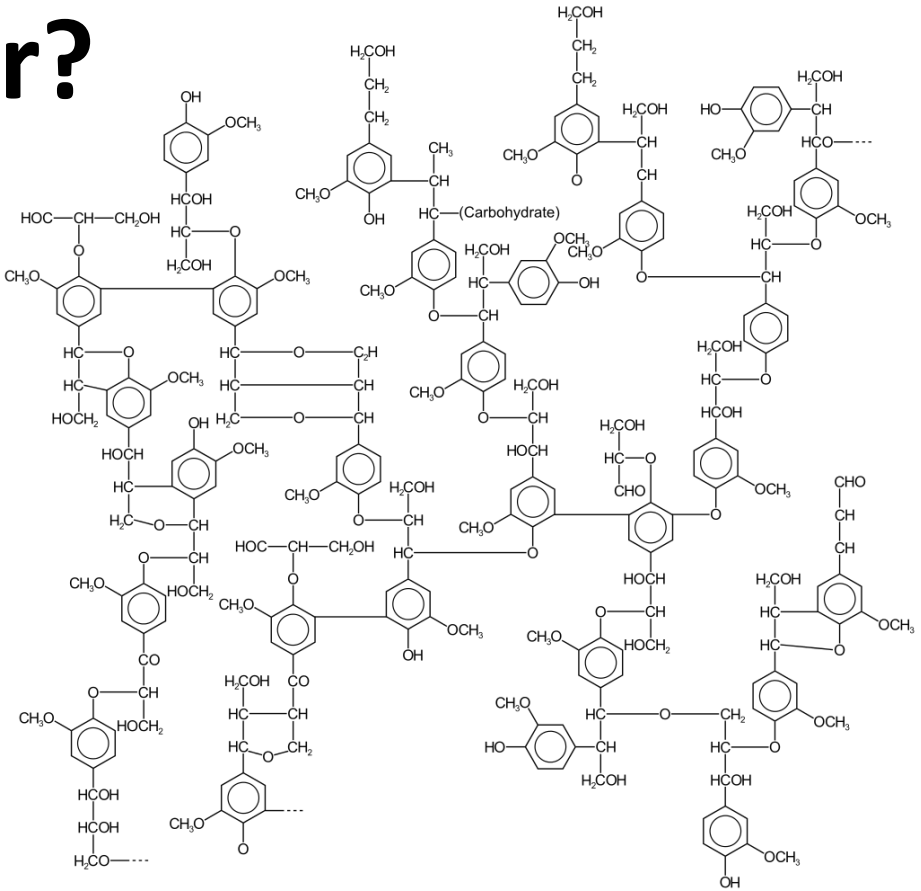
Arroyo, J., & Ryan, C. (2018). https://doi.org/10.3390/polym10121371

Why use a lignin sourced biochar?

Waste product

High percentage carbon

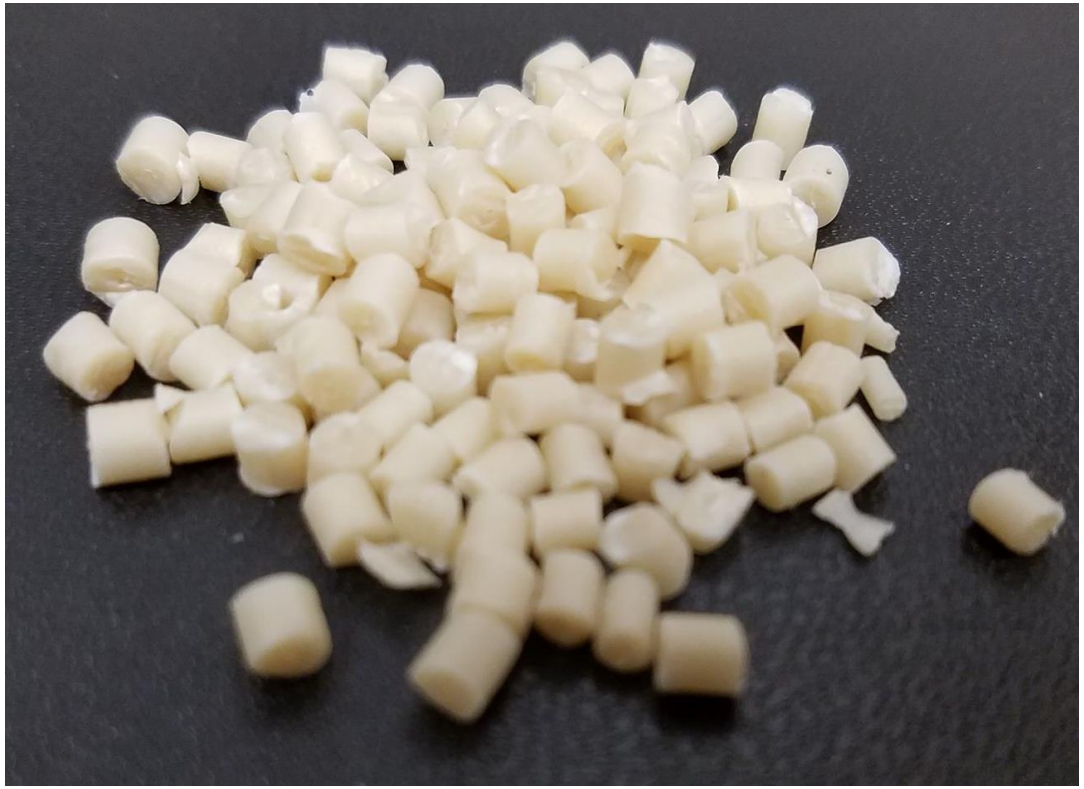
Ryan Lab Group, Unpublished 2019



https://en.wikipedia.org/wiki/Lignin

Biodegradable polymers

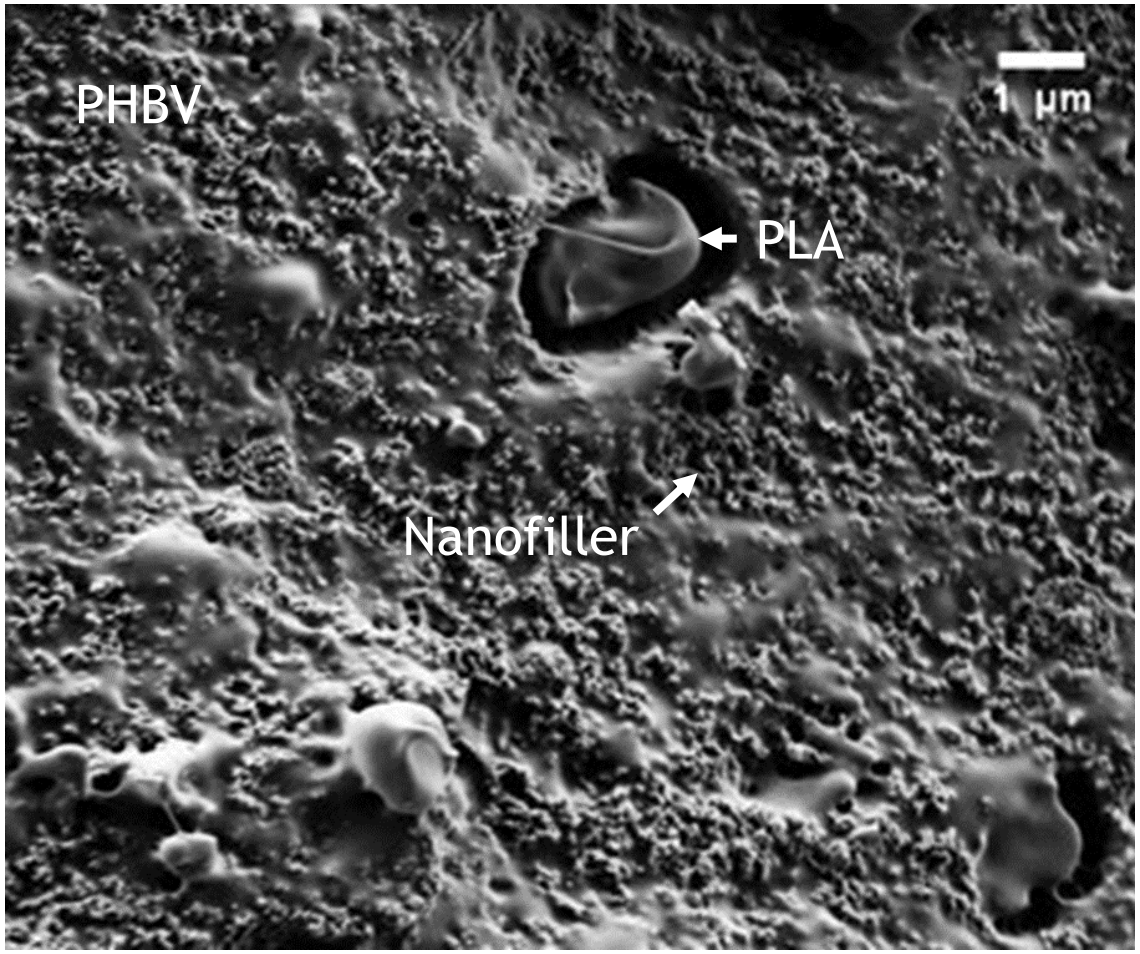
Poly(3-hydroxybutyrate-co -3- hydroxyvalerate) (PHBV)



Polylactic acid (PLA)

Ryan Lab Group, Unpublished 2019

Why use a polymer blend?



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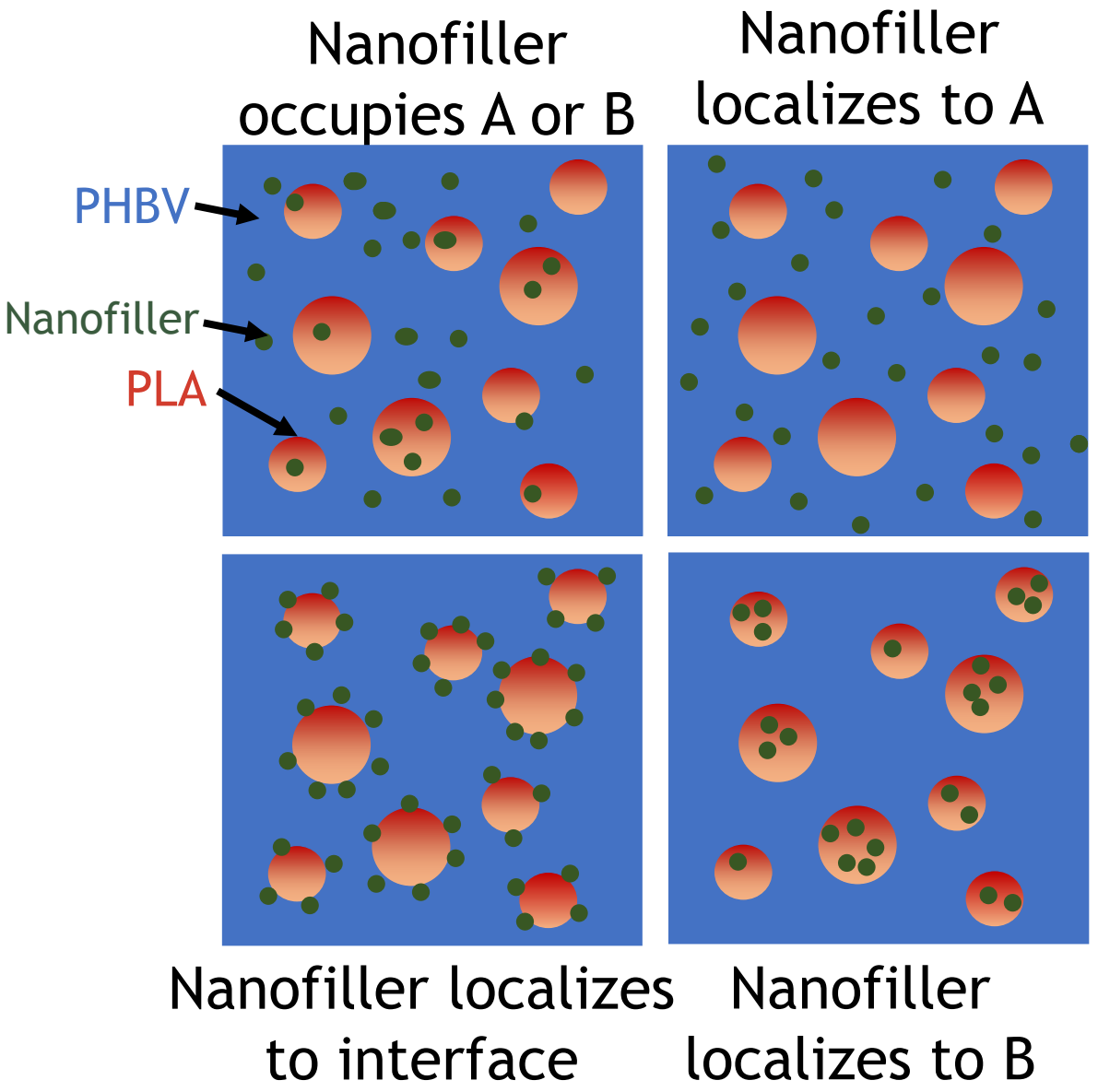

