Pretreatment of Lignocellulosic Biomass Using Room Temperature Ionic Liquids (RTILs)

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ABSTRACT

Lignocellulose represents a key sustainable source of biomass for transformation into biofuels and bio-based products. Because lignocellulose is highly recalcitrant to biotransformation, both microbial and enzymatic, effective pretreatment is vital to its bioconversion to a usable liquid fuel. A growing body of work has focused on using room temperature ionic liquids (RTILs) to pretreat lignocellulose for subsequent fermentation. In this work the RTIL 1-ethyl-3-methylimidazolium acetate [Emim] [OAc] was the first RTIL identified to selectively extract the lignin from lignocellulose, while leaving the cellulose and hemicellulose fraction largely intact. The remaining cellulose becomes far less crystalline without undergoing solubilization. When 40% of the lignin was removed, the cellulose crystallinity index dropped below 45 resulting in > 90% of the cellulose in wood flour to be hydrolyzed to *Trichoderma viride* cellulase. To better understand the physicochemical parameters that promote effective pretreatment, the relationship between the Kamlet-Taft α, β, and π* solvent polarity parameters of different RTILs ([Emim] [OAc], [Bmim] [OAc], and [Bmim] [$MeSO_4$]) and effective pretreatment of lignocellulosic biomass was explored. We found the β parameter is an excellent predictor of pretreatment efficacy. Acetate containing RTILs (β > 1.0) remove > 32% of lignin from maple wood flour and significantly reduce cellulose crystallinity, resulting in > 65% glucose yields after 12 h cellulase hydrolysis. Pretreatment in [Bmim] [$MeSO_4$] (β = 0.60) results in the removal of only 19% of the wood flour's lignin with no decrease in crystallinity, and no improvement in sugar yield over untreated wood flour. The addition of water and the dilution of the acetate anion with the methyl sulfate anion decrease the β value and subsequently have a negative impact on lignin extraction, cellulose crystallinity, and sugar yields. The coupling of biological pretreatment with RTIL pretreatment enhanced the solubility of biomass in RTIL, leading to more efficient use of the RTIL in this pretreatment.