More and more dynamic development of nanotechnology has become a reality. This creates a huge field to maneuver in terms of the use of its products in many sectors of science and industry. This development led to a significant intensification of research on the processes carried out in the micro and nanoscale, which naturally contributed to the creation of a new branch of rheology called mikroreologią. This area is a collection of many measurement methods that allow to study the rheological properties (associated with plastic deformation of materials) in unattainable for conventional microscopic examination ranges. This, seemingly young field, has laid the foundation in the XIX century and owes its origins to the biologist Robert Brown, who observed the chaotic movements of pollen on the surface of water (currently this movement is called Brownian motion) and Albert Einstein, who analyzed it theoretically. Another work of scholars such as Jean Baptiste Perrin led to the conclusion that the displacements (or more precisely its root mean square displacement MSD ) of micro-objects is directly proportional to time. Many measurement techniques currently used in microrheology are based on the determination of the displacement correlation function.
Undoubtedly, the development of micro-rheologic techniques would not be possible if there were absence of methods of observation and manipulation of micro and nano-objects such as optical tweezers (allows to manipulate objects with the use of focused laser), atomic force microscopy (allows to obtain a surface image with a resolution of the order of size of individual atoms), laser techniques (using the emission of electromagnetic radiation) or diffusion spectroscopy (allow e.g. on mobility observation of the particles in the solution). There are essentially two techniques for microrheology measurements: optical and flow microrheology. The first one uses a micro-channels of different shapes and cross sections. Optical microrheology is divided into two different methods: passive (classical observation of Brownian motion) and active (using external force to manipulate objects suspended in the medium). The main areas of microrheology research are hydrogel biomaterials used for therapeutic purposes, research on the DNA solution properties, study of hydrogels properties and gelling kinetics in the processes of controlled release of drugs.
The possibility of using nanometer-size objects arouse are of high interest by both theorists and experimentalists involved in engineering, biology, chemistry or medicine. Precisely with the adoption in medicine there is great hope, although the proportion of nanocomponents in this market is limited so far. The size of nano-objects allow for the penetration of most barriers, even those at the level of bio-organic. This gives the possibility of using spherical and elongated nano-objects as targeted conveyors of different substances with biologically active (e.g. drugs). Such systems allow targeting of drugs to specific organs, tissues, cells within the body in order to achieve targeted drug action. Such nano-transporters may also controllably release the drug at a predetermined rate and for a specified period of time.
In addition to these "tangible" applications of nano-objects in biology and medicine, there are also those that will expand our knowledge of the physical phenomena responsible for the behavior of long biological particles such as proteins and nucleic acids in the environment of the cell. Unfortunately, there is lack of experimental studies necessary to validate the assumptions of theoretical and numerical models. This lack of experimental research is mainly caused by the absence of a suitable models that would enable the determination and control of the flexibility and geometry of tested objects.
The proposed research include the fabrication of flexible hydrogel nanofilaments (nano-objects with an elongated shape), to examine their mobility in the flow of fluids and a strong crowding environment. The electrospinning technique (allowing to obtain micro and nanofibres from polymer solution using high voltage) will be used to form two-component hydrogel nanofilaments. To study the dynamics of the nanofilaments and their penetration abilities, specially designed and manufactured with PDMS polymer micro-channels connected with precise syringe pump generating accurate fluid flow and movement of objects in the system will be used. Fluorescence microscopy (light microscopy based on the phenomenon of fluorescence and phosphorescence) is applied in order to observe the examined folding phenomena and for reproducing the shape and the degree of deformation of nanofilaments. Due to the excellent resolution of recently constructed optical trap and using conventional atomic force microscopy, we should be able to accurately determine the geometry and elastic properties (associated with the ability to return to its original shape upon removal of the force) of the produced nanofilaments.
Our proposed research will open new opportunities to evaluate hydrodynamic, thermal and molecular influences on the mobility of such objects and to explain physical phenomena responsible for binding, folding, and knots formation of long molecular objects. There is a need to establish a well-defined experimental models in which we can answer some practical questions related to the transport of long, deformable objects.
The result of the project will open new perspectives for the understanding of its interaction with various configurations of flow, to allow for future applications in biomedicine as a targeted drug delivery capsules or fibrous structures transmitted by body fluids for the regeneration of tissues. We also want to know how moves in our body long and flexible structures built of protein, their penetration through porous structures, responsible for the formation of blood clots and preventing hemorrhages. Some effects are desirable, responsible for providing information, like DNA copying. Other harmful, e.g. blood clots. The understanding of the mechanisms of transport of such objects will allow for the planning of diagnostic methods based on such carriers, providing them in a specific areas and control their interaction with cells.

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