Ryan, C., Unpublished, 2018

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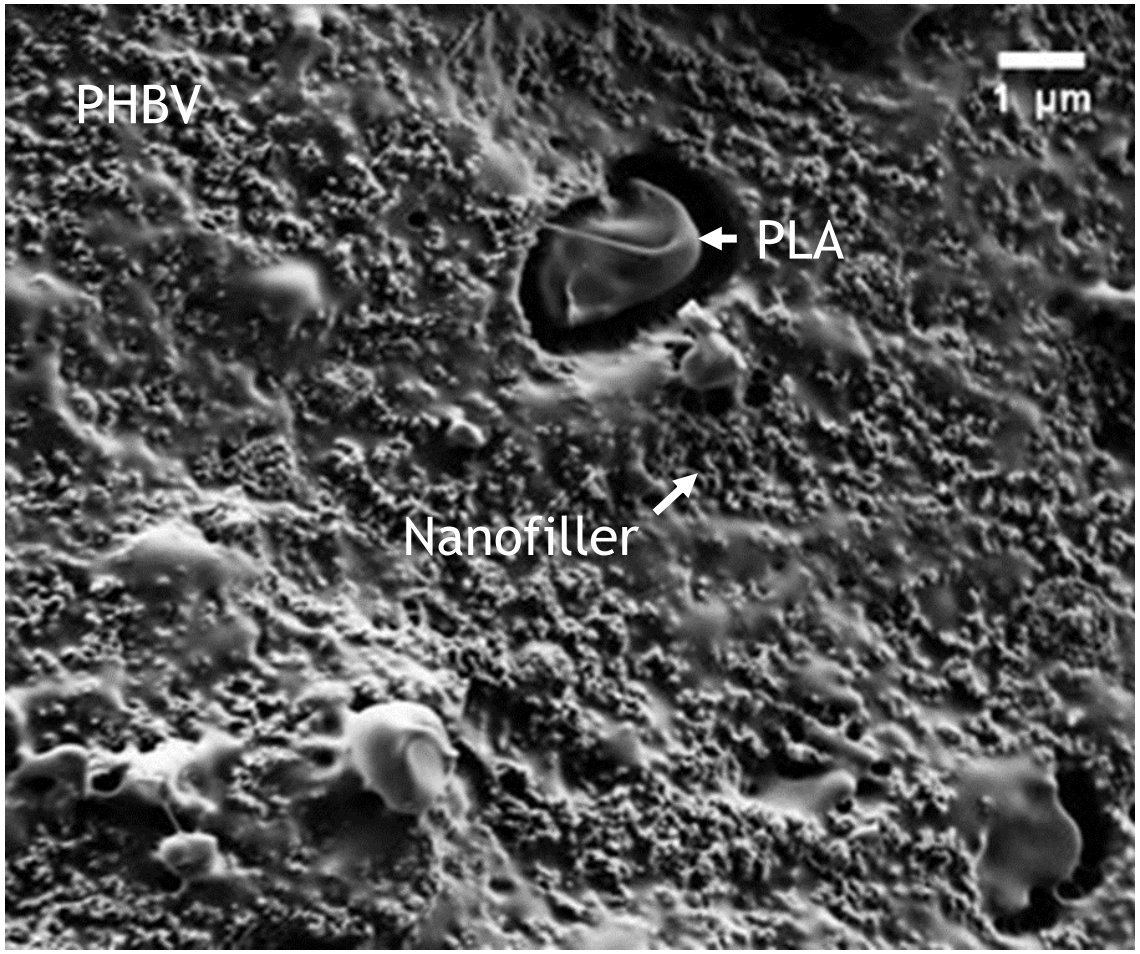
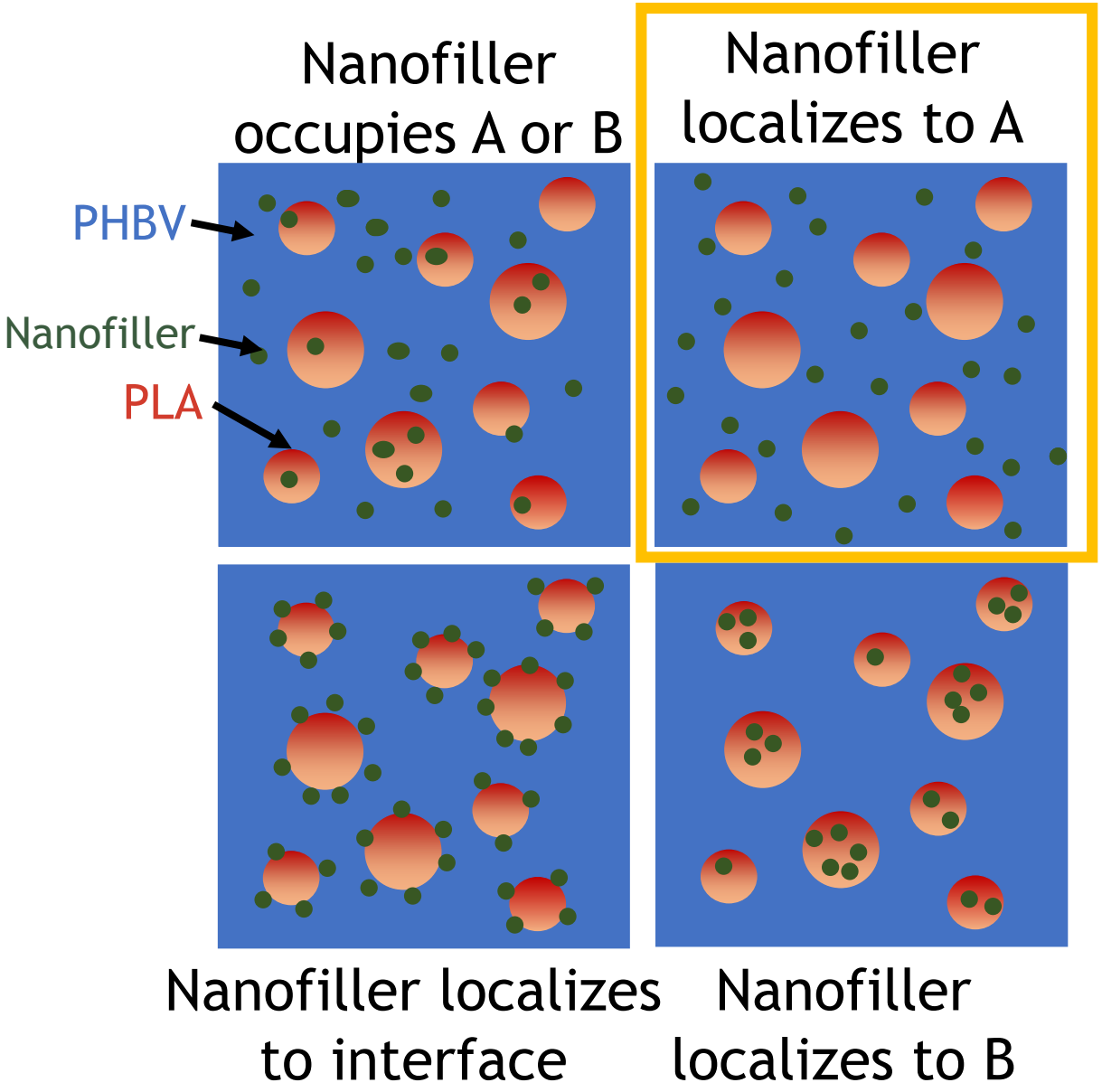


Arroyo, J., & Ryan, C. (2018). https://doi.org/10.3390/polym10121371



Ryan, C., Unpublished, 2018

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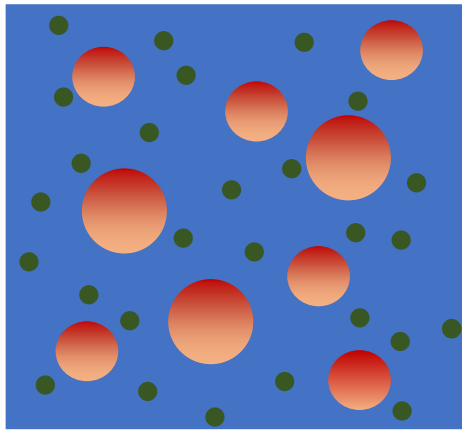
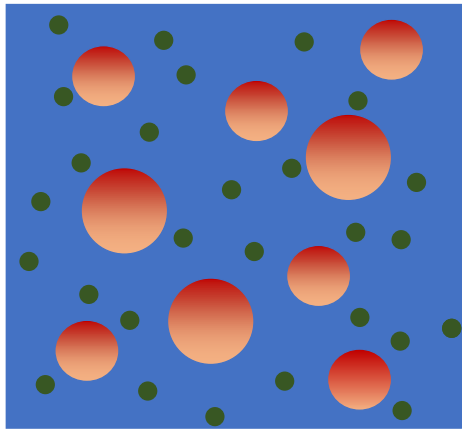


Below φ_c

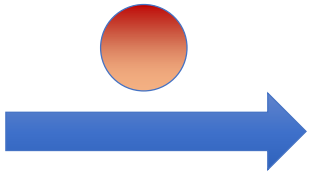


Percolation threshold

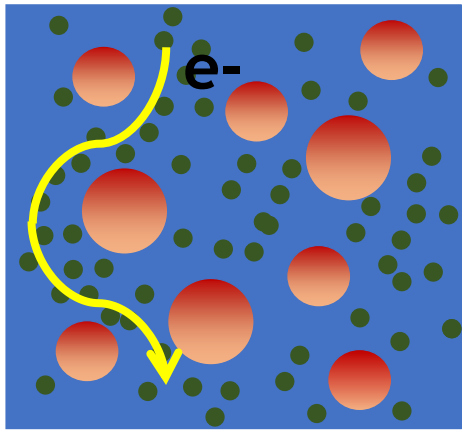
φ_c

Onset of connectivity

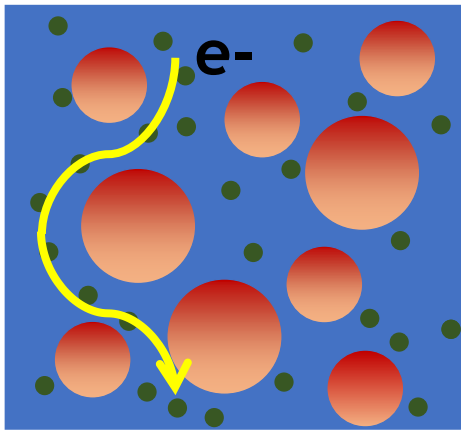
Add nanofiller



Change blend ratio



At/Above φ_c



Ryan, C., Unpublished, 2018

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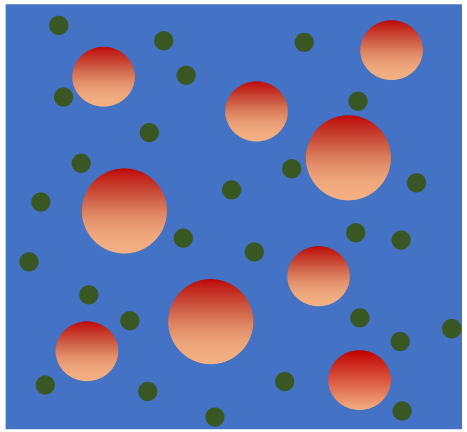
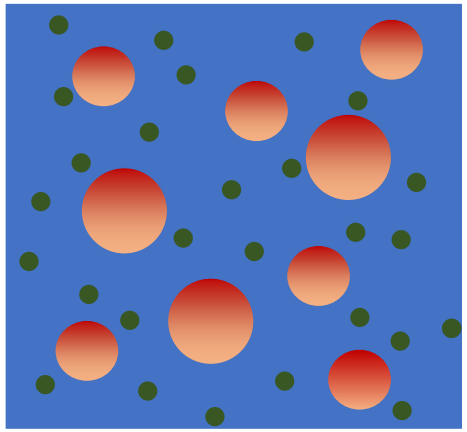


Below φ_c



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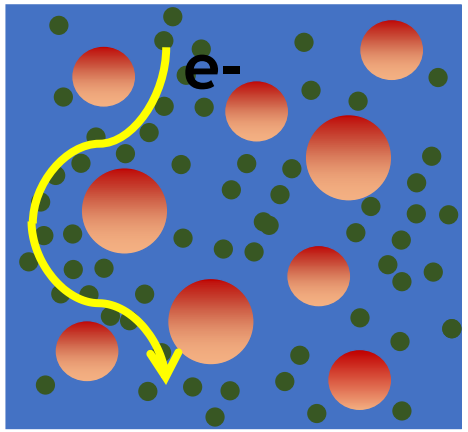

