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Design of Microfluidic enzymatic reactors for Biocatalytic reactions

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INTRODUCTION:

Miniaturization can significantly enhance the productivity of some chemical reactions. Miniaturization helps diffusion-limited reactions to occur faster than they would at the larger scale. Of particular interest is the potential for high throughput experimentation for rapid screening of reactions, determining kinetics, exploring hazardous chemistry and developing chemical reactions[1]. The aim of this study is to design a microfluidic system, for rapid screening, that can mimic or improve the performance of the reaction at larger scale using biocatalytic transamination as a model reaction (Fig. 1).

Fig 1: Biocatalytic transamination

The main challenges of the biocatalytic transamination are: (1) an unfavourable thermodynamic equilibrium position, necessitating processes to shift the equilibrium; (2) substrate and product inhibition; (3) low substrate solubility, giving low volumetric productivities; (4) high biocatalyst cost[2].

MICROFLUIDIC SYSTEM:

We attempt to design a microfluidic system taking the above challenges into consideration and study the performance of this reaction. An aqueous/organic segmented flow, microchannel system is designed and tested. A simple Y shaped micro-mixer has been fabricated where two inlet fluids, organic and aqueous phase, join at a junction creating alternate fluid segments. Fig 2 shows the influence of diffusion on the flow behaviour, modelled using CFD. Different reaction conditions have been studied simultaneously due to a micro-milling based parallel fabrication of the flow system. The focus has been on the user-friendliness of the system in order to perform rapid screenings. Some specific issues requiring careful consideration while developing such microsystems for biocatalytic reactions will be discussed: surface modifications, control of fluid behaviour in micro-channels and detection limitations[1].

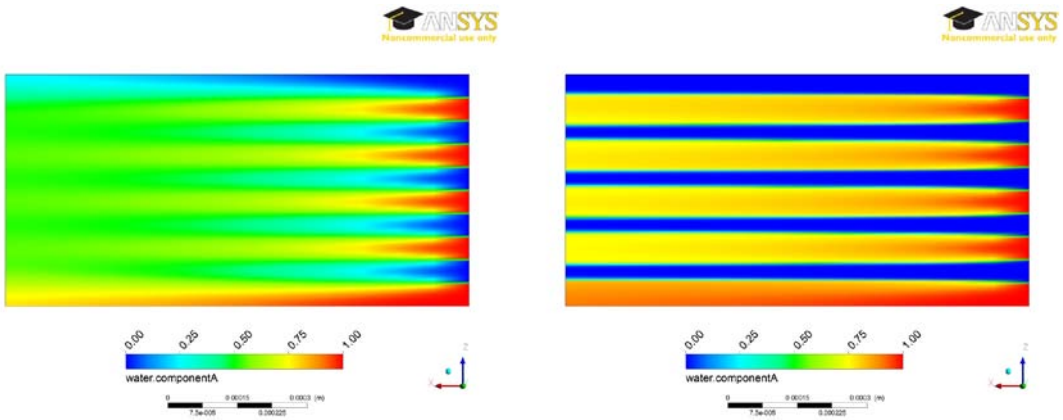

Fig 2: CFD simulation of a two phase flow with fast and slow diffusion rates of components

The substrate inhibition can be reduced by introducing an auxiliary phase in the form of a solid resin instead of the organic solvent. A solid resin has more advantages than organic solvents[3]. The slow release of the substrate will maintain the concentration below the inhibitory levels. It is very critical to select the appropriate adsorbent as the rate of release of the substrate should complement the rate of reaction. The microfluidic system can be used for rapid screening of resins.

The micro-mixer is to be used for a) screening of various organic solvents; b) studying the reaction rate - mass transfer rate limitations (Damköhler number); c) conducting experiments with varying process conditions like flow velocity, enzyme concentration and phase ratio; d) screening of different resins. CFD (computational fluid dynamics) modelling has been used to study the different reactor formats. This system is expected to give better understanding of the rate limitations, rapid screening of organic solvents and process conditions.

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