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Pre-treatment of lignocellulosic biomass using ionic liquids: Wheat straw fractionation

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HIGHLIGHTS

- An innovative method of biomass pre-treatment using [emim][CH_3COO] was developed.
- The valorization of biomass by the high purity biomass fraction samples.
- Enzymatic hydrolysis showed high purity cellulose fractions.
- Recovery and reuse of IL in a new pre-treatment process.

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ABSTRACT

This work is devoted to study pre-treatment methodologies of wheat straw with 1-ethyl-3-methylimidazolium acetate ([emim][CH_3COO]) and subsequent fractionation to cellulose, hemicellulose and lignin. The method developed and described here allows the separation into high purity carbohydrate and lignin fractions and permits an efficient IL recovery. A versatility of the established method was confirmed by the IL reuse.

The fractionation of completely dissolved biomass led to cellulose-rich and hemicellulose-rich fractions. A high purity lignin was also achieved.

To verify the potential further applicability of the obtained carbohydrate-rich fractions, and to evaluate the pre-treatment efficiency, the cellulose fraction resulting from the treatment with [emim][CH_3COO] was subjected to enzymatic hydrolysis. Results showed a very high digestibility of the cellulose samples and confirmed a high glucose yield for the optimized pre-treatment methodology.

1. Introduction

The biorefinery concept integrates conversion processes and equipment to produce fuels, power and chemicals from biomass, such as lignocellulosic biomass. The implementation of the biorefinery concept is challenging due to technological limitations and thus an economic feasibility of such industries is still questionable. Besides a large generation of energy and biofuels, production of value added products from lignocellulose processing is a key aspect towards an economic sustainability of biorefineries.

Lignocellulose is essentially represented as hardwood, softwood, grasses, agricultural and forest residues, domestic and municipal solid wastes, and food industry residues. These materials are mainly composed of cellulose, hemicellulose and lignin that form a complex and intricate structure. Cellulose, a semi-crystalline fibrous, linear and unbranched homopolymer of β-D-glucopyranose with cellobiose as the repeating unit and hemicellulose, an amorphous, branched heteropolysaccharide, build up the carbohydrate fraction. Lignin is a very complex and amorphous phenylpropanoid polymer. In the valorisation processes of lignocellulosic biomass, cellulose and hemicellulose are mostly hydrolysed to sugar monomers and subsequently converted into alcohols (ethanol, butanol), hydrogen or methane by fermentation processes, on biochemical platforms. Apart from biofuel and energy production, cellulose can be used to produce valuable products, such as hydroxymethylfurfural (HMF) (Zakrzewska et al., 2011). Hemicellulose can also serve as raw material for products with value added, such as xylitol or advanced fuels (Girio et al., 2010). The isolated lignin is required not only for the production of heat or

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