The Biochemical Process 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 economically produce 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 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

32nd Symposium on Biotechnology for Fuels and Chemicals

This Symposium will be held at the Hilton Clearwater Beach Hotel in Clearwater Beach, FL, April 19-22, 2010. Meeting information can be found at the following web site: http://www.simhq.org/meetings/sbfc2010/index.asp. A list of the technical session topics is as follows:

**Monday, April 19**
- Session 1 – Biomass Microbial Strain Development
- Session 2 – The Science of Biomass Recalcitrance
- Poster Session 1

**Tuesday, April 20**
- Session 3 – Biomass Enzyme Characterization and Catalysis
- Session 4 – Hydrocarbon and Algae-Based Biofuels
- Session 5 – Development in New/Improved Biomass Sources
- Session 6 – Biorefinery Deployment and Industry Infrastructure
- Poster Session 2

**Wednesday, April 21**
- Session 7 – Biomass Sustainability and Land Use
- Session 8 – Biomass Pretreatment and Fractionation
- Evening Special Topics: International Bioenergy Centers Update

**Thursday, April 22**
- Session 9 – Biomass Production and Logistics
- Session 10 – Application of Biomass Enzyme Technology
- Session 11 – Microbial Biomass Conversion
- Session 12 – Bioprocessing and Separations Technology

**Evaluating the Economic Impact of Solids Loading During Enzymatic Cellulose Hydrolysis**

We determined the impact of solids loading on enzymatic cellulose hydrolysis of a dilute-acid-pretreated corn stover slurry using an experimental response surface design methodology. From the experimental work, we obtained an empirical correlation that expressed monomeric glucose yield from enzymatic cellulose hydrolysis as a function of solids loading, enzyme loading, and temperature. This correlation was used in a technoeconomic model to study the impact of solids loading on the minimum ethanol selling price (MESP). We first studied the process economics assuming that cellulose conversion yields remained constant as a function of solids loading, as illustrated in Figure 1. The empirical model was used to provide a more realistic assessment of process cost by accounting for changes in cellulose conversion yields at different solids and enzyme loadings as well as for different enzyme cost (see Figure 2). As long as enzymes are end-product inhibited, there is an...
optimum value for the total solids loading that minimizes the ethanol production cost. The optimum total solids loading shifts to higher values as the enzyme cost decreases. However, the exact value of the total solids loading that minimizes ethanol production cost is dependent on the enzyme’s performance characteristics and cost. A manuscript on this work will be submitted for publication in January 2010.

MIT Practice School
This fall, NREL hosted the MIT Practice School. The students performed several projects supporting our work in process integration. Two of those projects are discussed below.

Analyzing a Separate C6/C5 Process Configuration
This project focused on modeling a separate enzymatic hydrolysis and fermentation (C6) and hemicellulosic sugar fermentation (C5) process configuration. The work modified our current Aspen process model (Base Case, see 2002 Process Design Report at http://www1.eere.energy.gov/biomass/for_researchers.html) to incorporate the following changes:
1. Separate fermentation trains for the glucose and xylose streams
2. Two different beer columns for the glucose and xylose fermentation trains
3. Recycling the bottom stream from the second beer column (xylose stream) to dilute the cellulosic solids
4. Incorporation of experimental data on the performance of solid-liquid separation and washing steps.
The model was also modified to contain empirical expressions for enzymatic hydrolysis and fermentation reaction yields based on experimental data. The study found that the MESP for the C6/C5 configuration is lower than the Base Case by up to $0.09/gal, primarily because the C6/C5 process configuration achieves the same cellulose conversion yield using less enzyme. These results, of course, depend heavily on characteristics of the enzyme and microorganism used in this study.
Understanding Process Measurement Uncertainty
This project’s main objective was to define error bounds on MESP caused by uncertainties in feedstock composition, yield estimates, and cost assumptions. The initial effort studied the impact of uncertainties in process variables and sample composition on the uncertainty in the calculated yield. It was found that the relative uncertainty in hemicellulose-to-soluble sugar yield is about 6%-10%. The main contributor to uncertainty is uncertainty associated with the fraction insoluble solids (FIS) measurement, with only minor contributions from the feed composition and process variables (e.g., feedstock flow rate and pretreated slurry flow rate). The relative uncertainty for cellulose-to-glucose yield from enzymatic hydrolysis was 24%, and again the FIS measurement dominated the uncertainty estimate. The second effort used a Monte Carlo analysis to calculate error bounds on MESP. Realistic probability distributions were assigned to various inputs required to calculate MESP including feedstock composition, yields of major reactions, and cost assumptions. The total error bound on MESP was found to be ±$0.24/gal.

2009 Task Member Publications


Biochemical Process Integration Task Information

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