Analyte Capture From Liquid Samples: Size Matters

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Abstract

Arrays of vertical pillars functionalized with antibodies have been widely used for analyte capture from liquid samples, i.g. quantification of analyte concentration in fluorescent assays [Henderson et. al, 2006], capture cells [Toner et. al, 2007, Nature].

These array, also known as, Micro Purification Chips, have shown promising results [Stern et. Al 2010], 10% capture efficiency, when applied as upstream filtration devices for direct cancer marker detection from whole blood.

Many applications of pillar arrays have been reported [Hwang et. al, 2011], however exact understanding of the capture efficiency mechanisms has not been previously explained.

Here we present a model created in COMSOL Multiphysics® which allows exact calculation of capture efficiency based on initial conditions: pillar size and density, flow rate and analyte binding constant. The model uses the chemical reaction engineering module, microfluidics module and the Navier-Stokes equation to solve the time-dependant analyte concentration after passing a pillar array at given flow conditions.

Here we report that depending on the choice of pillar size and density the analyte capture efficiency can vary from 10% to more than 99.999%.

Figure 1. shows analyte capture on three different pillar sizes: 2um, 4um and 10um. In the same microchannel geometry with varied only the pillar size the capture efficiency, where the capture efficiency is defined as the number of analyte molecules remaining in solution after the sample passes the array devided by the initial number of analyte molecules, varies from 10^3 to 10^{13}, which is a span of 10 orders of magnitude. Figure 2 shows 10% capture efficiency on 100um large pillars.
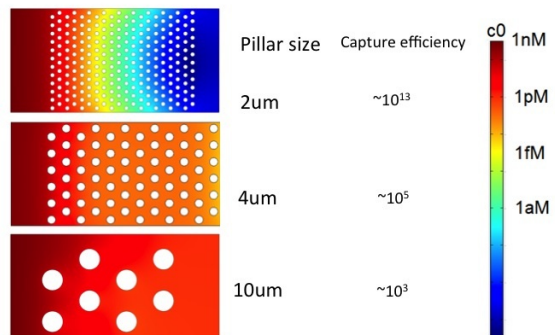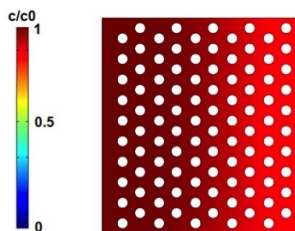
Figures used in the abstract

Figure 1: Analyte capture on pillar arrays: Top - 2um pillars, midlle – 4um pillars, bottom 10um pillars.

Figure 2: Analyte capture on 100um size pillars.