Mathematical modeling and simulation of batch acetone-butanol fermentation with immobilized cells of *Clostridium acetobutylicum*

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ABSTRACT

A comparative study of batch fermentation of butanol production is conducted to select the best carrier and the optimum conditions using a locally manufactured fermentor in an NRC workshop. A mathematical model describing this process was developed for 3 investigated cases ; free cells, immobilized cells using Ca-alginate and charcoal as carriers. The experimental results are used to determine the kinetic parameters of biocatalyst for the 3 mentioned cases: r_{sm} = 50, 80 and 100 kg/m^3.day and C_{bmax} = 15, 23 and 8 for free cells, immobilized on Ca-alginate and immobilized on charcoal cells respectively. The findings of this article show that the immobilized system of Ca-alginate carrier gives the maximum acetone-butanol production rate.

Keywords: *Clostridium acetobutylicum, acetone-butanol fermentation, solid carriers, cell immobilization*

INTODUCTION

Many years ago, several studies had focused on the fermentation of acetone and butanol with the objective of developing a low cost production process.

The acetone-butanol fermentation is subjected to strong product inhibition, which effects adversely the economics of the process. However, the effect of the end product inhibition can be reduced by in situ removal of the toxic metabolites from fermentation broth. Thus, the product inhibition during the acetone-butanol fermentation could be reduced by extractive fermentation wherein maximum butanol productivity was increased by 60% compared to the regular fermentation technique (Roffler *et al.*, 1987, 1988 and Ezeji *et al.*, 2003). Furthermore, several attempts had examined the activity of the cell immobilization technique either by entrapment or by adsorption for the production of acetone-butanol by *Clostridium acetobutylicum* (Welsh *et al.*, 1987, Qureshi and Blascheck, 2001). Carbohydrates have been used to entrap *C. acetobutylicum* cells (Haggstrom and Molin, 1980; Haggstrom and Enfors, 1982 and Haggstrom, 1985). While solid carriers such as beechwood shavings (Furberg and Haggstrom, 1985), charcoal (Bahadur and Saroj, 1960) and bone char (Ennis *et al.*, 1987) have been used for adsorptive cell attachment.

Previous studies in NRC's laboratory have shown that the production of n-butanol and acetone by a local *Clostridium*