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Convection-diffusion driven concentration gradients in nanolitre droplets for microfluidic screening applications RAVIRAJ THAKUR, School of Mechanical Engineering, Purdue University, AHMED AMIN, Microfluidic Innovations, STEVEN WERELEY, School of Mechanical Engineering, Purdue University
— Ability to generate a concentration gradients in emulsified aqueous droplets is a highly desired feature for several lab-on-chip applications. Numerous schemes exists for generating concentration gradients in continuous flow devices such as Y junctions, split-and-recombine techniques, etc. However, varying the sample concentration in emulsified droplets is quite challenging. In this work, we have developed a scheme for generating and controlling concentration gradients in programmable multi-layer PDMS microfluidic chips. Briefly, a high concentration sample is injected into a steady stream of buffer. The buffer with the sample pulse and an immiscible oil phase are flowed through a T-junction in an alternate manner. As the sample pulse advances, the combined effect of diffusion and convection produced dispersion of sample pulse in streamwise direction. This continuous gradient stream is split into discrete droplets at the T-junction. Pulsatile flow condition are maintained using on-chip diaphragm peristaltic pumps. The problem can be thought of an extension of Taylor-Aris dispersion with laminar pulsatile flow in rectangular channels. The concentration profile is found to be dependent upon the frequency of pulsatile flow and thus can be fine-tuned according to application needs. Theoretical framework is established for pump regimes that correlates the diffusion coefficients of the input samples with the resultant concentration profiles.

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