Pretreatment of Lignocellulosic Agricultural Wastes with Ionic Liquids for the Production of Sugars via Improved Enzymatic Hydrolysis

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ABSTRACT

Various ionic liquids (ILs) including 1-ethyl-3-methylimidazolium chloride (EmimCl), 1-ally-3-methylimidazolium chloride (AmimCl), 1-butyl-3-methylimidazolium chloride (BmimCl), 1-ethyl-3-methylimidazolium acetate (EmimAc) and 1-ethyl-3-methylimidazolium methyl phosphonate (EmimMP) were used for the pretreatment of two lignocellulosic agricultural wastes, cotton stalk and corn cob. IL pretreatment was observed to have a positive effect on the enzymatic hydrolysis of the samples compared to untreated controls. Among the different types of ILs, biomass samples pretreated with EmimAc had the highest enzymatic hydrolyzability. EmimAc also maintained its effect at increased biomass particle sizes unlike the other ILs utilized for pretreatment, since no notable reduction in the enzymatic hydrolyzability of the EmimAc pretreated biomass samples was observed despite of the increased particle size of the biomass samples. Finally the IL pretreatment was compared with a conventional pretreatment technique, namely alkaline pretreatment, by means of the enzymatic hydrolyzability of the pretreated cotton stalk samples. Both EmimCl and EmimAc pretreatment was found to result in higher enzymatic hydrolyzability of lignocellulosic biomass samples compared to alkaline pretreatment indicating that IL pretreatment may be regarded as a promising lignocellulosic biomass pretreatment method.

INTRODUCTION

Bioconversions of lignocellulosic materials to useful, higher value products require pretreatment techniques.

Lignocellulosic Biomass → PRETREATMENT → Cellulose, Hemicellulose, Lignin

PRETREATMENT TECHNIQUES[1]

- Alkaline
- Acid Hydrolysis
- Steam Explosion
- AFEX

→ **CONVENTIONAL**

Ionic Liquid (RECENT)

Appearance of microcrystalline cellulose after treatment with ionic liquid

What is **ionic liquid ?**

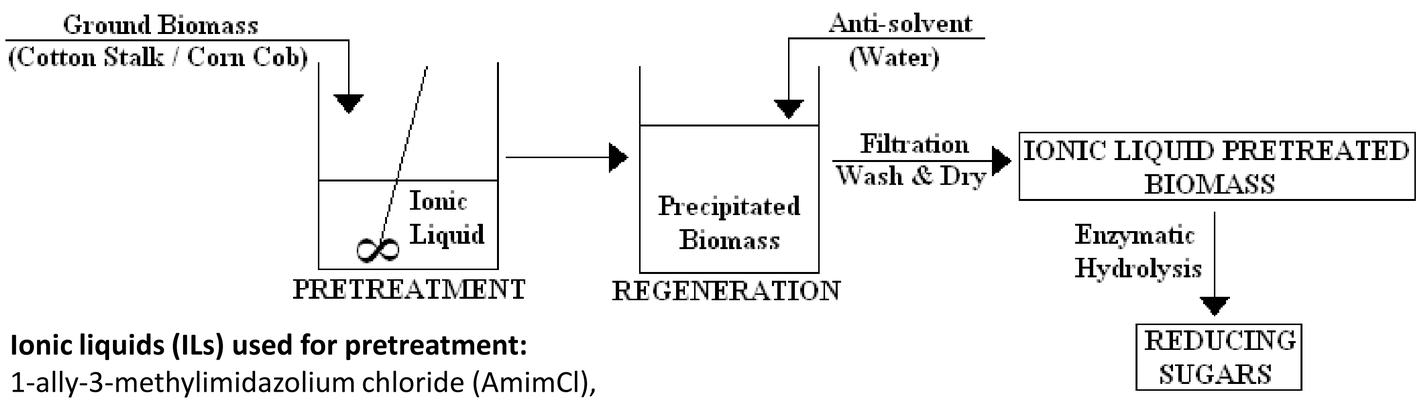
Group of salts that are in liquid form at moderate temperatures (< 100°C)[2]
Can be used to dissolve and modify cellulose[3]
Can be used as pretreatment solvents for lignocellulosic biomass[4]

