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## Bioresource Technology

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### An introduction to the special section on application of leading pretreatments to switchgrass by the Biomass Refining Consortium for Applied Fundamentals and Innovation (CAFI)

Pretreatment is among the most costly steps in the overall biological conversion of cellulosic biomass to fuels and chemicals. Pretreatment also has a profound effect on all other operations from choice and preparation of feedstock all the way to final product recovery and use of process residues. Yet, because cellulosic biomass is naturally resistant to breakdown to release the sugars contained in its cellulose and hemicellulose components, pretreatment is vital to preparing cellulosic biomass for biological conversion to sugars with high yields, and the economics become even worse if it is left out of the process. Thus, this conundrum led to the statement that “the only operation more expensive than pretreatment is no pretreatment.”

Over the years, numerous biological, chemical, and physical pretreatment approaches have been tried to prepare a wide range of plants for enzymatic hydrolysis followed by fermentation of the sugars released. However, the variety of biomass substrates, enzymes, enzyme loadings and formulations, and reaction conditions applied coupled with significant differences in definitions and approaches to reporting data made it very difficult to compare results among pretreatments. Nonetheless, it became evident that thermochemical approaches in particular, did an effective job of making biomass susceptible to enzyme attack with high yields of sugars. Furthermore, some pretreatments that appeared to be successful in achieving high yields from the coupled operations of pretreatment and enzymatic hydrolysis employed dilute acid while other pretreatments that applied dilute alkali appeared to be equally successful. Such a wide pH range resulted in removal of different portions of biomass, confounding simple assignment of a fundamental mechanism that could account for pretreatment performance. For example, low pH pretreatment with dilute sulfuric acid removed most of the hemicellulose from biomass, while pretreatment at high pH with lime removed much more lignin and left a large portion of hemicellulose in the pretreated solids. Thus, a better understanding of how pretreatment impacted enzymatic hydrolysis was also needed to tie together the different pretreatment technologies and support definition of pretreatments that could perform better while reducing costs.

Against this background, a group of leaders in development of pretreatment technology came together in late 1999 and early 2000 with the goal of applying competing pretreatment technologies to a common source of feedstocks and sharing the same enzymes. Furthermore, the team sought to apply identical methods to analyze compositions of all biomass streams. In addition, proto-

cols were developed to guide preparation of material balances for all the different pretreatments on a common basis, and yields and other terms were clearly defined to avoid confusion in the manner in which data was prepared. It was also desired to dig deeper into pretreatment attributes to try to reveal why pretreatments spanning such a wide range of operating conditions could all be so effective. The team adopted the name Biomass Refining Consortium for Applied Fundamentals and Innovation that was soon shortened to the acronym CAFI. The CAFI team was fortunate to be funded initially by the new, and unfortunately, short-lived, USDA Initiative for Future Agriculture and Food Systems (IFAFS) Program in 2000 for a project to develop comparative data on corn stover. The successful completion of that project was followed by funding by the Office of the Biomass Program of the US Department of Energy for a second CAFI project devoted to pretreatment of poplar wood that began in 2004 and then a project on pretreatment of switchgrass that started in 2007.

This section of *Bioresource Technology* contains eight CAFI papers that summarize much of the key data on the application of pretreatment technologies to three switchgrass feedstocks. The CAFI team worked diligently and cooperatively to make the project a success. We sincerely hope readers find the results from this final CAFI project valuable and that they will aid in the understanding, advancement, and commercialization of technologies for conversion of cellulosic biomass to liquid fuels that the world needs if we are to have sustainable processes for making liquid transportation fuels and overcome our growing habit of using depletable petroleum, much of which is controlled by unstable regions of the world and whose use contributes to global climate change.

Funding by the Office of the Biomass Program of the United States Department of Energy through contract number DE-FG36-07GO17102 to the University of California at Riverside was vital to performing this research. The true collaborative spirit of the CAFI Team made this project possible and pleasurable, and we thank the many undergraduate and graduate students, post-doctoral candidates, technicians, administrative assistants, and others on the CAFI Team for their vital role in developing this information.

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