Quarterly Update

National Bioenergy Center Biochemical Platform Integration Project

Biomass

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

April-June 2010, #27

The Biochemical Process Integration Task focuses on integrating the processing steps 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 economically produce ethanol or other fuels, as well as commodity sugars and a variety of other chemical products, from 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 the contents of this update, or for further information on the Biochemical Process Integration Task, contact Dan Schell at NREL, phone (303) 384-6869, email dan.schell@nrel.gov

R&D Progress Biomass

Progress on Understanding Performance of Three Alternative Process Configurations for Producing Ethanol from Biomass

We recently completed a preliminary evaluation of three potential process configurations for converting dilute-acid-pretreated corn stover to ethanol. This first configuration is the one described in NREL's 2002 design report* (solid-liquid separation followed by conditioning of the hemicellulose sugar-rich liquid fraction, which is then recombined with the solids), the second is a whole slurry process (no separation of the solid and liquid fractions), and the third is a separate C5/C6 process (after solid-liquid separation, the solid and liquid fractions are converted in separate fermentation trains). For each configuration, we investigated the effect of directly neutralizing (raising pH to 5.0 prior to enzymatic hydrolysis) or conditioning with ammonium hydroxide (raising the pH to 8.5 and then lowering the pH to 5.0 with sulfuric acid) on cellulose conversion and xylose-to-ethanol yields. Tests were run at solids loadings of 15.0%, 17.5%, 20.0%, 22.5%, and 25.0% (w/w) total solids (TS), and a high-enzyme loading (40 mg protein/g cellulose) was used to achieve good conversion of cellulose to glucose. Fermentation of sugars to ethanol was performed with the glucose-xylose fermenting bacterium *Zymomonas mobilis* 8b. We found no significant differences in cellulose conversion yields or ethanol yields between directly neutralized or conditioned pretreated stover. We speculate that conditioning was not required because this new material was pretreated at a lower reaction severity than used in previous studies. Cellulose conversion yields were also relatively constant as a function of solids concentration, varying from 80% to 85% of theoretical. Regardless of the solids loading, all of the glucose was fermented to ethanol. However, xylose-to-ethanol yields for the whole slurry process decreased from near 90% of theoretical at 15% TS to less than 10% at 25% TS. We will complete additional experiments on the separate C5/C6 process in the near future and thereafter will submit all this work for publication.

*Aden, A.; Ruth, M.; Ibsen, K.; Jechura, J.; Neeves, K.; Sheehan, J.; Wallace, B.; Montague, L.; Slayton, A.; Lukas, J. (2002). "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover." Report No. NREL/TP-510-32438. National Renewable Energy Laboratory, Golden, CO. http://www.nrel.gov/docs/fy02osti/32438.pdf.

Investigating Karl Fischer Titration as a Method to Measure the Water Content of Pretreated Biomass Slurries

We previously investigated the impact of uncertainty in the Fraction Insoluble Solids (FIS) measurement of biomass slurries on yield calculations for pretreatment processes (see Quarterly Update, Vol. 25). We found that uncertainty in determining the total solids (TS) content of acidic pretreated biomass slurry is the main contributor to uncertainty in FIS. In an effort to improve the TS measurement and thereby decrease errors in the FIS measurement, we investigated indirect Karl Fischer Titration (KFT) as a method to measure TS of pretreated biomass samples. Pretreated slurries at 20%, 30%, and 35% (w/w) TS and a liquor sample at 17% (w/w) total dissolved solids were shipped to two instrument vendors for

testing. Figure 1 shows the relative standard deviation (RSD, defined as the standard deviation divided by the mean) in measured TS levels for each of these samples as measured by the two vendors. We estimate that an RSD of 0.3% is needed to markedly reduce uncertainty in the FIS measurement and clearly this goal was not achieved. We are exploring freeze drying as an alternative method to measure TS of pretreated slurries. Initial results look promising, and we will report on the outcome of this study in a future newsletter.

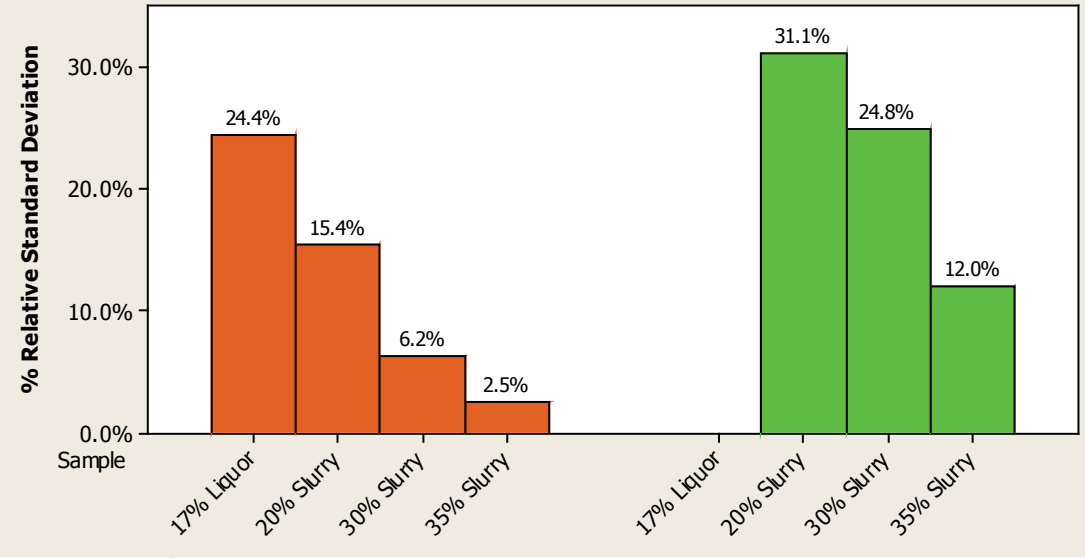

Figure 1. The relative standard deviation of the total solids measurement of several pretreated biomass samples by an indirect Karl Fischer measurement performed by two instrument vendors (red or green bars).

Biochemical Process Integration Task Information

Web-based information on the biochemical process integration project, including presentations made at past review meetings, is available at the following links: http://obpreview07.govtools.us/biochem/ and http://www.obpreview2009.govtools.us/biochem).

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