Ionic liquid is capable of:[5]

- Transforming the structure of cellulose from crystalline to amorphous
- Reducing the degree of polymerization of cellulose
- Increasing the surface area of cellulose

→ **IMPROVED ENZYMATIC HYDROLYSIS**

METHODS



Ionic liquids (ILs) used for pretreatment:

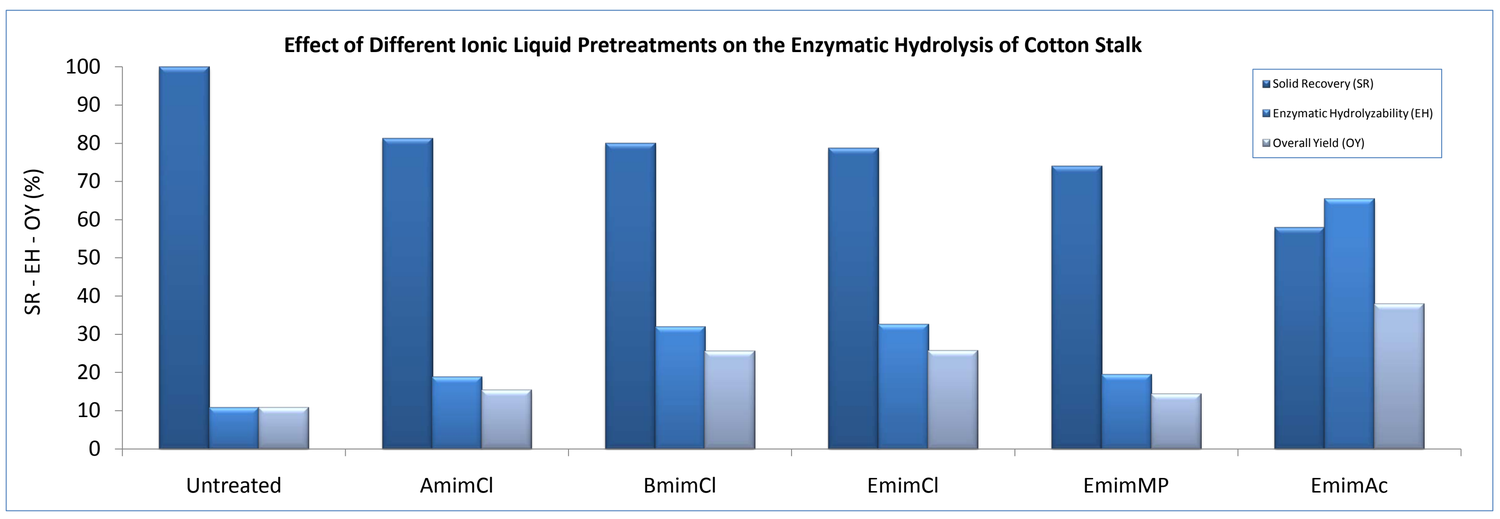
1-ally-3-methylimidazolium chloride (AmimCl),
1-butyl-3-methylimidazolium chloride (BmimCl),
1-ethyl-3-methylimidazolium acetate (EmimAc)
1-ethyl-3-methylimidazolium chloride (EmimCl)
1-ethyl-3-methylimidazolium methyl phosphonate (EmimMP)

$$\text{Solid Recovery (\%)} = \frac{\text{Weight of biomass after pretreatment and drying}}{\text{Weight of biomass subjected to ionic liquid pretreatment}} \times 100$$

$$\text{Enzymatic Hydrolyzability (\%)} = \frac{\text{Weight of reducing sugars obtained after enzymatic hydrolysis}}{\text{Weight of biomass sample subjected to hydrolysis}} \times 100$$

