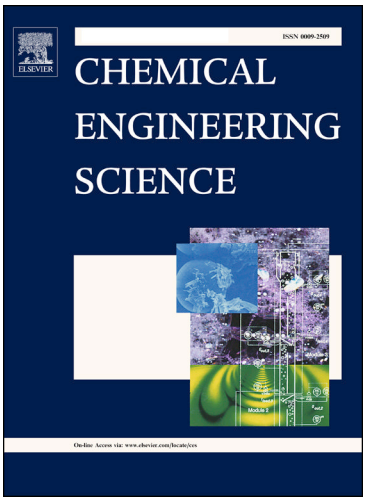

Micromixing by two-phase hydrodynamic focusing: A 3D analytical modeling

Arman Sadeghi

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Micromixing by two-phase hydrodynamic focusing: a 3D analytical modeling

Arman Sadeghi [1]

Department of Mechanical Engineering, University of Kurdistan, Sanandaj 66177-15175, Iran

ABSTRACT

Rapid and efficient mixing is crucial in microfluidic devices. The two-phase hydrodynamic focusing has already been shown to be a flexible method of micromixing. In this method, the sample stream composed of solute and solvent is squeezed between two sheath flows of a highly viscous fluid so as to reduce the diffusion path. The main challenge in modeling the associated transport phenomena is the difference between the viscosities and diffusivities of the sample and sheath flows. In this paper, 3D analytical solutions are presented for solute transport in two-phase focusing micromixers, regarding the sample and sheath flows as a single domain of variable physical properties. The model is shown to be able to capture the change of the concentration gradient at the sample/sheath interfaces. The results demonstrate that the mixing length can be reduced significantly by employing more viscous sheath flows while even having more values of efficiency, defined as the ratio of the solutes remaining in the sample flow to the total solutes. Although smaller mixing lengths may also be obtained by increasing the sheath flow rate in single-phase focusing, it is accompanied by sever reductions in efficiency, revealing that the single-phase focusing is not an efficient mixing tool.

Keywords: Microfluidic; Micromixer; Hydrodynamic focusing; Transport processes; Mathematical modeling; Multiphase flow

1. Introduction

Since initial introduction in 1979 (Angell et al., 1983), the lab-on-a-chip (LOC) devices have attracted a growing attention from the scientific communities, especially in the 21th century. LOCs are miniaturized laboratory platforms, curved on thin plates of plastic or glass, which integrate multiple laboratory functions. The fact that different chemical/biological analyses can be performed both quickly and simultaneously in such a chip with low volumes of expensive samples and reagents is considered as the main advantage of these instruments.

[1] Corresponding author, *E-mail address:* a.sadeghi@eng.uok.ac.ir