

## TRANSFORMING LIGNOCELLULOSES TO SUGARS AND LIQUID FUELS

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Extensive research has been done on the development of biofuel from low-cost and abundant lignocelluloses. Unfortunately, cost-effectively producing sugars and sugar derivatives still remains a barrier to developing a biorefining industry. In order to overcome this barrier, a few innovative processes were developed for converting lignocelluloses into sugars and liquid fuels. First, a sulfite pretreatment (SPORL-Sulfite Pretreatment to Overcome Recalcitrance of Lignocelluloses) was demonstrated to be more effective to enhance enzymatic digestibility of woody biomass like spruce than dilute acid pretreatment (DA). Addition of sulfite along with sulfuric acid partially dissolved lignin and sulfonated residual lignin in the SPORL substrate, which reduced non-productive adsorption of enzymes on lignin. The buffer effect of sulfite protected cellulose and hemicellulose from extensive acidic hydrolysis and further decomposition.

Therefore, SPORL recovered more fermentable sugars and generated less fermentation inhibitors than DA pretreatment. Second, a polystyrene-based cellulase-mimetic solid acid with both cellulose binding domain (-Cl) and catalytic domain (-SO<sub>3</sub>H) was synthesized for cellulose hydrolysis. The binding domain facilitated the association of substrate onto the catalyst surface and therefore accelerated the cellulose hydrolysis. The cellulose hydrolysis catalyzed by the solid acid had much lower apparent activation energy than the ones catalyzed by liquid acids and general solid acids without binding domains. Third, a one-step process was developed for direct saccharification of lignocelluloses at moderate temperature in concentrated metal halide solution without pretreatment. Fed-batch of biomass allowed to produce a concentrated sugar solution for downstream processing. Sugars and the salt were separated through a combination of solvent extraction of salt and ionexchange chromatography or other techniques.

Fourth, a one-pot process was developed for transforming lignocellulose into furan-based precursors for hydrocarbon fuels without pretreatment or saccharification. In a LiBr/acetone system with small amount of acid, unsolvated Li<sup>+</sup> and Br<sup>-</sup> rapidly disrupted hydrogen bonds in cellulose crystals and facilitated the hydrolysis of cellulose and hemicellulose. Br<sup>-</sup> further catalyzed the dehydration of sugars into hydroxymethylfurfural (or furfural), which subsequently reacted with acetone through aldol-condensation to form furan-based precursors with 5-21 carbons in high yield and selectivity. Lignin was extensively depolymerized into low-molecular-weight fragments that can be hydrodeoxygenated together with the precursors into hydrocarbon fuels. The lignin also had good potential for high-value co-products development.