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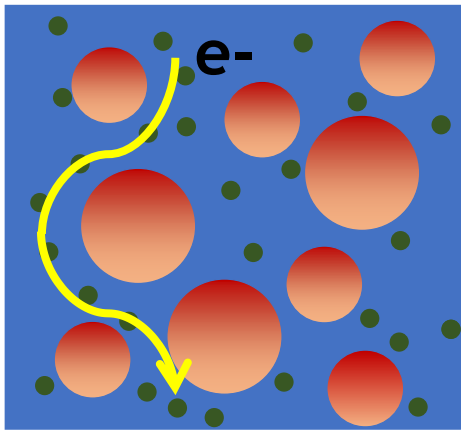
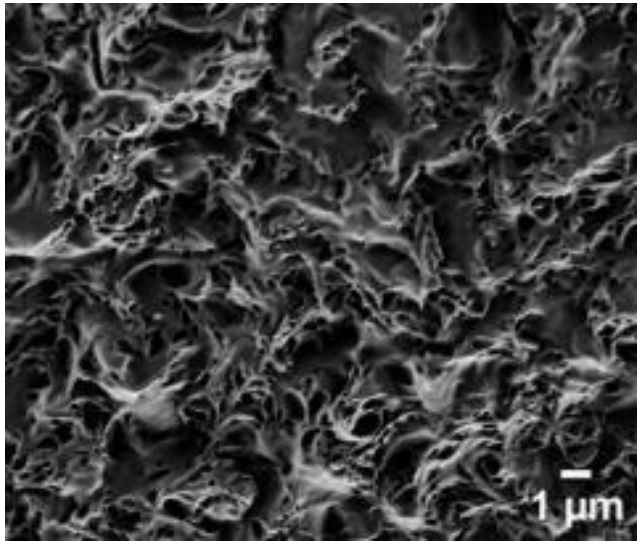


Ryan, C., Unpublished, 2018



Arroyo, J., & Ryan, C. (2018). https://doi.org/10.3390/polym10121371

Challenges for composite processing

Arroyo, J., & Ryan, C. (2018). https://doi.org/10.3390/polym10121371

Research Objectives

Characterize the reaction occurring between biochar and biodegradable polymers

Investigate how this reaction might be mitigated or eliminated via different sourcing or preprocessing

Characterize properties of resulting composite

Biochar Production Variables

Feedstocks:

Alkaline Lignin

Dealkaline Lignin

Wheat Stems

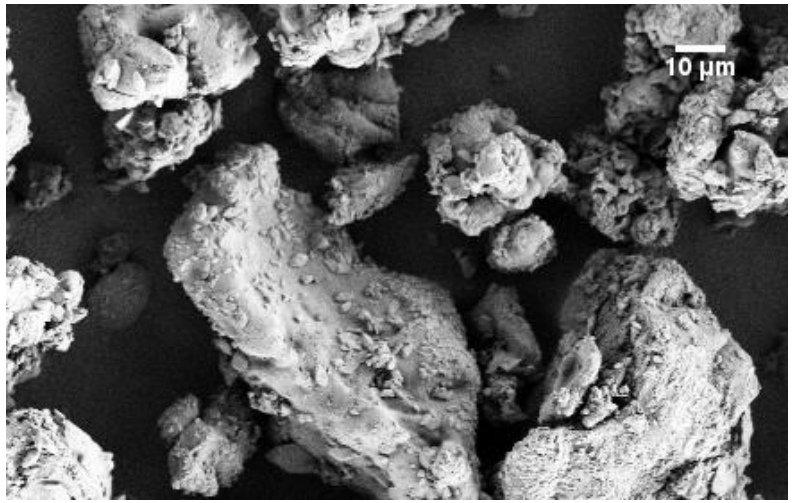
Ryan Lab Group, Unpublished 2019

Pretreatment:

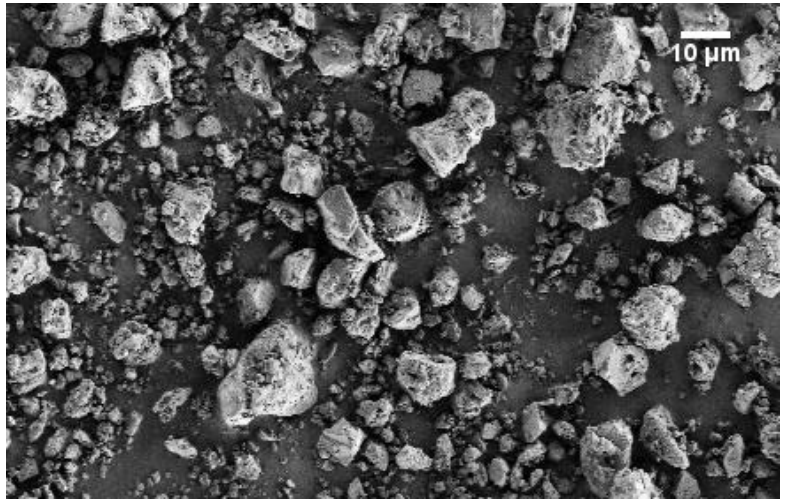
Ball milled to ~1-10 µm

Dried at 110°C for >24 hrs

Alkaline Lignin Pre-milled



Alkaline Lignin Milled



Ryan Lab Group, Unpublished 2019

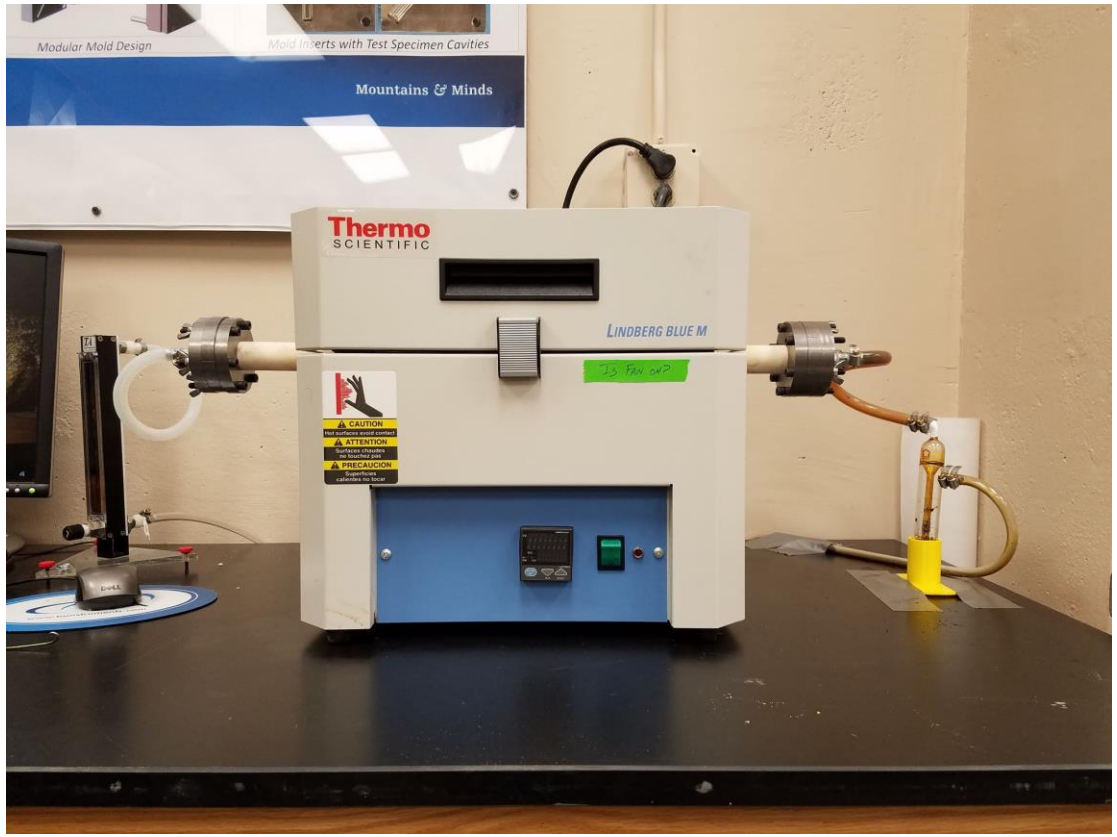
Biochar Production Variables

Highest Treatment Temperature:

700 °C, 900 °C, and 1100 °C

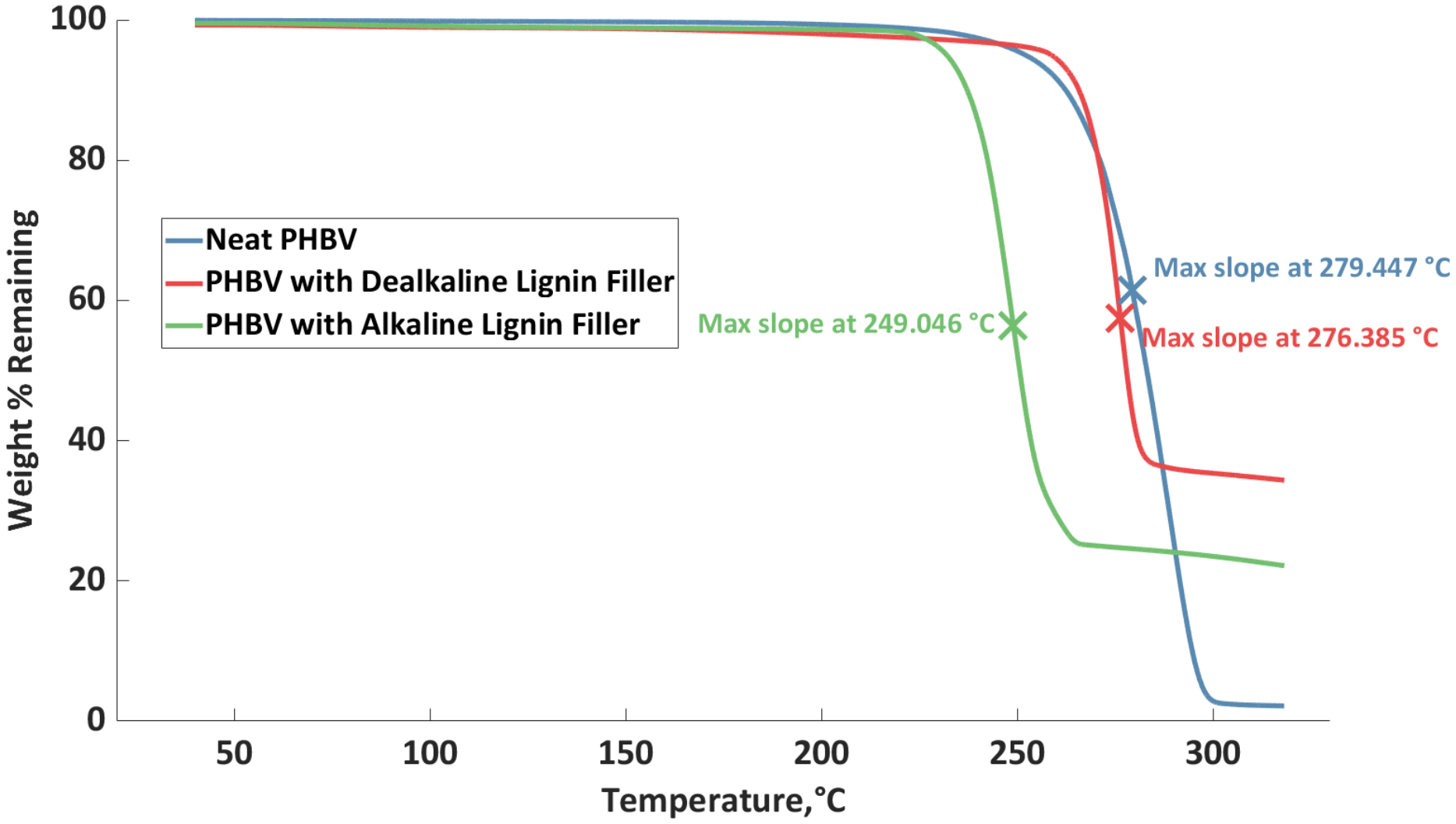
- Nitrogen flow
- Heat at 10 °C/min to HTT
- Hold 1 hr
- Ramp down

