Comparative Glycomics Provide Insights into Cell Wall Components that Affect Biomass Recalcitrance

Michael G. Hahn[1,2]* (hahn@ccrc.uga.edu), Sivakumar Pattathil,[1,2] Shishir P.S. Chundawat,[3] Jaclyn D. DeMartini,[1,4] Jeffrey Miller,[1,2] Virginia Brown,[1,2] Sindhu Kandemkavil,[1,2] Bruce E. Dale,[3] **Charles Wyman**,[1,4] and **Paul Gilna (BESC PI)**[1]

[1]BioEnergy Science Center, Oak Ridge National Laboratory, Oak Ridge Tennessee; [2]The University of Georgia, Athens, Georgia; [3]Great Lakes Bioenergy Research Center, East Lansing, Michigan; [4]University of California, Riverside, California

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Project Goals: The BioEnergy Science Center (BESC) is focused on the fundamental understanding and elimination of biomass recalcitrance. BESC's approach to improve accessibility to the sugars within biomass involves 1) designing plant cell walls for rapid deconstruction and 2) developing multitalented microbes for converting plant biomass into biofuels in a single step (consolidated bioprocessing). Addressing the roadblock of biomass recalcitrance will require a greater understanding of plant cell walls from synthesis to deconstruction. This understanding would generate models, theories and finally processes that will be used to understand and overcome biomass recalcitrance. This grand challenge calls for an integrated research approach, which is illustrated by the project described below. BESC research is multidisciplinary by design and multi-institutional in composition.

Plant biomass, which is considered a primary feedstock for sustainable biofuel production, is largely composed of plant cell walls, whose principal components are polysaccharides (e.g., cellulose, hemicellulose, pectin) and lignin. Plant cell walls are thus complex heteropolymeric composites that have evolved to be resistant to deconstruction. In addition, cell walls are different in their structure and composition in different plants. Achieving efficient, economic viable and ecologically sustainable biofuel production will require an in-depth understanding of cell wall structure/dynamics in the various plant species being considered as biomass feedstocks. We have developed a moderate throughput approach, called Glycome Profiling that can be used for comparative glycomic analyses of various biomasses to determine the glycan composition/make up of cell walls and also to identify cell wall components that affect biomass recalcitrance. Glycome Profiling takes advantage of the availability of a large and diverse collection of cell wall glycan-directed monoclonal antibodies that can monitor most major plant polysaccharides. We report here on the use of Glycome Profiling to monitor changes in cell wall composition and extractability that result from hydrothermal and ammonia fiber expansion (AFEX) pre-treatments of biomass from diverse plants. These studies suggest that xylans play a critical role in governing recalcitrance in grasses, while lignin plays a major role in poplar biomass recalcitrance. Furthermore, we have demonstrated that the two pre-treatments have very different effects on the biomasses examined. Hydrothermal pre-treatments rapidly cleave carbohydrate-lignin associations and destroy arabinogalactan structures in the wall. AFEX, on the other hand, results in changes to overall wall structure that result in the more facile release of sub-populations of hemicelluloses (xyloglucans and xylans) and pectic arabinogalactans from the pre-treated walls, with less destruction of wall glycan epitopes. The effects of both pre-treatments vary depending on plant source of the biomass. Experiments are underway to correlate the observed cell wall changes to improve sugar release from the treated biomass.

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