Quarterly Update

National Bioenergy Center Sugar Platform Integration Project

Biomass

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

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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.

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 listed below:

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

R&D Progress

Integrated Processing of Dilute Sulfuric Acid Pretreated Corn Stover. A dilute acid pretreated corn stover slurry hydrolysate was subjected to enzymatic cellulose hydrolysis and subsequent fermentation of the hemicellulose- and cellulose-derived sugars by a recombinant xylose-utilizing *Z. mobilis* in an effort to better understand integrated process performance. This study used a pretreated stover hydrolysate produced in a pilot-scale pretreatment reactor at about 35% total solids. Following a washing and solid-liquid separation step on the hydrolysate that removed approximately 70% of the liquor, the liquor was conditioned by overliming and recombined with the dewatered solids producing a 20% total solids slurry. This procedure realistically accounts for the fact that not all of the liquor can be removed from hydrolysate slurries and conditioned without exhaustive washing. The recombined slurry was then subjected to enzymatic cellulose hydrolysis and fermentation using a hybrid hydrolysis and fermentation (HHF) process configuration. In this process, the cellulosic slurry is first saccharified at conditions favorable for enzymatic cellulose conversion, then the conditions are changed to those favorable for fermentation and the slurry is inoculated with a co-fermenting microorganism. We initially performed a shake flask screening study to identify the cellulose saccharification time that optimized ethanol yield (see results in Figure 1). After determining that 4 days of cellulose saccharification was nearly optimal, performance was assessed in 1 L (working volume) bench-scale fermentors in order to more accurately assess performance. During these experiments, 95% cellulose conversion was achieved, but nearly 10 % of the hydrolyzed cellulose remained as higher order oligomers (degree of polymerization > 2) not available for conversion by the microorganism, and another 10% remained as monomeric glucose and cellobiose that was not utilized by the microorganism. Moreover, under the conditions tested, the fermentative microbe achieved poor xylose conversion yields (25% - 30%). As a result, overall ethanol yields were only approximately 50% - 55% of theoretical based on potential total glucose and xylose available in soluble and insoluble form at the start of saccharification. Unconditioned liquor remaining in the separated solids may have increased the toxicity of the hydrolysate and contributed to poor ethanol yields. Advanced enzyme preparations that improve both rates and yields and more robust ethanologens are expected to enable significantly better performance.

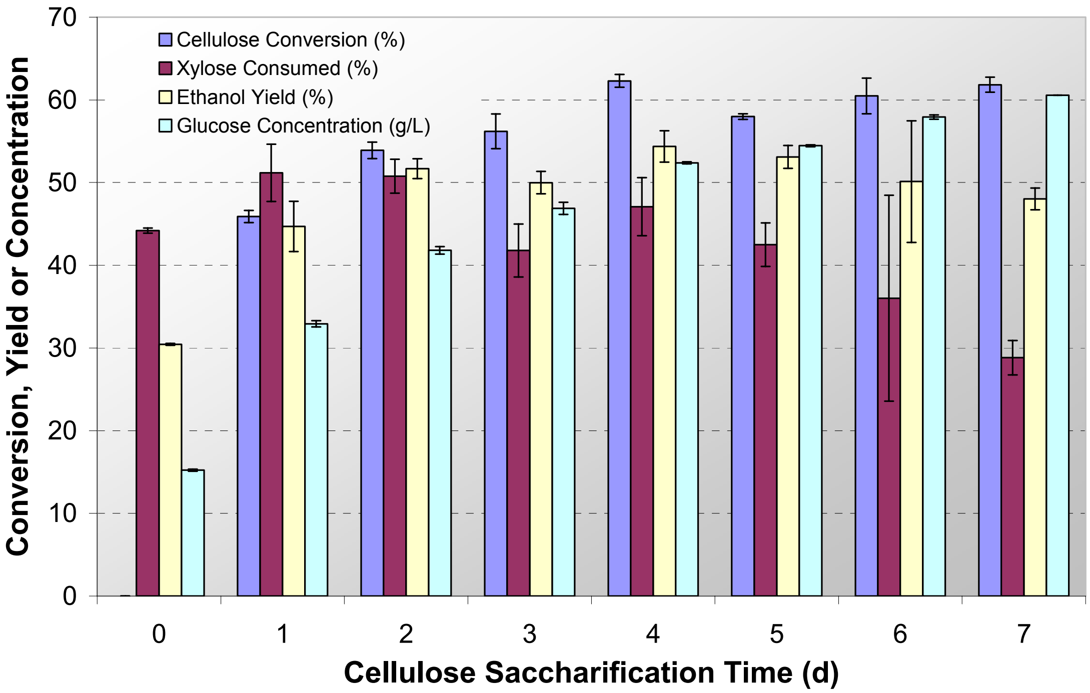

Figure 1. Summary of key performance parameters (cellulose conversion and glucose concentration upon enzymatic cellulose saccharification and subsequent xylose consumption and overall ethanol yield after fermentation by *Z. mobilis*) as a function of cellulose saccharification time for HHF. Error bars represent the observed range in duplicated experiments.

Updated Laboratory Analytical Procedures and Calculation Workbooks Are Available.

NREL recently updated many of its Laboratory Analytical Procedures (LAPs) including procedures for: samples preparation; determination of ash, carbohydrates, starch, lignin, protein and extractives content of biomass feedstocks; measurement of total solids; and determination of components concentrations in hydrolysate liquors. The updated procedures are available at the following website: http://www.eere.energy.gov/biomass/analytical_procedures.html. The web site also provides Excel© workbooks that perform the calculations specified in the LAP. The final versions of both the LAP documents and associated workbooks incorporate comments and suggestions received from many users of the draft versions of these documents, which have been posted on the website since May 2004. We would like to thank those that provided comments and suggestions.

On-line Measurement of Corn Stover Composition. Recently, a direct light sensor connected to a spectrophotometer was installed over an open weigh belt conveyor in the NREL pilot plant to scan stover as it passes underneath the sensor. The spectrum collected by the sensor is then translated into compositional information using a model relating near-infrared spectra to composition. Preliminary work has demonstrated that it is possible to predict stover composition in this highly non-uniform (variable path length) but industrially relevant environment. Effective noise reduction and path-length variation compensation techniques have been implemented that enable this system to produce quality spectra. Future work will integrate the system into the pilot plant's data acquisition and control system and focus on further improving the quality of the spectra produced and calibration model used to determine composition, which are both necessary to improve measurement accuracy to a level that makes this technique highly useful to industry.

Related Activities

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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