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mesoporous (pore size 2 to 50 nm) solids using classical BET helium void volume and commercial helium-free methods. Additionally, chipped and particulate solid biomass may cause problems related to feedstock handling, logistics and transfer.

Biomass Storage Simulation

INL's storage simulation reactors are used to monitor the behavior of feedstocks as they are stored in a variety of storage conditions. Raw biomass is naturally susceptible to microbial degradation. Depending on the type of feedstock, its moisture content, and the conditions in which it is stored, storage losses can be extreme. To better understand these relationships and develop engineered storage solutions aimed at minimizing biomass loss and quality changes in storage, INL has developed a series of highly instrumented and automated storage reactors. Microbial action within the reactors is monitored through evolution of CO_2 over time, allowing dry matter losses to be calculated throughout the entire storage period.

Schultz ring shear tester

Conclusion

Finding an integrated solutions provider with the toolset (i.e., instrumentation, equipment, experience and expertise) for addressing diverse biomass attributes (i.e., physical, chemical, biological and thermochemical) and requirements is perhaps the most important consideration for ensuring all biomass conversion puzzle pieces ultimately and correctly fit together. INL's BFNUF Characterization Team adeptly addresses these issues and aids in supplying the data and knowledge needed to make the most cogent return-on-investment decisions before important investments are made.

Biomass storage simulation reactor

15-GA50451-R2

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ENERGY AND ENVIRONMENT

The Bioenergy Feedstock National User Facility (BFNUF) Program, located at INL, investigates biofuel feedstock economics, logistics, preprocessing, sustainability, quality, and variability.

The Energy of Innovation

Idaho National Laboratory Biomass Feedstock Characterization

Solving tomorrow's biofeedstock challenges by addressing market forces today.

The U.S. Department of Energy's Bioenergy Technologies Office (BETO) promotes the production of a range of liquid fuels and fuel-blend stocks by funding fundamental and applied research that advances the state of technology in biomass collection, conversions and sustainability. Given that feedstock costs represent up to one-third of the final biofuel product costs, understanding feedstock quality and variability characteristics is crucial to the success of the BETO's Mission.

INL's Approach to Feedstock Optimization – characterization is key

The Bioenergy Feedstock National User Facility (BFNUF) Program, located at INL, investigates biofuel feedstock economics, logistics, preprocessing, sustainability, quality and variability.

INL's Biomass Feedstock Characterization Team investigates feedstock characteristics during harvesting, collection, and preprocessing to reduce feedstock degradation and transportation costs, minimize waste, manage variability and upgrade the raw biomass for optimized conversion performance.

INL Capabilities – a one-of-a-kind approach

A cornerstone of this optimization effort is the Bioenergy Feedstock Library. The library comprises a broad range of robust characterization capabilities, a sophisticated data and

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Idaho National Laboratory

Metadata and the physical storage location are linked to physical and chemical data via barcodes.

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sample management system, and statistical analysis functionality. The library's data management system is built to guide the development of advanced biomass feedstocks using the following:

- Feedstock pedigree, harvest and storage data
- Unit operational data from Process Demonstration Unit and field demonstration efforts
- Physical, chemical, biological and thermal property data
- Laboratory-based and demonstration-scale conversion performance data.

INL Biomass Characterization

The BFNUF Biomass Characterization Team is equipped to address important feedstock material quality and performance issues, including the following:

- Chemical/elemental composition and variability
- Thermochemical feedstock properties
- Particle-size distribution and morphology
- Particle density and properties
- Hydrolysis, fermentation and conversion performance
- Understanding changes in feedstock structure using:
  - Scanning electron microscopy
  - Confocal microscopy
  - Spatially resolved FT-IR microscopy
- Feedstock rheology
- Behavior of stored feedstock materials
- Pellet durability.

Chemical Composition and Analysis

INL uses laboratory analytical procedures established by the National Renewable Energy Laboratory and other established methods to determine the composition and summative mass closure of biomass feedstock materials. By combining the appropriate laboratory analytical procedures, the biomass sample is fractionated into the constituents that add up to 100 percent of the starting weight. Some of these constituents are individual components (such as individual carbohydrate and acid constituents) and some are groups of compounds (such as extractable materials). The goal of these analyses is to characterize all constituents in the feedstock sample.

