



Short communication

Evaluation of solid phase extraction for downstream separation of propane-1,3-diol and butan-1-ol from fermentation broth

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ARTICLE INFO

Article history:

Received 24 November 2011

Received in revised form 9 March 2012

Accepted 21 March 2012

Available online 30 March 2012

Keywords:

Propane-1,3-diol

Butan-1-ol

Glycerol

Chromatography

Downstream separation

ABSTRACT

Today, glycerol is mainly a by-product of fat splitting and biodiesel production. This study examined the use of chemically modified silica gels for downstream separation of propane-1,3-diol and butan-1-ol from fermentation broths obtained through the glycerol fermentation process. The developed method was found to be simple and efficient for the isolation and purification of butan-1-ol from the other components in the fermentation mixture. However, in the case of the separation of propane-1,3-diol from fermentation broth, the silica gel sorbents were ineffective.

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1. Introduction

To address energy security and climate change concerns, the EU enacted directive 2009/28/EC on 23 April 2009, setting a goal for all member countries to ensure that at least 10% of the energy used in transport comes from renewable sources by 2020. The production of biodiesel from biomass seems likely to play an important role in achieving that goal. Germany provided nearly 5 million tonnes of biodiesel production capacity in 2007 [1], but due to the significant breakdown in the market for biodiesel in Germany at the end of that year, German biodiesel plants are now operating at only 58% of their capacities. Glycerol is co-produced during the manufacture of biodiesel (via transesterification of plant oils such as rape, soya and palm oils) in a weight ratio of about 10% of the biodiesel. For example, approximately 500 thousand tonnes of glycerol was produced in 2007. The surplus of glycerol on the world market will increase further as other nations move to substitute fossil fuels with more sustainable alternatives. The price of crude glycerol decreased by 80% from 55 cents/kg in 2004 to as low as 4.4 cents/kg in 2006 [2]. Because the amount of glycerol has exceeded the current market need, biodiesel producers are requesting new methods for sustainable glycerol management. The GLYFINERY [3] project is focused on the development of a novel technology based on the biological conversion of glycerol by-products into known and new advanced liquid biofuels, bioenergy

and valuable biochemicals in an integrated biorefinery concept. In developing these goals, butan-1-ol and propane-1,3-diol (1,3-PDO) was targeted as the most promising biofuel and biochemical, respectively. Butanol is a biosynthetic alternative to gasoline. It has an energy density of 29.2 MJ/L, which is comparable to that of gasoline (32 MJ/L), an octane number of 87, can be mixed with gasoline in any percentage, or may even completely replace it [4]. A new 1,3-PDO-based polyester, poly(trimethylene terephthalate) (PTT) has received much attention because of several unique properties related to the production of fibres [5]. A number of techniques have been investigated for the more energy-efficient removal of butanol from fermentation broth [6,7]. Among these removal techniques, gas-stripping, liquid–liquid extraction, and pervaporation have been favourably considered as butanol recovery methods to be applied at a commercial level [8]. In recent studies, adsorption has also been identified as a simple technique that can be applied successfully for energy-efficient removal of butanol from fermentation broth [9]. There are numerous approaches for PDO recovery from fermentation broth [10,11]. These techniques include adsorption on activated carbon [12], as well as flocculation with chitosan and polyacrylamide, subsequent reactive extraction with butyraldehyde and reactive distillation on a strongly acidic cation exchange resin [13]. Liquid–liquid extraction was also examined with a variety of organic solvents, but the distribution coefficient of PDO in organic solvents was not high enough to make simple extraction efficient [14]. A patent application for a simple and cheap process has been filed for Du Pont de Nemour by Corbin and Norton [15]. They used zeolites in combination with a cross-flow filtration module to separate the biomass and to enrich the PDO in fermentation

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