Engineering New Materials from Biomass

The vast agricultural and forestry resources of the United States supply a variety of materials that can be used to make biobased products—from biofuels to cosmetics to the plastic in soda bottles. Oak Ridge National Laboratory's (ORNL's) bioderived materials research develops methods and technologies to fuel the bioeconomy, enabling greater and higher value use of biomass to sustainably produce a wider range of high-performance products.

ORNL is a US leader in materials science, with a new emphasis on the array of materials derived from biological feedstocks, specifically woody and herbaceous biomass. These bioderived materials are based on common forms of naturally occurring polymers, including cellulose, lignin, and hemicellulose. Scientists are working to advance fundamental and applied research throughout the production pipeline, from feedstocks to conversion to demonstration. By integrating scientific discovery and technology innovations, ORNL is leading the way to developing new bioderived materials for a variety of applications, including large-scale additive manufacturing or 3D printing.

APPLICATIONS

- AUTOMOTIVE PARTS
- ENERGY STORAGE DEVICES
- MOLDS AND TOOLS
- PACKAGING AND INSULATION
- BIOMEDICAL DEVICES

Developing New Materials

A cross-disciplinary team of scientists is combining fundamental knowledge about plant genetics with expertise in manufacturing to identify efficiencies and create new uses for biomass, matching plant characteristics and processing parameters to the end product. Researchers are using a variety of strategically identified feedstocks and developing new processing methods to enable novel breakthroughs.

Plant biology and genetics—Furthering an understanding of the relationship between genetics and plant characteristics based on studies of poplar trees, eucalyptus, and other feedstocks

Conversion and engineering—Examining ways to deconstruct plants into usable components without destroying inherent plant characteristics; synergistically combining biological and chemical conversion to achieve higher yields and novel products

Materials and manufacturing—Exploring material compositions and manufacturing methods to create opportunities to add value to production streams and create new structural and functional materials

"We are examining ways that plant genetics and biological design can influence the properties of the finished bioproduct."

Udaya Kalluri, ***Senior Staff Scientist***

OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY

Partnerships and Industry Innovation

ORNL is partnering with the University of Maine in the first large-scale biobased additive manufacturing program in the United States. This unique collaboration combines the Laboratory's bioscience, materials science, and additive manufacturing expertise and capabilities with the university's focus on forest-based biomaterials to develop new composites for 3D printing in support of Maine's forest products sector.

The collaboration aims to foster regional industries in rapidly deploying technologies, to position industry to print large, structurally demanding systems like boats from biomaterials, and to strengthen US competitiveness in manufacturing while preparing the workforce of the future. Technical focus areas include cellulose nanofiber production, drying, functionalization, compounding with thermoplastics, multiscale modeling, and sustainability life-cycle analysis.

The University of Maine and ORNL collaborated on this large-scale boat mold printed using bioderived materials.

Recent Impacts

Plant-based foams and films for mattresses, industrial uses—Developing bioderived polyurethane coatings and foams like those used in car seats from the lignin by-product streams of biorefineries

Printing with plants—Created a scalable processing technique that uses lignin, a current by-product of the biofuels production process, to produce a new material for 3D printing with excellent performance

Supertough bioplastic—Developed a bioderived polymer that is 10 times tougher than polylactic acid without sacrificing strength or stiffness and with improved manufacturability

Shape-memory conductors—Generated a renewable material programmed to remember its shape that offers a potential low-cost alternative to conventional conductors for sensors and robotics

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