

Hybrid Natural Fiber/CNF Thermoplastic Composites

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Macrofibers/feedstocks

Bleached Pulp



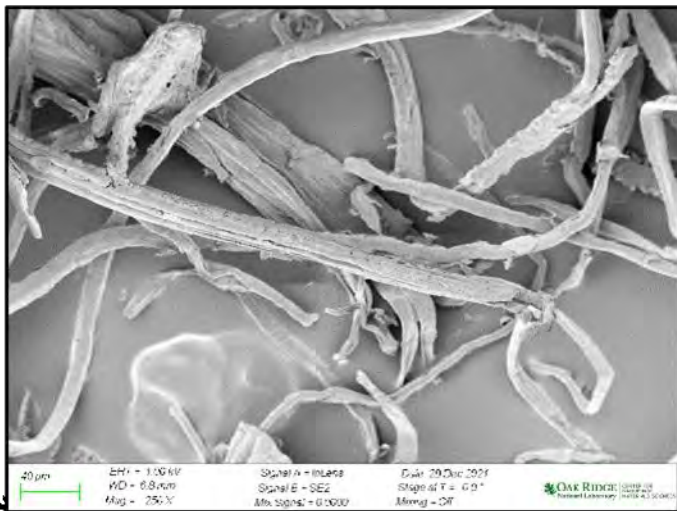
OCC



Unbleached Pulp



Wheat straw



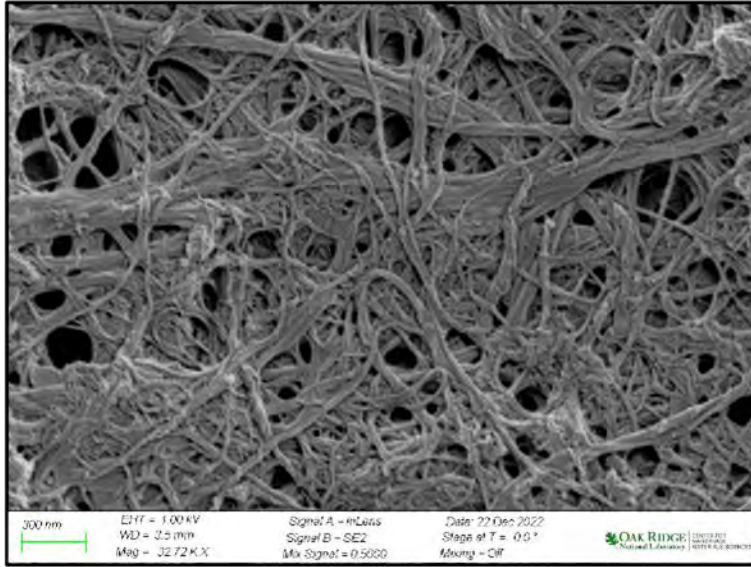
