337g Computational Modeling of Hydrodynamic Interactions between Two Vesicles Rolling on an Elastic Substrate in Shear Flow

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During an inflammatory response, leukocytes adhere and roll in postcapillary venues. Recently, in vivo experiments have shown that hydrodynamic interactions take place between closely rolling leukocytes. Moreover, considerable cellular deformations have been observed during cell collisions, which strongly affect the cell dynamics.

In present work, we consider the hydrodynamic interaction between two microvesicles, mimicking blood cells, which roll along a compliant surface under an imposed shear flow. The vesicles, consisting of an elastic shell filled with a viscous fluid, are immersed into a solvent, which propels them along the conduit. To model this multicomponent system, we employ a recently developed numerical technique based on a combination of the lattice Boltzmann and lattice spring methods for the fluid dynamics and the elastic solid, respectively. This technique allows for a dynamic interaction between moving elastic walls and the surrounding fluid. The moving walls exert a force on the fluid and, in turn, the confined fluid reacts back on the walls. To mimic the adhesive interactions among the vesicles and the compliant substrate, we consider vesicles that interact with each other and with the substrate through a Morse interaction potential.

We study the effect of adhesive potential, shear rate as well as relative vesicle sizes on rolling velocity and hydrodynamic interactions between two vesicles. We modify the stiffness of the vesicles and substrate in order to determine how the mechanical properties can affect behavior of the rolling vesicles. Collisions between the vesicles are also considered. In particular, our simulations predict that depending on the vesicles and substrate properties, flow parameters, as well as separation distance between the vesicles, the vesicles can either attract each other or separate while rolling on an elastic substrate. Furthermore, there are solutions when two closely rolling vesicles have equal velocities, thus keeping a constant distance between them. Our results suggest that mechanical properties of the substrate strongly affect the dynamics of vesicles and have to be accounted for in an accurate description of leukocyte rolling and interactions. Moreover, the results can be applied to design of microreactors utilizing elastic capsules to transport reagents and carry out the reactions.