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Acetone-Butanol-Ethanol continuous process: a comparison between two-stage reactor and one-stage coupled with repeated batch reactor

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Introduction

The biological production of butanol from anaerobic fermentation of *Clostridium acetobutylicum* bacteria is an alternative to the current chemical synthesis. Classical batch fermentation is governed by low total ABE (acetone, butanol, ethanol) solvent (15-20 g/l), low yield <0.2 g/g glucose, productivity <0.3 g/l/h and high butanol toxicity from 1%. Continuous fermentation has been shown to improve productivity but results in an unstable process. A comparison is made between a continuous two-stage reactor process and a one reactor stage coupled with a second reactor operated as a repeated batch.

Experimental

C. acetobutylicum growth follows a biphasic nature. The first stage entails cell growth also associated with the formation of weak carboxylic acids (acetic and butyric), a decrease in pH and an accumulation of acids. At low pH, from 4.5 to 4, the switch to the second growth stage occurs where reassimilation of acids to form ABE solvent takes place. The developed process shown in Figure 1 below, shows the partitioning of the two growth phases, both optimized for acids and solvent formation respectively.

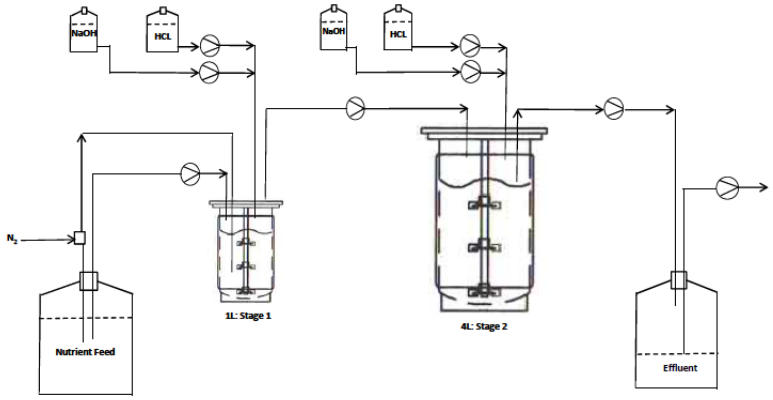

Figure 1: Schematic diagram of the two-stage reactor used for continuous fermentations

Stage 1 is conducted at T=35°C, pH =4.5 and D= 0.1 h^{-1} and the second stage 2 is conducted at T=35°C, pH =4.5 and D= 0.04 h^{-1}.

Results and Discussion

The high dilution rate D≥ 0.1 h^{-1} favour acid production, Figure 2 Stage 1. The process resulted in a 96% overall glucose usage. Higher ABE production of 14.6 g/l (butanol at 9.5 g/l) was achieved at dilution rate, D_2 =0.04 h^{-1}. The overall productivity was 0.58 g_{ABE}/l/h comparable to existing processes.

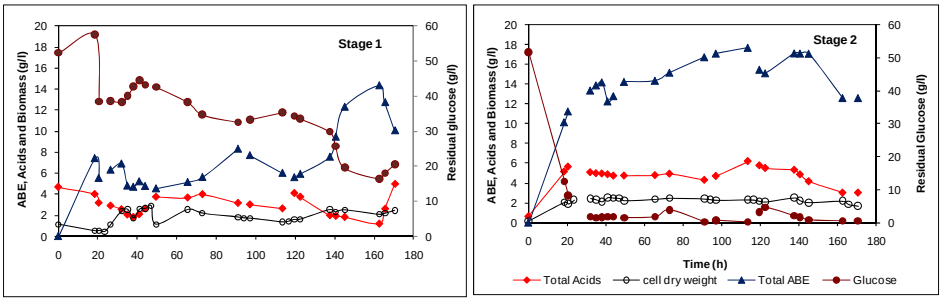

Figure 2: Kinetics of a two-stage reactor continuous fermentation of *C. acetobutylicum* ATCC 824

Operating second reactor stage as a repeated batch with continuous feed from stage 1 results in complete glucose utilization and 12 g/l butanol production.

Conclusions

Two-stage continuous fermentation contributes to process stability but not productivity. Second reactor stage operated as a repeat batch shows great potential for improving overall substrate utilization. Productictivity could be significantly improved with cell retention in the second reactor stage. Preliminary cell retention has been investigated with a loofa sponge (*loofa cylindrica*), which is a cheap, available, natural material.