Summary: A computational study is presented on cross-stream migration and focusing of deformable capsules in curved microchannels of square and rectangular sections under inertial and non-inertial regimes. The numerical methodology is based on immersed boundary methods for fluid-structure coupling, a finite-volume-based flow solver and finite-element method for capsule deformation. Different focusing behaviours in the two regimes are predicted that arise due to the interplay of inertia, deformation, altered shear gradient, streamline curvature effect and secondary flow. In the non-inertial regime, a single-point focusing occurs on the central plane, and at a radial location between the interior face (i.e. face with highest curvature) of the channel and the location of zero shear. The focusing position is nearly independent of capsule deformability (represented by the capillary number, $Ca$). A two-step migration is observed that is comprised of a faster radial migration, followed by a slower migration toward the centre plane. The focusing location progressively moves further toward the interior face with increasing curvature and width, but decreasing height. In the inertial regime, single-point focusing is observed near the interior face for channel Reynolds number $Re_C \sim O(1)$, that is also highly sensitive to $Re_C$ and $Ca$, and moves progressively toward the exterior face with increasing $Re_C$ but decreasing $Ca$. As $Re_C$ increases by an order, secondary flow becomes stronger, and two focusing locations appear close to the centres of the Dean vortices. This location becomes practically independent of $Ca$ at even higher inertia. The inertial focusing positions move progressively toward the exterior face with increasing channel width and decreasing height. For wider channels, the equilibrium location is further toward the exterior face than the vortex centre.

MSC:

76D25 Wakes and jets
76D17 Viscous vortex flows
76M12 Finite volume methods applied to problems in fluid mechanics
74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)
74S05 Finite element methods applied to problems in solid mechanics

Keywords:
cell dynamics; microfluidics; immersed boundary method; fluid-structure interaction; finite volume method; finite element method; curvature effect; secondary flow; Dean vortex

Full Text: DOI

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