Flax



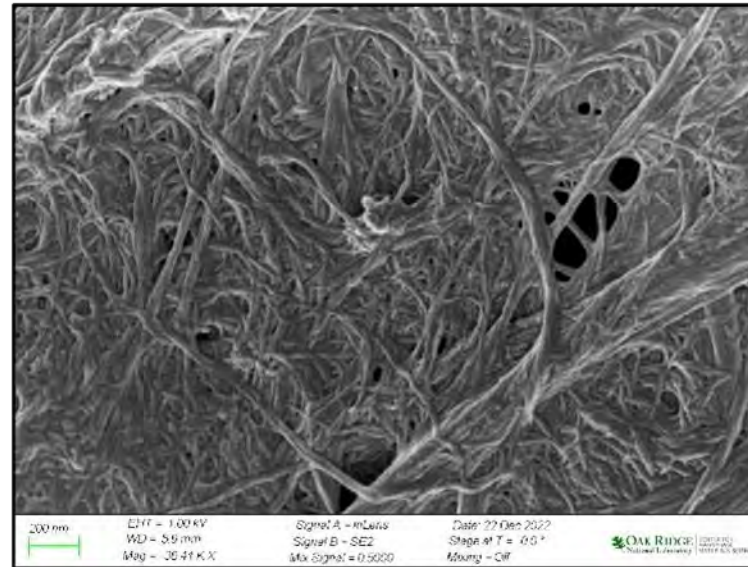
Hemp



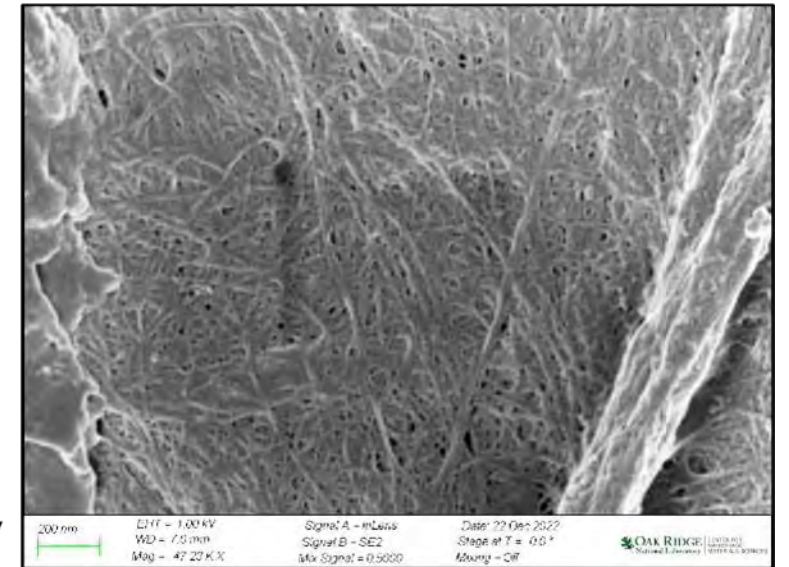
CNF



BSK

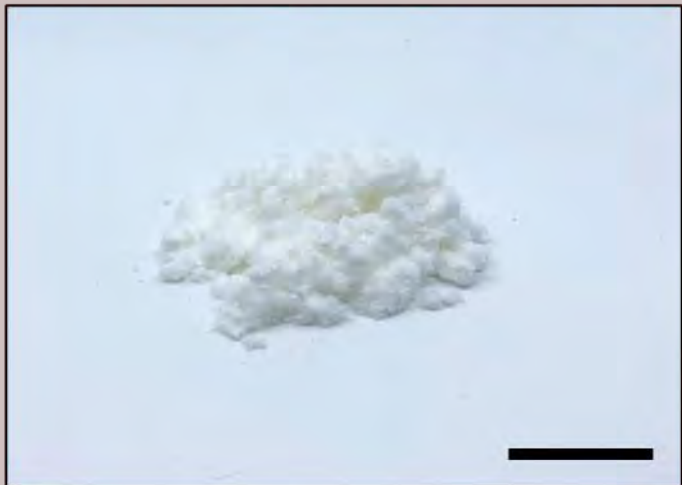


Flax

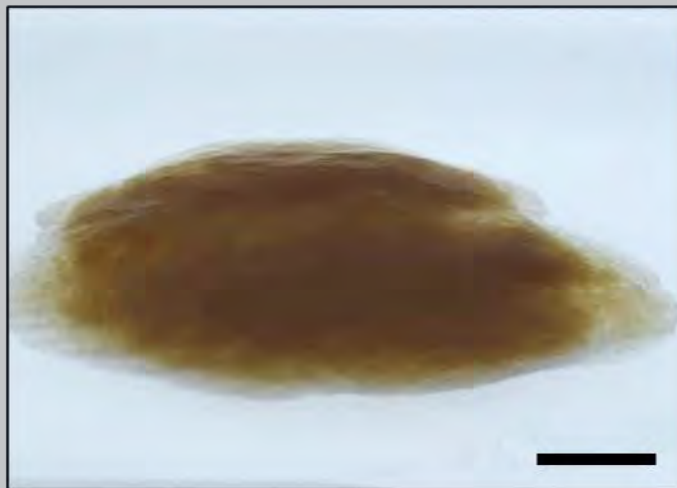


Wheat Straw

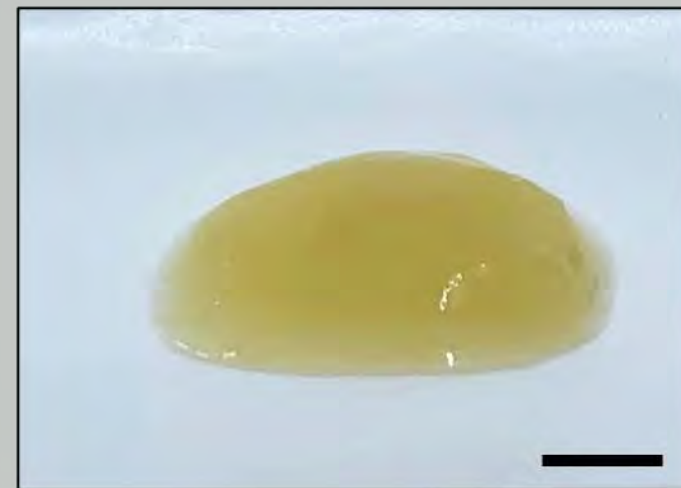
Bleached Pulp



