Pacific Northwest National Laboratory is advancing direct liquefaction technologies for making green crude oil from forest and agricultural residues, algae and other waste materials.

Pacific Northwest
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Liquefaction Technologies for Converting Biomass to Liquid Fuel

Direct liquefaction is a family of processes used to convert solid biomass into liquid fuel precursors, called biocrude, without the need for heavy pretreatment and deconstruction. Pacific Northwest National Laboratory has a rich history as a leading Department of Energy laboratory in liquefaction and our researchers are internationally known for their work in producing and upgrading biocrude to produce liquid fuels.

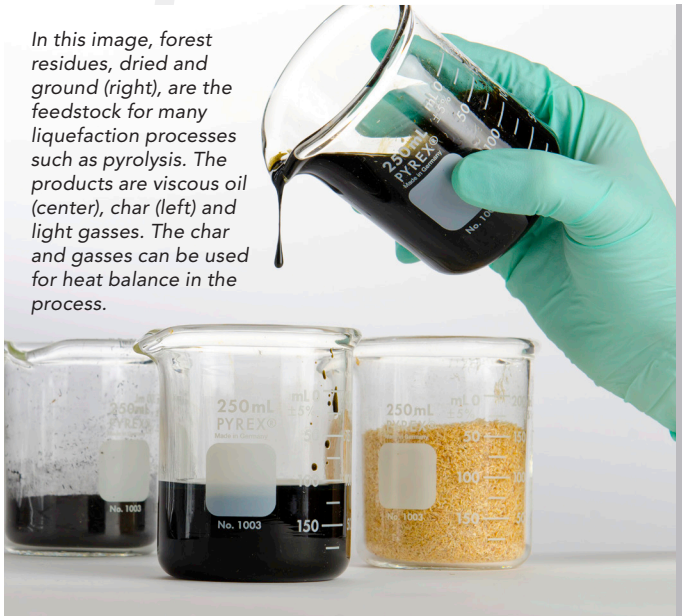
- PNNL is using fast pyrolysis and catalytic versions of this chemistry to convert wood and agriculture residues into oils that are suitable for upgrading to hydrocarbons.
- Our researchers are using hydrothermal liquefaction (HTL) to convert wet slurries of biomass, such as algae and various waste materials, to oil. Using catalytic processes developed at PNNL, we can make higher quality biocrudes as well as upgrade the biocrude to finished fuels.
- In addition to direct liquefaction, our researchers are finding innovative ways of performing indirect liquefaction via new oxygenates from syngas.
- PNNL uses process analysis, economic modeling and life cycle analysis to guide process optimization, ensuring the development of economically, environmentally and technically sound processes that can be successfully transferred to industry.

EXPERTISE AND CAPABILITIES

PNNL offers:

- Bench-scale (1.5 Kg/hour) fluidized bed reactors to make pyrolysis oils; we have the ability to catalytically upgrade vapors before condensing them to oil.
- Bench-scale (1.5 L/hour) and pilot-scale (7-10 L/hour) plug-flow and continuous-stirred tank reactors to produce hydrothermal liquefaction oils and catalytic hydrothermal liquefaction oils.
- A full-suite of continuous flow reactors ranging from 1.4 cc to 7 L bed size for upgrading biocrude to liquid fuels.
- Distillation apparatus with capacity of 4 gallons per hour to fractionate streams into gasoline, diesel and jet fuels.
- The ability to evaluate fuels in an Environmental Protection Agency fuel laboratory, which has extensive capabilities for analyzing the standard specification properties of petroleum products.
- New capabilities in nuclear magnetic resonance spectroscopy for analyzing components in nontraditional fuels.
- A full suite of tools for developing process models for technoeconomic and life cycle analysis examining economic and environmental sustainability.
- High-level computational modeling to examine mechanisms and guide research.

impacts



In this image, forest residues, dried and ground (right), are the feedstock for many liquefaction processes such as pyrolysis. The products are viscous oil (center), char (left) and light gasses. The char and gasses can be used for heat balance in the process.

OVERCOMING LIQUEFACTION CHALLENGES

Liquefaction, the process of converting biomass into liquid fuel precursors, or biocrude, provides low-cost options for producing bio-derived gasoline, diesel and jet fuels. PNNL has developed methods for stabilizing biocrude, making it higher quality, and has demonstrated a more active and stable catalyst with the ability to process biocrude for up to 1,500 hours. With these accomplishments, we are on our way to achieving our goal of driving down the cost of liquefaction, and ultimately, making biomass conversion a relevant industry.

DELIVERING IMPACT

- PNNL is working with industrial partners to commercialize hydrothermal liquefaction with wet biomass resources, such as algae, leveraging its work with DOE's National Advanced Biofuels Consortium (NABC) and National Alliance for Advanced Biofuels and Bioproducts (NAABB). Partners include Algenol Biofuels, which produces algal feedstock in ethanol production.
- Our researchers are developing new technologies to clean up wastewater that contains small organic acids and alcohols from the process. We use catalytic hydrothermal gasification, a process able to convert 99.9 percent of carbon to methane and carbon dioxide. Our commercialization partner is Genifuel Corp.
- We are working with W.R. Grace, UOP, and Battelle on three separate competitively funded projects, awarded by DOE, to advance processes for pyrolysis oil upgrading. Such processes yield hydrocarbon fuels and, depending on process conditions, these fuels can contain up to 40 percent jet fuel, with the remainder being gasoline and diesel.
- We are working with W.R. Grace, Tesoro, Los Alamos National Laboratory and Oak Ridge National Laboratory to develop new science and technology for co-processing biocrude with petroleum-based refinery intermediates.
- We offer refinery integration modeling to determine potential capacity for using today's petroleum refinery infrastructure.

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ABOUT BSEL

The Bioproducts, Sciences, and Engineering Laboratory (BSEL) is a multipurpose R&D facility that includes:

- Advanced laboratories for thermochemical conversion research and development
- 2,500-square-foot high-bay biorefinery for technology scale up
- Analytical chemistry lab equipped with a wide array of analytical instruments
- Modern laboratories for fungal strain and bioprocess development and optimization.

ABOUT IIC

The Institute for Integrated Catalysis, DOE's premier catalyst science center, resides at PNNL. Our expertise in catalysis contributes to the science and technology base of liquefaction and fuel product. Our catalysis work:

- Covers fundamental science supported by DOE's Basic Energy Sciences
- Brings capabilities on surface science and computation applied to catalysis
- Applies catalyst science and technology to DOE's applied missions sponsored by EERE-Bioenergy Technologies Office. To learn more about the IIC, visit ***http://iic.pnnl.gov/***.

COLLABORATIONS

PNNL collaborates with multiple industrial partners to keep its research relevant to the needs of industry and to facilitate technology transfer to the public domain. We also have major leadership roles in the Joint BioEnergy Institute (JBEI), DOE's National Advanced Biofuels Consortium (NABC) and National Alliance for Advanced Biofuels (NAABB). We partner with world-class regional, national and international universities and have active collaborations with other national laboratories.

ABOUT PNNL

PNNL's biomass conversion work is an important element in a wider portfolio of research and development funded by the U.S. Department of Energy, other federal agencies and the private sector. PNNL is a DOE Office of Science National Laboratory where interdisciplinary teams advance science and technology and deliver solutions to America's most intractable problems in energy, national security and the environment. To learn more about PNNL, visit ***http://www.pnnl.gov/***.

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