Multiple Ions in Ionic Liquid for Lignocellulosic Biomass Processing – A Boon or a Bane

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Project Goals: Affordable and scalable deconstruction with 90% yields of all major intermediates

The global energy and sustainability policies have stimulated new technology trends based on renewable energy resources such as lignocellulosic biomass (composed of cellulose, hemicellulose, and lignin) has accelerated. Nevertheless, a major constraint in the efficient utilization of lignocellulosic biomass is the embedment of crystalline cellulose within the polymer matrix of hemicellulose and lignin necessitating a pretreatment process to expose the constituents and facilitate further transformations. Significant efforts in this field has established the potential and benefits of ionic liquid (IL, organic salt that melts below 100 °C) based biomass pretreatment/processing owing to their outstanding ability to dissolve, fractionate, and convert biopolymers.

Research efforts from our group and others have established that both the cation and anion in an IL have a distinct mechanism of action and are active agents in the pretreatment. Thus, the incorporation of multiple ions with known distinct pretreatment mechanisms in an IL paves the path to develop new strategies to boost the pretreatment efficiency while reducing the cost associated with the pretreatment step. Interestingly, minimal efforts have been made to integrate the respective advantageous properties of various ions in one IL to afford a clean, viable, energy intensive, and economical biomass pretreatment method.

In this study, novel IL systems consisting of multiple ions known to be effective at biomass pretreatment were tested on woody and grassy biomass. Molecular simulations and experimental results established the synergistic advantages of combining specific individual components in these systems. For pine (woody) biomass, pretreatment with the combination of imidazolium, cholinium, acetate, and lysinate ions achieved 80% glucose and 70% xylose yields at high biomass loading. For sorghum biomass, an IL system comprising of cholinium, lysinate, and palmitate ions not only enabled a 98% glucose yield but was also found to be biocompatible in a one-pot configuration, producing the biofuel precursor bisabolene using an engineered strain of the yeast

Rhodosporidium toruloides. Additionally, the type of ions in isolation or combination also had a remarkable effect on the structure, composition, and content of lignin. The lignin content varied from ~40-75%, whereas, the weighted average molecular weight of these lignin samples was in the range of 3800-9700 Da. The HSQC analysis of these samples revealed the dominant effect of an ion over another when multiple ions were used in combination for biomass processing.

References

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2. H. Choudhary, H. D Magurudeniya, J. M. Gladden, B. A Simmons, "*Use of a plurality of salt ionic liquids in the pretreatment of biomass*," US Provisional Patent Application 63/129,494; (Filed on December 22, 2020).

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