Scale-up of Ionic Liquid Pretreatment and Enzymatic Hydrolysis of Lignocellulosic Biomass for Biofuels Production

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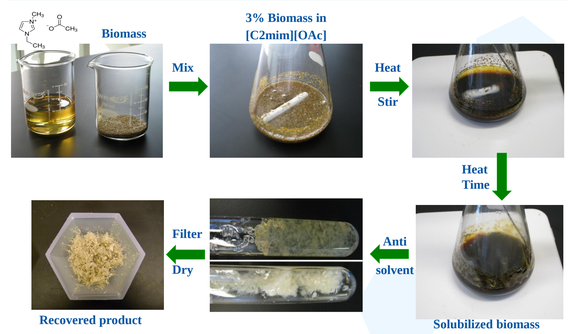
Abstract

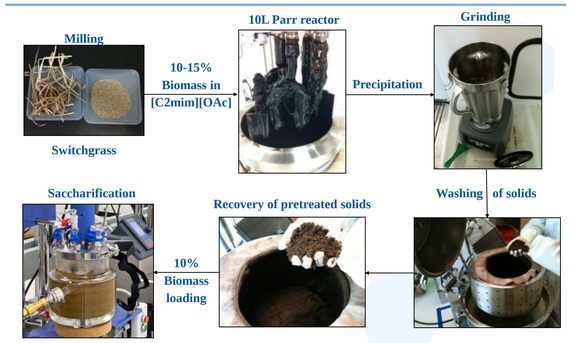
To access the sugars in lignocellulosic biomass, pretreatment is an essential step to deconstruct the recalcitrant plant cell wall structures and facilitate enzymatic hydrolysis of recovered cellulose. Ionic liquid (IL) pretreatment is gaining substantial attention as a potential pretreatment process that can efficiently fractionate biomass and provide clean sugar substrate for the production of ethanol and other advanced biofuels. Previous work at Joint BioEnergy Institute (JBEI) has demonstrated at milliliter scales that IL can dissolve significant amounts of several feedstocks and produce highly digestible polysaccharides. However, a key factor in the development of economically viable lignocellulosic biofuels is to establish novel pretreatment technologies coupled with saccharification by advanced enzyme systems at process relevant scales.

Building on the milliliter scale optimization, JBEI, in collaboration with Advanced Biofuels Process Demonstration Unit (ABPDU) is taking the first step to demonstrate IL pretreatment and subsequent saccharification at high solid loadings, liter scales (6 L) with variety of feedstocks. The scaling effects, mixing, washing, IL inhibition, and process energy flow are under evaluation and optimization to achieve a robust and reproducible technology based on the state-of-the-art facilities available at ABPDU. The knowledge gained from these initial scale-up studies will be critical and essential in developing techno-economic models for ionic liquid pretreatment and saccharification at larger scales, primarily in demonstrating commercial viability of this promising technology.

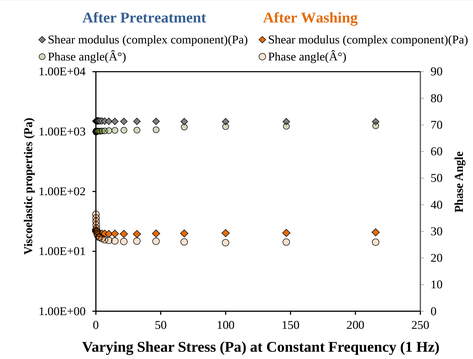
Small Scale Ionic Liquid Pretreatment Process



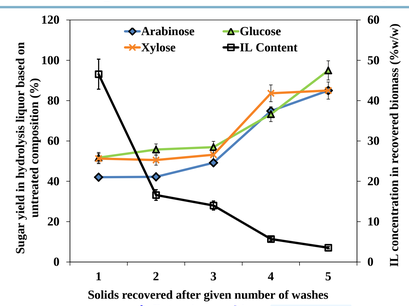
Scale Up Ionic liquid Pretreatment and Saccharification



Viscous Nature of Pretreated Switchgrass



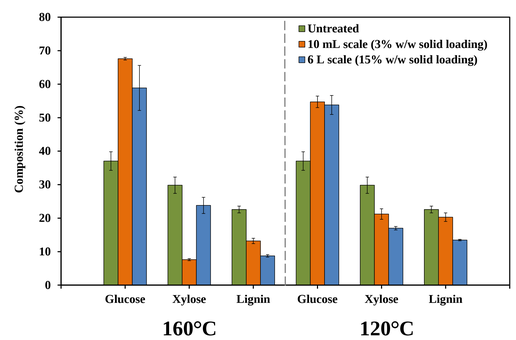
Residual Ionic Liquid Caused Inhibition to Hydrolysis



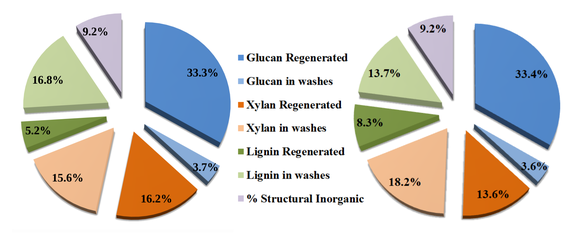
Solutions:

- → Extensive washing steps
- → IL/hydrolysates separation
- → IL tolerant enzyme development
- → IL tolerant microorganisms

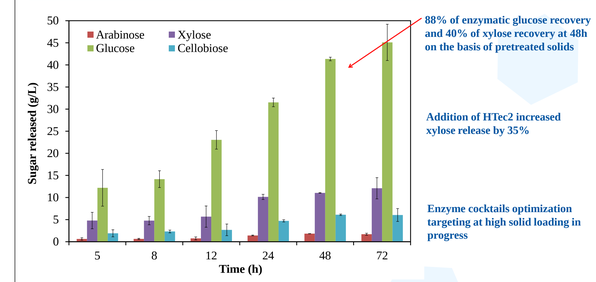
Changes of Switchgrass Compositions



Mass Balance of IL Pretreated Switchgrass



Enzymatic Saccharification of IL Pretreated Switchgrass



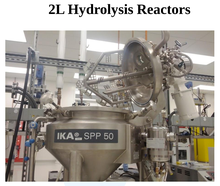
Biomass loading: 10% (w/w)
Enzyme loading: 54 mg Ctec2 /g glucan
6 mg Htec2/g glucan

Pretreatment and Saccharification Equipment at ABPDU

10L Parr Reactors

2L Hydrolysis Reactors

Basket Centrifuge

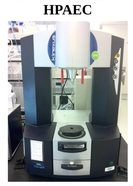


50L Hydrolysis Reactors

Analytical Equipment at ABPDU

HPAEC

Gas Chromatography



Rheology

Bomb Calorimery

Summary and Ongoing Work

Summary:

- Successfully scaled up the IL pretreatment of switchgrass to 6L scale and 15% loading
- Achieved consistent cellulose recovery and hemicellulose/lignin removal
- Successfully scaled up the enzymatic saccharification of IL pretreated switchgrass to 2L scale and 10% loading with fast and high sugar recovery

Ongoing Work

- Enzymatic cocktail optimization for high solid loading biomass saccharification
- Scale up of IL pretreatment and saccharification of various feedstocks at high solid loading
- Develop process mass balance and energy balance

Acknowledgements

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