Properties of Biomass Pretreated with Ionic Liquid at 10L Scale

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Introduction

Ionic liquid (IL) pretreatment has proven to be an effective method of biomass depolymerization for biofuel production. Understanding the physical and chemical properties of IL pretreated biomass at scale up level is essential to obtain better insights into challenges that may occur in large scale biorefineries. 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 and liter scales (10 L), with a variety of feedstocks. Here, we provide the results of our studies aimed at understanding mass balances, residual ionic liquid inhibition of enzymes, and rheological properties of IL pretreated solids recovered from 10L scale.

Materials and Methods

Biomass:	3/16" hammer-milled Switchgrass and Eucalyptus from INL
Pretreatment Solids Loading and Catalyst:	10% (w/w) and Emim Acetate [C2mim][OAc]
Pretreatment Reaction Temperature - Time:	140°C – 1 hour
Pretreatment Reactor:	High Pressure Series 4555 Floor Stand 10 L Parr Reactors
Working volume:	6 L
Saccharification Solids and Enzyme Loading:	10% (w/w) and Ctech 2 (54 mgenzyme/ g glucan) and Htec 2 (6 mg enzyme/ g glucan)
Saccharification Reaction Temperature – Time:	50°C – 72 hours
Saccharification Reactor:	2 L IKA reactors with Anchor impeller and flow breaker
Working volume:	1.5 L
Rheometer and geometry:	Malvern – Kinexus Stress Controlled oscillatory rheometer with smooth parallel plates at 2.5 mm gap

Residual Ionic Liquid Inhibited Enzymatic Saccharification

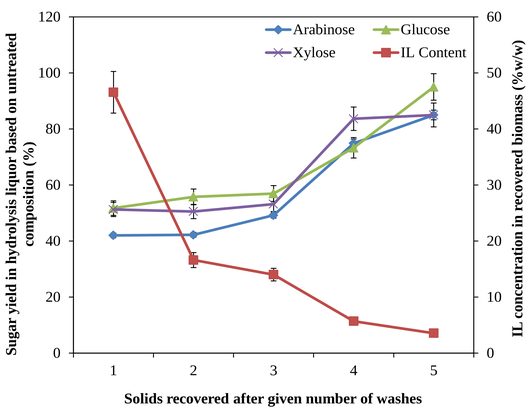


Figure 1. Effect of washing steps on IL removal and saccharification

Unit Processes in Scale Up Ionic Liquid Pretreatment and Saccharification Process Including Washing

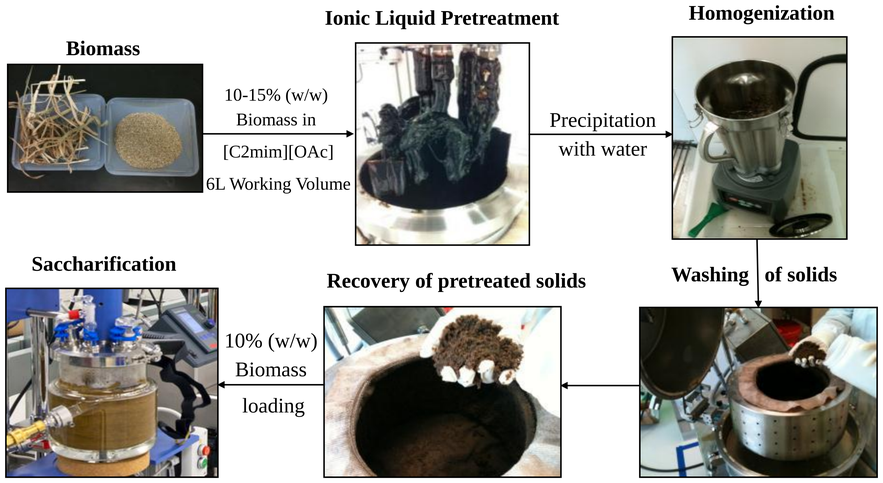


Figure 2. Ionic liquid pretreatment at 10L scale and saccharification at 2L scale

Large Scale Ionic Liquid Pretreatment was Effective in Lignin Removal and Carbohydrate Recovery

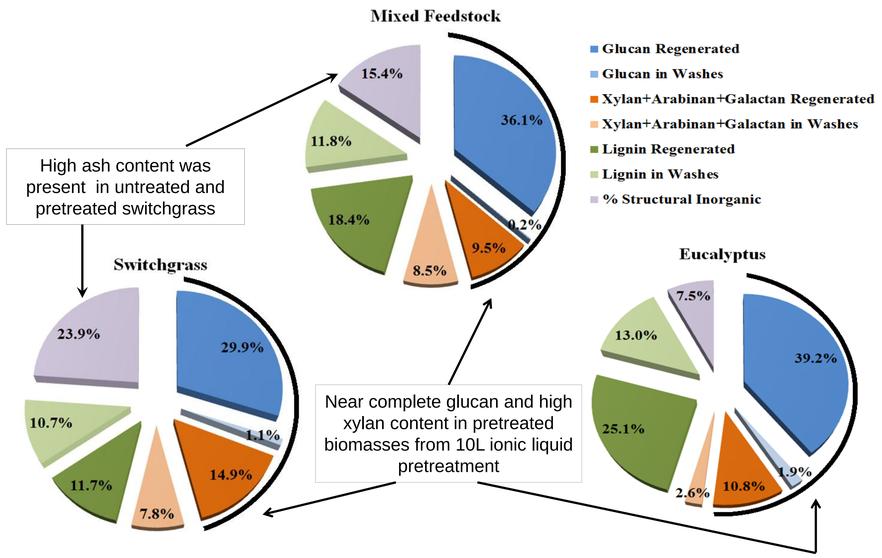
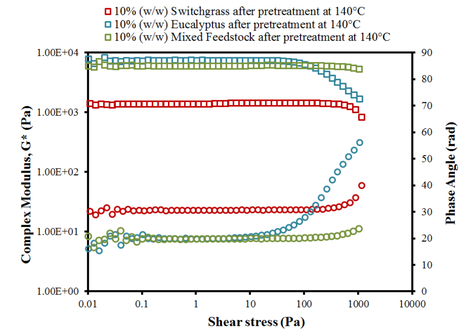


Figure 3. Mass balances for 10L scale Ionic liquid pretreatment of herbaceous (switchgrass), woody (eucalyptus), and mixed feedstocks

Mixed Feedstock Showed Higher Resistance to Flow

(a)



(b)

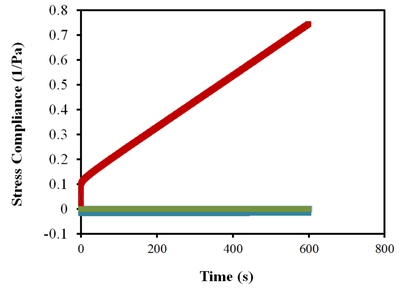


Figure 4 (a) Oscillatory stress sweep at 5 Hz and (b) Creep studies at 10 Pa for 10 minutes

Summary

- Scale up IL pretreatment and saccharification was established with desired lignin removal and carbohydrate conversion at 10L and 2L scale, respectively.
- Four washes of pretreated solids facilitated near complete enzyme activity during saccharification in this study.
- Mixed feedstock is as elastic as eucalyptus but does not lose integrity similar to switchgrass. Only 10% (w/w) switchgrass shows liquid like flow behavior in 10 Pa creep studies.
- Further understanding mass balances and material handling issues is required to scale up IL pretreatment for large scale biofuel production

Acknowledgements

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