Biofuels Development for Energy Alternatives

Biofuels studies will help reduce future needs for gasoline and other petroleum products.

Improving the efficiency of breaking down cellulose with an enzyme, known as enzymatic hydrolysis, is a key technological hurdle to reducing the cost of producing ethanol from lignocellulosic material for alternative fuels. A group of researchers at SNS and their collaborators are using neutron reflectivity (NR) to understand how they can speed up the catalytic process and help meet new national goals to produce biofuels alternatives for industry and transportation.

Team members are principal investigator Michael S. Kent, Jaclyn Murton, and Blake Simmons of the Joint BioEnergy Institute (JBEI) and Sandia National Laboratories; Jim Browning, John Ankner, and Candice Halbert of ORNL's NSSD; and Bulent Akgun from the National Institute of Standards and Technology.

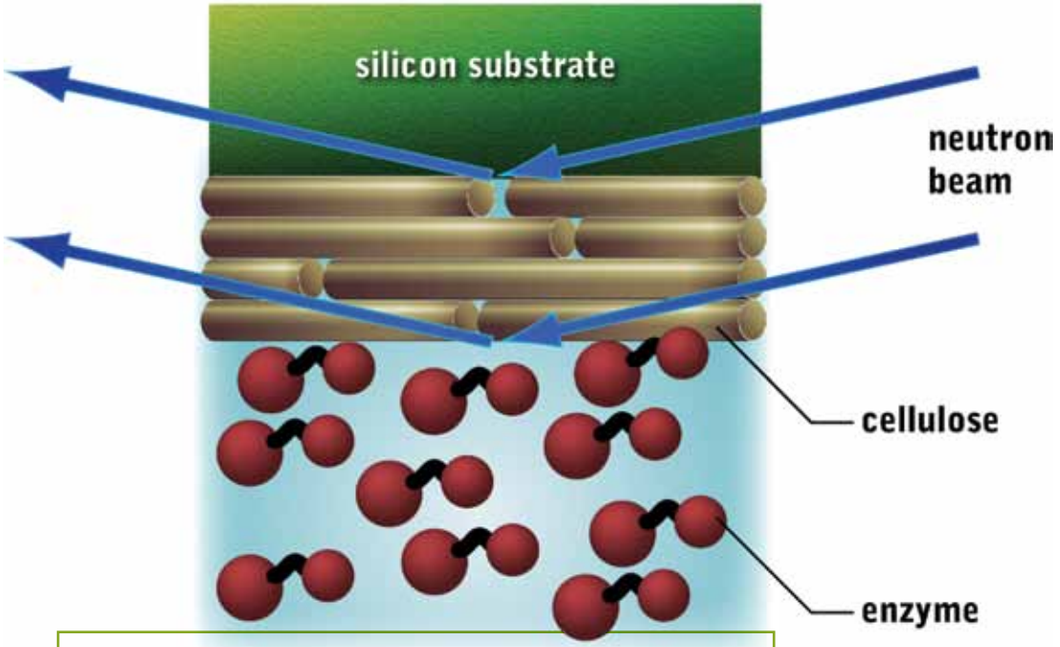
Jaclyn Murton produces the amorphous and crystalline films used in the study at Sandia (a JBEI partner). The films are sufficiently smooth to enable high-resolution study. The team then uses the SNS Liquids Reflectometer along with methods other than neutron scattering to probe the films. "We are using neutron reflection to resolve new details of the interaction between cellulase enzymes and amorphous and crystalline cellulose surfaces during digestion," Michael Kent explains. NR reveals changes in the cellulose films, such as the extent of water penetration into the films and the roughening of the solution-film interface, he said. NR could also be able to reveal some details of the conformation of the bound enzymes.

Enzymatic hydrolysis refers to the breaking down by catalysis of a chemical compound by reaction with water. The conversion of cellulosic materials into ethanol by adding specific enzymes is one example. "Typically, enzymatic hydrolysis proceeds to only a limited extent. High solution-to-solids ratios are required, and the rate of enzymatic hydrolysis typically decreases with time," Kent explains. "A range of mechanisms have been proposed to explain these phenomena, including denaturation of enzymes, nonproductive binding, product inhibition, differences in binding affinity, and activity for amorphous and crystalline cellulose." The current research is part of a broad program at JBEI to parse out the underlying mechanisms in the enzymatic digestion of cellulose, he said. The researchers hope that their study will help to distinguish among these mechanisms and to develop more efficient enzyme systems and pretreatments for the biofuels industry.

This research advances DOE's current programs in cellulosic biofuels. In October 2008, the U.S. Department of Agriculture and DOE released the National Biofuels Action Plan (NBAP), an interagency plan detailing the collaborative efforts of federal agencies to accelerate the development of a sustainable biofuels industry. The NBAP was developed to meet goals for cutting U.S. gasoline consumption by 20% over the next 10 years by investing in renewable and alternative fuel sources, increasing vehicle efficiency, and developing alternative-fuel vehicles. Mandatory funding of more than $1 billion followed, as loan guarantees for cellulosic ethanol projects as well as

other renewable energy and energy-efficiency-related programs, a DOE news report said.

Under the strategy outlined, interagency working groups have been chartered to deliver key results such as the development of science-based sustainability criteria and indicators, 10-year research and development forecasts for research to develop cost-effective methods of producing cellulosic biofuels from nonfood-based feedstocks, advancement of these next-generation biofuels to commercialization, and recommendations on infrastructure issues. DOE has dedicated more than $1 billion to research, development, and demonstration of cellulosic biofuels technology through 2009. The current research is funded by DOE through JBEI.



Neutron reflection reveals details of enzymes in D_2O solution in contact with a cellulose film deposited onto a silicon substrate.

"Commercial enzyme products are cocktails that include many enzymes of different types that are believed to act synergistically," Kent observes. "Future work will involve individual, purified enzymes to better characterize their behavior alone and in concert with other enzymes."

Candice Halbert, scientific associate for the Liquids Reflectometer.