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ABSTRACTS

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ST-37: Tumbling, rotating and coiling of nanofilaments in an oscillating microchannel flow

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Behavior of long, deformable objects conveyed by flow is one of the fundamental problems of modern rheology with important impact on a variety of biological and medical contexts. Analysis of cross flow migration of micro-sized objects conveyed by flow of viscous fluid in a tube have attracted considerable efforts, for example drag reduction observed for flow of blood in capillaries. Experimental studies performed for solid spherical particles and droplets confirmed presence of their radial migration, however its theoretical interpretation still remains far from being completed. In case of long deformable objects like molecules and filaments the cross-flow migration problem becomes quite complex, additionally it could be influenced by conformational changes, tumbling and elongation. Our flexible hydrogel nanofilaments [1] cover effects of mechanical properties of complex molecular structures, whereas simplify mobility description by allowing to neglect short range molecular effects, screening potentials, hydrophobicity, steric effects, and van der Waals interactions. Hence, our main aim is to use flexible nanofilaments as model objects to systematically investigate influence of flexible objects properties on their interaction with given flows and the resulting macroscopic transport properties. The complex shaped variations of such object can be described in a reduced way as that of a chain of spherical subunits. Its dynamic structure may be regarded as stochastic behavior of randomly moving chain elements bounded by flexible springs. The statistics of chain deformations can be described by persistence length, being a measure of the chain stiffness or flexibility; the stiffer the chain, the larger is the persistence length. Such approach allows us for relatively straightforward interpretation of observed shape variations in terms of basic mechanical parameters. The present study is based on the idea that the phenomenon of cross-flow migration during pulsatile flow inside the microchannel is strongly associated with the bending dynamics of the studied materials. Hence, the hydrogel nanofilaments with mechanical properties (persistence length) equivalent to that of long molecular chains are placed in a microchannel, and then conveyed by a laminar flow. Study of bending dynamic and migration of nanofilaments moving in the flow is carried out using pulsatile flow, which is designed to simulate intercellular flows in the body. Our experimental study shows in the majority of the observed cases migration of tested objects towards center of the channel. The rate of migration across the channel depends on several factors, including the occurrence of rotation, bending, and knots formation for filaments. The study can be fundamental to create biocompatible nanoobjects for drug delivery systems and regeneration of body tissues.

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[1] Pawlowska S (2016) J. of Physics: Conf. Ser. 760:012022.