Researching cleaner, more efficient bioenergy production using neutrons

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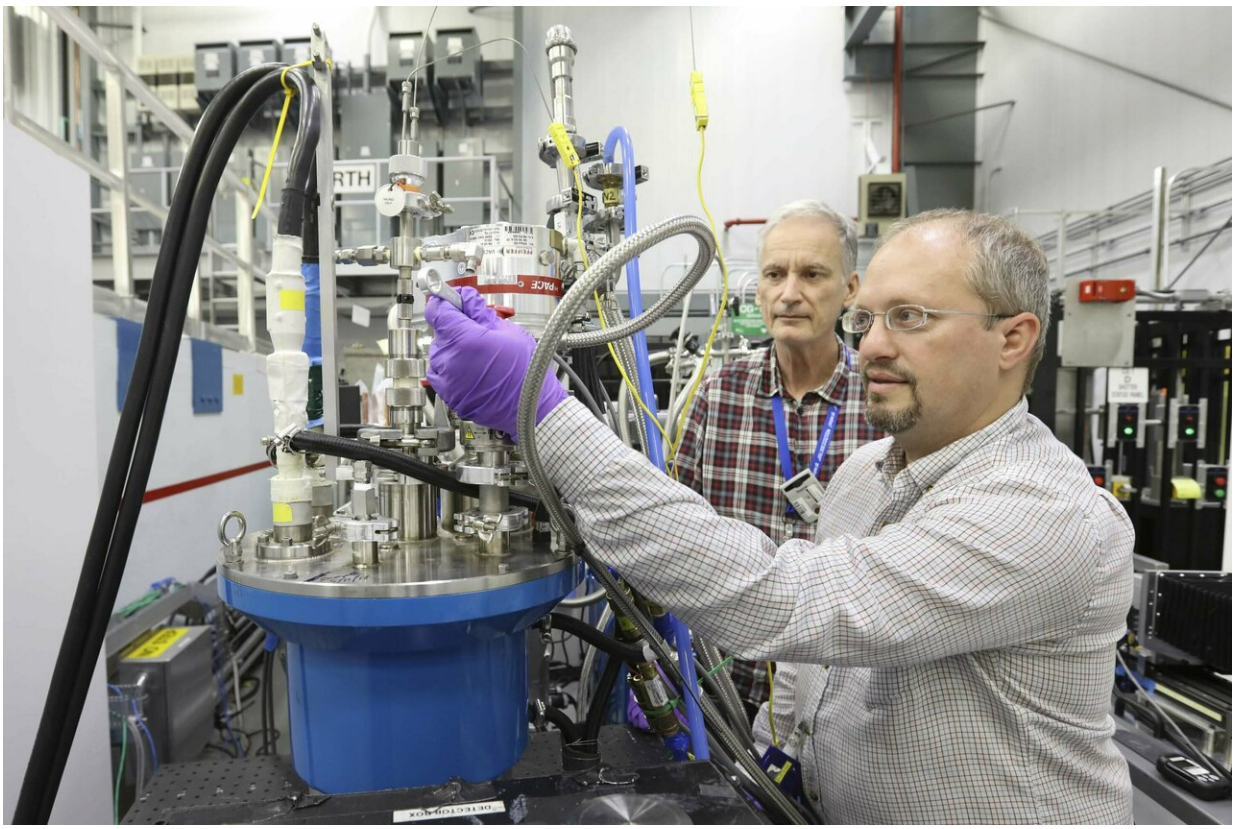

Lund University professor Frederik Ossler (left) and ORNL researcher Charles Finney are using ORNL's CG-1D instrument to study biomass fuels as they pyrolyze using neutron scattering. Their research could lead to more efficient energy production from biomass. Credit: ORNL/Genevieve Martin

Nordic countries such as Sweden rely heavily on biomass-derived fuels

to power their homes and businesses. However, in the process of burning biomass like wood or straw, gases are released that can pollute the air, damage the environment, and harm public health.

To mitigate these negative effects, Frederik Ossler, an associate professor at Lund University, Sweden, and Charles Finney from the Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL) are studying approaches to cleaner energy conversion of biomass. Using neutron scattering at ORNL, Ossler and Finney are investigating how biomasses degrade as they are exposed to extreme temperatures. Insights from their experiments could also point to possible applications for the byproducts of bioenergy production.

"A near-term objective of this is to provide insight into the way that biomasses pyrolyze—that is, how they degrade in thermal environments—to improve the models that researchers use for these processes," said Finney, a researcher in ORNL's Fuels and Engines Research Group in the Energy and Transportation Science Division.

Neutrons are well suited for these types of experiments because they are nondestructive, can penetrate materials more deeply than x-rays, and are highly sensitive to light elements such as hydrogen.

Ossler and Finney observed biomass samples of wood, straw, and cork as they were exposed under vacuum to temperatures as high as 1,000°C (1,832°F). They used the CG-1D IMAGING beamline at ORNL's High Flux Isotope Reactor (HFIR). By analyzing the hydrogenous and other gases emitted, the researchers can understand how the biomass structures change as they degrade.

As the biomass degrades, it also releases trapped water, gases, and hydrocarbons. These pyrolysis products can be captured and used to produce biofuels, which can be used for transportation or power

generation.

"Basically, the main idea is to make all the products from pyrolysis helpful," said Ossler.

Frederik Ossler from Lund University analyzed samples of wood (pictured), straw, and cork to better understand how these biomass fuels degrade as they are subjected to extreme temperatures. Credit: ORNL/Genevieve Martin

After the biomass has been pyrolyzed, it leaves behind a byproduct material known as biochar, which resembles charcoal and can be used to improve soil quality for farming and gardening. Using neutron scattering, Ossler and Finney can track how the biomass changes

internally as it pyrolyzes and becomes biochar.

"The idea is that you would extract fuels from the biomass, and the remaining char has high value as a soil amendment. It actually has positive benefits for soil through retaining nutrients and moisture," said Finney.

This isn't the first time Ossler has visited ORNL to conduct research using neutrons.

"I come from a background of lasers, x-rays, and synchrotrons, but neutrons are exceptional," Ossler said. "I would say it's a unique technique to probe inside materials and complex systems where you basically have no access in other ways."

This project expands on previous research and is part of an ongoing multiyear study applying neutron scattering techniques to explore the internal structure of biomass while it is heated. This research also benefits DOE Bioenergy Technologies Office research programs that address the complex challenge of computer modeling of pyrolysis for a wide range of biomasses.

Additional team members include Hassina Bilheux, Jean-Christophe Bilheux, Rebecca Mills, and Harley Skorpenske from ORNL's Neutron Scattering Division, Jeffrey Warren from ORNL's Environmental Sciences Division, and Louis Santodonato from Advanced Research Systems, Inc. Ossler is supported by the Swedish Energy Agency through project GRECOP.

Provided by Oak Ridge National Laboratory

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