Biochar Production Tube Furnace

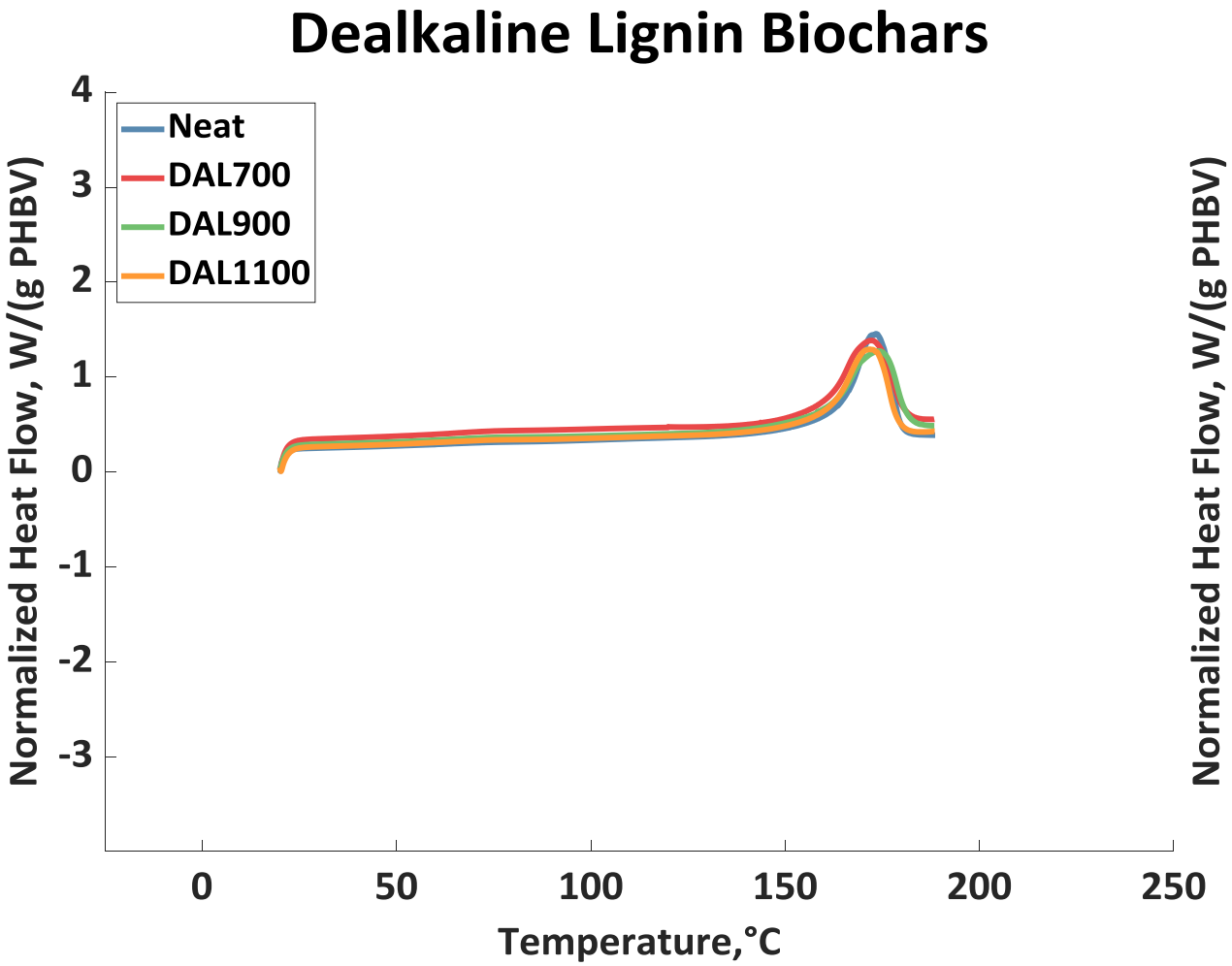


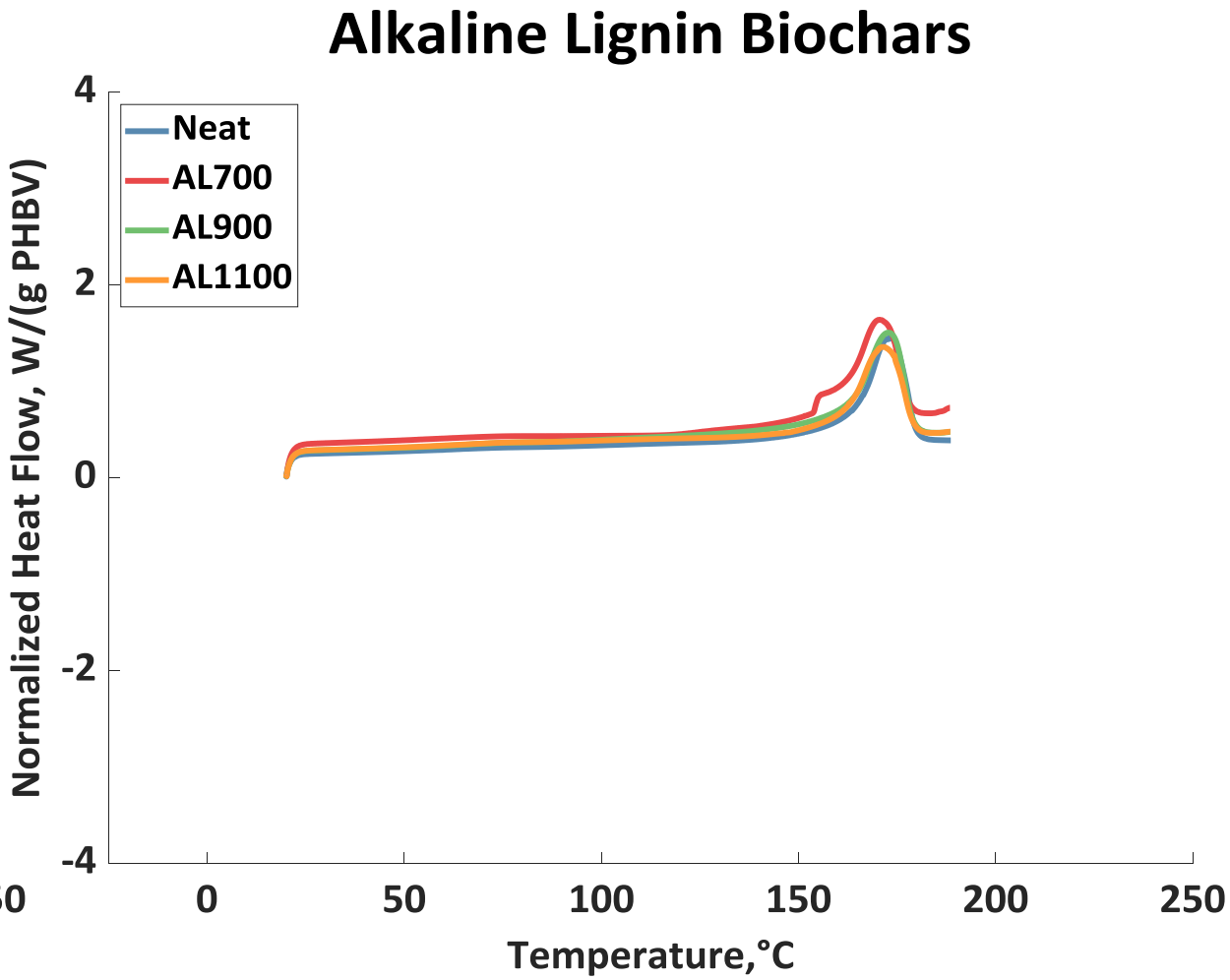
Ryan Lab, Unpublished 2019

Thermogravimetric Analysis: PHBV and Lignin



Differential Scanning Calorimetry: PHBV & Biochar





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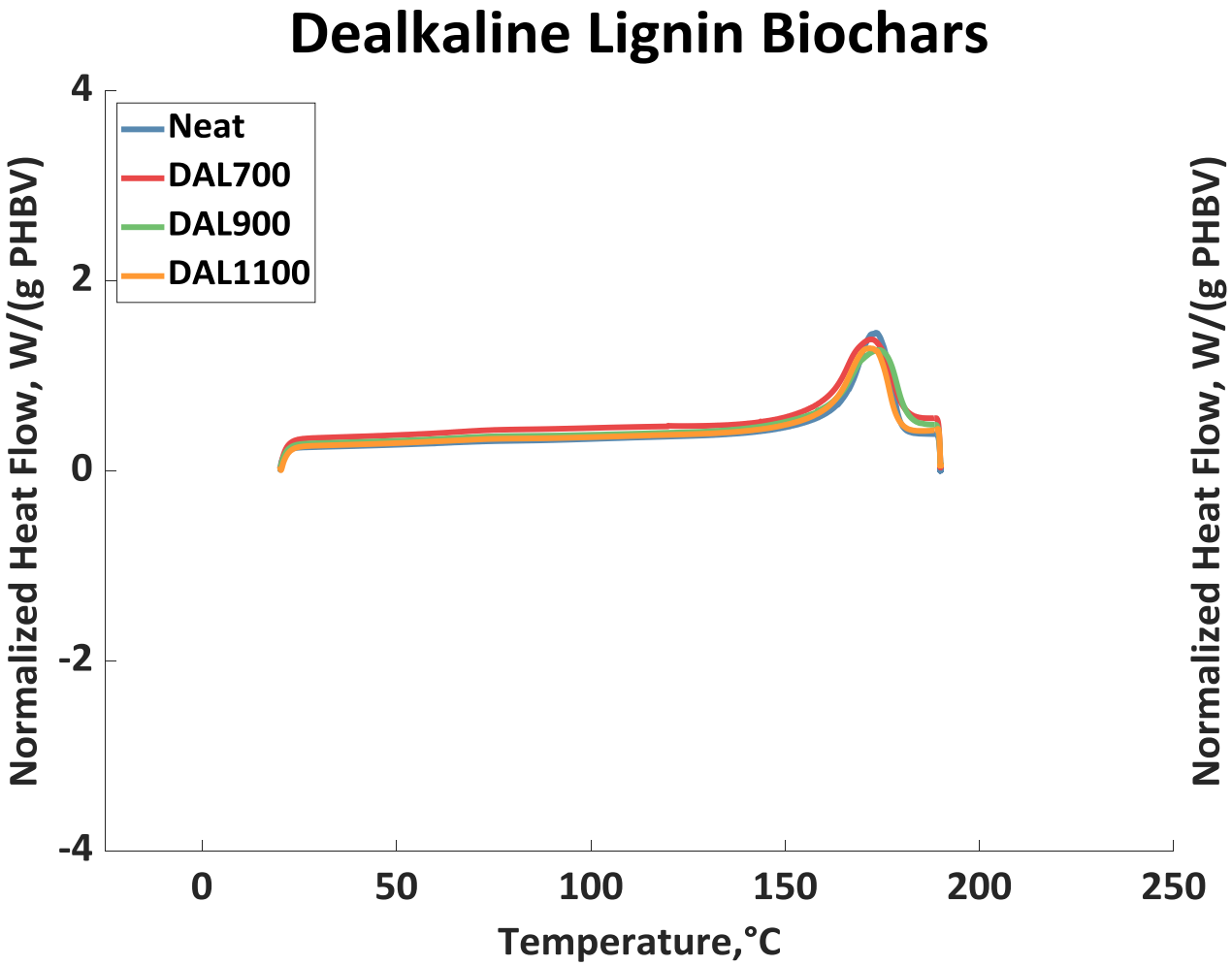

