IMPACT OF ALKALINE HYDROGEN PEROXIDE PRETREATMENT ON CELL WALL PROPERTIES THAT CONTRIBUTE TO IMPROVED ENZYMATIC DIGESTIBILITY OF STRUCTURAL CARBOHYDRATES TO BE UTILIZED FOR BIOFUEL PRODUCTION

Lignocellulosic plant material is an attractive option as a source of sugars that can be converted to fuels such as ethanol due to it being an abundant and renewable resource. One of the more compelling process schemes to do this is the biochemical conversion platform, where enzymes are used to hydrolyze sugar polymer bonds and release monomeric sugars that can be used by fermenting organisms to produce the desired fuel. However, due to the recalcitrant nature of lignocelluloses, a pretreatment step is usually required before hydrolysis to improve cell wall polysaccharide accessibility to enzymes in order to facilitate enzyme binding. Within this pretreatment step it is necessary to increase polysaccharide accessibility by removing or redistributing lignin and hemicelluloses and increasing cell wall porosity. This work investigates pretreatment, primarily alkaline and alkaline hydrogen peroxide (AHP) pretreatment, in two ways: 1) as a unit operation integrated with enzymatic hydrolysis and fermentation for a complete conversion process and 2) as a tool for investigating cell wall properties that are
important for improved deconstruction, or more specifically, enzymatic digestibility. Two studies in each category are presented in this work.

In the first, corn stover and switchgrass were AHP pretreated over a range of pretreatment conditions to understand the space of changes that take place during the process; specifically, the impact of H$_2$O$_2$ loading, feedstock, pretreatment time, solids loading and scale were determined on compositional changes of solid biomass, inhibitor release and pretreatment effectiveness measured by enzymatic digestibility.

In the next study, soluble sugars from a sweet sorghum were simultaneously extracted while the remaining lignocellulose in bagasse was alkali pretreated in a novel combined diffusion extraction/pretreatment technique. The carbohydrates in the bagasse were then hydrolyzed with enzymes and the hydrolyzate was combined with the extraction juice and fermented. Near 100% soluble sugar extraction was achieved and a glucose yield of 70% was obtained on the pretreated bagasse. An ethanol concentration of 21 g/L was obtained corresponding to 85% ethanol yield indicating that this combined technique has potential.

In the last two studies, absorbed water within the solid matrix of corn stover and switchgrass, AHP and liquid hot water (LHW) pretreated, was quantified by water retention value (WRV) and settling volume and found to be linearly correlated with glucose yield after hydrolysis. Results indicate that AHP and LHW pretreatment can increase water sorption to biomass surfaces and increase swelling which is indicative of increased surface accessibility not only to water molecules, but also to enzymes. However, the follow up study showed that linear regression of WRV with glucose yield does not fit for all pretreatment types and conditions, which included more severe conditions of LHW and ammonia fiber expansion (AFEX) pretreatments. A multiple linear regression model was then developed to include composition
features of the pretreated biomass with WRV and yielded much better prediction results across all pretreatments and conditions.

AHP pretreatment of corn stover and switchgrass proved to be an effective unit operation in biofuel production and a useful tool for investigating cell wall changes that contribute to reduced recalcitrance toward cell wall deconstruction.

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