Bio-Based Products

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

A New Approach to Biomass

While biomass holds potential for a ready supply of renewable energy, the primary success factor for this resource—the ability to profitably produce products from biomass—has stymied government and industry alike.

The U.S. Department of Energy's Pacific Northwest National Laboratory, operated by Battelle, is overcoming this barrier by taking a new approach to using biomass. Our research is focused on producing high-value bioproducts, such as chemicals for plastics, fibers and solvents, in addition to fuels and power. Since these bioproducts often can be made less expensively than similar products made from petroleum, they can provide the economic driving force necessary to make a biorefinery-based industry a reality. In addition, a biomass-based feedstock offers the opportunity to make entirely new products with processes that are more energy efficient and environmentally friendly.

Recent advances by Pacific Northwest National Laboratory and its partners make development of these sophisticated biorefineries technically and economically feasible. These advances offer an unprecedented opportunity to create a new and growing market for agriculture while meeting national needs, including reducing U.S. dependence on foreign oil and gas, providing economic opportunities for agriculture and rural-based economies and reducing environmental impact.

At Pacific Northwest National Laboratory, our 30 years of experience in biomass science and technology development offer opportunities for grower associations, commodity processors, chemical companies and others interested in the environmental and economic benefits of renewable biomass resources.

The Pacific Northwest National Laboratory delivers financially attractive systems that use biomass to produce industrial and consumer products.

Leading Edge Capabilities

To create new uses for agricultural products and other biomass resources, Pacific Northwest National Laboratory offers integrated capabilities in chemistry, advanced process science and engineering, applied microbiology and molecular biology.

Novel catalyst research

The Laboratory is a leading research institute in the fundamental understanding and development of novel, highly active and highly selective catalysts for biomass conversion. Our researchers have extensive experience in formulating, synthesizing and testing catalysts for chemical production applications, including

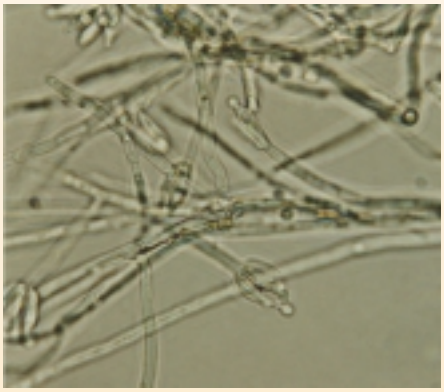
- Catalytic hydrogenation of organic acids and sugars to monomers, esters and solvents
- Catalytic oxidation of oils and sugars to produce monomers, esters and epoxides
- Acid catalysis for sugar conversion, esterification, decarboxylation and deamination.

In addition, we have extensive experience in conversion of biomass for energy uses, such as

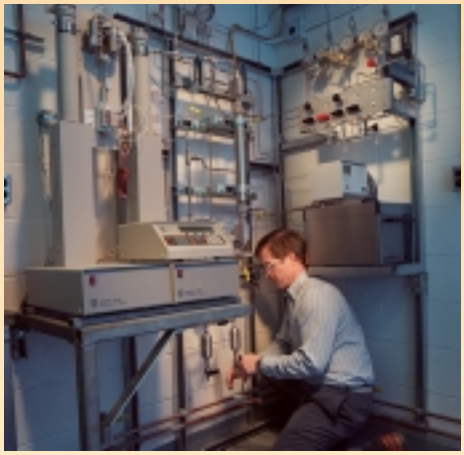
- Thermochemical gasification of biomass for medium-Btu gas production
- Upgrading of bio-oils to transportation fuels
- Conversion of organic acids to fuel additives.

Eukaryotic organisms in fermentation and enzyme discovery

The Laboratory has a group dedicated to fully exploiting the capabilities of filamentous fungi, the group of microorganisms largely responsible for recycling lignocellulose biomass in nature and the source of beta lactam antibiotics, the miracle drugs of the mid-twentieth century. The Laboratory is building a fungi culture collection for discovery, characterization and product screening; establishing a fungal fermen–tation laboratory; and developing novel molecular biology tools for genetic manipulation of the fungi as part of developing optimal production systems. These capabilities allow us to rapidly develop novel fermentation systems for producing a wide variety of industrially relevant compounds.



