CO-SOLVENT ENHANCED LIGNOCELLULOSIC FRACTIONATION (CELF) FOR HIGH YIELDS OF PRECURSORS FOR BIOLOGICAL AND CATALYTIC CONVERSION TO FUELS AND CHEMICALS

Charles E. Wyman, Rajeev Kumar, Vanessa A. Thomas, Thanh Y, Nguyen, and Charles M. Cai*
Chemical and Environmental Engineering Department and
Center for Environmental Research and Technology (CE-CERT)
1084 Columbia Avenue
University of California, Riverside
Riverside, California 92507
*cewyman@engr.ucr.edu

The University of California Riverside recently invented a novel pretreatment called Co-solvent Enhanced Lignocellulosic Fractionation or CELF that applies renewable tetrahydrofuran (THF) as an aqueous co-solvent to greatly increase yields of primary (i.e., sugars) or secondary (i.e., furfural, 5-hydroxymethylfurfural (5-HMF), and levulinic acid) fuel precursors from dilute acid processing of lignocellulosic biomass. For biological conversion to fuels and chemicals, CELF pretreatment of corn stover at 160°C for 25 mins with 0.5% sulfuric acid recovered over 95% of the major hemicellulose sugars (glucose, xylose, arabinose) in the liquid while also solubilizing over 90% of the lignin. CELF was particularly noteworthy in realizing nearly theoretical glucose yields from the resulting glucan-enriched solids at enzyme loadings as low as 2 mg-enzyme/g-glucan due to high hemicellulose and lignin removal. Furthermore, 90% of the same pretreated solids could be converted to ethanol by simultaneous saccharification and fermentation (SSF) in 7 days at an enzyme loading of only 5 mg-enzyme g-glucan^{-1}, while consolidated bioprocessing (CBP) with *Clostridium thermocellum* consumed most of the glucan in only 1 day. The highly volatile THF could be evaporated from the CELF liquid stream to produce a nearly pure lignin feedstock. For catalytic pathways, about 87% of the pentose sugars in biomass could be converted to furfural by operating CELF at more severe conditions of 170°C for 40 to 60 mins with 1 wt% sulfuric acid. The remaining glucan-enriched solids could be enzymatically digested to glucose or further reacted with dilute acid to produce levulinic acid with a yield of about 75% of theoretical from maple wood. Metal halide acid catalysts, such as $FeCl_3$, increased yields to about 95% and 51% of theoretical for furfural and 5-HMF, respectively, from maple wood and corn stover in “one-pot.” In fact, CELF demonstrated consistent performance with a number of lignocellulosic feedstocks including agricultural residues and highly recalcitrant hardwoods. Beyond its ability to enhance yields of primary and secondary fuel precursors, CELF can provide a valuable tool for understanding biomass deconstruction.