Supplementary Material S2 to Mass Transfer Enhancement in Moving Biofilm Structures

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Effect of Decreased Solute Diffusivity in the Biofilm

In the model set up used throughout this study it has been assumed that the diffusion coefficient in the biofilm D_B is equal to that in the liquid, D. This assumption was made only for simplicity of the model analysis, as there is no further difficulty in model implementation when the diffusion coefficients are different in the Ω_F and Ω_B sub-domains. For low biofilm densities (10-20 kg dry weight/m^3 biofilm) a maximum of 50 % reduction in diffusivity is common for small molecules (such as oxygen) or elemental ions (Na^+, Cl^-, etc.), while for larger biofilm densities (20-35 kg dry weight/m^3 biofilm) $D_B = 0.4D$ to $0.8D$ (Horn and Morgenroth, 2006). Therefore, to test the influence of a reduced diffusion rate in the biofilm region, compared with the one in bulk liquid, we also conducted model runs with $D_B = 0.5D$.

The calculated overall Sherwood number was slightly larger when $D_B = 0.5D$ than when $D_B = D$, both in static and in oscillatory biofilms (Fig. S2.1). The maximum relative increase in $\overline{Sh}$ due to streamer movement was 11 % when $D_B = D$ and 12 % for $D_B = 0.5D$. Since the calculated change in $\overline{Sh}$ was very similar with or without 50 % decreased diffusion coefficient in the biofilm, we decided to simplify the model construction and, most importantly, the model analysis by studying only the case when $D_B = D$.

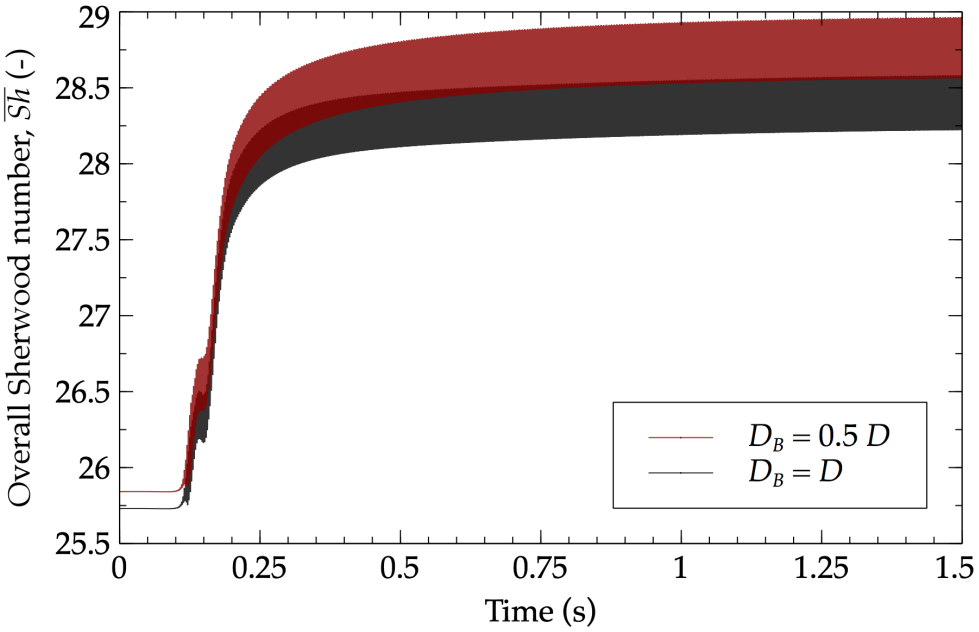

Figure S2.1: Change in the liquid-biofilm mass transfer of solute from static condition to steady oscillatory regime, as characterized by the overall Sherwood number $\overline{Sh}$. Black line: model results for equal solute diffusion coefficients in biofilm and liquid ($D_B = D$); red line: model results for 50 % decreased solute diffusivity in the biofilm ($D_B = 0.5D$). Simulations performed in standard conditions, with $E_B = 4000$ Pa and $u_0 = 0.4\ \mathrm{m \cdot s^{-1}}$.

Reference Horn, H., and E. Morgenroth. 2006. Transport of oxygen, sodium chloride, and sodium nitrate in biofilms. *Chemical Engineering Science*. 61(5):1347-1356.