Quarterly Update

National Bioenergy Center Sugar Platform Integration Project

Biomass

Biomass Program—Sustainable Fuels, Chemicals, Materials, and Power

January-March 2006, #10

The Biochemical Processing Integration Task focuses on integrating the processing steps involved in enzyme-based lignocellulose conversion technology. This project supports the U.S. Department of Energy's efforts to foster development, demonstration, and deployment of "biochemical platform" biorefineries that produce inexpensive commodity sugars and fuel ethanol, as well as a variety of other fuel and chemical products, from abundant renewable lignocellulosic biomass.

The National Renewable Energy Laboratory manages this project for DOE's Office of the Biomass Program. Information on the Biomass Program is available at Biomass Program

To discuss information in this update or for further information on the Biochemical Processing Integration Task, contact Dan Schell at NREL, phone (303) 384-6869, email dan_schell@nrel.gov

28th Symposium on Biotechnology for Fuels and Chemicals Fast Approaching.

The 28th Symposium will be held in Nashville, TN on April 30-May 3, 2006. Online meeting information and registration can be found at the following web site: http://www.simhq.org/heml/meetings.html. This year's sessions are:

Session 1A Enzyme Catalysis and Engineering
Session 1B Plant Biotechnology and Genomics
Session 2 Biomass Fractionation and Hydrolysis
Session 3A New and Developing Industrial Bioproducts
Session 3B Feedstock Supply and Logistics
Session 4 Microbial Catalysis and Metabolic Engineering
Session 5 BioProcessing and Separations R&D
Session 6 Bio/Thermo-chemical Integrated Biorefinery
Topic A Life Cycle Analysis/Sustainability
Topic B International Biomass/Biofuels Update

Below is a list of posters we will be presenting. Please stop by and see us.

"Impact of Recycle Water on Fermentation of a Dilute Acid Pretreated Corn Stover Hydrolysate," Ali Mohagheghi and Daniel Schell.

"Testing Performance of an Integrated Corn Stover to Ethanol Process," Edward Jennings and Daniel Schell.

"Investigating Factors Affecting Enzymatic Hydrolysis of Dilute Acid Pretreated Corn Stover Slurries," David Hodge and Daniel Schell.

"Total Solids Measurement of Acid Pretreated Biomass by Karl Fischer Titration," Chris Scalata.

"Fraction Insoluble Solids (FIS): Procedure and Effect on High Solids Saccharification Yield Calculations," David Templeton, Raymond Ruiz, Melvin Tucker, Rick Elander, and Bonnie Hames.

NREL Hosts President Bush.

For the second time in history, a United States President visited NREL. President George W. Bush visited NREL on Monday February 20th. At NREL, he led a panel discussion with several of the DOE's industry partners. Prior to the panel discussion, President Bush toured the Biochemical Pilot Plant. During his tour, the President received a basic overview of the cellulosic biomass to ethanol process and viewed samples of corn stover, poplar sawdust, and switch grass.

R&D Progress Biomass

NIR-Based Feedstock Compositional Analysis Method Used on Multiple Instruments. We recently completed an effort to transfer a near-infrared (NIR) analysis method for compositional analysis of corn stover from the instrument (spectrometer) on which it was developed to instruments in other laboratories. This was demonstrated by transfer of the method to an instrument at Idaho National Laboratory (INL). The composition of ten stover samples predicted by the model installed on INL's instrument were nearly identical to the values obtained from the original instrument at NREL. As a result of this effort, high-throughput screening of corn stover feedstock can now be performed on three different instruments in laboratories at NREL and INL. This work facilitates future transfer to industry of on-line analysis methods for corn stover composition currently being developed in our laboratories. These techniques may ultimately be used for on-line process control and optimization.

New Centrifuge Installed in the Biochemical Pilot Plant. We recently installed a new semi-automatic centrifuge (Model Q-120 Quadramatic, Western States Machine Co., Hamilton, OH) in the Biochemical pilot plant. This centrifuge will primarily be used for solid/liquid separation of pretreated biomass slurries produced in the pilot-scale vertical pretreatment reactor, but can also be used on other process streams. The addition of a hose pump enables automated feeding of slurries into the centrifuge. The solids are washed and/or dewatered and automatically discharged from the unit.

Automated Biomass Analysis. We recently meet with representatives from Chemspeed Technologies AG, a manufacturer of automated robotic sample handling and R&D workstations. This technology could be used to automate lignocellulosic biomass sample preparation and analysis, thus potentially leading to significant improvements in sample throughput and analysis quality. We are working to understand how their equipment could be adapted for this application.

Related Activities Biomass

Enzymatic Hydrolysis Subtask Assesses Effect of Inhibitors on Enzymatic Hydrolysis of Pretreated Corn Stover. Cellulase activity is known to be inhibited by sugars, particularly glucose and cellobiose. Recent work explored the effect of various other compounds found in pretreated lignocellulosic biomass on the activity of a commercial cellulase preparation. A factorial experiment was conducted to study the influence of phenolics (representing lignin monomers), furans (furfural and 5-hydroxymethylfurfural), acetic acid, and sugars (all five biomass-derived sugars in the proportion found in pretreated corn stover) on cellulose conversion. All compounds were tested at concentrations similar to those obtained in corn stover pretreated by dilute sulfuric at a 30% total solids loading. Every component except phenolics had a negative effect on seven-day cellulose conversion yields. Sugar, whose presence reduced yields by 11%, had the most significant effect, followed by acetic acid (4%) and furans (2%), but the affect of each compound was additive. Understanding the relative importance of compounds affecting enzymatic cellulose hydrolysis may suggest strategies for improving enzyme performance.

Recently Published Article of Interest. A journal paper, entitled "Atomic and Electronic Structures of Molecular Crystalline Cellulose Iβ: A First-Principles Investigation," has been published in American Chemistry Society journal by NREL's National Bioenergy Center researchers (X. Qian, S. –Y. Ding, M. Nimlos, D. Johnson, and M. Himmel; *Macromomolecules,* 2005, **38**, 10580-10589). In this study, the atomic and electronic structures of native crystalline cellulose Iβ were investigated using the *ab initio* pseudopotential method. The hydrogen bonding interaction in crystalline cellulose is the binding force forming these highly recalcitrant molecular crystals. A model based on the competition between the hydrogen bonding energy and electronic strain energy was established to explain the size of native crystalline cellulose. The binding energies between the chains in one-cellulose sheet and between the neighboring sheets were determined. It was found that the hydrogen-bonding interaction dominates the inter-chain interaction, whereas both hydrogen bonding and *van der Waals* interaction are of significance for inter-sheet interaction. The inter-sheet binding energy was found to be about eight times smaller than that of inter-chain binding energy. This study provides insights into macromolecular structure of plant cell wall polysaccharides, and new understanding of the root cause of lignocelluloses recalcitrance in biomass conversion processes.

Sugar Processing Integration Task Information. Web-based information on the process integration project, including presentations made at the most recent stage gate interim review meeting, can be found at the following link (Process Integration Project Information). A discussion of how Stage Gate management is used in the Biomass Program is also available at this site (Stage Gate Management).

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