# Kinetic Parameters and Mass Transfer Coefficients in *Pseudomonas fluorescens* Biofilms

**F.A. Lopes, M.J. Vieira, L.F. Melo**
Centro de Engenharia Biológica - IBQF, Universidade do Minho, 4700 Braga, Portugal

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Much effort has been put into modeling all the phenomena occurring in biofilms in order to predict biofilm behaviour in different situations. In fact, predicting is necessary and useful for ecosystem analysis, proper design and scaling-up, waste water treatment plant design and operation, and for determining the feasibility of biofilm reactors in a large number of biotechnological applications. A theoretical model developed for heterogeneous catalysis has been frequently used to describe diffusion-reaction mechanisms that take place inside a biofilm.

The general purpose of this research is to determine the Monod kinetic parameters ($\mu_{max}$ and $K_S$) and the concentration profiles within *Pseudomonas fluorescens* biofilms developed under different limiting substrate conditions in an airlift reactor with basalt particles. Furthermore, it is expected to obtain some information about the activities of the microorganisms in a microbial film in comparison with those in a homogeneous suspension.

In this mathematical model, a Monod kinetics was used to describe the substrate uptake rate by the biofilm and appropriate numerical methods were applied in order to solve the differential equations developed. Besides, an adjustment was made in order to incorporate experimental mass transfer coefficients determined in a flow cell system operating in similar velocity conditions (between 0.28 and 0.63 m/s) to those of the airlift reactor. Measurements were carried out with an inert tracer (LiCl). Although biofilm thickness decreased with increasing velocity, steady-state mass transfer coefficients were approximately the same in all tests (therefore, the diffusivity was lower in the thinner and more compact biofilms).This coefficient takes into account all the mechanisms of mass transport occurring in the matrix.

To obtain the concentrations profiles within the biofilms and the Monod kinetic parameters, experimental data of steady-state substrate consumption, biofilm thickness, mass transfer coefficient and bulk substrate concentration were required. Biofilm development was followed in several assays using different limiting substrate concentrations (glucose) and liquid velocity of 0.26 m/s. Substrate uptake rates and thicknesses were measured.

Results provided by the model clearly show active biofilms, completely penetrated. This result confirms the advantage of using biofilm airlift suspended reactors for aerobic treatment since it is possible to obtain highly active biomass concentrations, leading to high volumetric conversion rates. Moreover, the turbulent conditions prevent the development of too thick and partially active biofilms.

The kinetic parameters estimated ($K_s$ = $0.73\times10^{-3}$ kg/m$^3$ $m_{max}$ = 0.24 h$^{-1}$) differed from those obtained in a suspended culture ($K_s$ = 6.21 kg/m$^3$, $m_{max}$ = 0.31 h$^{-1}$), especially the Monod saturation constant. Microorganisms are subject to different environments within a biofilm so their activities may be significantly altered from those in a dispersed culture. Taking into account the concentrations profiles and the Monod saturation value, a zero order reaction is expected to occur within the studied biofilms.

Finally, the validity of the model was verified comparing its predictions of the substrate uptake rates to the corresponding experimental data.