Patel Manojkumar, MESc, “Development of Dual-Particle Liquid Solid Circulating Fluidized Bed (DP-LSCFB) Fermenter for Lactic Acid Production”, The University of Western Ontario, December 2006.

Abstract

Lactic acid is an organic acid and is widely used in different applications for years. Lactic acid is also a precursor for most promising biodegradable polymer. In the past two decades, biological production of lactic acid is growing exponentially and leads to major interest for researchers. However, the biological production of this enigmatic chemical is associated with problems of product inhibition and separation. Many reactor systems and separation technologies have been proposed but discovery is by far from ending. Fluidized bed reactors have many advantages over fixed bed and continuous stirred tank reactors, such as better heat and mass transfer.

A new and even better reactor system, liquid-solid circulating fluidized bed is gaining importance owing to its ability to carry out two reactions in a single reactor system. Such reactor is highly favorable for biological processes so as it gives potential for lactic acid production.

In this study, a novel liquid-solid circulating fluidized bed (LSCFB) bioreactor is developed for the fermentative production of lactic acid. In this system, ion exchange is used for in-situ removal of lactic acid so as to control the pH of fermentation so as to eliminate product inhibition without using any conventional pH control. As a primary step in this development, proper ion exchange resin needs to be selected. Amberlite IRA-67 ion exchange resin is selected for this reactor system among five tested resins. Detailed kinetic study of lactic acid ion exchange is carried out using Ambelite IRA-67 to test its susceptibility to different parameters such as the presence of other ions, lactic acid concentration, and temperature. Rates of adsorption and desorption are studied and it was found that majority of lactic acid adsorbs in initial 10 minutes while taking 24 hrs to reach equilibrium. Desorption rate is found faster than adsorption. Based on this kinetics and batch fermentation kinetics, a novel type of liquid-solid circulating fluidized bed is designed. This LSCFB works with two types of particles, one is ion exchange resin and another is calcium alginate immobilized bacteria. Downer is used for fermentation and adsorption purpose and riser is used here for recovery of lactic acid.

This dual particle liquid-solid circulating fluidized bed (DP-LSCFB) is then first studied for lactic acid ion exchange using different lactic acid concentration and with different strength of regeneration stream. These studies showed that even with high flowrate of lactic acid feed having 8 g/L concentration, the DP-LSCFB is able to maintain desired fermentation pH in the downer fermentation zone. Thus in-situ removal of lactic acid during fermentation is possible using the DP-LSCFB fermenter. The adsorption efficiency was found high.

After assuring the ion exchange of lactic acid, fermentative production of lactic acid was performed in the DP-LSCFB. The results show reliably that the DP-LSCFB is suitable for fermentation of lactic acid. Thus, a novel dual-particle liquid-solid circulating fluidized bed is developed and proves to be potential fermenter.