1. Research project objectives/ hypothesis/ methodology

The advancement of biopolymeric nanocomposites has been motivated by the need for materials with a specific combination of mechanical properties. Integration of reinforcement into polymers at the nanoscale can provide a significant increase in the physical and mechanical properties. However, in applications where contact with liquid media is unavoidable, the mechanical properties suffer degradation. Plastic deformation of biopolymers in air occurs mainly via the mechanism of crazing. In contrast, the plastic deformation of these materials in adsorptionally active liquid environments is carried out through solvent crazing, characterized by its own specific features. Non aggressive liquid such as water is capable of lowering the mechanical properties of polymeric nanocomposites by acting as plasticizers while moderate and severe aggressive liquid when combined with residual stresses can cause unexpected brittle failure known as environmental stress cracking (ESC). Swelling, plasticization, and detachment of fibre and particulate reinforcement from the matrix are commonly observed phenomena in polymer nanocomposites when exposed to liquid media.

The project is dedicated to the studies of plastic deformation of modified biopolymers with a focuse on the processes occurring inside the structure of biopolymeric composites under deformation, identifying deformation mechanisms acting on a micro and nanosize scales, and also mutual relations between the exposed liquid-active media and the deformation of amorphous/crystalline components. The scientific objective of the project is to study the influence of modified biopolymers chemical structure, droplet or fibrillar morphology of dispersed biopolymers within another biopolymer, and topology of nanocomposites on the plastic deformation behavior. stability of deformation, transformation of crystalline morphology, limited/massive fragmentation of lamellae, and related structural transformations. Another subject of the project will be the strain hardening behavior induced by formation of fibrillar network morphology of minor phase that occurs at high strains and leads to reversible deformation, well applicable for shape memorial biopolymers. The strain hardening is expected to be highly sensitive to the amount, density of physical entanglements, morphology, and interaction of the dispersed phase with matrix. The employed biopolymers will be modified through variation of the molecular structure (e.g. chain length, branching, crosslinking). We will examine the effect of introducing selected reinforcing biopolymeric additive with fibrillar morphology into the matrix on several physicochemical parameters of the bio nanocomposites such as: structure, morphology and mechanical properties, properties of the amorphous and crystalline phase, as well as on the deformation behavior. On this basis the active micromechanisms of deformation and their modification due to liquid-active media will be assessed. The in-situ microscopic observation during tensile deformation have been chosen for most of experiments within this project. The mechanical properties correlation to the microstructural evolution, as well as the mechanisms of plastic deformation and fragmentation of crystalline lamellae, will be studied for biopolymeric blends and nanocomposites.

2. Expected impact of the research project on the development of science, civilization and society

Implementation of this research will provide a deep knowledge about the environmental crazing phenomena and explain unknown mechanisms acting in biopolymeric systems exposed to liquid-active media. The obtained understanding will help us to develop new nanocomposites with controlled environmental crazing. In order to slow down or accelerate environmental crazing process, new blends or composites will be developed depending on the results obtained for the neat biopolymers. The comprehensive studies of the structure-property relationships will form the scientific basis of developing bio-polymeric blends and composites with improved performance in different environmental media.