Flax



Wheat Straw

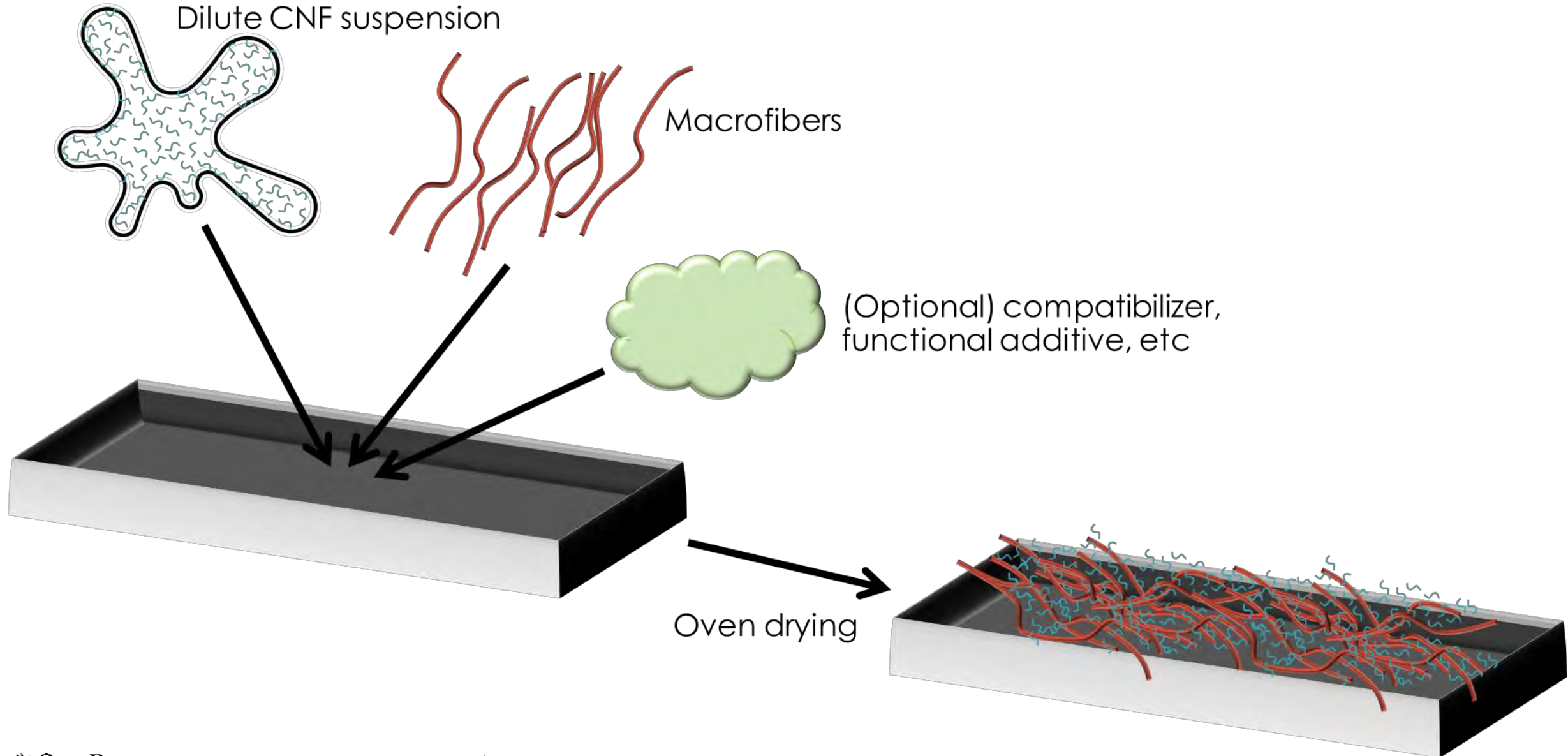


Macrofibers

CNF Suspension

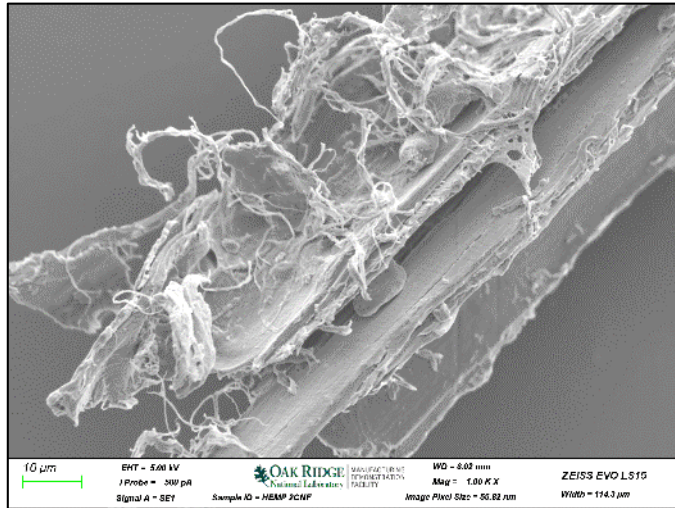
Scale bars: 1 cm

Hybrid fiber preparation

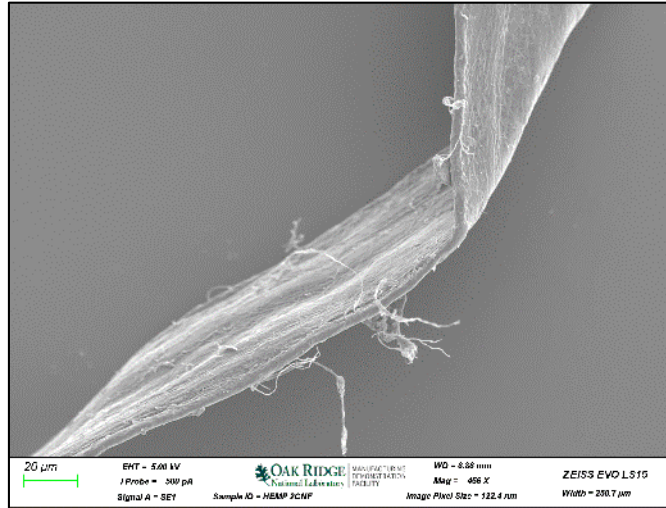


Hybrid fibers

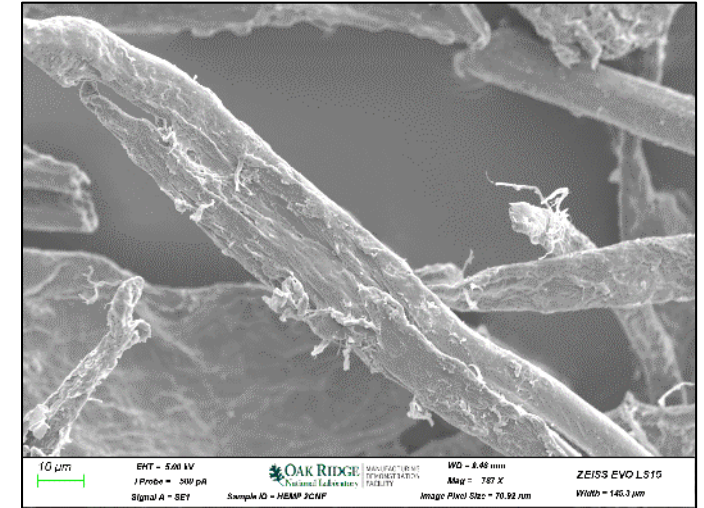
