High Performance Bio-Based Polymers

Research Objective

- Prepare high performing thermoplastics and thermosets from renewable resources to improve performance and sustainability of Army polymers.

Challenges

- Use of lignin, carbohydrates, and other renewables pose chemistry challenges to produce desired molecular structures.
- Development of bio-based polymers with higher performance than commercial polymers.
- Convincing manufacturers to produce unproven bio-based polymers instead of commercially viable petroleum-derived polymers.

Progress

- Developed bio-based replacements for bisphenol A (BPA) with reduced toxicity.
- Formulated, demonstrated, and validated low styrene resins for DoD composites.
- Structure-property relationships of furan-based polymers.
- Highest performing lignin-based carbon fiber ($\sigma = 1.3$ GPa).
- Developed vinyl ester resins with highest properties ($T_g \sim 250^\circ C$, $G_{IC} \sim 2000$ J/m$^2$).

ARL Facilities and Capabilities Available to Support Collaborative Research

- State-of-the-art chemistry laboratory, including flash chromatography/MS to isolate and characterize.
- Full suite of laboratory chemical characterization, including NMR, FTIR, SEC, and MS.
- Full suite of thermal analysis, including DMA, DSC, TGA, TMA, and rheology.
- Full suite of mechanical and ballistic testing.
- Collaboration with coatings team to incorporate promising technology into Army coatings, such as CARC.
- Expertise in resin formulation
- Authored Standard on Resin Characterization
- Multi-scale Standard on Resin Characterization

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Capabilities to decompose lignin and cellulose into chemicals of relevance for monomers and polymers.
- Methods to probe microstructure of growing polymer network.
- Partners in polyamide synthesis and processing.
- Manufacturing capabilities to scale-up and produce bio-based monomers and polymers.

Furan chemistry is significantly different from standard building blocks, resulting in challenges to creating pure monomers and high quality polymers.