Trivedi Umang, Ph.D., “Biotechnological Applications of Liquid-Solid Circulating Fluidized Bed”, The University of Western Ontario, May 2006.

Abstract

Fluidized beds offer a beneficial alternative to fixed bed and stirred tank bioreactors as they provide better heat and mass transfer and the possibility to treat unfiltered biological broths directly. In particular, the liquid-solid circulating fluidized bed (LSCFB) system has been applied recently to investigate biotechnological applications such as continuous ion exchange recovery of proteins. The LSCFB consists of two columns; the riser and the downcomer and under certain operational conditions can handle two liquid streams without inter-mixing while allowing solid (catalyst) particles circulated between the two columns simultaneously and continuously. A capability of handling two distinct processes in one system and a flexibility of interchanging the processes within two columns of LSCFB with an independent control makes the system an attractive reactor for many biotechnological processes where a regeneration of the solid catalyst is needed.

In this study, a liquid-solid circulating fluidized bed system has been successfully demonstrated for the first time as an immobilized bioreactor system for the enzymatic polymerization of a phenolic stream. The reaction proceeds in the presence of an immobilized soybean seed-hull peroxidase (SBP) enzymes and a reactant stream of H2O2. A continuous regeneration of the biocatalysts was carried out simultaneously and independently in two columns of the LSCFB system. In the LSCFB system, the enzymatic process was carried out in the riser and the regeneration of the immobilized enzyme particles coated by polyphenol was performed in the downcomer. The solid biocatalysts were fabricated by entrapping the soybean peroxidase (SBP) enzymes within the hybrid structure of sol-gel and calcium-alginate system. The effect of operating conditions and the hydrodynamics was investigated for the continuous enzymatic phenol polymerization. Under optimized hydrodynamic conditions and by keeping the molar concentration ratio 1 : 2 of phenol to H2O2; 54% conversion of phenol was achieved.

In addition, in this study, a scale-down twin-riser LSCFB system has been proposed and demonstrated for continuous protein refolding. This system represents a completely new approach of handling three liquid streams of different properties without mixing with each other under an appropriate operating window. A continuous uptake of denatured lysozyme protein on the ion-exchange resin particles, followed by in-vitro protein refolding and the regeneration was successfully demonstrated in the twin-riser liquid-solid circulating fluidized beds system. A dynamic protein adsorption rate was determined to be 84% at a loading rate of 72 mg/h in the downcomer. An overall refolded protein recovery was found to be approximately 47% with protein desorption ratio of 0.58 in the system. An amount of 16.8 mg protein was refolded per hour in the twin-riser LSCFB reactor system and an overall productivity was determined as 21 mg/h•g. The designed LSCFB system can be applied to many other recombinant protein production processes, immuno-adsorption processes and clinical processes. Finally, the scale-up and scale-down criteria for designing the LSCFB system for this application has been outlined and discussed in this study.