Thermochemical Feedstock Properties

Researchers use thermochemical feedstock properties analysis, including proximate and ultimate analysis, to evaluate the thermal efficiency and energy content of a given feedstock. INL's analytical capabilities can readily determine volatiles, ash content, fixed-carbon content, elemental composition (e.g., carbon, nitrogen, hydrogen, sulfur and oxygen) and the higher and lower heating value. Thermogravimetric analyzer/differential scanning calorimetry, coupled with chromatographic techniques, is used to determine the caloric effects, (such as transformation temperatures, enthalpies, evaporation, and devolatilization mass changes), to better understand the fuel's properties.

Automated carbon, hydrogen and nitrogen analysis system

Accelerated solvent extraction system with pH-hardened sample cells

Rapid-Screening Techniques

INL uses rapid-screening techniques to determine feedstock composition, ash and elemental content and bench-scale conversion performance of biomass feedstocks. These cost-effective, alternative screening techniques allow for characterization and analysis of feedstock materials in a matter of minutes, instead of days or weeks. Methods include predictive NIR spectroscopy, laser-induced breakdown spectroscopy, and an automated dilute-acid pretreatment method for assessing the recalcitrance and reactivity of feedstock materials.

Particle-Size Distribution and Morphology

INL uses many different methods and types of instrumentation to determine the size distribution, shape and general particle characteristics of intermediate feedstock materials. One approach is the automated digital Camsizer, which can measure particle size, particle size distribution, particle shape, density and other parameters including geometric mean diameter width, geometric mean diameter length, sphericity and the aspect ratio of feedstock materials.

Microscopy and Imaging

Understanding changes in feedstock structure at the tissue and cellular level is increasingly important as INL continues to investigate and develop mechanical preprocessing, preconversion, and densification options that impact the chemical and physical attributes of feedstock materials. INL uses digital microscopy, confocal laser microscopy, scanning electron microscopy and Fourier-Transform infrared microscopy to investigate such changes.

Particle Characteristics

Researchers need quantitative information about how particles interact with their surroundings. Particle characteristics impact the rates of dissolution and affect recalcitrance, combustion, and other rate-related phenomena. INL employs state-of-the-art gas sorption analysis and pycnometry for determining the true (skeletal) density, surface area, pore volume, average pore size and pore size distribution of microporous (pore size up to 2 nm) and

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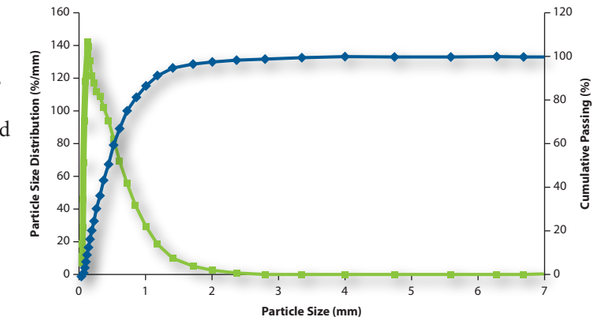
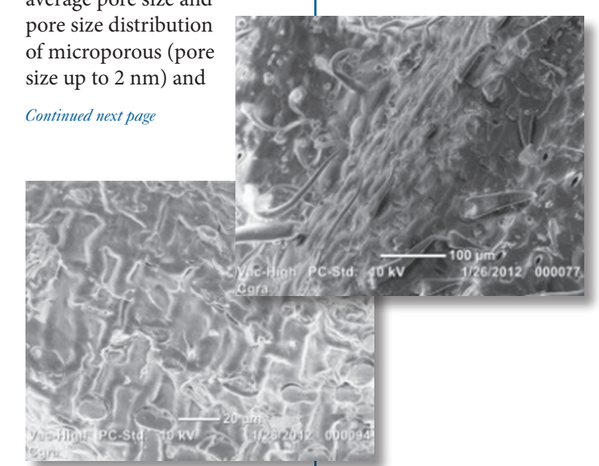


Particle size distribution sorghum, as determined by a Camsizer dynamic image analyzer



NeoScope scanning electron microscopy characterization of unprocessed (L) and densified corn stover (R)

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