Wood flour/CNF



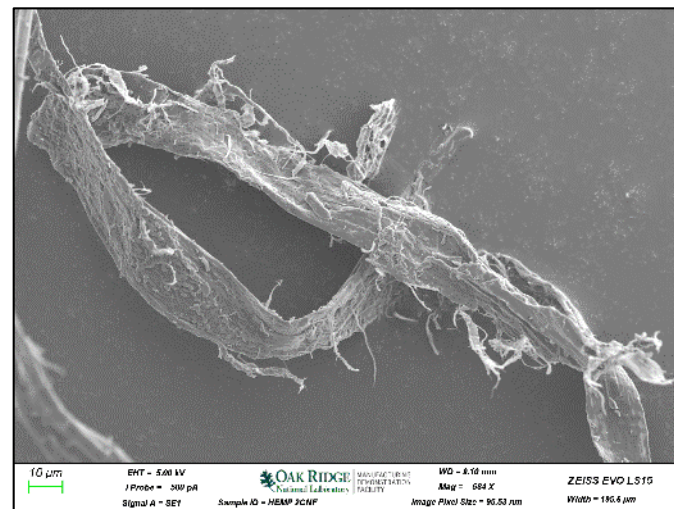
OCC/CNF



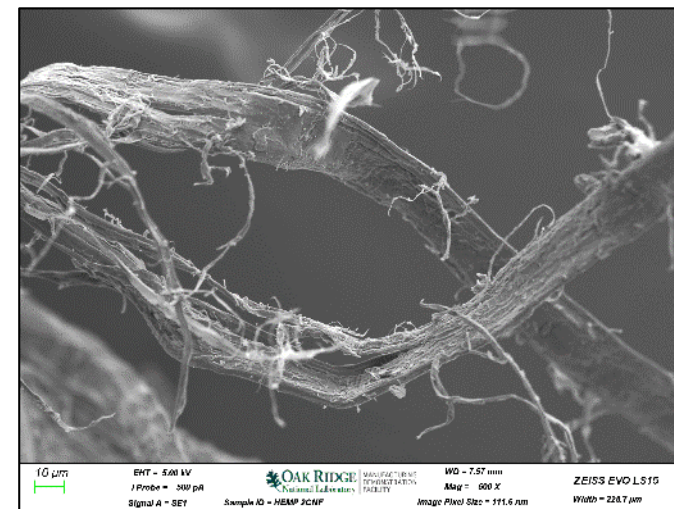
Wheat straw/CNF



Flax/CNF

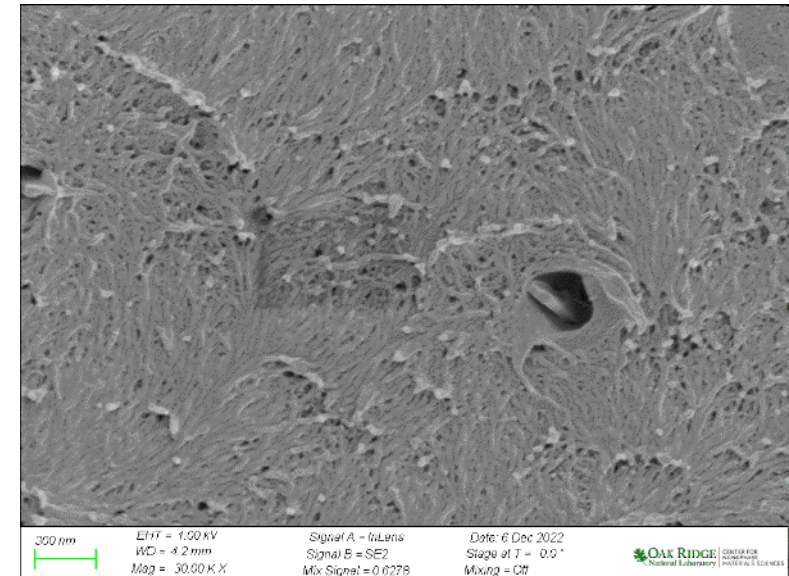
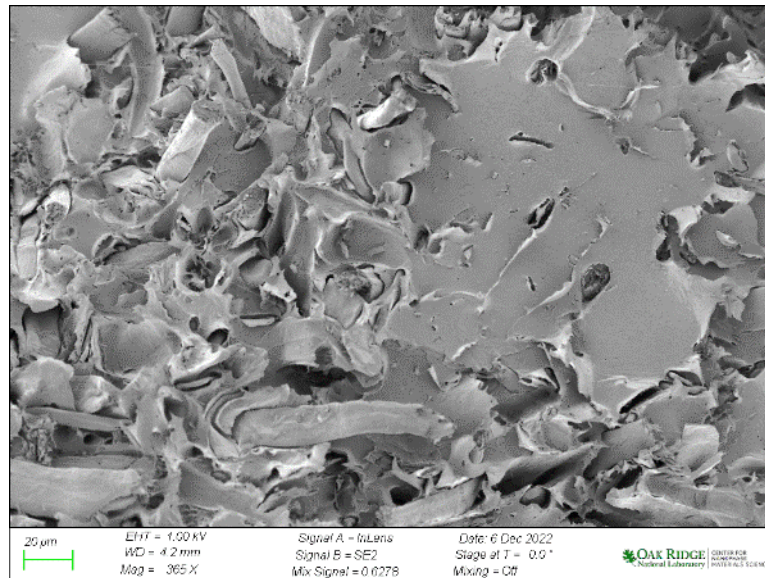
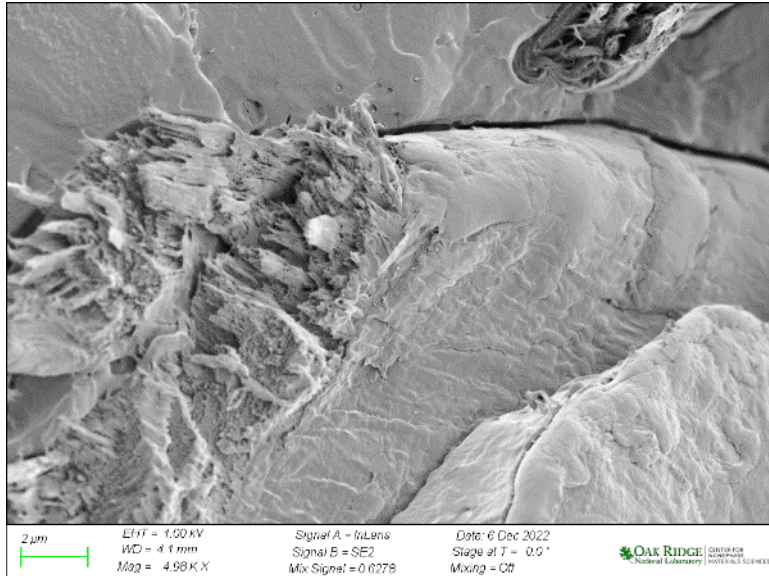


