Simulations of Lateral Flow and Vertical Flow Microarray Assays for Point of Care Diagnostics

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Introduction: Computer simulations can facilitate the development of microarray assays by predicting how parameters such as analyte concentration, flow rate and spot size affect the system. Our lab has developed models for lateral and vertical flow assays as a complement to our practical lab work.

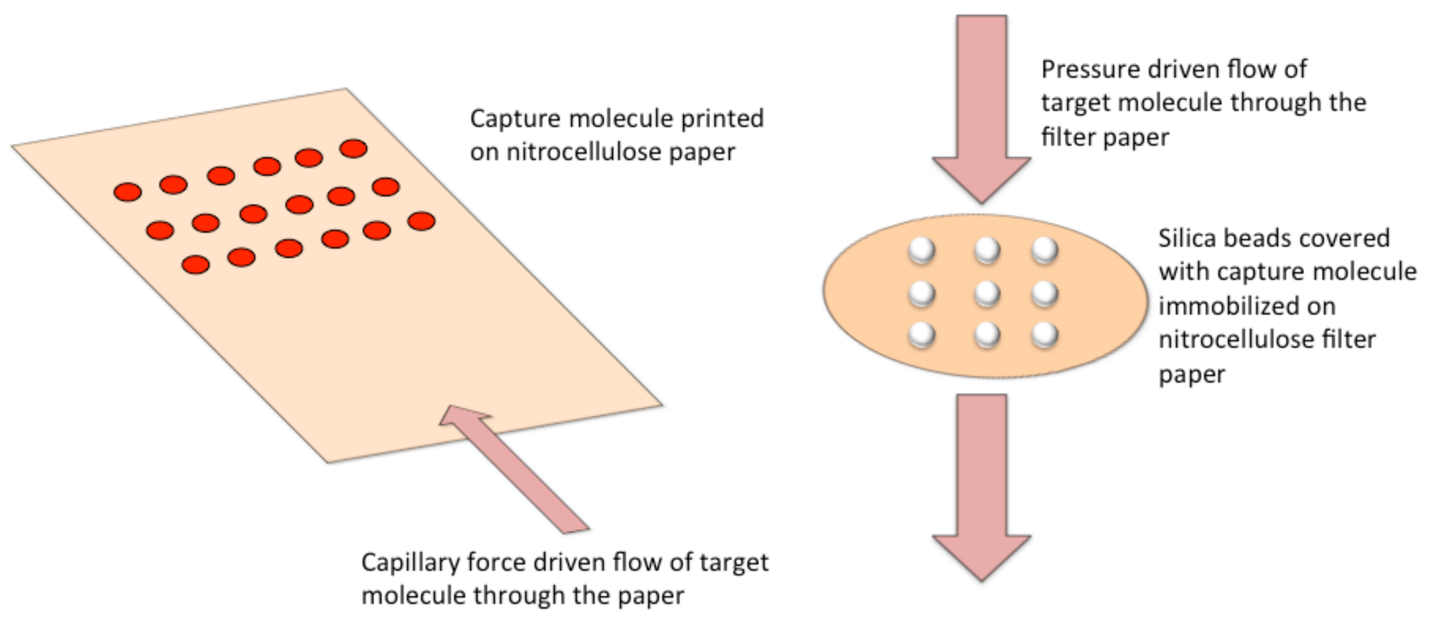

Figure 1. Overview of vertical flow and lateral flow microarray assays.

Computational Methods: Microarray spots/spheres are assigned a given concentration of binder B. Analyte A is brought to these spots/spheres via convection and the following reaction takes place:

$A+B \rightleftharpoons AB$

Model parameters that can be controlled include spot/sphere size, binder/analyte concentration, on and off binding rate constants and flow rate.