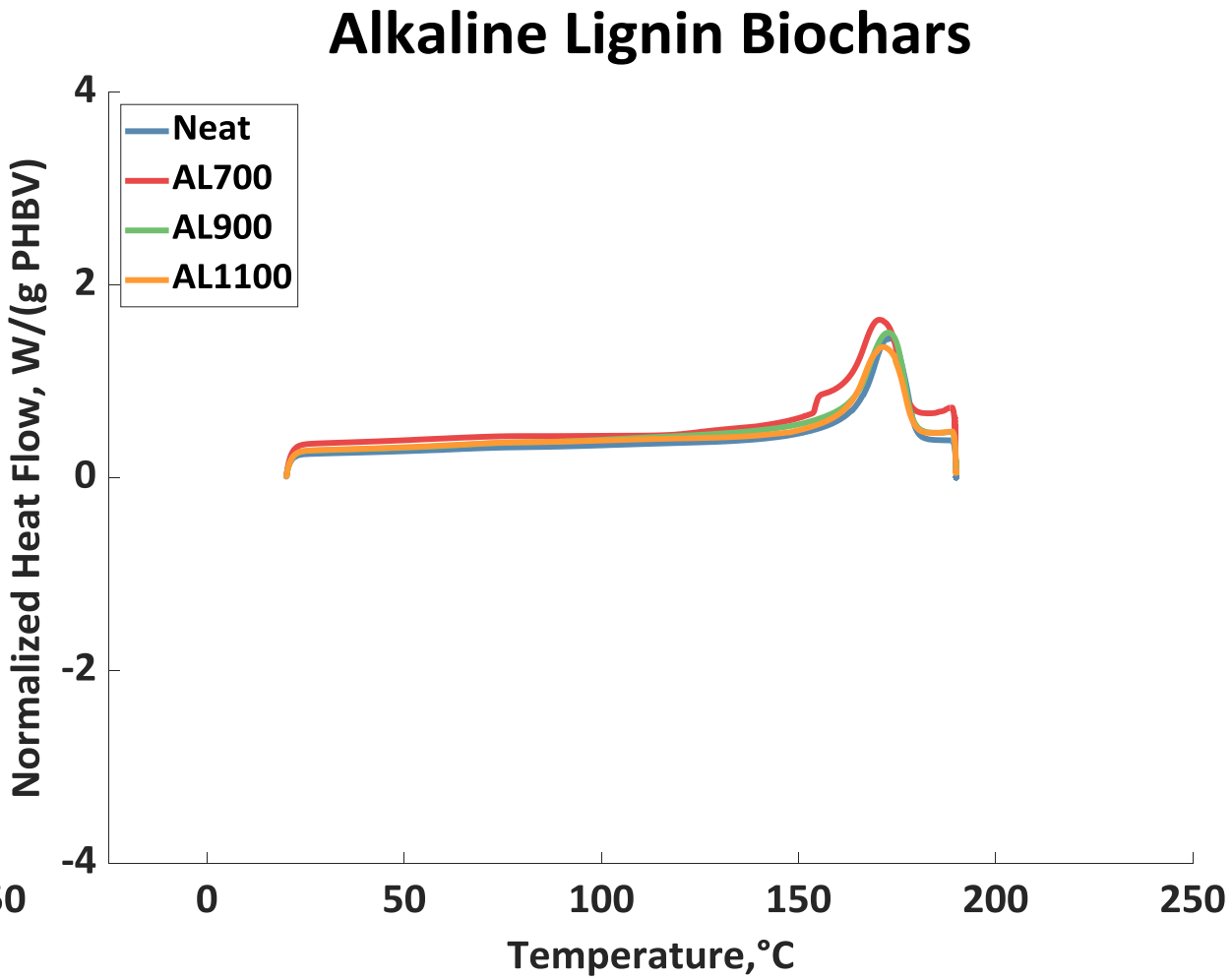

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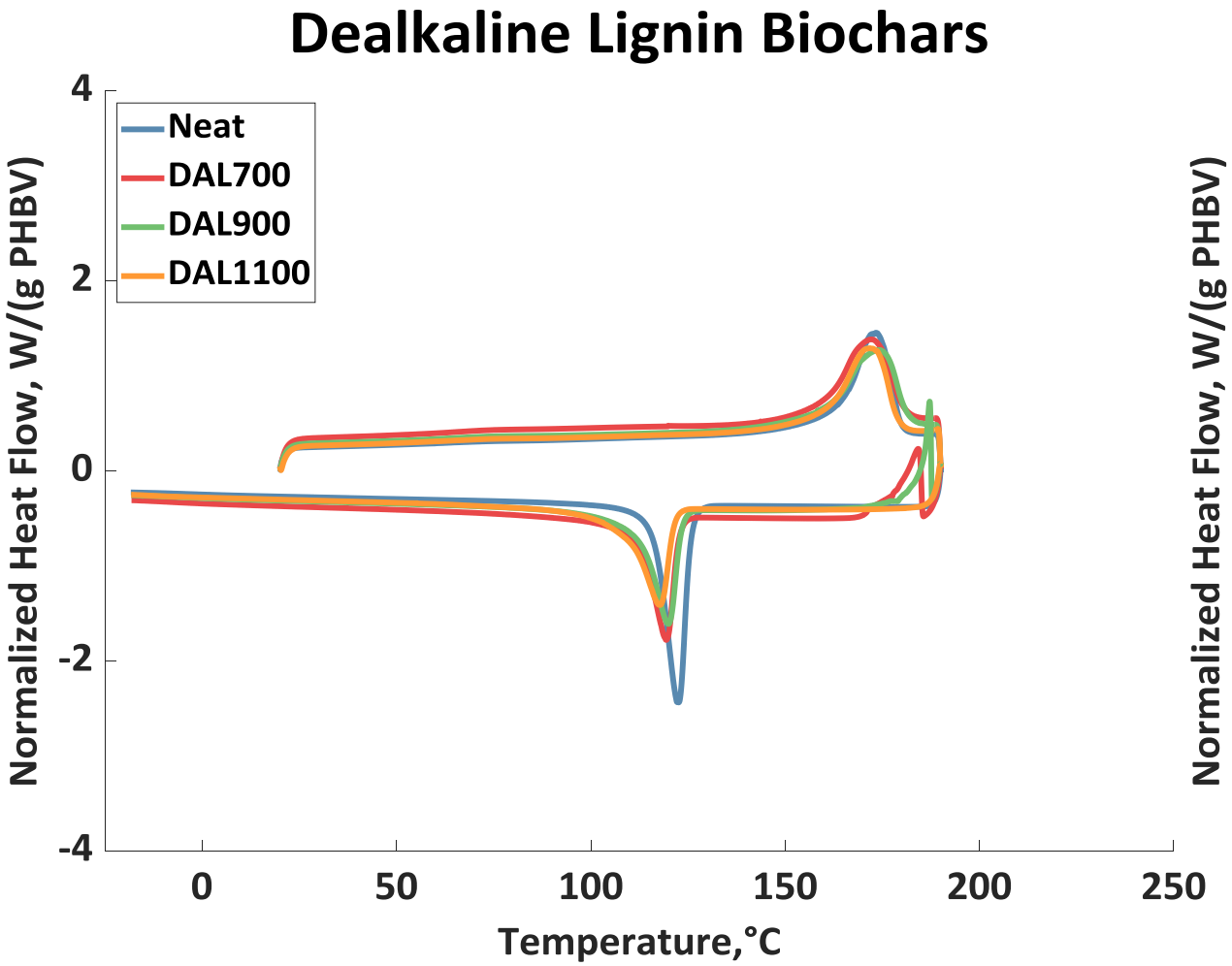

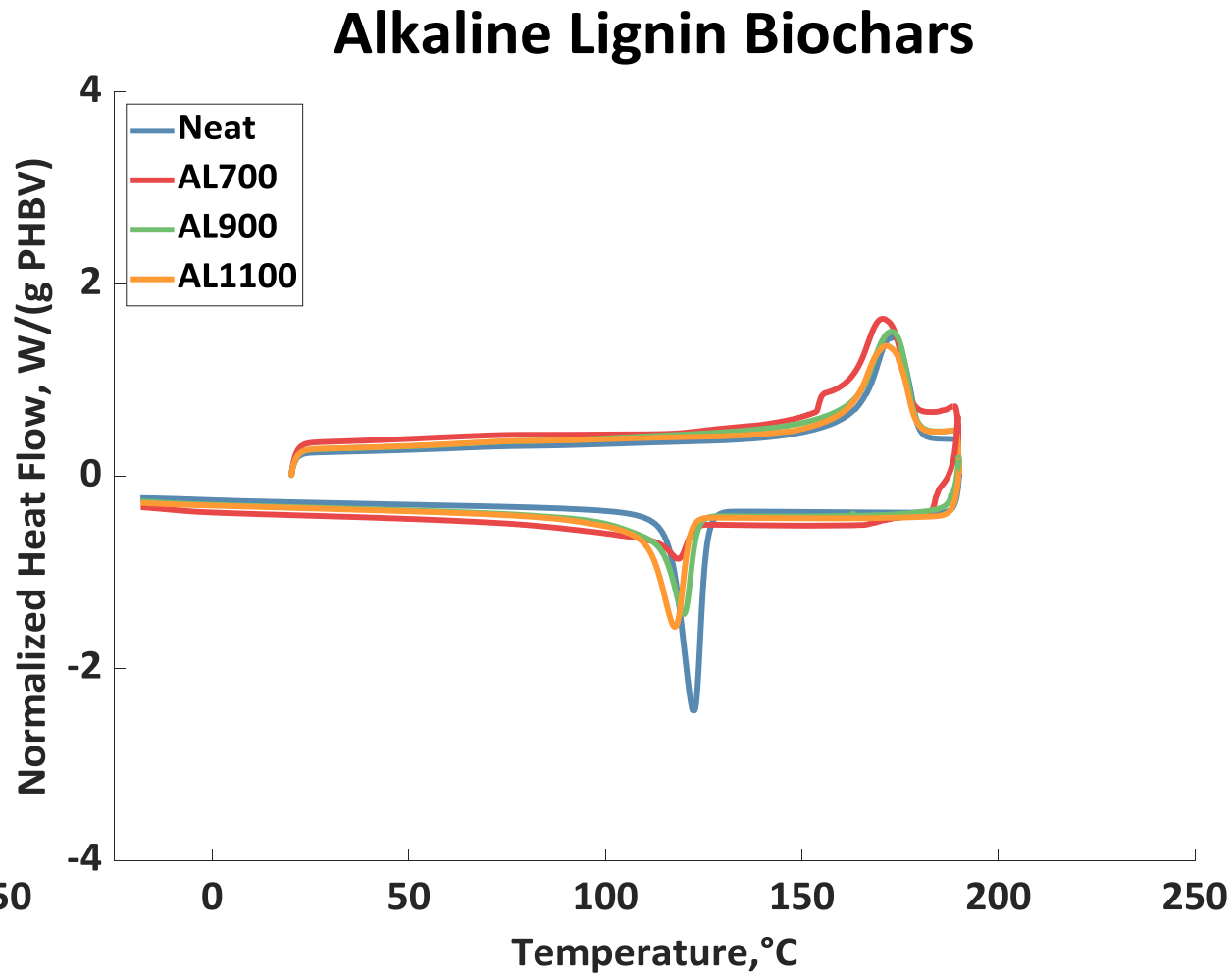

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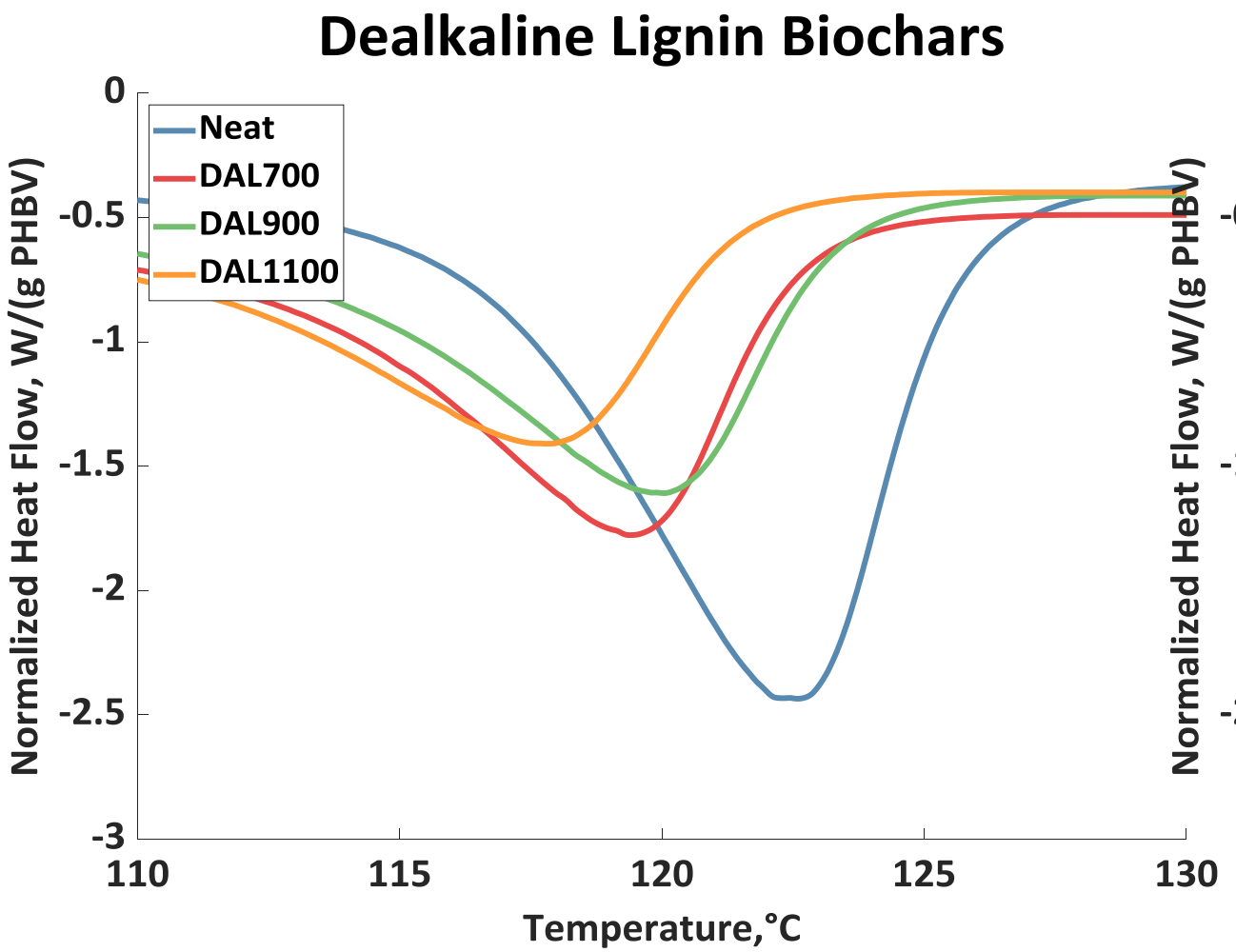

