Bioresource Technology 118 (2012) 553–562

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Batch- and continuous propionic acid production from glycerol using free and immobilized cells of *Propionibacterium acidipropionici*

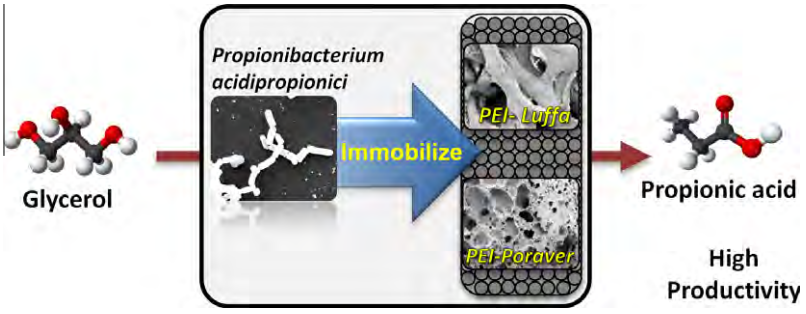
Tarek Dishisha *, Maria Teresa Alvarez [1], Rajni Hatti-Kaul

Department of Biotechnology, Center for Chemistry and Chemical Engineering, Lund University, P.O. Box 124, SE-221 00 Lund, Sweden

HIGHLIGHTS

- Polyethylenimine-treated matrices for immobilization of *Propionibacteria*.
- High propionic acid production rates from glycerol using immobilized cells.
- Establishment of stable process for repeated batch production of propionic acid.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 2 January 2012
Received in revised form 12 April 2012
Accepted 17 May 2012
Available online 24 May 2012

Keywords:
Fermentation
Platform chemical
Organic acid
Cell adsorption
Polyethylenimine

ABSTRACT

Propionic acid production from glycerol was studied using *Propionibacterium acidipropionici* DSM 4900 cells immobilized on polyethylenimine-treated Poraver (PEI-Poraver) and Luffa (PEI-Luffa), respectively. Using PEI-Luffa, the average productivity, yield and concentration of propionic acid from 40 g L^{-1} glycerol were 0.29 g L^{-1} h^{-1}, 0.74 mol_{PA} mol_{Gly}^{-1} and 20 g L^{-1}, respectively, after four consecutive recycle-batches. PEI-Poraver supported attachment of 31 times higher amounts of cells than PEI-Luffa and produced 20, 28 and 35 g L^{-1} propionic acid from 40, 65 and 85 g L^{-1} glycerol, respectively (0.61 mol_{PA} mol_{Gly}^{-1}). The corresponding production rates were 0.86, 0.43 and 0.35 g L^{-1} h^{-1}, which are the highest reported from glycerol via batch or fed-batch fermentations for equivalent propionic acid concentrations. Using a continuous mode of operation at a dilution rate of 0.1 h^{-1}, cell washout was observed in the bioreactor with free cells; however, propionic acid productivity, yield and concentration were 1.40 g L^{-1} h^{-1}, 0.86 mol_{PA} mol_{Gly}^{-1}, and 15 g L^{-1}, respectively, using immobilized cells in the PEI-Poraver bioreactor. The choice of the immobilization matrix can thus significantly influence the fermentation efficiency and profile. The bioreactor using cells immobilized on PEI-Poraver allowed the fermentation of higher glycerol concentrations and provided stable and higher fermentation rates than that using free cells or the cells immobilized on PEI-Luffa.

1. Introduction

There is a growing interest in sustainable production of chemicals from renewable resources. Propionic acid (PA), a C-3 platform chemical and its calcium-, sodium- and ammonium-salts are widely used as preservatives in feed, food and pharmaceuticals. It is also incorporated into cellulose plastics, herbicides, perfume bases and a range of other products (Rogers et al., 2006). According to the US Department of Energy, propionic acid is among the top 30 candidate platform chemicals employed as building blocks for products with various applications (Werpy et al., 2004). Industrially, propionic acid is produced from petrochemical raw materials via oxo-synthesis utilizing ethylene and carbon monoxide followed by liquid-phase oxidation of the resulting aldehyde, oxidation of propane gas or from propionitrile (Rogers et al., 2006). An alternative renewable route for its production has been extensively

* Corresponding author. Tel.: +46 46 222 8157; fax: +46 46 222 4713.
E-mail address: Tarek.Dishisha@biotek.lu.se (T. Dishisha).
[1] Present address: Instituto de Investigaciones Fármaco Bioquímicas, Facultad de Ciencias Farmacéuticas y Bioquímicas, Universidad Mayor de San Andrés, P.O. Box 3239, La Paz, Bolivia.

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.05.079