The main scientific goal of this project is to obtain new knowledge on the design, preparation and production conditions of (nano)fibers made of thermoplastic non-isocyanate polyurethane (NIPU)-based hybrids with polyhedral oligomeric silsesquioxanes (POSS) and their blends with selected polysaccharides, and especially to check the influence of preparation conditions of hybrid fibers by electrospinning technique on their structure and thermal / mechanical / biological properties.

The planned research works include (i) Optimization of the synthesis conditions of 4,4'-(1,4-phenylene)bis(1,3-dioxolan-2-one)-based cyclic carbonates and Bisphenol A-based cyclic carbonates, (ii) Adaptation of the synthesis protocol of POSS-diamine based on hydrolytic co-condensation of siloxane compounds, (iii) Design and preparation of NIPU-POSS segmented thermoplastic copolymers with diamino-POSS built in the main chain, (iv) Preparation of NIPU-POSS/chitin, chitosan or (nano)cellulose solutions with different solvents and concentration of the components, (v) Fabrication of NIPU-POSS/chitin, chitosan or (nano)cellulose fibers by electrospinning technique, (vi) Assessment of the structure and morphology of the fabricated hybrid materials by spectroscopic (NMR, IR), X-ray diffraction, X-ray microtomography and microscopic methods (SEM, AFM), (vii) Characterization of the thermal and mechanical properties, as well as investigations using cell lines of NIPU-POSS/chitin, chitosan or (nano)cellulose hybrids, (viii) Determination of structure-morphology-property relationships for NIPU-POSS/chitin, chitosan or (nano)cellulose hybrid materials, and (ix) Elaboration of the material and energy balances for production process of NIPU-POSS/chitin, chitosan or (nano)cellulose fibers by electrospinning; production engineering-oriented design of technological process scheme and scale-up of the fabrication process.

The reasons for attempting this particular research topic arise from the new possibilties that are offered by non-isocyanate polyurethanes (NIPUs) which are a novel class of polyurethanes showing a set of promising, but still not fully discovered properties. Contrary to conventional polyurethanes (PUs), synthesis of NIPU does not involve application of harmful diisocyanates as substrates, allowing thus to avoid the main direct threats of human exposure to isocyanates, such as respiratory tract disorders, sensitization of respiratory tracts, poisoning, asthma and allergic reactions. A useful route to enrich NIPUs with Si-containing moieties is through incorporation of polyhedral oligomeric silsesquioxanes that are a class of zero-dimensional nanomaterials, with the structure resembling a cage of ca. 1-3 nm diameter, in which corners are silicon atoms bound with oxygen bridges. Chemical and physical properties of POSS can be tailored by changing the kind and composition of substituents that are either reactive or inert ones. While remaining non-toxic, antithrombogenic and cytocompatible, POSS cages can improve mechanical and thermal properties of polymer-based hybrid materials. Specific interactions the NIPUs can be utilized in the preparation of blends with biopolymers, namely (nano)cellulose, chitin and chitosan. In fact, blends of conventional polyurethanes with polysaccharides have attracted considerable research attention in previous years; the use of cellulose, chitin and chitosan as PU fillers lead through mutual interactions of the components to considerable improvements in composite properties and biocompatibility.

Substantial results expected include getting new knowledge in the field of design, preparation and electrospinning production conditions of (nano)fibers made of thermoplastic NIPU-based hybrids with POSS, as well as their blends with selected polysaccharides.