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Three-dimensional simulations on the formation of droplets in a T-type microchannel

Jr-Ming Miao[1,2], Fuh-Lin Lih[3], Yi-Chun Liou[4], Hsiu-Kai Chen[1]

Summary

To date, miniaturization of fluid handling and fluid analysis devices in the medicine engineering has been emerging in the interdisciplinary research field of micro-fluidics, as a result of miniaturization of the detective device to allow parallelization as well as to reduce analysis time and sample volume. Micro-total-analysis-system (μ-TAS) researches aimed at developing miniaturized and integrated "lab-on-a-chip" devices for biochemical analysis applications. Droplet-based micro-mixer is the one of the key components in the developing of μ-TAS. Numerical approach on the dynamic formation of water droplets in a T-type microchannel with a $200\mu\text{m}\times 50\mu\text{m}$ rectangular cross section and $1000\mu\text{m}$ long was performed in present study. The transient three-dimensional two-phase flow is solved using computational fluid dynamics in conjunction with a volume of fluid (VOF) method. Simulations of the processes of individual droplet emergence, growth, deformation, detachment and movement in the straight microchannel are performed to explicitly track the evaluation of liquid-liquid interface. The effects of contact angle values, volume flow ratio and Ca number on the departure diameter and frequency of droplets were systematically conducted to build empirical correlations. Parametric studies highlight the importance of various factors affecting the formation of liquid droplet from the junction of microchannels. Besides, inspection on the flow pattern within single droplet reveals the existence of counter-rotating vortices.

keywords: CFD, droplet-based micro-mixer, VOF, Ca number, microchannel

[1]Corresponding author. Email: jmmiao@ndu.edu.tw

[2]Department of Mechatronic, Energy and Aerospace Engineering, Chung Cheng Institute of Technology, National Defense University, Taoyuan, Taiwan , R.O.C.

[3]Center of General Education, R.O.C. Military Academy, Kahsiung, Taiwan, R.O.C.

[4]Graduate Scholl of Defence and Science Studies, Chung Cheng Institute of Technology, National Defence University, Taoyuan, Taiwan, R.O.C.