Advanced Carbonization and Torrefaction

INL equipment transforms biomass by roasting it at high temperatures

Torrefaction is a process that changes biomass resources into a feedstock suitable for conversion to biofuels or for direct energy production.

Bioenergy technologies can produce homegrown, price-competitive feedstock for biopower and bioproducts. These biomaterials can be utilized to create new market products or generate electricity at energy plants that might otherwise shut down due to the cost of emissions. Despite these opportunities, biomass presents a number of challenges, including its low energy density, high moisture content, grinding performance, variability and anisotropic properties, handling performance and irregular particle sizes.

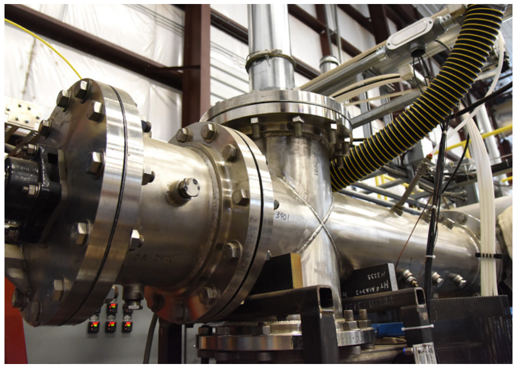
One technology to address these challenges, carbonization (e.g. torrefaction at mild temperatures), converts biomass into a feedstock suitable for either direct energy production, conversion to biofuels or generation of biomaterials. The process roasts raw biomass in the absence of oxygen, degrading the material structure. The resulting material has grinding and combustion characteristics that are compatible with existing heat and power boilers without expensive infrastructure modifications.

ADVANCED CARBONIZATION SYSTEM

Idaho National Laboratory's advanced carbonization system allows researchers and industry to thermally modify resources such as wood chips, agriculture residues and municipal solid waste for lab- and pilot-scale testing. The system is capable of continuous feeding and can process 10s of kg of feedstock per hour at temperatures ranging from ambient to 800 C and under inert or reactive atmospheres. The process is also versatile enough to incorporate third-party technology for testing and validation.

Located at the Department of Energy's Biomass Feedstock National User Facility (BFNUF), the pilot scale system is part of BFNUF's Process Development Unit (PDU), a full-size, fully integrated feedstock preprocessing system. The PDU allows for on-site drying, grinding, pelleting and packaging of carbonized feedstocks.

Idaho National Laboratory



Left: INL's advanced torrefaction system allows researchers and industry to torrefy feedstocks such as wood chips, agriculture residue and municipal solid waste for lab- and pilot-scale testing.

Right: Torrefied material can produce biopower in coal-fired plants.

With the PDU's counterparts — the Characterization Laboratory and the Bioenergy Feedstock Library — the BFNUF is a world-class feedstock research and development facility designed to provide knowledge for industry partners during scale up and integration of biomass preprocessing facilities.

CARBONIZATION BENEFITS

Thermal treatment breaks down lignocellulosic matter and other volatile components without actual combustion, resulting in several benefits.

- Improved Stability: Carbonized feedstocks are less hydrophilic (water attracting) or even hydrophobic (water repelling), promoting energy retention during storage and transport.
- Improved flowability: Carbonized feedstocks tend to have improved feeding performance.
- Improved energy value: Carbonization retains most of the resource's energy content while reducing moisture, volatile liquids and gases.
- Reduced grinding energy: Carbonized feedstocks require 50 to 80 percent less grinding energy.
- Reduced variability: Carbonized feedstocks have a greater concentration of thermally stable components, make variable resources look more chemically similar.
- Reduced off-gassing: In storage, carbonized woody biomass emits lower levels of carbon monoxide, carbon dioxide and methane gases than untreated biomass. A high degree of processing can create stable carbon sequestration materials for storage in soils.
  - Enhanced separations: Thermal modification of complex material structures can create enhanced differential properties for mechanical separations.
  - Template for carbon materials: Reaction conditions can be tuned to enable functionalization, or otherwise taking advantage of natural carbon sources for market products.

OPPORTUNITIES

While carbonization results in a loss of the initial feedstock's mass and energy content, INL researchers have tested technology that captures that lost energy and mass in the form of effluent gases and chemicals. Those products can then be reintroduced into the system for specific purposes, such as heating the reactor or drying moist feedstocks, resulting in a process efficiency as high as 92 percent.

CHALLENGES

Though torrefaction offers several potential benefits, significant challenges remain. Providing an inert atmosphere and processing/treating the evolved gases and liquids, for example. Heat and energy losses with high-temperature system must be managed to be efficient. Creating fine material powders of any kind can be potentially explosive. Volatizing waste components can carry harmful gases throughout the facility.

INL researchers have the expertise to help industry overcome these barriers, so energy plants and biorefineries can use carbonization to its full commercial potential.

FOR MORE INFORMATION

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