World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:19, No:07, 2025

Mixing Enhancement with 3D Acoustic Streaming Flow Patterns Induced by Trapezoidal Triangular Structure Micromixer Using Different Mixing Fluids

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Abstract : The T-shaped microchannel is used to mix both miscible or immiscible fluids with different viscosities. However, mixing at the entrance of the T-junction microchannel can be difficult mixing phenomena due to micro-scale laminar flow aspects with the two miscible high-viscosity water-glycerol fluids. One of the most promising methods to improve mixing performance and diffusion mass transfer in laminar flow phenomena is acoustic streaming (AS), which is a time-averaged, second-order steady streaming that can produce rolling motion in the microchannel by oscillating a low-frequency range acoustic transducer and inducing an acoustic wave in the flow field. The newly developed 3D trapezoidal, triangular structure spine used in this study was created using sophisticated CNC machine cutting tools used to create microchannel mold with a 3D trapezoidal triangular structure spine alone the T-junction longitudinal mixing region. In order to create the molds for the 3D trapezoidal structure with the 3D sharp edge tip angles of 30° and 0.3mm trapezoidal, triangular sharp edge tip depth from PMMA glass (Polymethylmethacrylate) with advanced CNC machine and the channel manufactured using PDMS (Polydimethylsiloxane) which is grown up longitudinally on the top surface of the Y-junction microchannel using soft lithography nanofabrication strategies. Flow visualization of 3D rolling steady acoustic streaming and mixing enhancement with high-viscosity miscible fluids with different trapezoidal, triangular structure longitudinal length, channel width, high volume flow rate, oscillation frequency, and amplitude using micro-particle image velocimetry (μPIV) techniques were used to study the 3D acoustic streaming flow patterns and mixing enhancement. The streaming velocity fields and vorticity flow fields show 16 times more high vorticity maps than in the absence of acoustic streaming, and mixing performance has been evaluated at various amplitudes, flow rates, and frequencies using the grayscale value of pixel intensity with MATLAB software. Mixing experiments were performed using fluorescent green dye solution with de-ionized water in one inlet side of the channel, and the de-ionized water-glycerol mixture on the other inlet side of the T-channel and degree of mixing was found to have greatly improved from 67.42% without acoustic streaming to 0.96.83% with acoustic streaming. The results show that the creation of a new 3D steady streaming rolling motion with a high volume flowrate around the entrance was enhanced by the formation of a new, three-dimensional, intense streaming rolling motion with a high-volume flowrate around the entrance junction mixing zone with the two miscible high-viscous fluids which are influenced by laminar flow fluid transport phenomena.

Keywords : micro fabrication, 3d acoustic streaming flow visualization, micro-particle image velocimetry, mixing enhancement.
Conference Title : ICMN 2025 : International Conference on Microfluidics and Nanofluidics
Conference Location : Washington, United States
Conference Dates : July 15-16, 2025