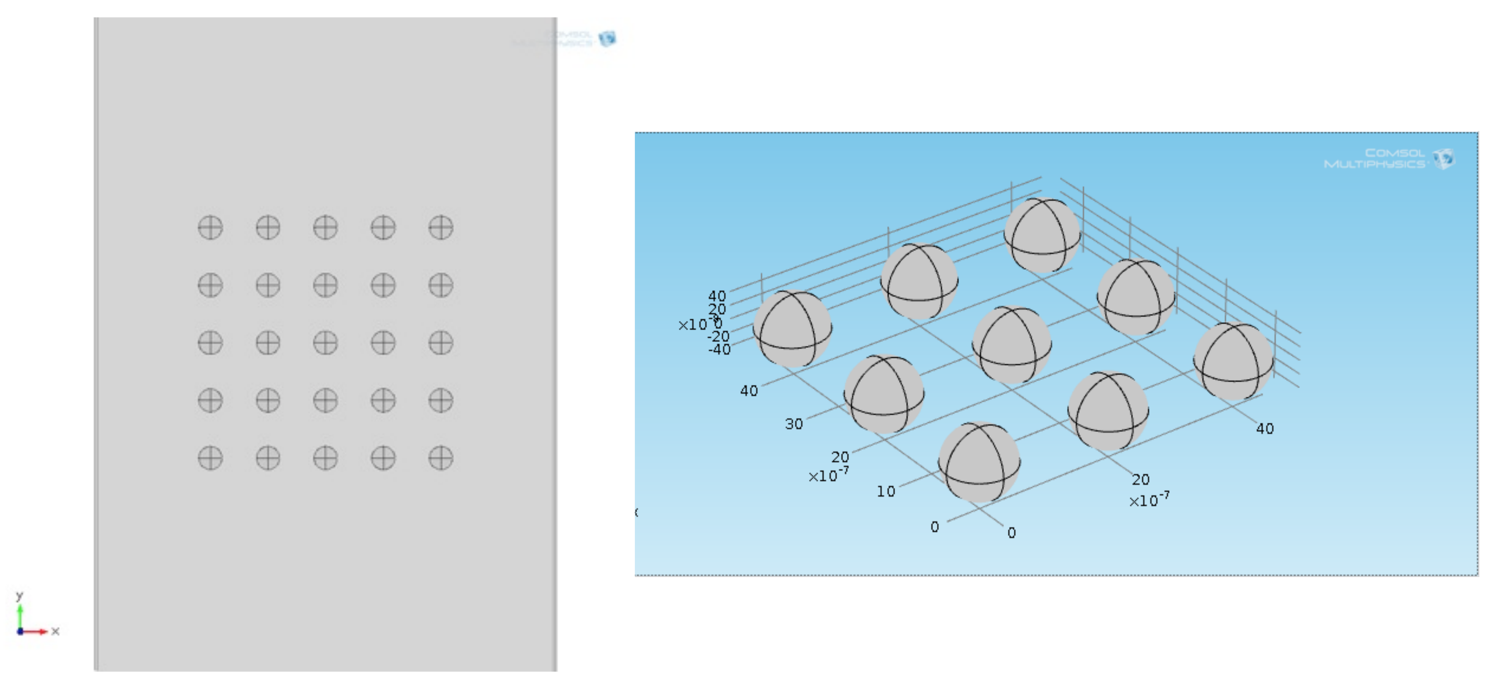

Figure 2. Geometry of the lateral flow and vertical flow models. In the lateral flow model, binders are placed in circles on the surface of a rectangular block through which the analyte flows. In the vertical flow model, binders are placed on the surface of spheres and analyte flows in from above the array.

Results: The distribution of analyte over a microarray spot or sphere at a given point in time was visualized, see figure 3.

The amount of time required for the system to reach equilibrium for a given set of model parameters was calculated, see figure 4.

