



Pervaporative recovery of ABE during continuous cultivation: Enhancement of performance

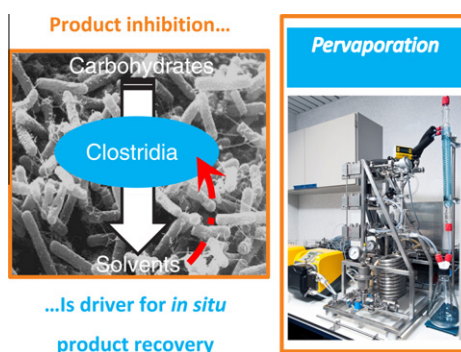
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HIGHLIGHTS

- ▶ Elevated carbohydrate concentrations lead to substrate inhibition in the first bioreactor.
- ▶ High solvent titers in the second bioreactor were beneficial for pervaporation performance.
- ▶ Hybrid design combining pervaporation and conventional downstream processing was proposed.
- ▶ Trade-off between solvent productivity and energy consumption of pervaporation.

GRAPHICAL ABSTRACT



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ABSTRACT

Acetone, butanol and ethanol were produced in a continuous two-stage fermentation integrated with pervaporation using freely suspended cells of *C. acetobutylicum* ATCC 824. PDMS composite pervaporation membranes were directly coupled to the second fermentor which lead to decreased solvent titers. Overall productivity was increased from 0.45 g L⁻¹ h⁻¹ to 0.88 g L⁻¹ h⁻¹ when increasing the carbohydrate concentration in the feed from 60 to 120 g L⁻¹. The highest overall productivity of 1.13 g L⁻¹ h⁻¹ was achieved when increasing the carbohydrate concentration further to 150 g L⁻¹ even though productivity decreased significantly in the first fermentor due to substrate inhibition. In this phase that lasted 200 h, the average flux reached 0.621 kg m⁻² h⁻¹ and the total solvent concentration in the permeate was 202 g L⁻¹. High solvent titers in the second fermentor were beneficial for the performance of the pervaporation unit leading to higher fluxes and total solvent concentrations in the permeate.

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1. Introduction

The ABE fermentation using clostridial strains has been widely studied before. At the first half of the twentieth century, two thirds of the n-butanol was produced biotechnologically before it was gradually replaced in the 1950s and 1960s with the more competitive petroleum derived n-butanol. A first revival in biobutanol research occurred after the oil crisis in 1973. Today, large scale

butanol fermentation is poised for re-introduction. The depletion of today's fossil fuel stocks, the fluctuations in fossil fuel price and security of energy sources are the impetus of the current revival in biobutanol production as substitute for petroleum-derived commodity products and fuels. N-butanol is an important commodity chemical used as a solvent while it is also converted to acrylates, ethers and butyl acetate. It provides a viable commercial market outlet that allows for biobutanol production to gain a foothold (Harvey and Meylemans, 2011). In addition, biobutanol holds great promise as a second-generation biofuel. It has a considerably higher combustion value than ethanol and its chemical properties allow blending in fuels more readily than ethanol, therefore it can

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