"Bioenergy Conversion and Science – Challenges in Making Cellulosic Fuels"

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Extended Abstract

The challenge of converting sustainable cellulosic biomass into fuels has the opportunity for science and technology making an appreciable national impact in the next 20 years. Bioenergy interest is driven partly by the economics and national security. The effective conversion of lignocellulose into fermentable sugars is the dominant obstacle to cost-effective production of biofuels in sustained quantities capable of impacting U.S. consumption of fossil transportation fuels. Three key questions are: can we do this effectively and efficiently; can we make a significant impact; and can we do this sustainably? The application of new tools from modern system biology has the potential to overcome many current technological and economic challenges. We will discuss the biological approaches being taken to address these questions including the BioEnergy Science Center (BESC) at the Oak Ridge National Laboratory.

The author will touch on the converging drivers of climate and security which have led interest in biofuels to greatly increase since 2005. Bioenergy is a complex multiple choice problem where choices can be made in land, feedstock, process and product (or fuel). There are also several "generations" of technology competing for research and deployment support. This ranges from the "established" corn starch ethanol plants to the first generation cellulosic biorefineries, which are just breaking ground, to second generation technologies entering piloting on to third and fourth generation technologies in the laboratory. We are seeing a compressed technology development cycle for a commodity industry due to the important drivers.

Challenges for research and development extend into the supply chain and how biology can help find solutions (see Ragauskas *et al.*, 2006; and DOE Report "Breaking the Biological Barriers to Cellulosic Ethanol"). Part of the increased funding in this area has come from the U.S. Department of Energy's Office of Science through its Genomics: GTL program (http://genomicsgtl.energy.gov/) establishing of three fundamental Bioenergy Research Centers in late 2007. One of these, BESC (http://www.bioenergycenter.org/), is a multi-partner project pursuing an integrated strategy to understand and overcome biomass recalcitrance and provide accessible sugars. We believe that access to the sugars in lignocellulosic biomass is the current critical barrier for widespread adoption of biofuels and that solving this will cut processing costs significantly and be used in most conversion processes (see Lynd *et al.*, 2008). This includes all fermentation based processes whether to ethanol, butanol or other potential fuels.

BESC is following a two-pronged approach to increase the accessibility of biomass sugars: modify the plant cell wall structure to increase accessibility and improve combined

microbial approaches that release sugars and ferment into fuels. This can be visualized in Figure 1 where a current conceptual baseline for a generation one cellulosic biorefinery is shown along with a potential future concept. The BESC is using a strategy of developing various integrated higher-throughput pipelines for generating and screening large numbers of samples of modified biomass or biocatalysts followed by more detailed analysis of the most interesting ones.

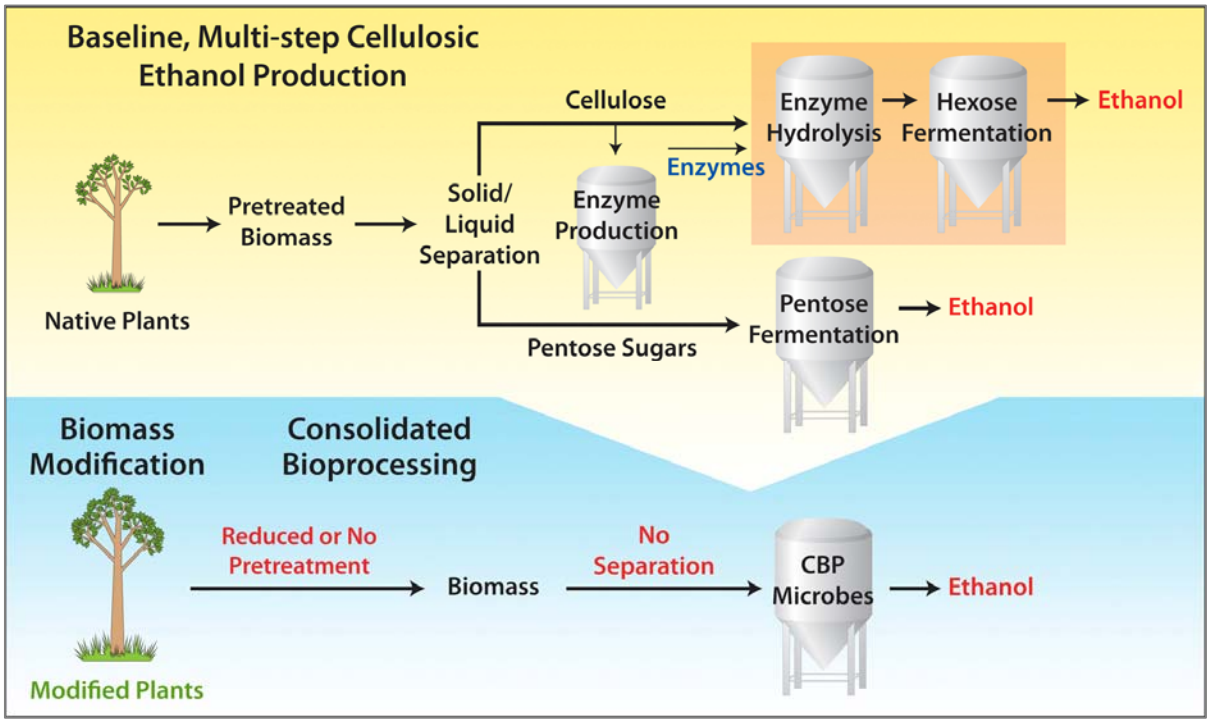

Figure 1: Conceptual baseline for a generation one cellulosic biorefinery.

References

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DOE Report "Breaking the Biological Barriers to Cellulosic Ethanol," can be found at http://genomicsgtl.energy.gov/biofuels/.

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