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Effect of pressure and temperature on alcoholic fermentation by *Saccharomyces cerevisiae* immobilized on γ-alumina pellets

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ABSTRACT

Saccharomyces cerevisiae was immobilized on γ-alumina pellets and used for repeated batch fermentations in glucose medium (16.5 g/100 mL) at various temperatures and pressures. An increase in pressure from 3 to 7 atm and a decrease in temperature from 30 to 20 °C reduced the ethanol productivity by about 50% and 70%, respectively. Increasing concentrations of volatile by-products were observed at lower fermentation temperatures, while the pressure influence on the concentrations of these by-products was proved to be more complex. Mathematical expressions were established to allow the calculation of the fermentation rate at various pressures and sugar concentrations when the corresponding rate at atmospheric pressure is known. The study showed that the height of bioreactors has to be limited to 19.5 m due to hydrostatic pressure shock at higher fill levels.

1. Introduction

Cell immobilization has been proposed as means to enhance the stability of yeast against physicochemical stress during fermentation, increase productivity, and improve the quality of the final product (Kourkoutas et al., 2004; Kosseva, 2011; Reddy et al., 2011). Nano- and microporous materials such as γ-alumina, kissiris (a volcanic and foaming siliceous rock), and cellulosic materials have been evaluated as cell immobilization supports to accelerate alcoholic fermentation of waste effluents (Golfinopoulos et al. 2011; Plessas et al., 2007; Kourkoutas et al., 2002). It is well-established that increased temperatures (up to 32 °C) increase the activation of immobilized cells and decrease the fermentation time (Mallouchos et al., 2003; Kourkoutas et al., 2004); however, reports dealing with the effect of pressure on immobilized cells during alcoholic fermentation are limited.

Mallouchos et al. (2002) studied wine fermentation using yeast immobilized on grape skins and kinetic data were integrated using the Runge–Kutta method and the least squares approach. Staniszewski et al. (2009) developed a model for the simulation of product recovery using pervaporation and semi-continuous ethanolic fermentation in whey by co-immobilized *Saccharomyces cerevisiae* and β-D-galactosidase. Modeling of fermentation processes induced by immobilized cells can help increase product quality, minimize time-to-market and decrease environmental impacts (Kosseva, 2011).

The objective of the present investigation was to study the effects of pressure and temperature on alcoholic fermentation of glucose by commercial baker's yeast (*S. cerevisiae*) immobilized on porous γ-alumina pellets. Experiments were conducted in batch mode and the effects of pressure and temperature on the fermentation kinetics as well as on the production of volatile compounds were evaluated. The results were analyzed following the differential method (Levenspiel, 1999) to correlate fermentation rate with pressure and temperature. Finally, potential industrial applications of the study outcomes are proposed.

2. Methods

2.1. Microorganism, support and media

Commercial baker's yeast (*S. cerevisiae*) (ZANAE S.A., Greece) was used in the fermentation experiments. Cylindrical γ-alumina pellets (γ-Al_2O_3, AKZO, Alumina Extrudates, HDS-000-1.5 mm E, 250 m^2g^{-1} specific surface area, 10 mm length, 1.5 mm diameter, 0.7 cm^3/g pore volume) were used as immobilization support. Glucose media consisting of (g/L): $(NH_4)_2SO_4$ 0.1, KH_2PO_4 0.1, $MgSO_4{\cdot}7H_2O$ 0.5, yeast extract 0.4, and glucose monohydrate 113 or 165, were used for yeast immobilization or for alcoholic fermentation experiments, respectively. All media were sterilized at 130 °C for 20 min.

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