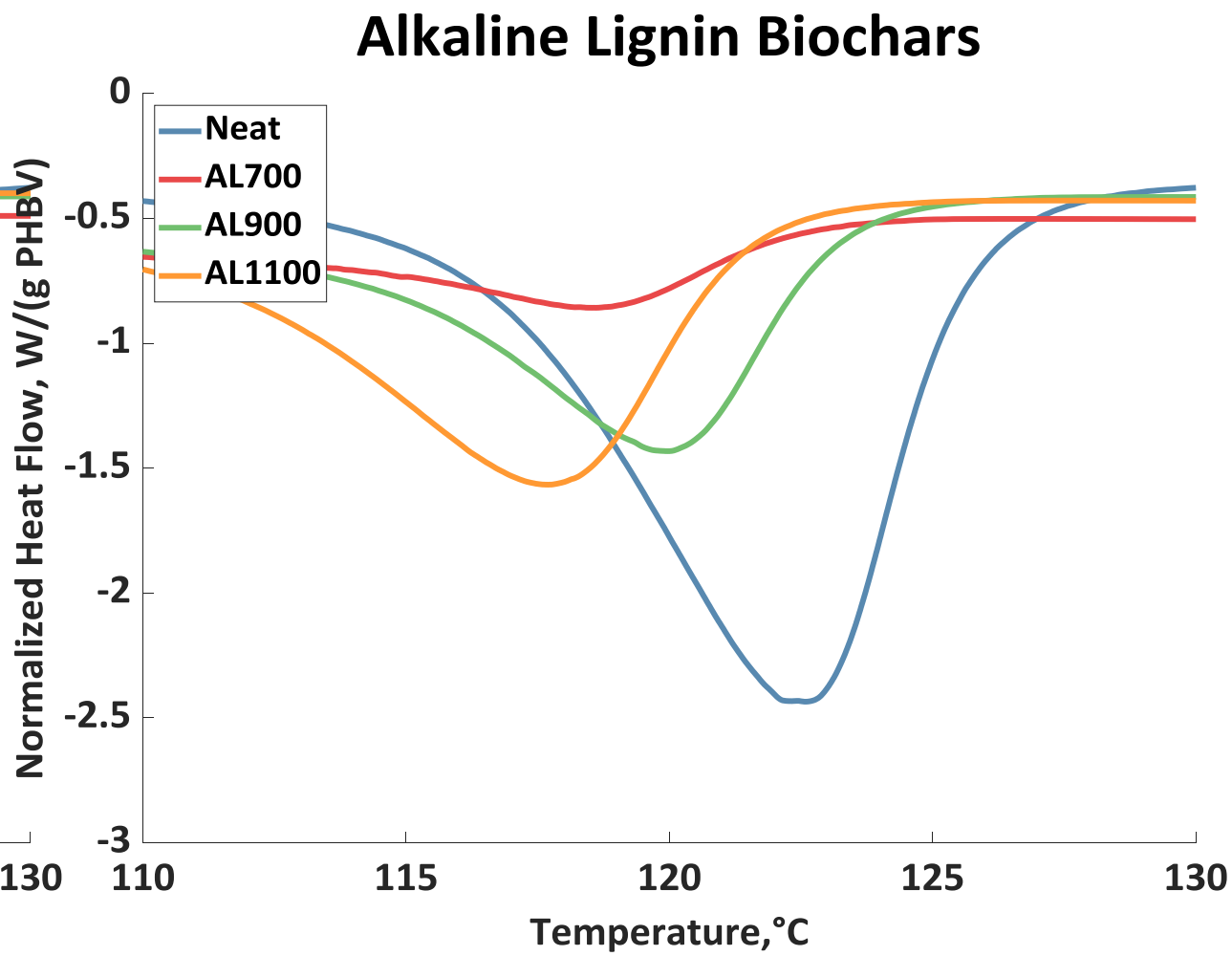

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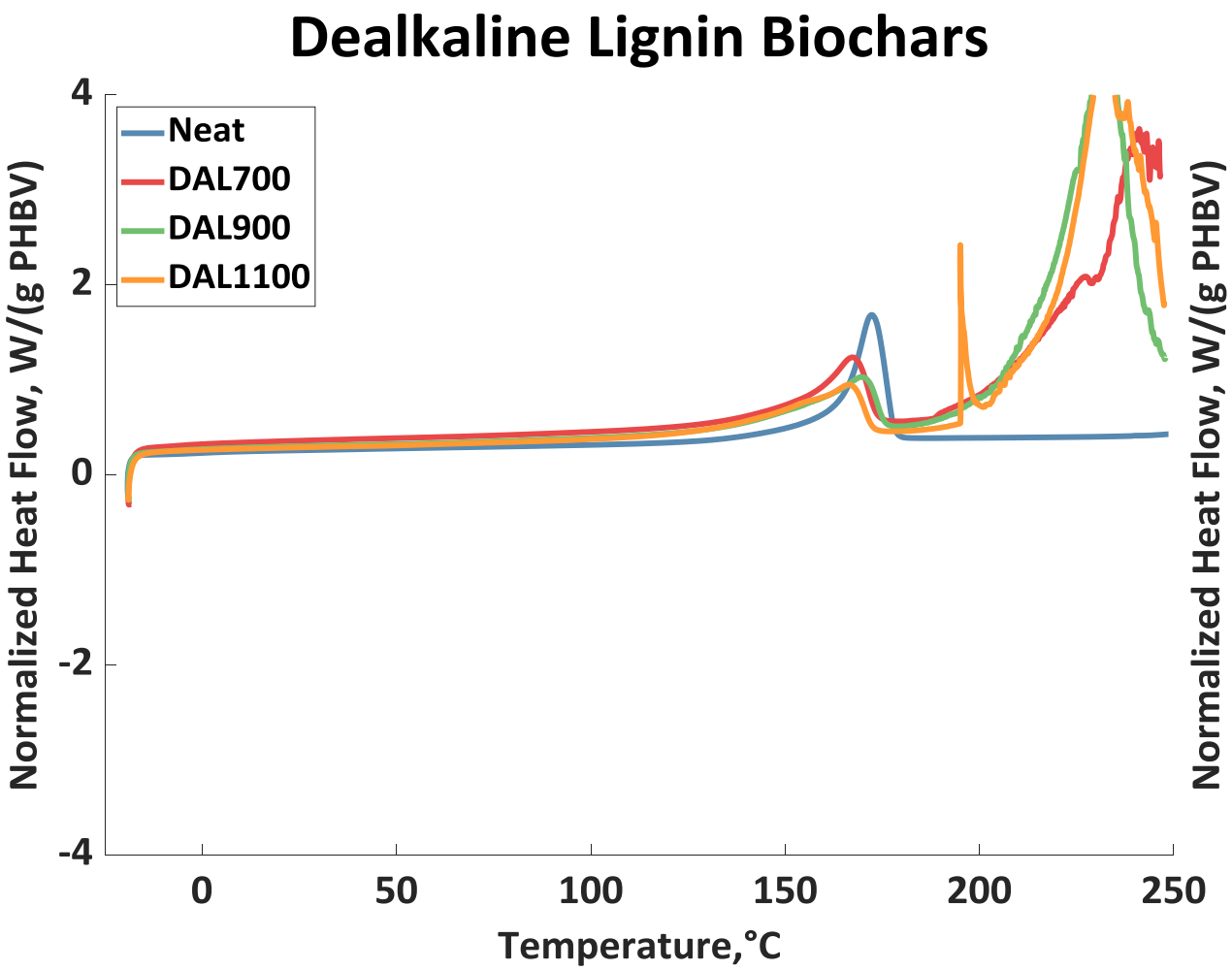
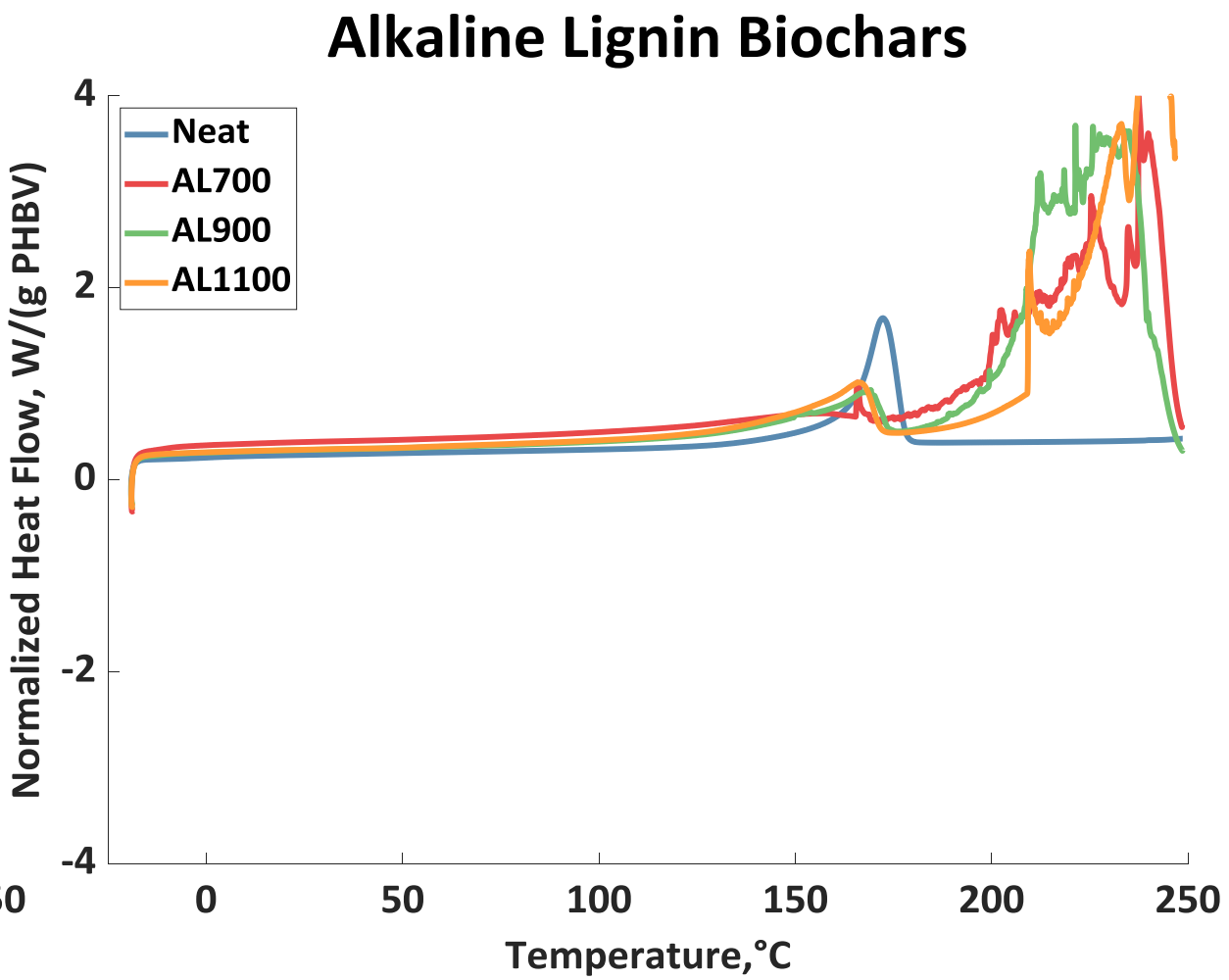
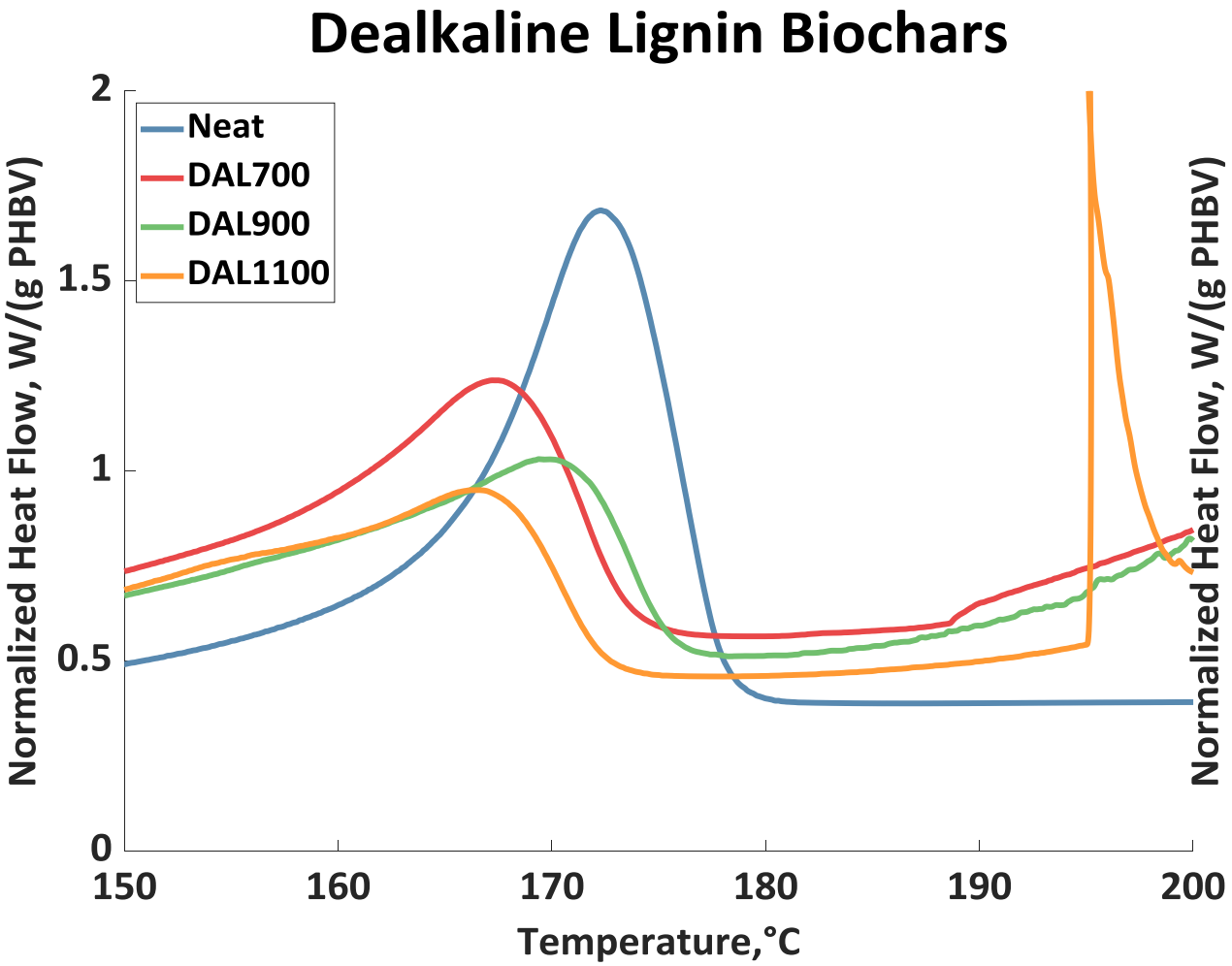
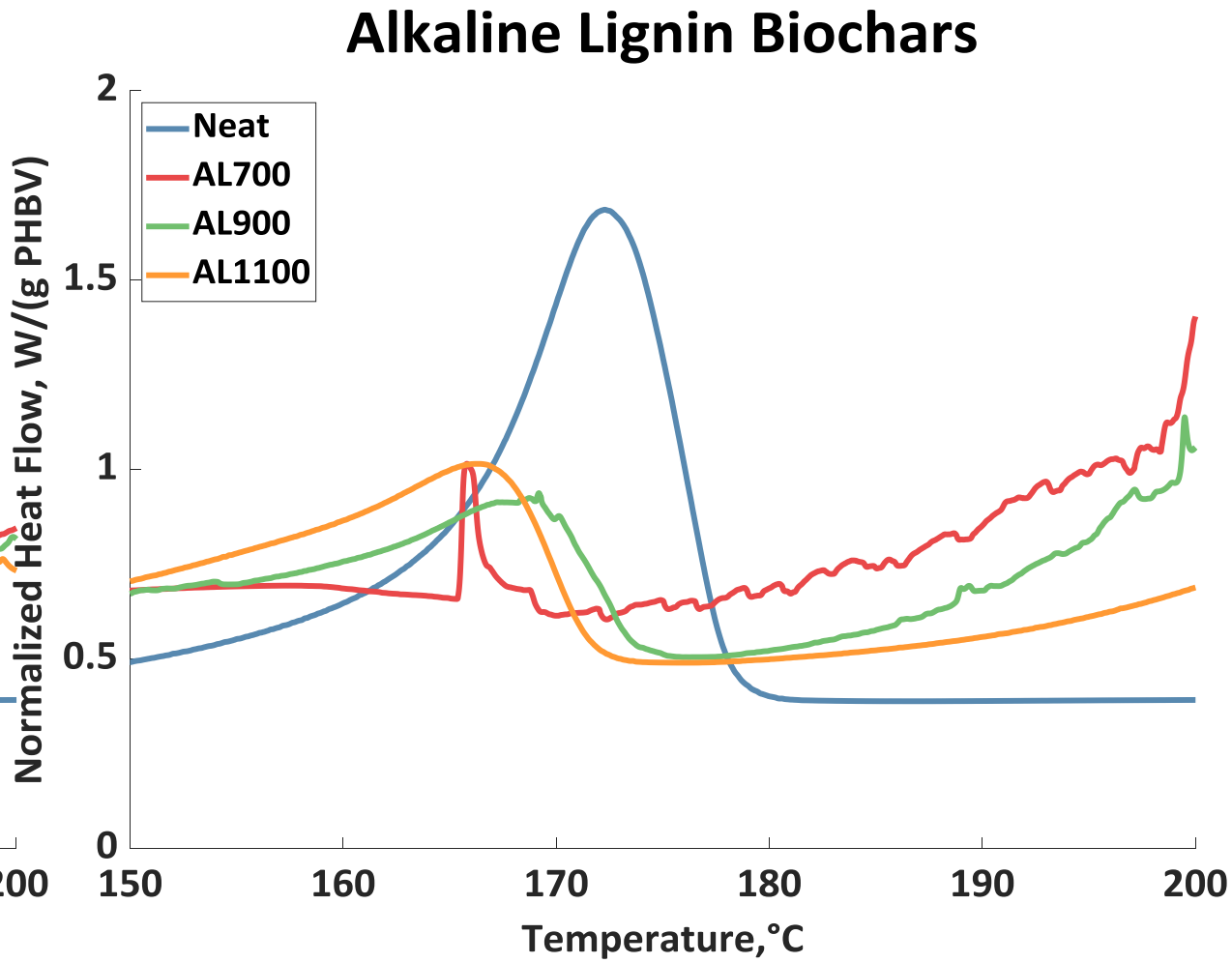




