



Short Communication

Removal of inhibitors from pre-hydrolysis liquor of kraft-based dissolving pulp production process using adsorption and flocculation processes

Xin Liu^a, Pedram Fatehi^{b,*}, Yonghao Ni^{a,*}^a Department of Chemical Engineering and Limerick Pulp and Paper Centre, University of New Brunswick, Fredericton, NB, Canada E3B 5A3^b Department of Chemical Engineering, Lakehead University, Thunder Bay, ON, Canada P7B 5E1

ARTICLE INFO

Article history:

Received 28 November 2011

Received in revised form 21 February 2012

Accepted 22 March 2012

Available online 29 March 2012

Keywords:

Biorefinery

Lignocelluloses

Activated carbon

Adsorption

Flocculation

ABSTRACT

A process for removing inhibitors from pre-hydrolysis liquor (PHL) of a kraft-based dissolving pulp production process by adsorption and flocculation, and the characteristics of this process were studied. In this process, industrially produced PHL was treated with unmodified and oxidized activated carbon as an adsorbent and polydiallyldimethylammonium chloride (PDADMAC) as a flocculant. The overall removal of lignin and furfural in the developed process was 83.3% and 100%, respectively, while that of hemicelluloses was 32.7%. These results confirmed that the developed process can remove inhibitors from PHL prior to producing value-added products, e.g. ethanol and xylitol via fermentation.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Forest biorefinery has the goal of utilizing biomass in the production of various value-added products (van Heiningen, 2006). Pre-hydrolysis is a crucial stage in the production of dissolving pulp based on kraft technology (Li et al., 2010). In this stage, the majority of hemicelluloses and part of lignin are dissolved in the pre-hydrolysis liquor (PHL) (Li et al., 2010; Saeed et al., 2012). Additionally, a part of the dissolved hemicelluloses in the PHL is converted to other byproducts, e.g. furfural (Saeed et al., 2012). Lignin and furfural in PHL inhibit the fermentation of hemicelluloses to value-added products, e.g. ethanol and xylitol (Helmerius et al., 2010; Zhuang et al., 2009). To facilitate the application of the lignocelluloses of PHL in the production of value-added products, the amounts of inhibitors in the PHL need to be minimized.

Solvent extraction and ultrafiltration have been proposed to extract lignocellulosic compounds from the spent liquors of pulping processes (Liu et al., 2011a); however, these process may not be industrially attractive due to a high operational cost and technical issues (e.g. blocking). Alternatively, adsorption can be considered for removing lignocellulosic compounds from spent liquors (Chaichanawong et al., 2010; Radovic et al., 2000). In one study, XAD-4 resin was employed as adsorbent for lignin in hydrolysis liquor produced from hot water extraction of mixed northern

hardwood chips (Schwartz and Lawoko, 2010), approximately 90% of acid-soluble lignin and less than 10% of hemicelluloses were removed from the hydrolysis liquor via treating 5 ml of hydrolysis liquor with 4 g of XAD-4 for 5 min at room temperature. Also, the desorption analysis demonstrated an 85% lignin recovery from XAD-4 in 75 vol.% acetone at room temperature (Schwartz and Lawoko, 2010). In another study, 10.4 g furfural was adsorbed on 36.1 g XAD-4 at 30 °C (the adsorption of glucose on XAD-4 was not determined) from a synthetic solution containing 0.5 wt.% glucose and 15.3 g furfural, and more than 95% of adsorbed furfural was recovered from XAD-4 in pure ethanol solution at 50 °C (Weil et al., 2002). Activated carbon (AC) possesses a high adsorption capacity for various lignocelluloses (Lee et al., 2011; Montane et al., 2006). If desorption of lignocelluloses from the AC is performed, the AC can be readily recycled and reused. Previously, we demonstrated that the AC was an efficient adsorbent of the lignocelluloses of PHL, and its adsorption capacity could be increased via oxidation (Liu et al., 2011b). Cationic polymers, e.g. polydiallyldimethylammonium chloride (PDADMAC), were able to interact with lignocelluloses of PHL via patch flocculation, form complexes and be eventually removed from PHL (Saeed et al., 2011a). In one study, the concentration of PDADMAC (with a molecular weight ranging from 50 to 100 kDa) in a hydrolysis solution (produced from the hot water hydrolysis of mixed northern hardwood) was maintained at 47.3 ppm at room temperature for 120 min, resulting in 36% lignin and 3% hemicellulose removals (Duarte et al., 2010). One objective of the current work was to introduce a detoxification process that could be integrated into

* Corresponding authors. Tel.: +1 807 343 8697; fax: +1 807 346 7943 (P. Fatehi), tel.: +1 506 453 4547; fax: +1 506 453 4767 (Y. Ni).

E-mail addresses: pfatehi@lakeheadu.ca (P. Fatehi), yonghao@unb.ca (Y. Ni).