Bioresource Technology 124 (2012) 306–310

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Pretreatment of wheat straw using SO_2 dissolved in hot water

Weina Liu [a], Yucui Hou [b], Weize Wu [a,*], Muge Niu [a], Wenhua Wang [a]

[a] State Key Laboratory of Chemical Resource Engineering, Beijing University of Chemical Technology, Beijing 100029, PR China
[b] Department of Chemistry, Taiyuan Normal University, Taiyuan 030031, PR China

HIGHLIGHTS

- Wheat straw hemicellulose was efficiently pretreated in an H_2O–SO_2 system.
- SO_2 in the H_2O–SO_2 system could be recovered and reused after reaction.
- SO_2 in water favors hemicellulose conversion rather than xylose dehydration.
- Kinetic analysis was performed by Saeman modeling and Arrhenius equation.

ARTICLE INFO

Article history:
Received 21 February 2012
Received in revised form 9 July 2012
Accepted 9 August 2012
Available online 17 August 2012

Keywords:
Pretreatment
Wheat straw hemicellulose
Recoverable catalyst
H_2O–SO_2 system

ABSTRACT

Efficient pretreatment is important for complete enzymatic conversion of lignocellulosic materials. Pretreatment of wheat straw with sulfur dioxide (SO_2) dissolved in hot water achieved xylose and total product yields of up to 61.1% and 93.9%, respectively, based on the mass of lignocellulose in wheat straw. The apparent activation energies for hemicellulose conversion and xylose dehydration were 7.8 and 9.0 kJ/mol. FT-IR spectra of the residual solid after treatment showed that the hemicellulosic components were converted, the hydrogen bonds in cellulose were broken, but the lignin structure was not changed. Importantly, the SO_2 was recovered from the product mixture by steam stripping and could be reused. Thus, the SO_2–H_2O system is an efficient and environmentally friendly way for the conversion of hemicellulose in wheat straw into monosaccharides, such as xylose, glucose and arabinose.

1. Introduction

The utilization of lignocellulosic materials for the production of value-added chemicals or biofuels generally requires a pretreatment process (Dadi et al., 2006; Grous et al., 1986; Kumar et al., 2009; Qi et al., 2009). Chemical pretreatment processes such as dilute acid hydrolysis are efficient, but create waste, require additional recovery steps and can lead to degradation of products. When sulfuric acid is used, the derived sugars, mainly xylose, are easily converted into furfural, which has an inhibitory effect on the subsequent enzymatic hydrolysis (Almeida et al., 2009).

Orozco et al. (2007) reported that H_3PO_4, a medium strong acid, could promote the yield of glucose from cellulose, since its acidity is just sufficient to break the bonds of cellulose, but not too strong to control the reaction process. SO_2 dissolved in water can react with water to form sulfurous acid as a medium strong acid, like H_3PO_4, to generate H^+ (Donaldson et al., 2009) and also can exist as a Lewis acid (Jonas et al., 1994). Thus, SO_2 in water may potentially be able to convert hemicellulose with a high sugar yield, but a low yield of furfural. Moreover, SO_2 can be removed by steam stripping from an aqueous solution, and the recovered SO_2 can be reused. However, pretreatment of wheat straw in an H_2O–SO_2 system has not been reported in the literature. Therefore, in the present study wheat straw was treated in hot water using SO_2 as a recoverable catalyst. Kinetics analysis of the hemicellulose conversion and xylose degradation with time were established, and the reaction rate constants and apparent activation energy were calculated according to Saeman models and Arrhenius equation.

2. Experimental

2.1. Chemicals

Wheat straw was dried at 105 °C for 12 h and milled to small particles (less than 0.5 mm). The contents of cellulose and hemicellulose in the wheat straw were 40.7% and 30.1%, respectively, as measured with an ANKOM A2000i automatic fiber analyzer. Aqueous 6% solutions of SO_2 were purchased from Aladdin Reagent Inc. (Shanghai, China). N_2 with a volume fraction purity of 0.9995 was supplied by Beijing Haipu Gases Ltd. (Beijing, China). Anhydrous D-glucose, xylose, arabinose, furfural and levulinic acid (LA) with

* Corresponding author. Tel./fax: +86 10 6442 7603.
E-mail address: wzwu@mail.buct.edu.cn (W. Wu).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.08.028