TURBULENT FLOW SIMULATION OF DISPERSION MICROSYSTEM WITH CUMULANT LATTICE BOLTZMANN METHOD

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Micro-systems minimize required quantities and make processes economically efficient and environmentally friendly. A desirable size of each drug component can help physicians to improve the patient's health effectively. A micro-machined disperser is an efficient way to break-up large agglomerates into suitable small-sized ones. This motivates to analyze a complex micro-system used for dispersion. The disperser generates stresses (shear, elongational, turbulent flow) inside micro channel geometries designed to break-up nanoparticle agglomerates. The advancement in computational fluid dynamics (CFD) theory and in high performance computing able us to study orifice flow with a high-fidelity CFD method. Cumulant lattice Boltzmann method (LBM) is used to study the dispersion micro-orifice [1,2]. The agglomerates are modelled as tracer particles with mass and drag coefficient. They record the history of the stresses and the relative velocity of the agglomerates with respect to the fluid. The tracer particles are implemented in a massively parallel multi-resolution lattice Boltzmann framework. The simulation of the disperser is validated against PIV and flow rate measurements [3]. The drag coefficients of the agglomerates are obtained by detailed simulations of synthetic agglomerates in simple shear flow, elongational flow, and rotational flow. An empirical relation between the drag coefficient and the number of primary particles in the agglomerate and its fractal dimensions is found and used in the tracer simulation of the disperser. Maximal strain, exposure time to a certain strain, and relative velocity of the particles with respect to the surrounding fluid are measured. The distribution of the maximum strain rate seen by an agglomerate can be condensed into a simple exponential cumulative probability distribution.

References

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