Trapping DNA Molecules in Fluids Using Electrokinetic Effects Generated By Different Electrode Geometries

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Abstract

In this paper we present results of simulations done to predict the behavior of a system consisting of DNA molecules in an aqueous medium under the combined effect of AC Electroosmosis and Dielectrophoresis (DEP) [1]. AC Electroosmosis (ACEO) is caused by the movement of fluid particles under the influence of the electric field which drags the DNA particle along with itself. Dielectrophoresis is caused by polarization of the DNA particle. Two different electrode geometries, namely, convex triangular and concave triangular, have been adopted for the simulations (Refer Figure 1 and Figure 2).We have used mirror plane symmetry using the method of images to reduce the domain in both simulations to a half electrode region. The sharpness of the vertex V was varied by varying the fillet radius. This was done in order to account for the non-feasibility of fabricating perfectly sharp electrode tips. It is worth mentioning that in its coiled form, the DNA molecule is assumed to be spherical in shape [2] . The objective of the exercise was to locate trapping points. A point or region qualifies as a trapping point if the total force vector in the neighbourhood of that point gives rise to a stable equilibrium. Numerically, this means that the plot of the force vs. co-ordinate cuts the co-ordinate axis with a negative slope giving rise to a local harmonic oscillator like behavior. The force calculation was done by obtaining the vector sum of the Dielctrophoretic force [3] and the AC Electroosmotic drag [4].

Two modules have been used for the simulation.
1. CFD Module: This module has been used to simulate the fluid dynamics caused by ACEO.
2. AC/DC Module: This module, specifically the Electric Current interface has been used to simulate the DEP force and also the AC voltage of the electrodes.

For both electrode geometries, it was observed that the total force vectors on the particles are concentrated in the region near the vertex and smeared along the electrode. Trapping points were observed near the vertices of the triangular electrodes which point toward the plane of symmetry. It was also observed that the value of the slope of the force vs co-ordinate plots increased with a decrease in the the fillet radius of vertex V.

From the data gathered, we can conclude that trapping points exist. Further work can be done by changing the angle of the vertex pointing toward the plane of symmetry and by considering more

complex electrode geometries.

Reference

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Figures used in the abstract

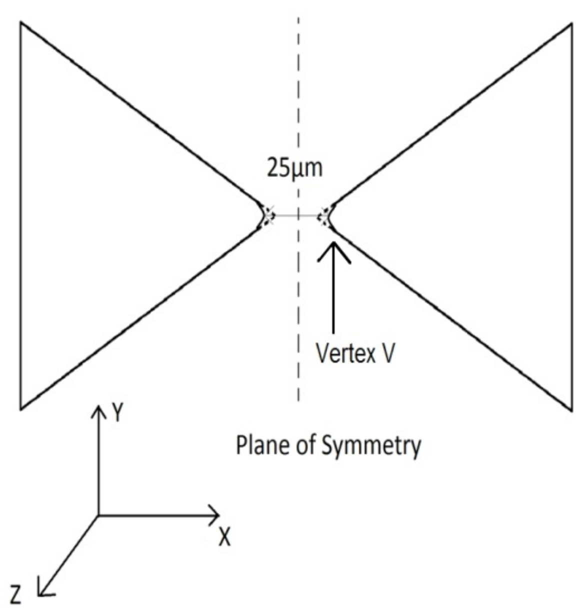

Figure 1: Top view of the convex triangular electrodes.

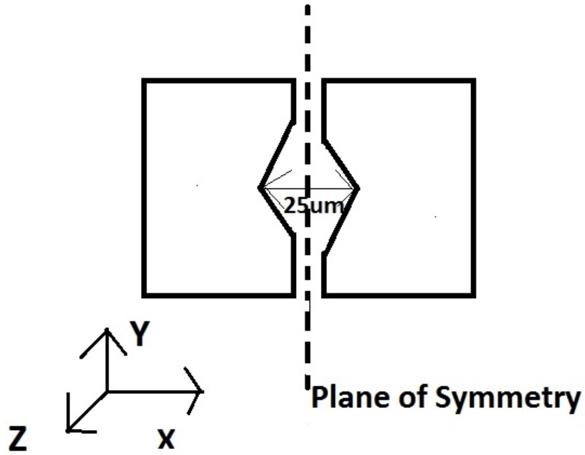

Figure 2: Top view of the concave triangular electrodes.