

266e Microfluidic Mixing Based on Transverse Electro-Osmotic Flows

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As with their macroscale counterparts, laminar fluid mixing becomes a very important, albeit inherently difficult step at the microscale. Active micromixers based on electro-osmotic forces have historically relied on either a modification of microchannel geometries or a modification of the zeta-potential of the microchannel surfaces to perturb fluid streamlines in a manner that leads to enhanced fluid mixing. When the electric field is applied in the axial direction of the microchannel, electro-osmotic flow (EOF), as well as any recirculation profiles, tends to be parallel to the main axis of the channel. Rather than place electrodes driving EOF at the inlets and outlets of a microchannel, one can place them along the microchannel walls, thus allowing for EOF in the non-axial (transverse) direction. EOF possesses the capability to introduce transverse flow rates of much higher magnitudes than passive methods alone.

Here we present a new method of achieving chaotic advection in microchannels by applying an electric field perpendicular to the mean flow direction driven by a pressure gradient in a planar rectangular microchannel. EOF on microchannel surfaces in a direction orthogonal to the main channel axis is generated via an electric field produced by integrated electrodes at the corners of a microchannel. We show that a number of flow profiles, containing 2, 4, 5, or 6 secondary vortices, can be introduced by modulating the applied potentials on the corner electrodes. By using serial combinations of different mixing cycles, we show that complete mixing can occur in a straight microchannels of length scales on the order of a millimeter. Theoretical analysis via computational fluid dynamics (CFD) is used to characterize and optimize the mixing efficiency of the system and to compare with experimental measurements.