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Modeling the transport of binary fluid/nanoparticle mixtures through microchannels with ciliated walls YONGTING MA, AMITABH BHATTACHARYA, OLGA KUKSENOK, University of Pittsburgh, Pittsburgh, PA 15261, DENNIS PERCHAK, Kodak Research Laboratories, Rochester, NY 14650, ANNA C. BALAZS, University of Pittsburgh, Pittsburgh, PA 15261 — We study the dynamic behavior of nanoparticle-filled binary fluids that are driven through a microchannel with ciliated walls. To carry out these studies, we use a hybrid computational approach that combines the lattice Boltzmann model for binary fluids and a Brownian dynamics model for the nanoparticles. The ciliated walls of the microchannels are composed of flexible filaments that are modeled as beads connected by elastic springs. This hybrid model allows us to capture the interactions between the binary fluids, nanoparticles, and the hairy walls. We show that the process of capillary filling of such microchannels strongly depends on the rigidity of the hairs, their grafting density, and their affinity to the fluid components and nanoparticles. We demonstrate that by tailoring the properties of the nanoparticles, one can effectively control not only the velocities of the capillary filling, but also the deposition of nanoparticles on the hairy walls, and hence dynamically alter the properties of these ciliated surfaces. Our findings provide fundamental insights into the dynamics of this complex system, as well as potential guidelines for technological processes involving capillary filling with nanoparticles in a structured flexible porous medium.

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