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Research Article

Controlled Depolymerization of Cellulose Fibres Isolated from Lignocellulosic Biomass Wastes

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Various types of lignocellulosic biomass wastes (LBW) had been successfully converted into cello-oligomers with different chain lengths via a controlled depolymerization process. Cellulose fibres isolated from LBW samples were dissolved with room temperature ionic liquid (RTIL) in the presence of an acid catalyst, Amberlyst 15 DRY. The effects of reaction time on the degree of polymerization and yields of water-insoluble cello-oligomers formed were studied. Besides, the yields of water-soluble cello-oligomers such as glucose and xylose were also determined. The depolymerization of cellulose fibres isolated from LBW was observed to follow both second-order and pseudo-second order kinetics under specific conditions. As such, cello-oligomers of controllable chain lengths could be obtained by adjusting the duration of depolymerization process under optimized conditions.

1. Introduction

In recent decades, the production of biofuels from renewable biomass have gained increasing attention of scientists worldwide [1]. However, the use of food resources such as glucose derived from direct extraction of saccharose in sugarcane and sugar beet or through hydrolysis of corn starch for production of biofuels would inevitably compete with food supply [2]. As such, the use of cellulose fibres derived from lignocellulosic biomass wastes (LBW) as the feedstock is considered to be more appropriate than starch and saccharose. Cellulose is the most abundant organic compound on earth, and utilization of cellulose fibres derived from LBW does not compete with food supply [3]. Nevertheless, the presence of extensive intra- and intermolecular hydrogen bond networks, the basicity of glycosidic bonds, and high crystallinity of cellulose have posed great challenges for breaking down cellulose fibres through both chemical or biological processes [4, 5].

In conventional hydrolysis of lignocellulosic biomss materials, mineral acids such as hydrochloric acid, sulfuric acid, or even hydrofluoric acid are being used as liquid catalysts [6]. These liquid catalysts need to be employed in high concentration and/or at high reaction temperature (170–240°C) in order to enhance product yields. Typically, lignocellulosic raw materials are not being completely solubilized in the reaction medium [7]. Although valuable products are obtained from the hydrolysis process, full-scale hydrolyses of cellulose have never been commercially implemented due to issues which include corrosion, high energy demand, catalyst recovery, and degradation of sugars.

In recent years, ionic liquids have been used as solvents and catalysts in various fields of research [8, 9]. Ionic liquids are defined as salts with a melting point below 100°C which exhibit several unique properties such as negligible vapor pressure, extraordinary dissolution properties, wide liquid range, high electrical conductivity, low volatility, and low flammability [10, 11]. Ionic liquids have been reported to dissolve cellulose for up to 25 wt% [12]. This has led to intense research into the conversion of biomass in ionic liquids. Besides, ionic liquids can be easily recovered and recycled by evaporating water or alcoholic residues using vacuum distillation and then purified by passing it through a neutral alumina column [5, 13]. All these unique properties of ionic liquid have led to their uses as the preferred solvent for the depolymerization of cellulose.