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Combined use of completely bio-derived cholinium ionic liquids and ultrasound irradiation for the pretreatment of lignocellulosic material to enhance enzymatic saccharification

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HIGHLIGHTS

- Totally bio-derived cholinium ionic liquid (IL) was used to pretreat lignocellulose.
- We suggested pretreatment method using the cholinium IL and ultrasound.
- This was more efficient than the existing method using the cholinium IL and heating.

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ABSTRACT

Completely bio-derived cholinium ionic liquids (ILs) such as choline acetate (ChOAc) are reported to be less expensive, more biocompatible, and more biodegradable and bio-renewable in comparison with the imidazolium ILs that are conventionally used for the pretreatment of lignocellulosic biomass. We demonstrated here, for the first time, that the cholinium-IL-assisted pretreatment of lignocellulosic biomass is enhanced by ultrasound irradiation in comparison with conventional heating. The cellulose saccharification ratio of bamboo powder was approximately 55% when pretreated thermally in ChOAc at 110 °C for 60 min. Conversely, after ultrasonic pretreatment in the same IL at 25 °C for 60 min, 92% of cellulose was hydrolyzed to glucose. Moreover, X-ray diffractometry and Fourier-transform infrared spectrometry analyses revealed that the cellulose crystallinity of pretreated bamboo powder was lower in case of ultrasonic pretreatment in ChOAc than in case of thermal pretreatment in the same IL.

1. Introduction

Lignocellulosic materials such as waste woods and agricultural residues have attracted attention as renewable sources of fermentable sugars for bioconversion into ethanol as biofuels and other metabolites, which are converted into value-added products [1]. In general, the conversion of lignocellulose into ethanol and other valuable metabolites consists of (i) the pretreatment of lignocellulose to enhance the subsequent enzymatic saccharification of cellulose and hemicellulose; (ii) the enzymatic hydrolysis of cellulose and hemicellulose to fermentable sugars; and (iii) the microbial fermentation of the sugars to ethanol or other metabolites. The pretreatment of lignocellulosic biomass is important because it significantly affects the efficiency and methodology of subsequent saccharification and fermentation.

Lignocellulose is a component of plant cell walls that is composed mainly of cellulose, hemicellulose, and lignin. Cellulose is a linear polymer comprising β(1-4)-linked-glucose units. Hydroxyl groups present in cellulose are involved in inter- and intramolecular hydrogen bonding, resulting in an ordered, crystalline structure. Hemicellulose is relatively amorphous and can be hydrolyzed to yield fermentable sugars. Lignin is a highly branched aromatic polymer that binds to hemicellulose with covalent cross-linkages, tightly embedding the cellulose fibers. These crystalline, rigid structures of cellulose and lignin prevent hydrolytic enzymes from accessing polysaccharides [2]. Therefore, the hydrogen bonds in crystalline cellulose and the covalent cross-linkages in the lignin structure must be disrupted to ensure efficient enzymatic hydrolysis of the lignocellulose.

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