Bioresource Technology 120 (2012) 206–211

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Influence of nitrogen sources on ethanol fermentation in an integrated ethanol–methane fermentation system

Ke Wang, Zhonggui Mao *, Chengming Zhang, Jianhua Zhang, Hongjian Zhang, Lei Tang

The Key Laboratory of Industrial Biotechnology, Ministry of Education, School of Biotechnology, Jiangnan University, Wuxi 214122, China

HIGHLIGHTS

- ▶ Effects of anaerobic effluent and urea on ethanol fermentation were studied.
- ▶ Anaerobic effluent led to higher growth and ethanol production rates than urea.
- ▶ Anaerobic effluent can be used as nitrogen source instead of urea.

ARTICLE INFO

Article history:
Received 6 December 2011
Received in revised form 17 May 2012
Accepted 14 June 2012
Available online 26 June 2012

Keywords:
Ethanol–methane fermentation system
Two-stage anaerobic digestion
Ammonium
Urea

ABSTRACT

An integrated ethanol–methane fermentation system was proposed to resolve wastewater pollution in cassava ethanol production. In the integrated system, wastewater originating from ethanol distillation was treated by two-stage anaerobic digestion and then used in medium for the next batch of ethanol fermentation. Ammonium and other components in the effluent promoted yeast growth and fermentation rate but did not increase the yield of ethanol. Fermentations with the effluent as the nitrogen source showed higher growth and ethanol production rates (0.215 h^{-1} and 1.276 g/L/h, respectively) than urea that resulted in corresponding rates of 0.176 h^{-1} and 0.985 g/L/h, respectively. Results indicated that anaerobic digestion effluent can be used as nitrogen source for the ethanol fermentation instead of urea in the ethanol–methane fermentation system.

1. Introduction

Distillery waste generation has limited the development of cassava-based ethanol industry. Direct recycling of distillery waste has been studied (Bialas et al., 2010; Ding et al., 2009; Kim et al., 1997), but this approach faces problems. Since the distillery waste contains sand, liquid–solid separation at high temperature and low pH causes serious physical wear and chemical corrosion in the separation equipment and consumes lots of energy. By-products in the fermentation liquor such as low-carbon organic acids, glycerol, ethanol homologues (butanol, amyl alcohol and isoamyl alcohol) and other organic compounds are difficult to remove by distillation and are bound to accumulate when the wastewater is directly recycled.

To avoid some of these problems, an ethanol–methane fermentation system was developed for wastewater reutilization (Zhang et al., 2010a,b). In this process (Fig. 1), cassava starch is transformed into ethanol by fermentation while fiber, pectin, and other metabolites of *Saccharomyces cerevisiae* are converted to biogas by anaerobic digestion. The biogas can be used to produce electricity and the anaerobic digestion effluent reused in ethanol fermentation. The solid materials withdrawn from liquid–solid separation can be used as fertilizer. Zero wastewater discharge and low energy consumption are two major advantages of this process; however, the quality of the anaerobic digestion effluent can influence ethanol fermentation performance (Zhang et al., 2011; Wang et al., 2011) since the constituents of the effluent are very complex, which include the suspended substance, organic substance and inorganic salt.

In the ethanol–methane fermentation system, urea is used as an additional nitrogen source for the yeast. Since it is known that the concentration and type of nitrogen source affect yeast growth and metabolite formation (Albers et al., 1996; Ter Schure et al., 2000; Thomas and Ingledew, 1990; Torija et al., 2003), the present study examined the effects of ammonium contained in the effluent and of added urea on ethanol fermentation to further optimize the ethanol–methane fermentation system.

* Corresponding author. Address: The Key Laboratory of Industrial Biotechnology, Ministry of Education, School of Biotechnology, Jiangnan University, 1800 Lihu Avenue, Wuxi 214122, China. Tel./fax: +86 510 85918296.

E-mail address: feelingmao@yahoo.cn (Z. Mao).

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http://dx.doi.org/10.1016/j.biortech.2012.06.032