Hemp/CNF



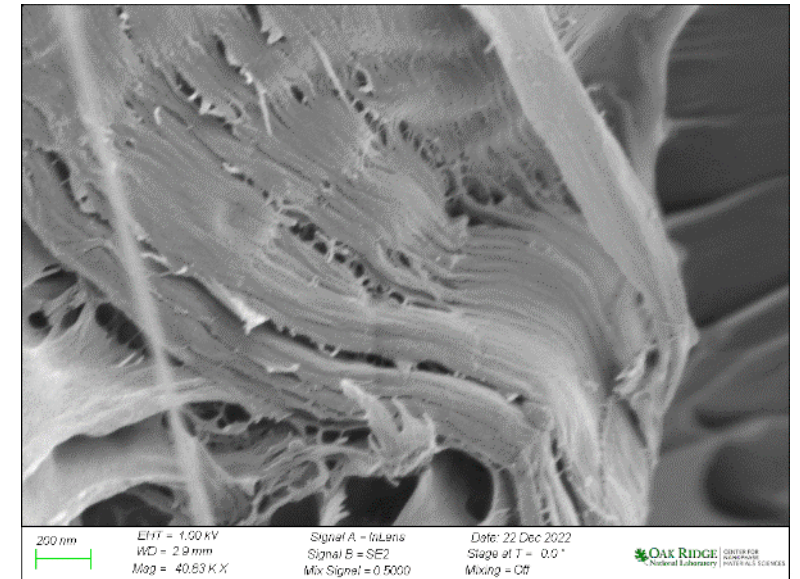
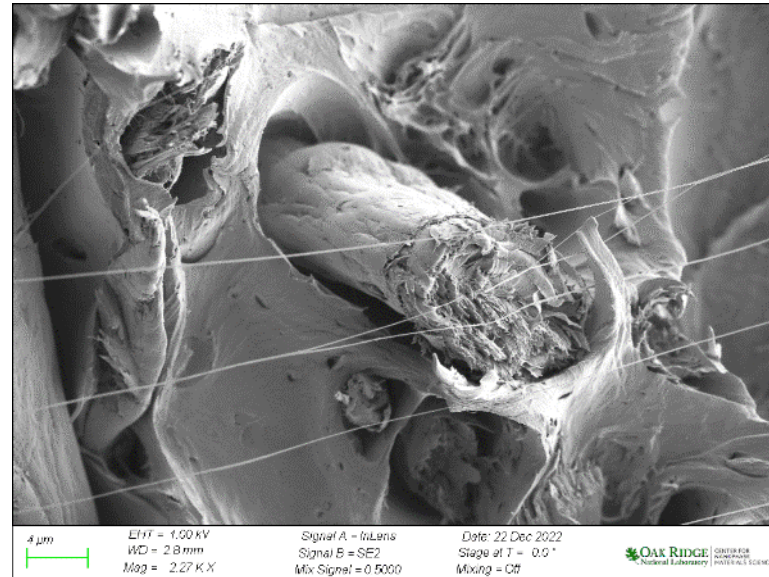
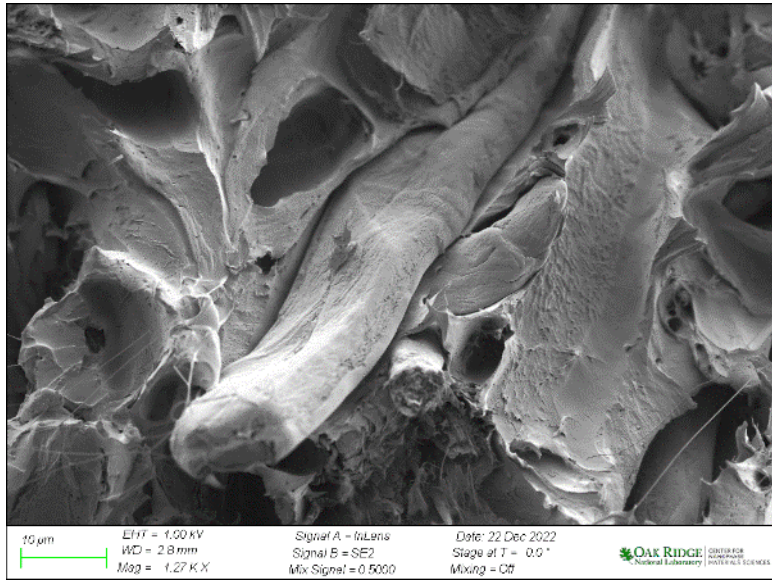
Composites—20wt% total fiber content

