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Taylor Dispersion in Oscillatory Flow in Rectangular Channels

JINKEE LEE, Sungkyunkwan University, ANUBHAV TRIPATHI, Brown University, ANUJ CHAUHAN, University of Florida — This paper focuses on exploring the effect of the side walls on dispersion in oscillatory Poiseuille flows in rectangular channels. The method of multiple time scales with regular expansions is utilized to obtain analytical expressions for the effective dispersivity D^*_{3D}. The dispersion coefficient is of the form$\frac{D^*_{3D}}{Pe^2} = f(\Omega \equiv \frac{\omega h^2}{D}, Sc \equiv \frac{D}{\nu}, \chi \equiv \frac{w}{h})$ where $Pe \equiv \frac{<u>h}{D}$, <u>is the root mean square of the cross-section averaged velocity, ω is the angular velocity, 2w and 2h are the width and the height of the cross-section, D is the solute diffusivity, ν is the fluid kinematic viscosity. The analytical results are compared with full numerical simulations and asymptotic expressions. Also effect of various parameters on dispersion coefficient is explored. For small oscillation frequency Ω, the dispersion coefficient approaches the time averaged dispersion of the Poiseuille flow and for large Ω, D^*_{3D}scales as Pe^2/Ω^2 where Pe=$<u>h/D$. Due to its relative simplicity, the 2D model is frequently utilized for calculating dispersion in channels. However at small dimensionless frequencies, the 2D model can significantly underestimate the dispersion, particularly for channels with large χ. At large Ω, the dispersion coefficient predicted from the 2D model becomes reasonably accurate, particularly for channels with large χ. For a square channel, the 2D prediction is reasonably accurate for all frequencies. The results of this study will enhance our understanding of transport in microscale systems that are subjected to oscillating flows, and potentially aid technological advances in diverse areas relevant to microfluidic devices.

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