Researchers at the Pacific Northwest National Laboratory are developing new tools for manipulating the genetic material of filamentous fungi, which could serve as a source of effective fermentation organisms.



With the help of batch and continuous flow chemical reactor systems, researchers at the Pacific Northwest National Laboratory have developed novel, highly active and selective catalysts for biomass conversion.

Advanced process science and engineering

The Laboratory's core capabilities in molecular science, advanced chemical analysis and process science and engineering provide the basis for developing and deploying novel processing technologies. These capabilities enable us to develop original approaches to feedstock pretreatment, conversion and product purification. For example, our capability in reaction kinetics has allowed us to carefully separate biomass fractions to ensure optimal value recovery. We also have developed novel reactor and separation systems, such as advanced micro-thermal and chemical systems, to provide the process intensification necessary to significantly reduce capital and energy requirements for biomass processing.

Our capabilities provide the building blocks to create and optimize a fully integrated bio-based products manu–facturing system that economically converts biomass into energy and industrial products.

Unique Facilities

Pacific Northwest National Laboratory facilities provide sophisticated analytical equipment and chemical and biochemical reactor systems. This suite of facilities offers an ideal environment for advanced bio-based products research.

State-of-the-art nuclear magnetic resonance and electron paramagnetic resonance instrumentation located in the William R. Wiley Environmental Molecular Sciences Laboratory help users understand the molecular structure and fundamental processes needed to advance biomass science.

Our chemical engineering and process development laboratories offer highly advanced chemical analytical equipment and chemical and biochemical reactor systems, such as batch and continuous flow catalytic reactors, in which to perform a diverse range of hydro–genation and oxidation reaction steps. Other facilities provide the capability to operate batch fermentation vessels, collect and screen microbes, conduct genetic sequencing and carry out metabolic engineering experiments using microbes and plants.

The Laboratory also is working with a variety of organizations to establish a joint bioproducts research and education facility. This facility will contain the capabilities necessary to rapidly translate scientific discoveries into commercial technologies and provide a comprehensive educational experience aligned with industry needs.

At Pacific Northwest National Laboratory's Process Development Laboratory, which accommodates demonstration-scale plants and equipment, researchers conduct engineering assessments of biomass processing methods with market potential.

An 800 MHz nuclear magnetic resonance spectrometer in the William R. Wiley Environmental Molecular Science Laboratory is one of more than 15 NMRs available to help determine the chemistry of feedstocks or products.

Breakthrough Science and Technology

The Pacific Northwest National Laboratory offers a strong track record of fundamental scientific advances and new technology developments.

Fractionation and recovery of high-value products

Our scientists are finding ways to extract additional, high-value products from low-value food processing by-products. We have developed processes to selectively recover various carbohydrates and other valuable products from these low-value streams. The recovered carbohydrates are converted to sugars and further processed either catalytically or through fermentation to a suite of products such as monomers for plastics and fibers. Other high value products, like valuable oils or proteins, are extracted and recovered for uses such as nutraceuticals.

Catalytic conversion of biomass-derived sugars to chemicals

The Pacific Northwest National Laboratory has developed several highly selective and robust catalyst processes to convert sugars into valuable commodity and specialty chemicals. Our processes create chemicals from sugars at far lower cost than the same chemicals made from petroleum. For example, we have produced polyols, such as ethylene glycol and propylene glycol, with catalysts that can provide high selectivity for a given glycol, resulting in a more valuable product stream. We also have developed an efficient solid acid catalysis technique to turn sorbitol into isosorbide, which can be used to add strength and rigidity to polymers.