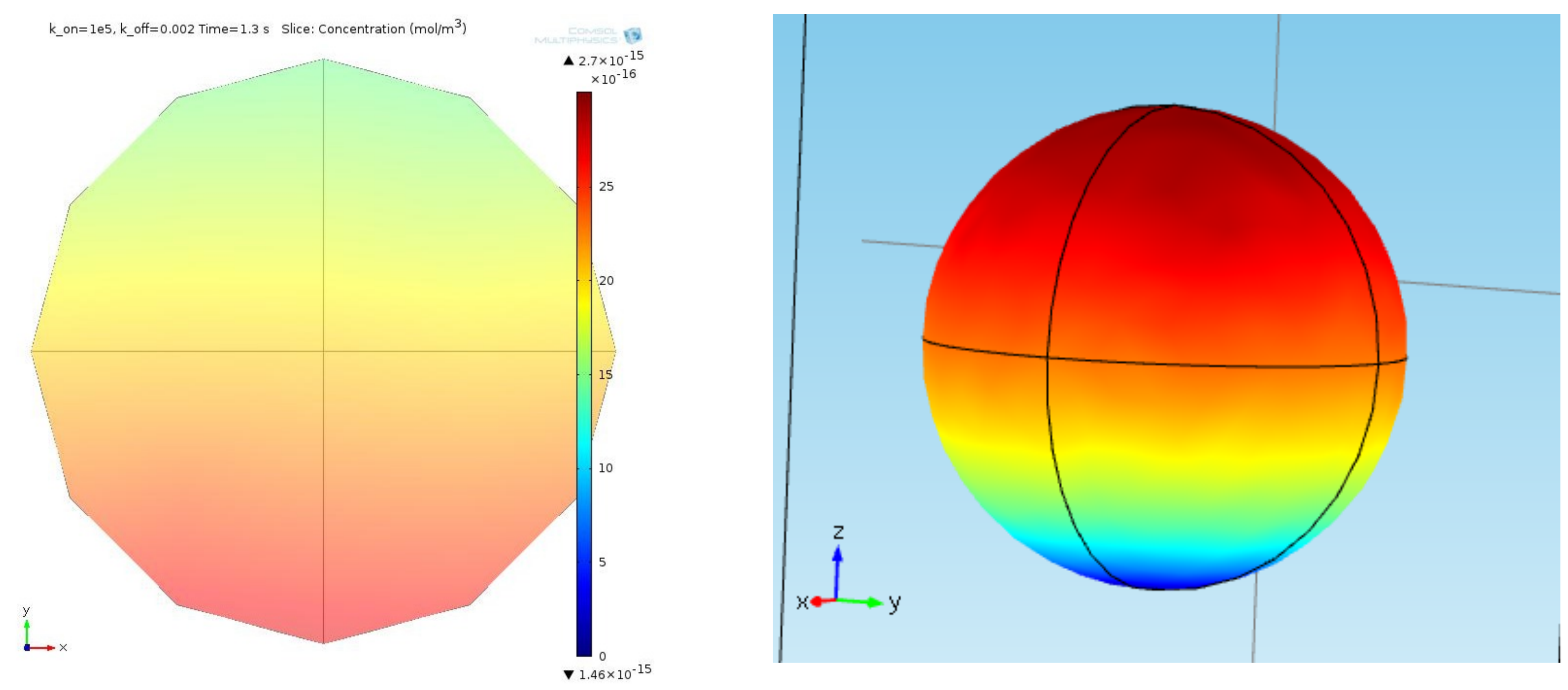

Figure 3. Distribution of analyte across a microarray spot in a lateral flow assay and across the surface of a sphere in a vertical flow assay.

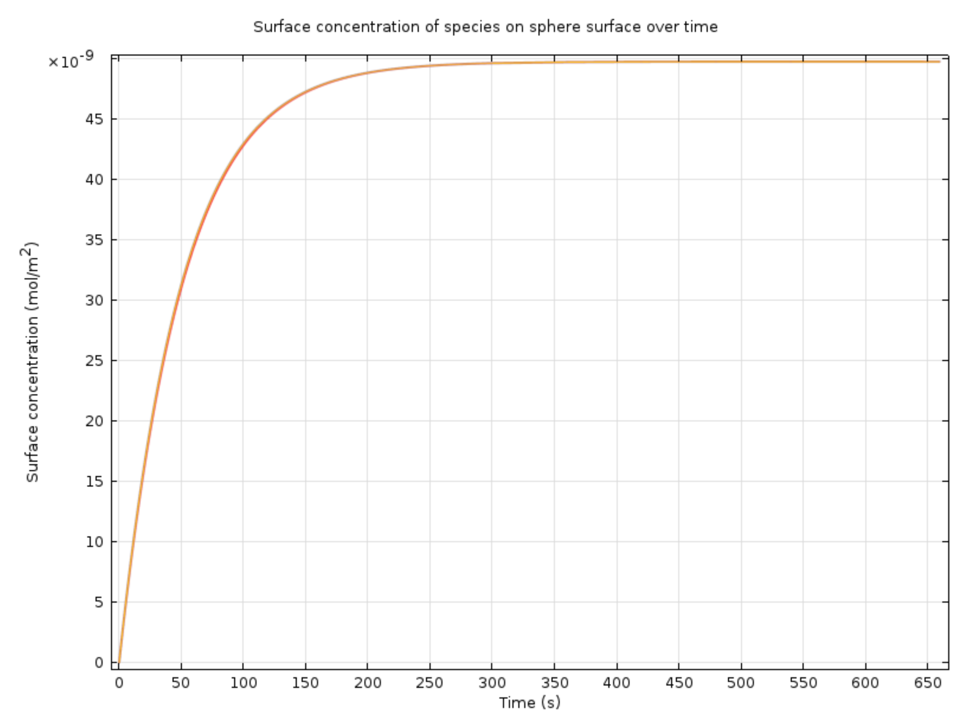

Figure 4. Concentration of analyte on sphere surface over time.

Conclusions: Using COMSOL Multiphysics® models of our molecular diagnostic assays, it is possible to better understand how various parameters such as flow rate, binder concentration and analyte concentration may affect the system performance which limits the amount of practical optimization work. Using these models will therefore likely save us both time and resources in our work to further develop, improve and apply novel point of care diagnostic assays.

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