Differential Scanning Calorimetry: PHBV & Biochar





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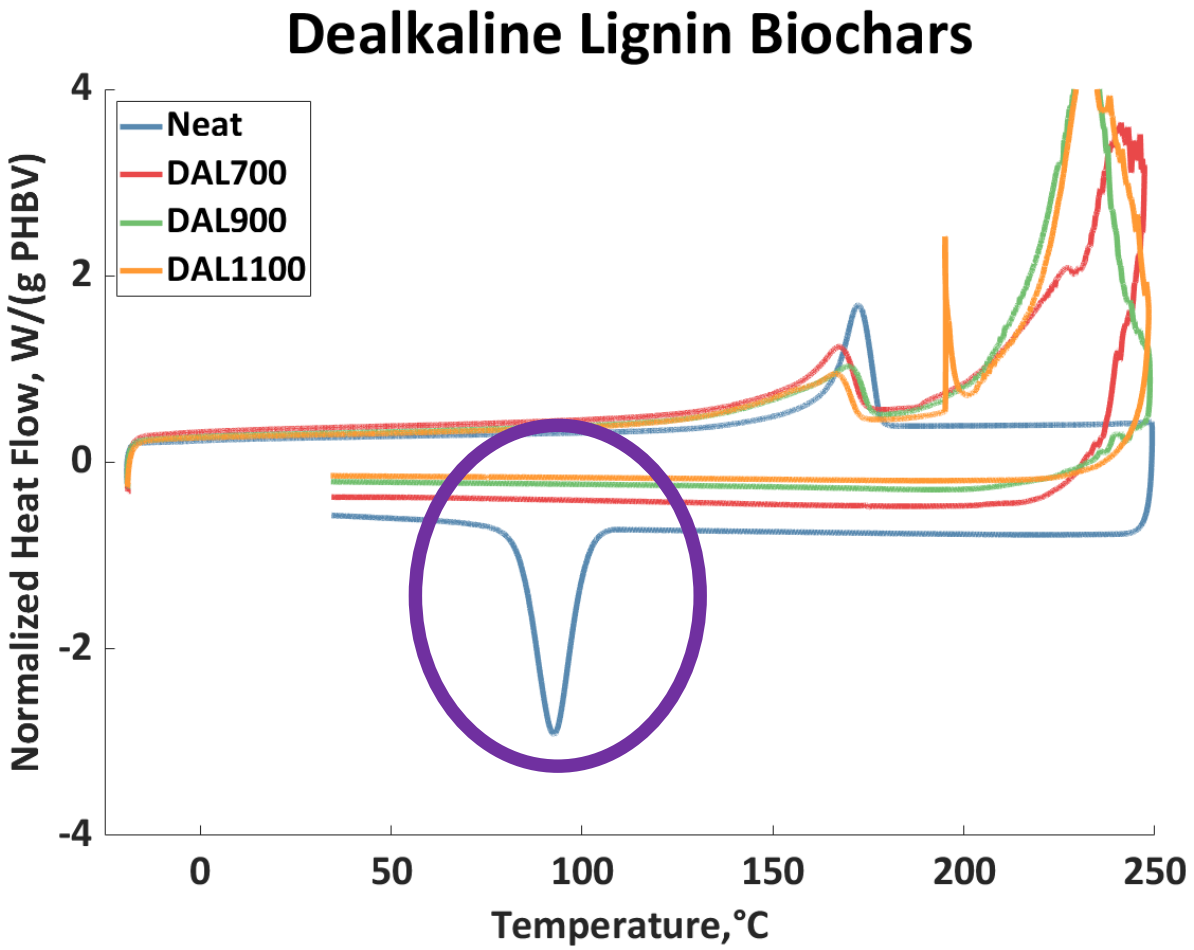