- PLA/bleached pulp/1%CNF



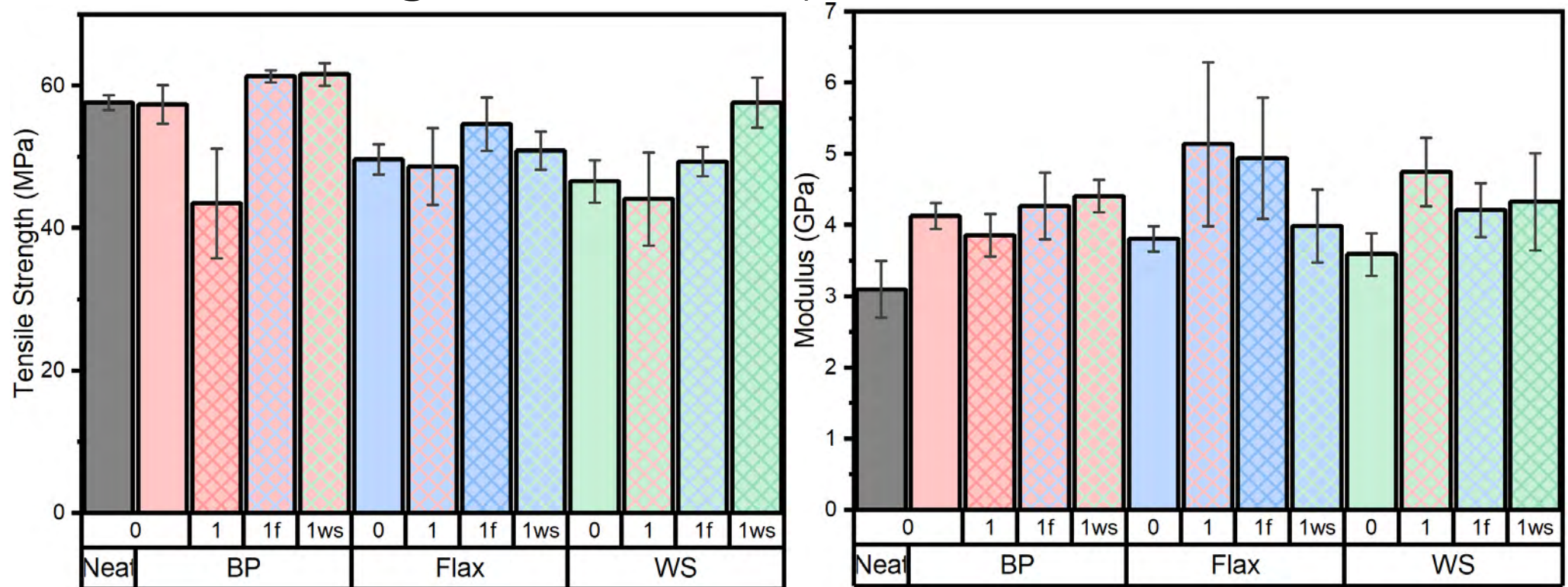
Composites—20wt% total fiber content

- PLA/flax/1%CNF



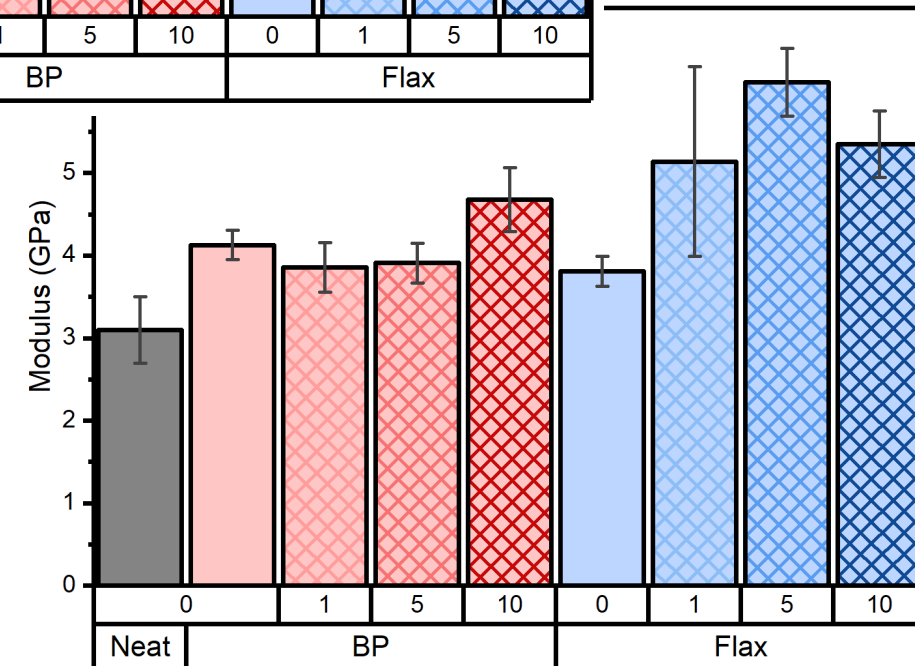
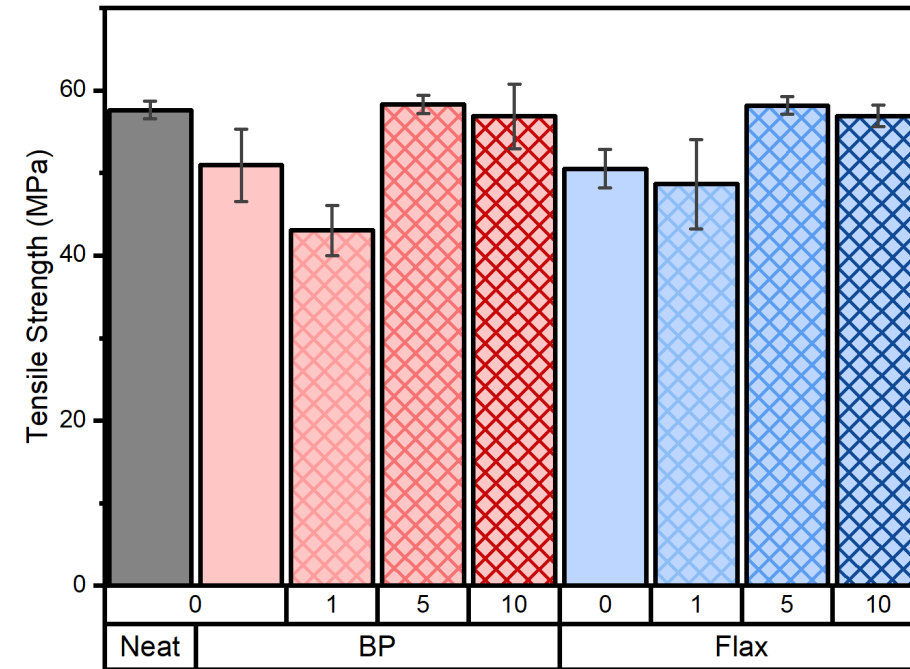
Hybrid Composites—varying CNF and feedstock type

