CURRENT RESEARCH AND DEVELOPMENT IN BIOTECHNOLOGY ENGINEERING AT IIUM

VOLUME III

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Md. Zahangir Alam
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CHAPTER 21

DIFFUSION-REACTION OF NUTRIENT IN IMMOBILIZED SLAB BIOCATALYST FOR FIRST AND ZERO ORDER REACTIONS

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ABSTRACT

The effect of nutrient diffusion on the overall reaction rate inside porous slab biocatalyst containing an immobilized enzyme or cells has been investigated theoretically. Zero-order and first-order kinetics were studied. The problem is represented in mathematical model developed using shell mass balance on the thin slab of biocatalyst. The second order differential equations developed for zero and first order kinetics are solved analytically to find the concentration profile inside the slab biocatalyst. The concentration profile is obtained as a function of Thiele modulus which in turn was used to evaluate effectiveness factor. From the analysis, high diffusion rate of substrate into the porous area increased the concentration profiles and effectiveness factor.

Keywords: immobilized biocatalyst, effectiveness factor, Thiele modulus, approximate solution, slab geometry.

INTRODUCTION

Reaction involving solid (e.g., immobilized enzyme/cell) and liquid (substrate) phases is important in bio-processing. Immobilized biocatalyst is a solid support that trapped cells or enzymes in a porous and relatively soft gel allowing diffusion of reactants and products to and from the interior of the particle. For the purpose of using this biocatalyst effectively, kinetics behaviour of immobilized enzyme or cell is studied which provides a better insight into the function of certain biological membrane (Bischoff, 1965). The use of immobilized biocatalyst pellets offers several advantages over free enzymes/cells such as long-term continuous operation and significant yield enhancement due to the repeated use of the biocatalyst (Doran, 1995). Generally in biological reactions there is no large temperature gradient thus the rate of reaction depends on the mass transfer outside or within the solid catalyst due to the concentration difference of the substrate. If the pore size is small, convection can be neglected and thus only diffusion is taken into consideration. This assumption helps in simplifying the overall model equation (Doran, 1995). Slab geometry is chosen because it can be used with reasonable accuracy to approximate a sphere in the limit of very small thickness of the immobilized layer of enzymes/cells relative to the large radius of sphere. There are 3 general reaction kinetics in biological reactions; zero-order, first-order and Michaelis-Menten. Here