MFBM, Class Exercise 3, 3.2.2021

1. Diffusion

a) The dye Brilliant Blue FCF (E133) has a diffusion coefficient about $5* 10^{-10}$ m^2 s^{-1}. This unit is not very useful for understanding microsystems. Write the diffusion coefficient instead in units of cm^2 s^{-1} and μm^2 s^{-1}.

b) In exercise 1 we were looking at a microchannel which had width and height 100 µm and length 2 cm. We calculated that with volumetric flow rate of 0.25 µl/min, the average linear velocity was 400 µm/s. What is the average residence time of a liquid element in the channel? (t = L/v, length of the channel divided by the average linear velocity).

c) In the same amount of time, estimate how far the dye travels in one dimension by diffusion. For 1D diffusion: $<x^2> = 2Dt$.

d) Based on your result and the channel dimensions, estimate whether the channel will be a diffusive mixer, or whether there are two parallel laminar flows that largely do not mix, or whether a gradient will form.

Bonus: change the dimensions or flow rate to get full mixing or (practically) no mixing

2. Adsorption

a) You are designing a chip to analyze a medium sized protein. Your chip is made from a polymer that is slightly hydrophobic (Advancing contact angle 95°, receding contact angle 79°). The chip will adsorb a monolayer of proteins with a thickness of 2 nm. You can assume that the density of the adsorbed protein layer is $1 g/cm^3$.

If the channel dimensions are once again 100µm width and height and 2 cm length, how big problem is adsorption if the total amount of protein in the sample is 1 ng, 100 ng or 10 µg.

b) What would be possible solutions to the problem of adsorption in that kind of chip?

Bonus:

c) Single molecule analysis. You want to analyze very low concentrations of the above protein, up to single molecule sensitivity. To limit adsorption, an anti-adsorption PEG (polyethyleneglycol) coating is used and the chip is made as small as possible which in this case is 10 µm width and height and 2 mm length. If we assume that the coating prevents 99.999% of adsorption, will you be able to reliably do single molecule analysis? The size of the protein is 50 kDa.