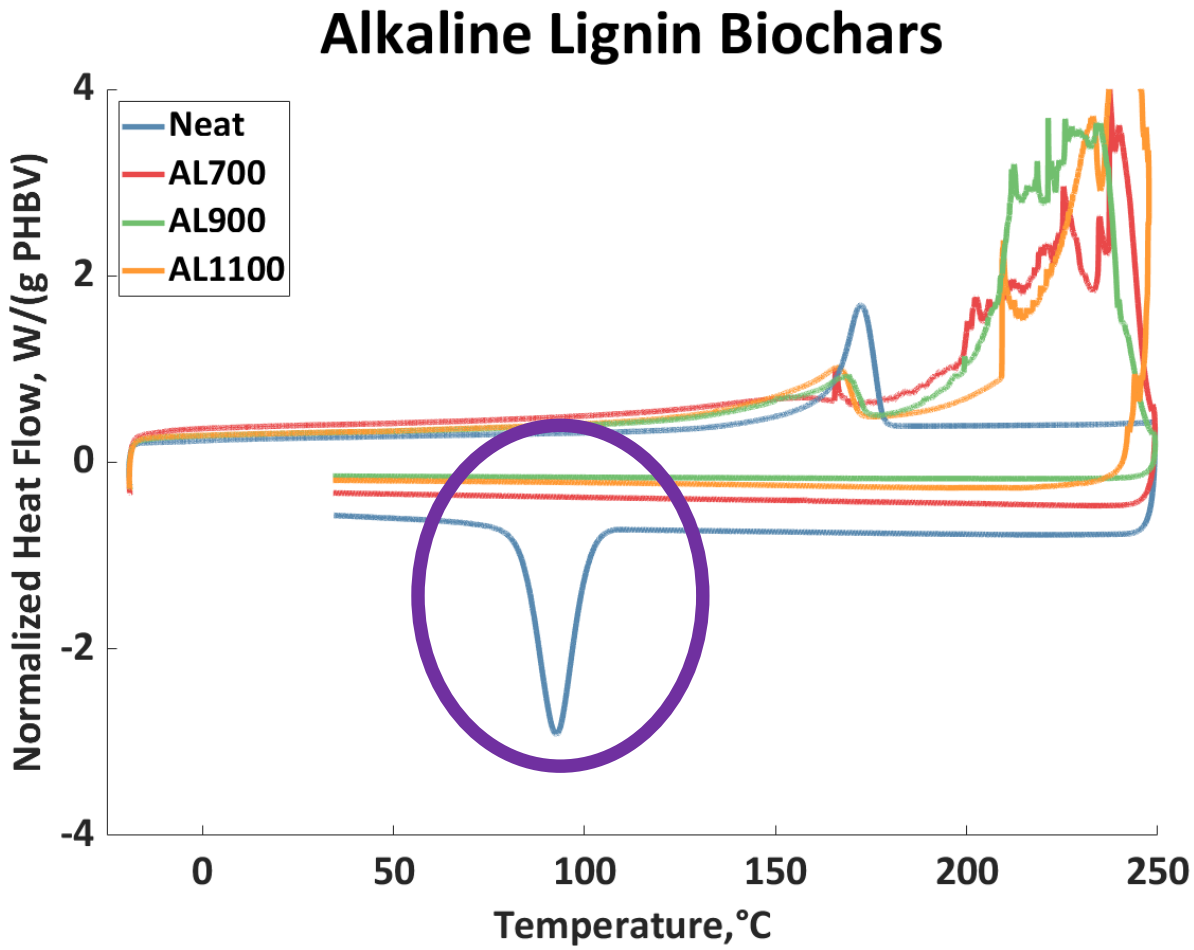

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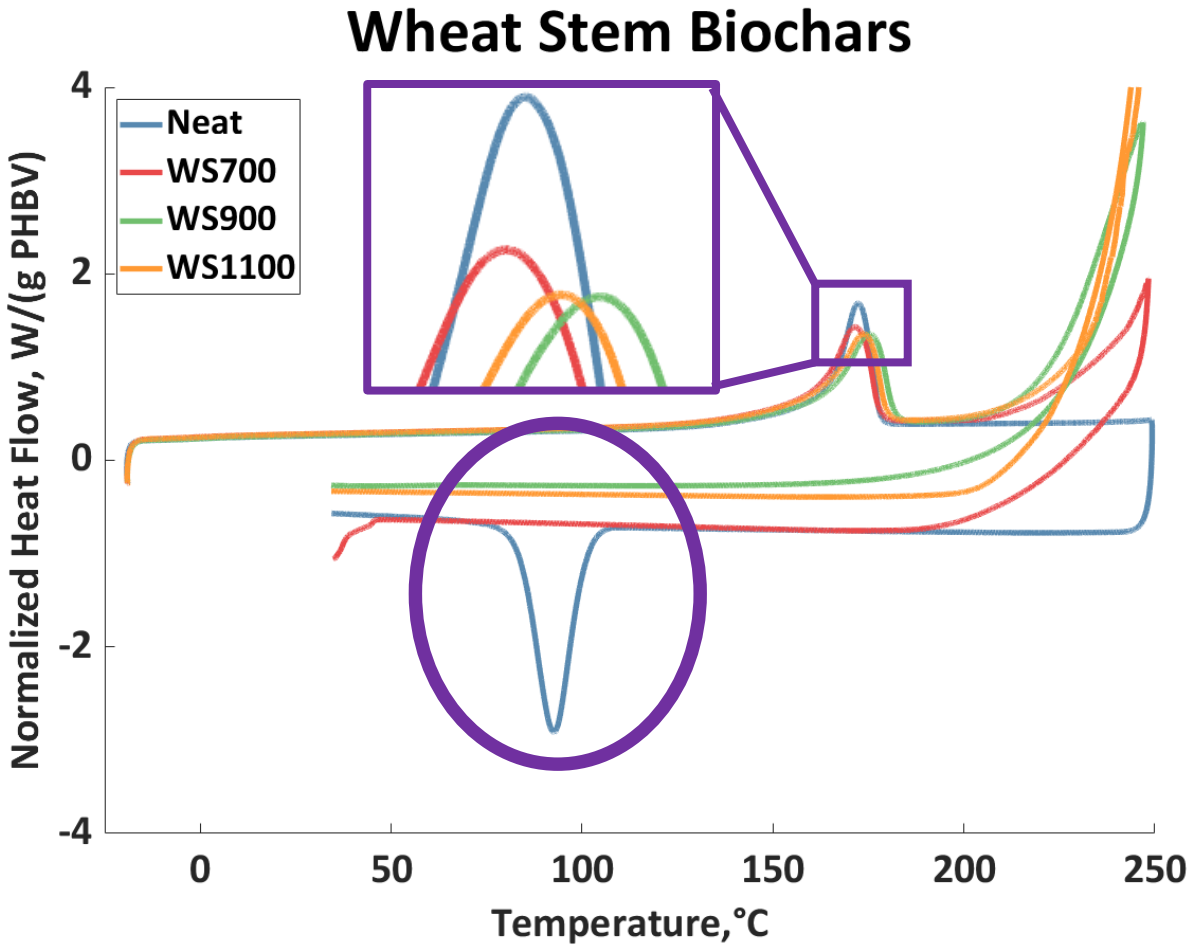
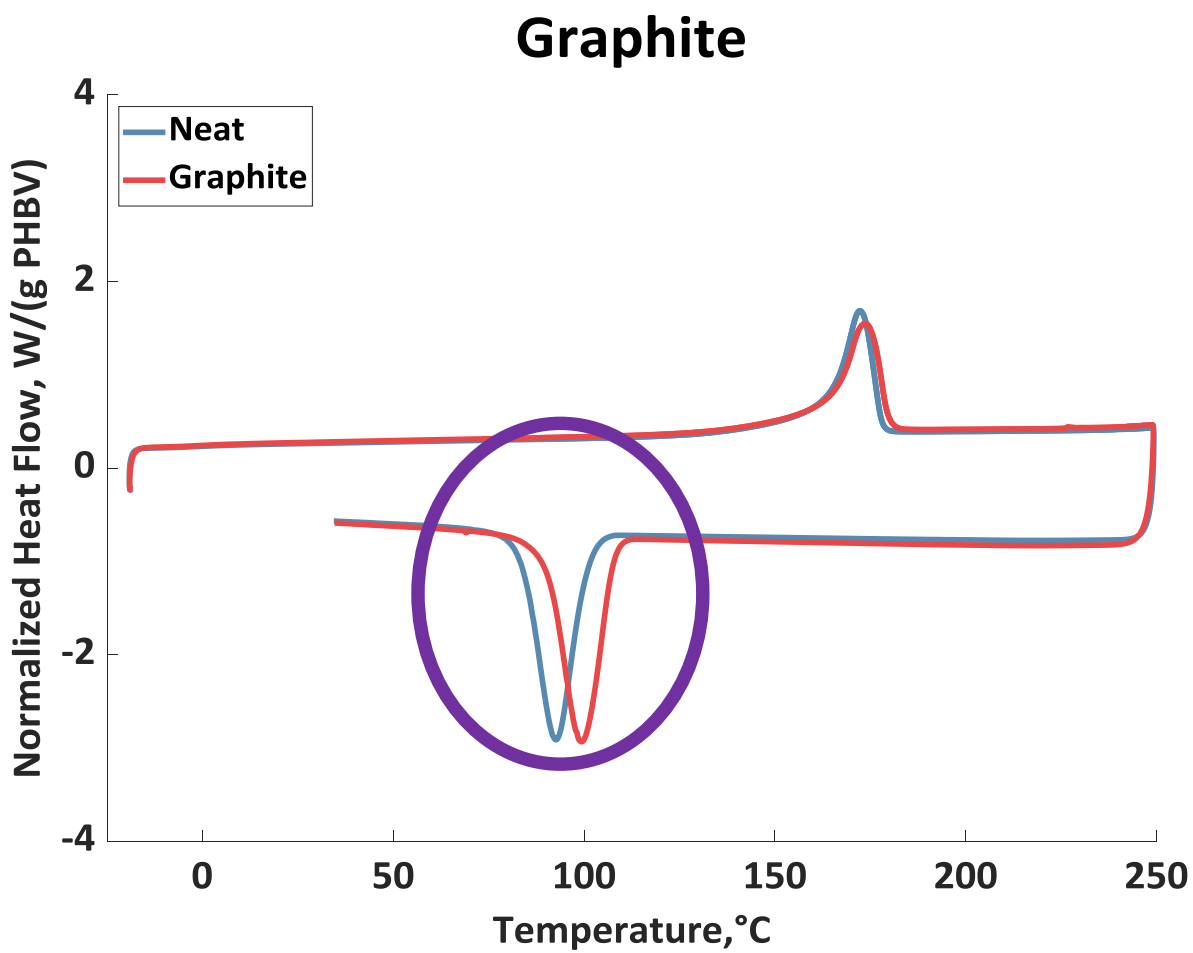
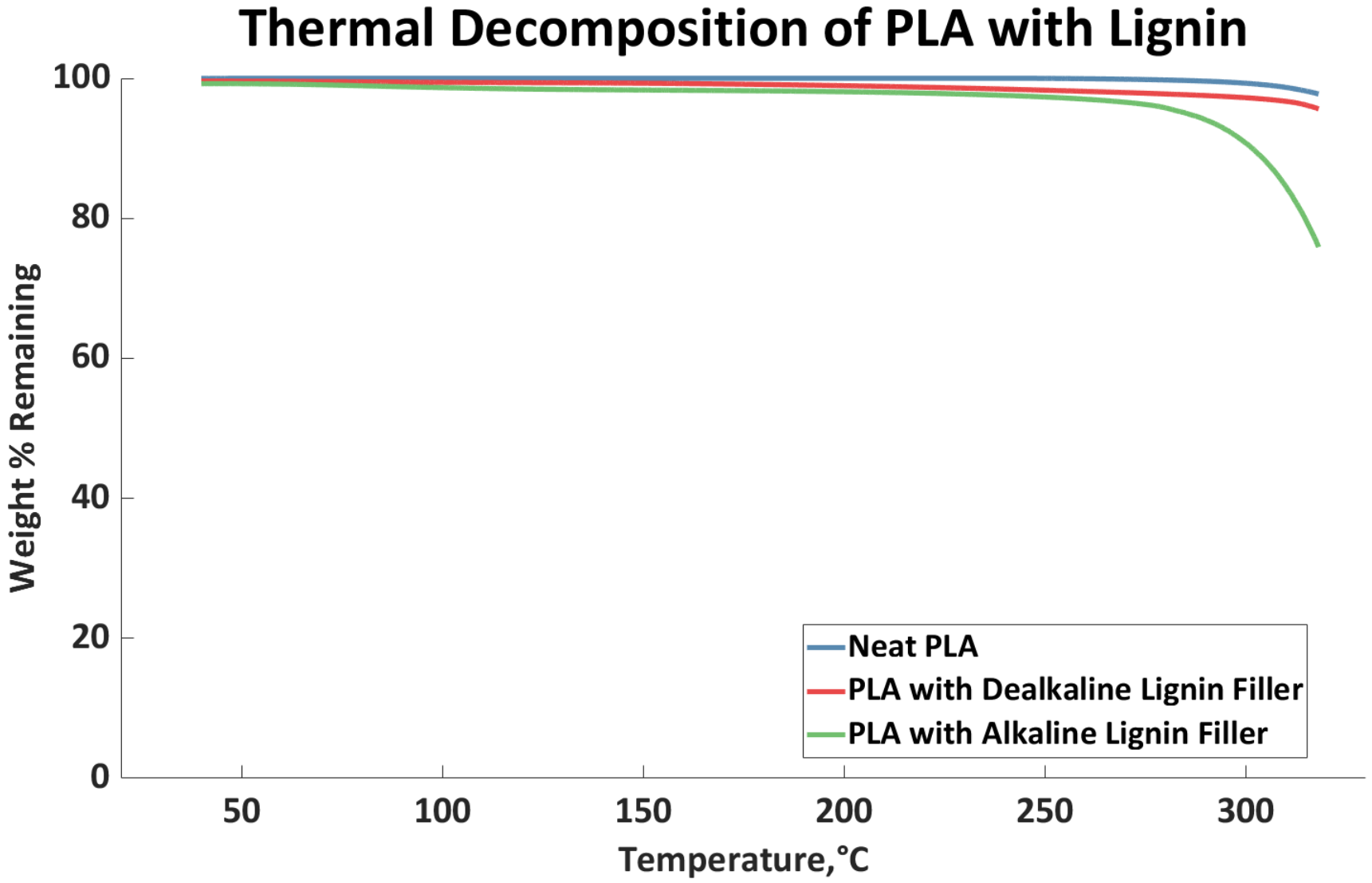




Similar trends seen in TGA of PLA…



Initial Conclusions

Reduction in thermal degradation temperature responsible for the behavior seen

Present with biochar from multiple lignin feedstocks and wheat stems

Arroyo, J., & Ryan, C. (2018). https://doi.org/10.3390/polym10121371

Next Steps

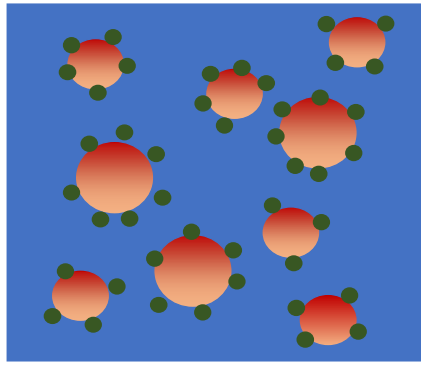
Characterize the reaction between biochar and plastics

How can we avoid this reaction?

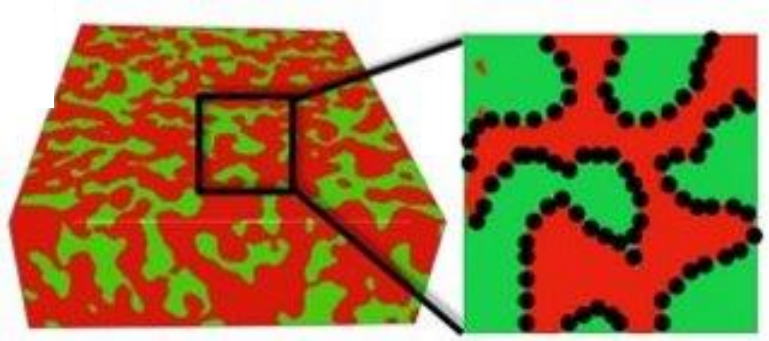
Characterize the properties of resulting material

Electrical conductivity, mechanical properties, life cycle analysis

Biochar in other biodegradable plastic blends



Nanofiller localizes to interface

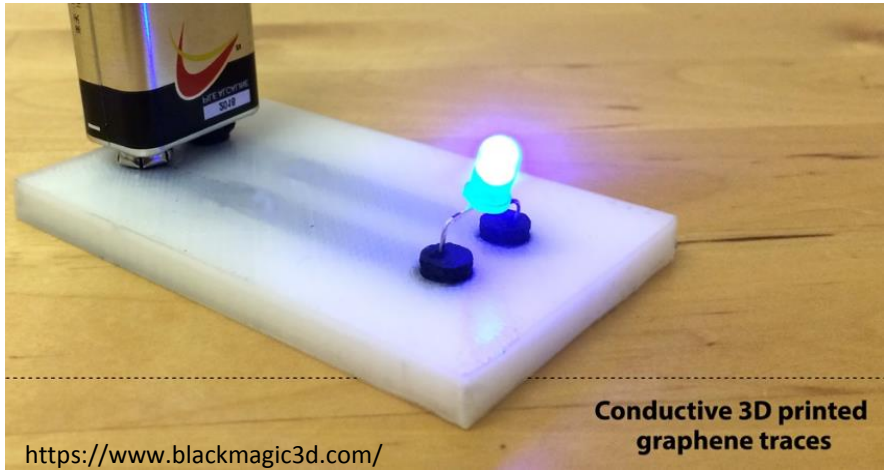


Expected Significance

A biodegradable replacement for carbon black would be highly desirable as the market share of biodegradable plastics increases

Long term

Fully biodegradable and 3D printable semi-conductive materials



Thank you!

Questions?

sethkane@montana.edu