Numerical study of magnetic particles concentration in biofluid (blood) under the influence of high gradient magnetic field in microchannel

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ABSTRACT

A meshless numerical scheme [1] is developed in order to simulate the magnetically mediated separation of biological mixture used in lab-on-chip devices as solid carriers for capturing, transporting and detecting biological magnetic labeled entities [2], as well as for drug delivering, magnetic hyperthermia treatment, magnetic resonance imaging, magnetofection, etc. A modified one-way particle-fluid coupling analysis is considered to model the interaction of the base fluid of the mixture with the distributed particles motion. In details, bulk flow influences particle motion (through a simplified Stokes drag relation), while it is strongly dependent on particle motion through (particle) concentration. Due to the imposed magnetic field stagnation regions are developed, leading to the accumulation of the magnetic labeled species and finally to their collection from the heterogeneous mixture. The role of (i) the intensity of magnetic field and its gradient, (ii) the position of magnetic field, (iii) the magnetic susceptibility of magnetic particles, (iv) the volume concentration of magnetic particles (nanoparticles) and their size, (v) the flow velocity in the magnetic-fluidic interactions and interplay between the magnetophoretic mass transfer and molecular diffusion are thoroughly investigated. Both Newtonian and non-Newtonian blood flow models are considered, along with different expressions for the concentration and numerical results are presented for a wide range of physical parameters (Hartmann number (Ha), Reynolds number (Re)). A comprehensive study investigates their impact on the biomagnetic separation. For verification purposes, the numerical results obtained by the proposed meshless scheme were compared with established numerical results from the literature, being in excellent agreement.

References

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