



Kinetic study of pentosan solubility during heating and reacting processes of steam treatment of green bamboo



Xiaolin Luo^{a,b,c}, Xiaojuan Ma^a, Huichao Hu^c, Canghai Li^a, Shilin Cao^a, Liulian Huang^a, Lihui chen^{a,*}

^a College of Material Engineering, Fujian Agriculture and Forestry University (FAFU), Fuzhou 350002, China

^b Key Laboratory of Biofuel, Chinese Academy of Sciences, Qingdao Institute of Bioenergy and Bioprocess Technology, Qingdao 266101, China

^c State Key Laboratory of Pulp and Paper Engineering, South China University of Technology, Guangzhou 510641, China

HIGHLIGHTS

- ▶ A modified parameter called steam treatment factor ($f(P)$) was proposed.
- ▶ Pentosan in substrates during heating and reacting processes was well predicted.
- ▶ Steam treatment factor is a useful tool to compare pretreatment performance.

ARTICLE INFO

Article history:

Received 19 July 2012

Received in revised form 11 December 2012

Accepted 12 December 2012

Available online 20 December 2012

Keywords:

Pentosan solubility
Steam treatment
Kinetic model
Steam treatment factor
Green bamboo

ABSTRACT

Green bamboo was hydrolyzed over a range of durations at different temperatures. A simple pseudo-homogeneous irreversible first order kinetic model was developed to describe pentosan solubility during steam treatment of green bamboo. To avoid the influence of soluble pentosan during heating process, kinetic parameters were effectively dissolved based on the data in the reacting process. Moreover, the pentosan solubility during heating process was also well modeled by numerical algorithm method. According to the origin of H factor, a modified parameter called steam treatment factor ($f(P)$) was proposed in this paper based on the determined kinetic constants. Finally, residual pentosan in whole process could be predicted properly based on the $f(P)$ and the introducing of potential hydrolysis degree (h_d). After using $f(P)$ to combine reaction temperature and time into a single factor, comparative result showed that steam treatment is more effective for removing pentosan compared with hot water extraction.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Awareness of climate change and of diminishing fossil fuel reserves has spurred extensive research efforts for bio-fuel production (such as bio-ethanol) from renewable biomass (Himmel et al., 2007). Compared with other renewable lignocelluloses, non-woody materials have attracted increasing attention due to their advantages in terms of abundance and low cost, particularly in countries with a scarcity of wood (Sundqvist, 2001). As one of the most important non-woody resources, bamboo is a perennial species and is distributed widely in Asia (Scurlock et al., 2000). Due to its fast growth (3–5 years), easy propagation, high productivity, and high holocellulose content (64–70%), bamboo is one of the ideal raw materials for the production of bio-fuels, such as ethanol (Shimokawa et al., 2009) and methanol (Tsuda et al., 1998). However, due to the tree-like structure of bamboos, the celluloses

are tightly connected with other main components, particularly hemicelluloses. For this reason, enzymatically hydrolyzing bamboo cellulose into fermentable sugar is very difficult (Sathitsuksanoh et al., 2010). Therefore, the pretreatment for removing the hemicelluloses in bamboo is necessary for the production of sugars via enzymatic saccharification.

Among many practical technologies, steam explosion (Mason, 1929) is regarded as one of the most effective pretreatment methods for non-woody resources, such as corn stover (Alvira et al., 2010; Saddler et al., 1993). Although the effectiveness of such pretreatment, including those integrated with chemical reaction and mechanical treatment, on the substantial enzymatic hydrolysis has been fully investigated (Dekker et al., 1987; Kling et al., 1987; Ramos et al., 1992; Tanaka and matsuno, 1990), the kinetic study of hemicelluloses solubility during the steam treatment process alone has been few reported.

Understanding the kinetics of hemicellulose hydrolysis is extremely important for testing mechanisms, process control, and optimization during hydrothermal and steam pretreatment

* Corresponding author. Tel.: +86 591 83715175; fax: +86 591 83789495.

E-mail address: luoxiaolin128@yahoo.com.cn (L. chen).