- Bleached pulp (BP), flax, and wheat straw (WS) with 1wt.% (wrt fiber wt) BSK-CNF (1), flax-CNF (1f), and WS-CNF (1ws)
- In PLA at 20wt.% fiber content
- BP showed highest TS when paired with nonwood CNFs; flax and WS showed highest TS when paired with their own CNF



Hybrid Composites—varying CNF content

- Bleached pulp (BP) and flax with 1, 5, and 10 wt.% BSK-CNF (wrt fiber wt)
- In PLA at 20wt.% fiber content
- Both show initial decrease in TS upon addition of CNF, increase with more CNF addition
- Scaling up BP and flax + 5wt% CNF (20wt.% total fiber in PLA)



Compounding



- Leistritz co-rotating twin screw extruder
- ~25 lbs of PLA/20%BP and PLA/20%(BP+5% CNF) produced, sent to UMaine ASCC for print trials



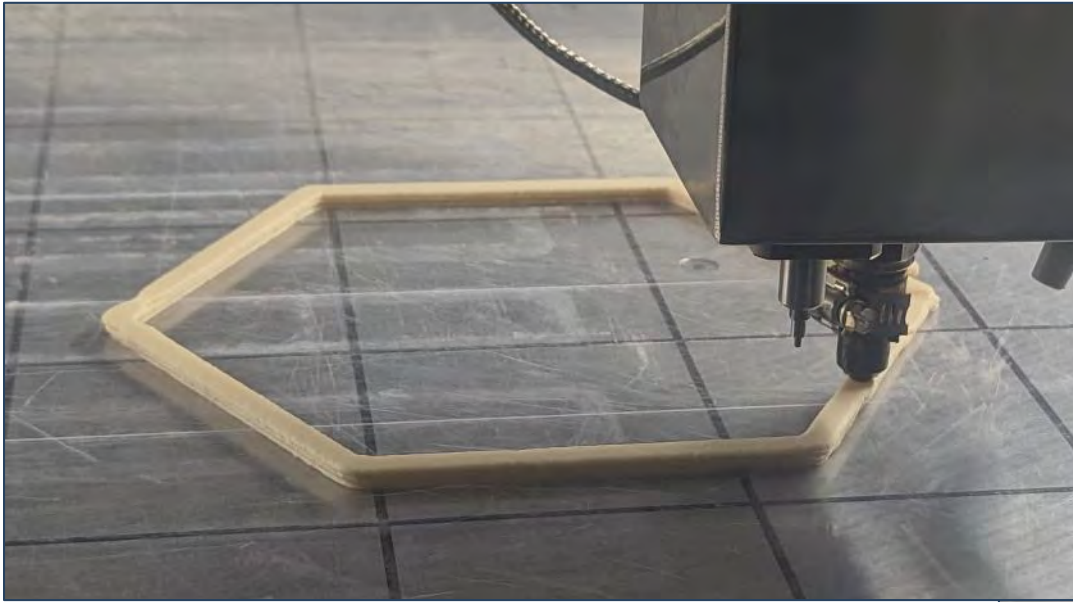
PLA/20%BP

- Printed on pellet-fed Juggerbot medium-scale system
- Issues with flow consistency and material stick to nozzle



PLA/20%(BP+5%CNF)