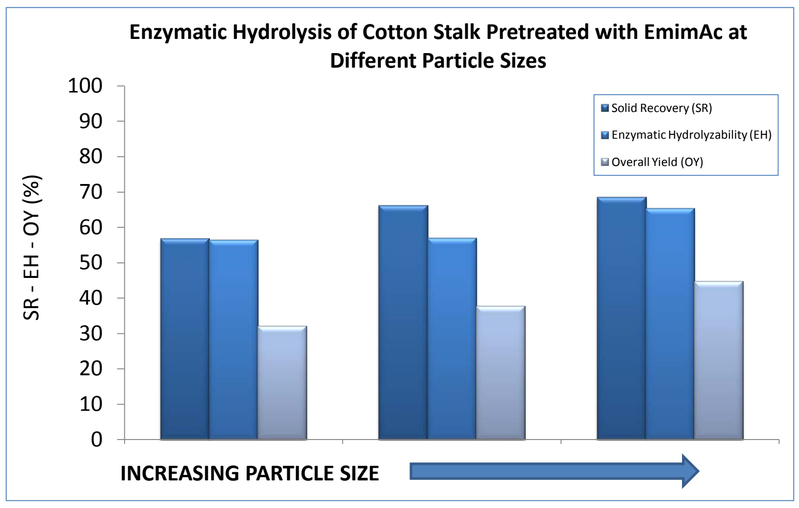
$$\text{Overall Yield (\%)} = \text{Solid Recovery (\%)} \times \frac{\text{Enzymatic Hydrolyzability (\%)}}{100}$$

RESULTS

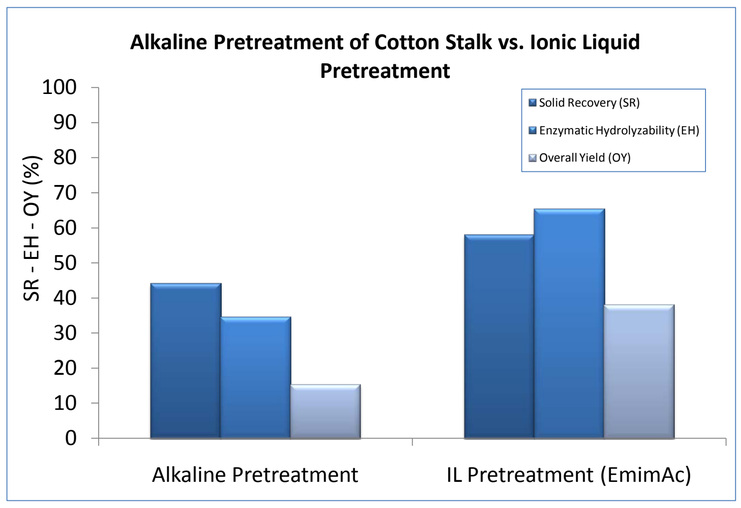


Ionic liquid pretreatment was observed to have a positive effect on the enzymatic hydrolysis of cotton stalks where EmimAc was found to be more effective than the other ILs used.

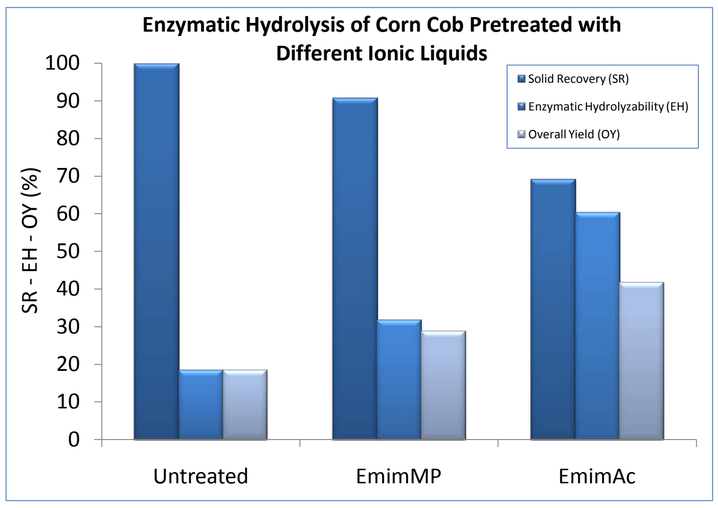
Appearance of regenerated corn cob after pretreatment with the ionic liquid EmimAc.



With increasing particle size of cotton stalk the pretreatment with EmimAc was found to be more effective by means of enzymatic hydrolysis.



Ionic liquid pretreatment with EmimAc results in a better enzymatic hydrolysis of cotton stalk compared to alkaline pretreatment.



Corn cob responds well to ionic liquid pretreatment similar to cotton stalk by means of enzymatic hydrolysis.

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