Biofilm Kinetics in an Airlift Reactor

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A mathematical model based on the porous-catalyst model has been frequently used to describe the diffusion-reaction phenomena occurring in a biofilm. The main goal of the present work was to apply this model to biofilms developed in an airlift reactor operating at different substrate concentrations, in order to obtain the concentration profiles and the values of the Monod kinetic parameters (μ_{max} and K_S) within the microbial films. An additional purpose was to verify whether the kinetic behaviour of microorganisms in biofilms differed fundamentally from that in a homogeneous suspension.
The porous catalyst model had to be adjusted to incorporate the experimental values of the mass transfer coefficients measured in a special flow cell. It was assumed that the biofilm activity followed a Monod-type kinetics and appropriate numerical methods (1) were developed to solve the differential equations thus obtained. The input data to this model were: substrate concentrations, substrate uptake rates (r_f), biofilm thickness values (L_f) and mass transfer coefficients within biofilms.
In this work, thin biofilms of *Pseudomonas fluorescens* were grown in a concentric-tube airlift reactor with suspended basalt particles. Biofilm characteristics were determined in several assays with different glucose concentrations. During these experiments, r_f and L_f were also measured. The experimental data were then introduced in the model and the results obtained clearly demonstrate that all biofilms were completely penetrated by the substrate, as expected in thin and highly active microbial layers (Figure 1). This suggests that the **B**iofilm **A**irlift **S**uspension **R**eactor (BAS Reactor) is a promising technology for aerobic treatment, since it can maintain highly active biomass, achieved by growing thin biofilm on small carriers. The constant K_s (0.73×10^{-3} kg/m^3) obtained from the model was significantly lower than the one measured in a suspended culture (6.21 kg/m^3), while μ_{max} (0.24 h^{-1}) was similar to the suspended value (0.31 h^{-1}). Taking into account the K_s value and the concentration profiles, it may be concluded that the reaction inside the biofilm is of zero order. The model fitting was good, as confirmed by the similarity between the experimental and calculated values of the substrate uptake rates (Table 1).

Table 1. Substrate uptake rates and biofilm thickness values at different glucose concentrations

Glucose (mg/L)	L_f (μm)	$r_{f,experimental}$ (kg/m$^2_{Biofilm}$ s)	$r_{f,model}$ (kg/m$^2_{Biofilm}$s)
13.5	7	3.155×10^{-8}	1.513×10^{-8}
31.0	36	6.450×10^{-8}	8.206×10^{-8}
42.0	38	8.335×10^{-8}	8.754×10^{-8}
76.5	69	19.000×10^{-8}	16.05×10^{-8}
100	105	23.25×10^{-8}	24.54×10^{-8}

(1)Vieira, M.J., Melo, L.F., Monteiro, M.T., Fernandes, M.E., Biotec' 98, 1998.

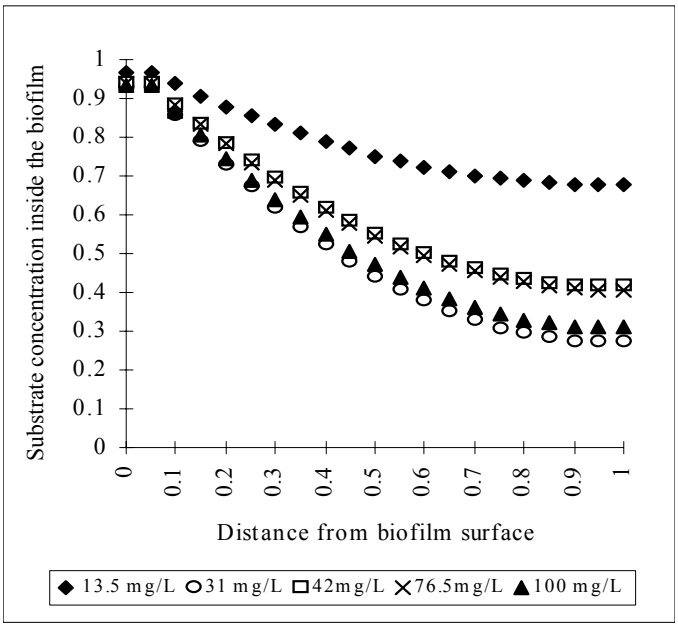

Figure 1 - Concentration Profiles