9.4. IMMOBILIZED CELL SYSTEMS

9.4.1. Introduction

Immobilization of cells as biocatalysts is almost as common as enzyme immobilization. Immobilization is the restriction of cell mobility within a defined space. Immobilized cell cultures have the following potential advantages over suspension cultures.

1. Immobilization provides high cell concentrations.
2. Immobilization provides cell reuse and eliminates the costly processes of cell recovery and cell recycle.
3. Immobilization eliminates cell washout problems at high dilution rates.
4. The combination of high cell concentrations and high flow rates (no washout restrictions) allows high volumetric productivities.
5. Immobilization may also provide favorable microenvironmental conditions (i.e., cell–cell contact, nutrient–product gradients, pH gradients) for cells, resulting in better performance of the biocatalysts (e.g., higher product yields and rates).
6. In some cases, immobilization improves genetic stability.
7. For some cells, protection against shear damage is important.

The major limitation on immobilization is that the product of interest should be excreted by the cells. A further complication is that immobilization often leads to systems for which diffusional limitations are important. In such cases the control of microenvironmental conditions is difficult, owing to the resulting heterogeneity in the system. With living cells, growth and gas evolution present significant problems in some systems and can lead to significant mechanical disruption of the immobilizing matrix.

In Chapter 3 we discussed enzyme immobilization. Figure 3.16 provides a useful summary of immobilization strategies. Many of the ideas in enzyme immobilization have a direct counterpart in whole cells. However, the maintenance of a living cell in such a system is more complex than maintaining enzymatic activity. The primary advantage of immobilized cells over immobilized enzymes is that immobilized cells can perform multistep, cofactor-requiring, biosynthetic reactions that are not practical using purified enzyme preparations.

9.4.2. Active Immobilization of Cells

Active immobilization is entrapment or binding of cells by physical or chemical forces. The two major methods of active immobilization are entrapment and binding.

Physical entrapment within porous matrices is the most widely used method of cell immobilization. Various matrices can be used for the immobilization of cells. Among these are porous polymers (agar, alginate, κ-carrageenan, polyacrylamide, chitosan, gelatin, collagen), porous metal screens, polyurethane, silica gel, polystyrene, and cellulose triacetate.