Tomasz A. KOWALEWSKI, Sławomir BŁOŃSKI
Institute of Fundamental Technological Research, Polish Academy of Sciences (IPPT PAN)

NANO-FIBRES & MICRO-FLOWS

The design of new procedures for fabrication of nano-structured materials is one of the “hot topics” in the current materials science, due to the great potential for their applications in various modern technologies. Preparation of micro and nano-size structures is a fundamental task of research in this area. Most of the processes involve fluid mechanics, however due to extreme dimensions modifying physical description of the phenomena, modelling of the flow is mainly based on empirical data.

In the paper we present two projects aiming preparation of nano-structures, conducted in in the Department of Mechanics and Physics of Fluids of IPPT PAN: electrospinning of nano-fibres and encapsulation of emulsion by nano-particles.

The process, known since several years as electrospinning, offers simple and cost effective method of producing solidified polymer nano-fibres. The electrically-driven bending instability of the liquid jet enormously increases its elongation path and effectively leads to its tinning by very large ratios. Unfortunately, the jet instability responsible for the thinning process is still difficult to control. Under ordinary conditions it causes that collected fibres are randomly oriented, their diameter and structure may vary in a broad range. Also the efficiency of nano-fibres production is difficult to increase. The aim our study is to obtain detailed experimental data on the process itself and to correlate these data with the existing models describing basic mechanisms responsible for the electrospinning.

The main purpose of the second project is to explore several new and promising directions for fabrication of nano-composites (microcapsules, core-shell and other composite particles), as well as nano-structured surfaces and porous layers by using emulsion droplets as precursors and/or templates for structuring nano-particles. The procedures involve the formation of emulsions stabilized by solid particles. Therefore, a large fraction of our effort is directed to reveal the main factors governing the process of emulsification and the emulsion stability in the presence of solid particles. The experimental and theoretical work is focussed on production of emulsion droplets in turbulent flow using a narrow-gap homogenizer. The need to get detailed and accurate measurements in micro-scale of the device enforce application of new experimental techniques, unusual in classical fluid mechanics. One of them is micro-PIV, full field microscopic velocity measurements using tracers with only several nano-meters dimension. The microflow measurements are based on epifluorescence illumination and high speed imaging, allowing to collect detailed data on turbulent shear stresses in the flow, necessary for modelling the emulsification process. In parallel to the experiments, numerical simulations are performed to elucidate optimal molecular properties of components, allowing for efficient structuring of nano-particles at the interface of emulsion droplets.