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Unsteady Flow Simulations for Microchannel Design and Its Fabrication for Nanoparticle Synthesis

Authors : Mrinalini Amritkar, Disha Patil, Swapna Kulkarni, Sukratu Barve, Suresh Gosavi

Abstract : Micro-mixers play an important role in the lab-on-a-chip applications and micro total analysis systems to acquire the correct level of mixing for any given process. The mixing process can be classified as active or passive according to the use of external energy. Literature of microfluidics reports that most of the work is done on the models of steady laminar flow; however, the study of unsteady laminar flow is an active area of research at present. There are wide applications of this, out of which, we consider nanoparticle synthesis in micro-mixers. In this work, we have developed a model for unsteady flow to study the mixing performance of a passive micro mixer for reactants used for such synthesis. The model is developed in Finite Volume Method (FVM)-based software, OpenFOAM. The model is tested by carrying out the simulations at Re of 0.5. Mixing performance of the micro-mixer is investigated using simulated concentration values of mixed species across the width of the micro-mixer and calculating the variance across a line profile. Experimental validation is done by passing dyes through a Y shape micro-mixer fabricated using polydimethylsiloxane (PDMS) polymer and comparing variances with the simulated ones. Gold nanoparticles are later synthesized through the micro-mixer and collected at two different times leading to significantly different size distributions. These times match with the time scales over which reactant concentrations vary as obtained from simulations. Our simulations could thus be used to create design aids for passive micro-mixers used in nanoparticle synthesis.

Keywords : Lab-on-chip, LOC, micro-mixer, OpenFOAM, PDMS
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