Vision

Produce and commercialize biomass waste stream-derived industrial-grade fibers, polymers, and their composites, with properties rivaling current petroleum-derived alternatives.

Biomass waste stream → Separation and Isolation of biomass constituents

- Lignin fractions
- Hemicellulose fraction-polymer modifier and carbon precursors

Thermoplastic and thermoset formulations as composite matrices

Carbon fibers and carbon particulate manufacturing

Functional composites
Spinning neat or modified lignin to fibers

Lignin formulation

1. Oxidation or stabilization
2. Carbonization

Melt extruder

Drying
Melt-blown lignin web production was demonstrated at ORNL

- ORNL demonstrated hardwood lignin web production
- First reported semi-production scale web forming with softwood lignin (~20 lb quantity).
- Process modification and subsequent stabilization/carbonization protocols are being developed.
Oxidation of lignin fibers produce infusible carbon precursor filaments

Melt-spun lignin fiber

Tension is applied during oxidation and the tow was stretched

Processed & carbonized without tension

Carbonized with tension

Mays, Naskar et al. POLY Symposium (2013)
Immediate FUNCTIONAL applications of lignin-derived carbon fibers

• Lignin-derived CF is a “drop-in” replacement for commercial isotropic pitch CF used in GrafTech’s commercial GRI™ product

• High performance battery electrodes and supercapacitor with potential for low cost were made from lignin-derived CF at laboratory scale
Grand Challenge

Both the biorefineries and pulping industries are keenly interested in developing new revenue streams ....

......and automotive part manufacturers are also extremely interested in gaining access to thermally and hydrolytically stable, uv-resistant, and renewable polymers. Such an economically advantageous technology is yet to develop mainly due to the lack of integrated knowledgebase and interdisciplinary research approach involving:

1. lignin feedstock consistency,
2. ability to control lignin self-assembly in soft polymer matrix,
3. understanding chemistry and physics of lignin-derived polymers,
4. process engineering, and
5. melt-rheology of the polymeric products
A new methodology of extruding reactive lignin with soft matrices exhibits outstanding performance in the product (Exceeds performance by ABS)

Tensile stress-strain profile of lignin-polymer materials synthesized by state-of-the-art method vs. newly developed method that shows dramatic improvement in modulus, a yield stress, and extraordinary toughness mainly due to our ability to tailor the phase morphology and interface of the multiphase material.

Lignin-extended high performance thermoplastics: composites applications

Lignin (residue) | Cellulose (sugar and biofuel) | Hemicellulose (C5 sugars & chemicals)

High performance thermoplastics are being made as substitute for ABS, a automotive composite resin

Conclusions

Our results demonstrate feasibility of i) functional carbon manufacturing from lignin, and ii) synthesizing a new class of elastomers, prepared by nanoscale dispersion of lignin, a renewable phenolic oligomer, in rubber.