- More consistent flow than pure BP, no sticking issues observed



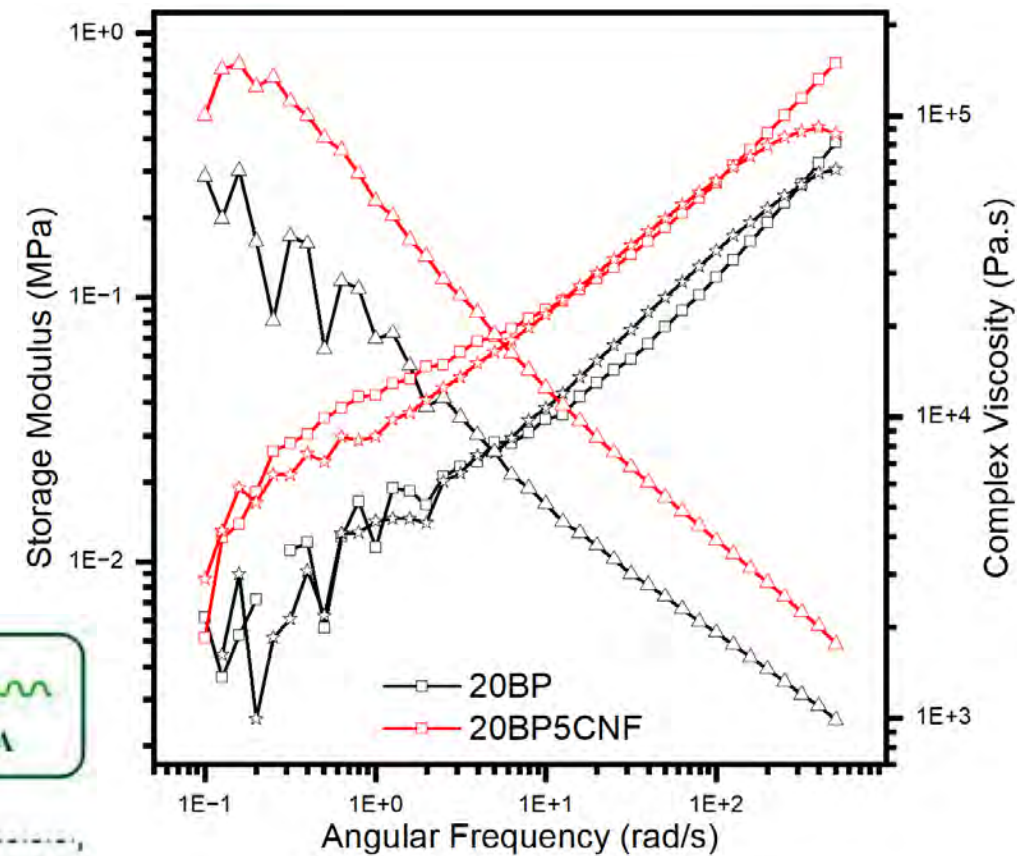
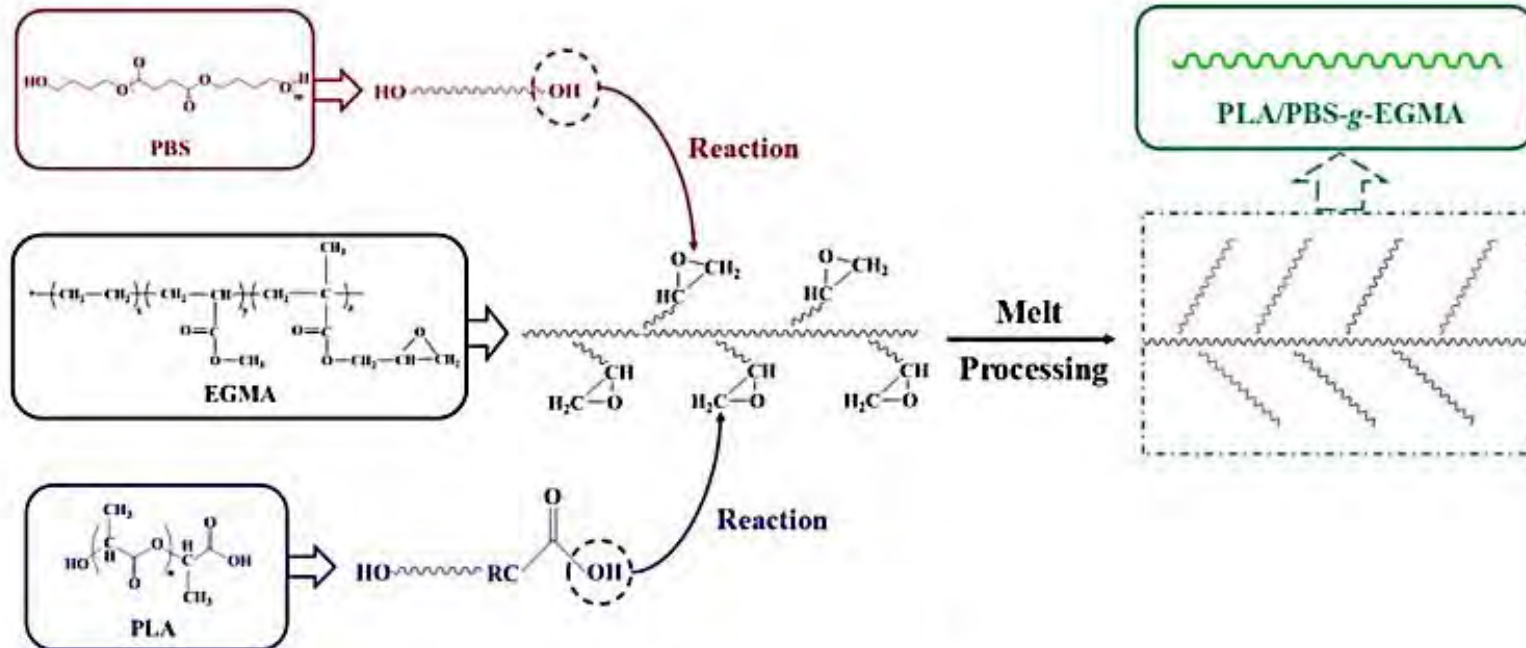
PLA/BP



PLA/BP/CNF

Ongoing work

- Characterization of printed PLA/BP samples
- Compounding/printing of flax and hybrid flax samples
- Addition of surface modifiers/compatibilizers/dispersion agents



Clariant licocare RBW (wax)

- Bio-based (rice bran) lubrication/dispersion agent
- Polar-modified



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