Advances in Ionic Liquid Pretreatment Technologies: Impact on the Economics of Cellulosic Biofuel Production

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Project Goals: One of the main goals of JBEI's Deconstruction Division is to develop efficient, scalable, and economically viable pretreatment technologies. Towards this goal, the technoeconomic analysis (TEA) group has been developing technoeconomic models for lignocellulosic biorefineries to understand the technical potential and cost impacts of novel ionic liquid (IL) pretreatment process configurations currently under development at JBEI.

Abstract.

Our previous work (Konda et al., 2014) has shown that the traditional IL pretreatment configuration – referred to as the water-wash (WW) route – presents environmental challenges (due to excessive water usage during the water-wash step) and economic challenges (due to wastewater treatment costs). In an effort to move away from this WW configuration, the Pretreatment group (Shi et al., 2014) developed a novel process in which the water-wash step was eliminated. This simplification was possible with the use of an IL-tolerant enzyme mixture (JTherm), which eliminated the need for IL removal prior to hydrolysis, and is referred to as JTherm process in this study. In a previous study (Konda et al., 2014), we showed that the JTherm process, while successful in reducing water demand, required further improvements to achieve significant cost savings relative to the WW route. This was largely due to the lack of economically viable technologies to extract sugars from the resulting hydrolysate. To address this challenge, JBEI's Pretreatment group has recently developed a novel one-pot (OP) process, using biocompatible ILs, that does not require any separation steps (i.e., water-wash or sugar extraction) between pretreatment, hydrolysis, and fermentation. Furthermore, this process is capable of handling 'high gravity' conditions (i.e., >20% solids loading) and thus referred to as the OP-HG process. In this work, we have evaluated the economic viability of this OP-HG

process if it were to be scaled up to industrial throughputs (e.g., to process 2000 MT/day of dry biomass). The economic analysis utilizes parameters consistent with the NREL study (Humbird et al., 2011) and the minimum ethanol selling price was (MESP) computed based on a detailed cash flow analysis using a 10% internal rate of return (IRR). Two scenarios ('current' and 'projected') were constructed to quantitatively evaluate the economic potential in terms of MESP. Based on the modeled scenarios, the OP-HG process was found to be a promising configuration, capable of lowering the MESP below $3/gal. We found that the main cost bottleneck for the OP-HG system is currently the fact that xylose sugars are not being fermented, reducing overall ethanol yield – co-utilization of both the glucose and xylose sugars is necessary to realize full potential of this system. In future work, the TEA group will conduct more rigorous process engineering and feasibility assessment for downstream processes in the OP-HG system.

References:

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