Bioresource Technology 130 (2013) 1–7

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Process optimization and performance evaluation on sequential ionic liquid dissolution–solid acid saccharification of sago waste

Kiat Moon Lee, Gek Cheng Ngoh *, Adeline Seak May Chua

Department of Chemical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

HIGHLIGHTS

- Effective sequential ionic liquid dissolution–solid acid saccharification process.
- 98.3% reducing sugars yield was achieved under optimized conditions.
- The quadratic models developed are of good predictive accuracy.
- The process is of better yield compared to other saccharification schemes.
- It offers high reaction rate, ease products separation and catalyst reusability.

ARTICLE INFO

Article history:
Received 26 July 2012
Received in revised form 23 November 2012
Accepted 29 November 2012
Available online 8 December 2012

Keywords:
Lignocellulosic biomass
Ionic liquid
Solid acid catalyst
Saccharification
Optimization

ABSTRACT

The production of reducing sugars from sago waste via sequential ionic liquid dissolution–solid acid saccharification was optimized in this study. Ionic liquid dissolution of sago waste with 1-butyl-3-methylimidazolium chloride ([BMIM]Cl) was conducted prior to the solid acid saccharification with Amberlyst 15 (A15). The effect of time, temperature and substrate loading during dissolution reaction; and the effect of time, temperature and catalyst loading during saccharification reaction were examined by applying central composite design (CCD) separately. Both dissolution and saccharification reactions were respectively modeled into quadratic polynomial equations with good predictive accuracies. A high reducing sugars yield of 98.3% was obtained under the optimized conditions, i.e. dissolution at 1.75 h, 160 °C, 1.5% substrate loading, and saccharification at 0.5 h, 130 °C, 4% catalyst loading. From comparison studies of different saccharification schemes, the sequential ionic liquid dissolution–solid acid saccharification has proven to be a potential method in reducing sugars production from the lignocellulosic biomass.

1. Introduction

Ionic liquids have attracted tremendous attention in chemical processing attributing to their numerous advantages, including low volatility, low toxicity, and high thermal and chemical stability (Feng and Chen, 2008; Wang et al., 2011; Zhu et al., 2006). Their applications have been found in the field of catalysis, electrolytes, advanced materials and polymer systems (Dwiatmoko et al., 2010). In recent years, ionic liquids have been used to dissolve lignocellulosic biomass (Fort et al., 2007; Kilpeläinen et al., 2007; Li et al., 2009, 2010; Sun et al., 2009; Zavrel et al., 2009) as the solvents have the ability to disrupt the extensive hydrogen network of the carbohydrate polymers in biomass. Through dissolution in ionic liquid, the carbohydrate polymers in the biomass is susceptible to chemical and biological transformation into biofuels and other valuable products such as enzymes and cellulose composites.

Prior to the biofuels production, lignocellulosic biomass needs to be saccharified to glucose or other fermentable sugars. Acid and enzymatic saccharifications are the two well known saccharification processes. Although they have been reported to be effective in saccharification, related shortcomings such as the need of expensive corrosion-resistant equipments and acid waste disposal problem have been encountered in acid saccharification (Dadi et al., 2006; Li and Zhao, 2007; Zhang and Zhao, 2009); while low saccharification rate and incomplete conversion of reducing sugars are common in enzymatic saccharification (Rinaldi et al., 2010). A better solution to the mentioned drawbacks could be the employment of solid acid catalyst in saccharification. The solid form of the catalyst can reduce equipment corrosion problem apart from offering facile catalyst separation from products mixture. Besides, the thermal stable solid acid catalyst enables the saccharification reaction to be conducted at higher temperature to facilitate a higher saccharification rate than the enzymatic saccharification.

Several studies incorporating both ionic liquid and solid acid catalyst in saccharification of cellulose or lignocellulosic biomass

* Corresponding author. Tel.: +60 3 7967 7691; fax: +60 3 7967 5319.
E-mail address: ngoh@um.edu.my (G.C. Ngoh).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.11.124