Production and conversion of fermentation products

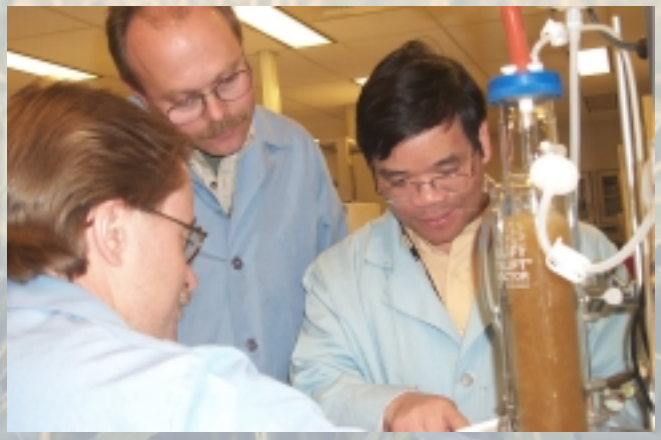
The Laboratory has developed several unique catalyst processes to convert fermentation products, such as organic acids and amino acids, into valuable chemicals. Using this catalytic conversion approach, for example, we produced 1,4-butanediol, which is a monomer used for products like plastic car bumpers, from biologically derived succinic acid. This technology won a prestigious R&D 100 Award.

Our researchers also are developing unique fermentation processes using filamentous fungi, a group of micro-organisms essential to converting and recycling biomass in nature. These organisms produce a wide variety of industrially important products such as organic acids that can replace petroleum-derived feedstocks in the synthesis of polymers, esters, solvents and other useful chemicals, as well as new enzymes that can be applied to specific chemical reactions. Combined fermentation and catalytic processes can provide unique and lower cost routes to several important chemicals.

Thermochemical conversion processes

The Pacific Northwest National Laboratory has more than 25 years experience in developing thermo-chemical conversion processes to produce fuels and products from biomass. Initial work began in 1975 in biomass liquefaction. Since then, our work has included production of transportation fuels from bio-oils and catalytic and non-catalytic steam gasification of biomass.

This research led to the development of an entirely new catalytic gasification concept using high-pressure liquid water for low-temperature gasification. This concept, which converts wet organic residues to medium-Btu fuel gas (methane and carbon dioxide) was an R&D 100 award winner and is currently being evaluated to convert animal wastes to fuel gas.



Pacific Northwest National Laboratory researchers are developing the capabilities of filamentous fungi to serve as a potential source of organic acids or new enzymes.

Collaborative Success

Through collaborative projects with universities, research institutions, trade organizations and commercial companies, the Pacific Northwest National Laboratory has advanced fundamental understanding as well as the economics and efficiency of biomass-to-chemicals processes. We used a variety of mechanisms to achieve results, including cooperative research and development agreements, memorandums of agreement, licenses of patented technologies and work for other government agencies. Through a unique contractual arrangement between DOE and Battelle, the Laboratory's operating contractor, our staff members also have performed work for commercial firms.

New processing options that simultaneously produce high value chemicals, fuels and energy may finally release the power of biomass resources like this pulp mill sludge.

Award-Winning Technology

Among our achievements are a Presidential Green Chemistry Challenge Award in 1999 for groundbreaking work in developing a patented catalysis process that adds value to paper mill sludge; a 1997 R&D 100 Award for a process that converts corn into a cost-efficient, environmentally friendly source of chemicals; and a 1990 Federal Laboratory Consortium Award for Technology Transfer for a process that combines fermentation with catalytic processes to produce lactic acid.

About the Pacific Northwest National Laboratory

The U.S. Department of Energy's Pacific Northwest National Laboratory, operated by Battelle, delivers breakthrough science and technology to meet the DOE's science, environmental quality, energy and national security missions.

Established in 1965, a quick snapshot of the Laboratory today shows 3,600 staff, $535 million in business volume, 1,523 patent awards since 1965 and 48,320.9 square meters of active lab space.

For more information about bio-based products or to discuss development opportunities, contact

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