A Lumen–Tissue Magneto-Two-Phase Flow Model with Transendothelial Transport for Magnetic Drug Targeting

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Abstract

Motivated by magnetic drug targeting, we develop a thermodynamically consistent magneto-two-phase flow model describing the dynamics of superparamagnetic iron oxide nanoparticles (SPIONs) in the blood vessel lumen as well as their transendothelial transport into the surrounding tissue. The strongly coupled system consists of a modified Navier–Stokes equation with an additional inertia term for the volume-averaged velocity, a transport equation for the SPION volume fraction, and a quasi-static nonlinear elliptic equation for the magnetic potential. Using Onsager's variational principle, we derive constitutive relations, including a transmission condition for the SPION phase at the lumen–tissue interface. Finally, we present a numerical framework and experiment-inspired simulations that pave the way toward optimized therapy strategies.