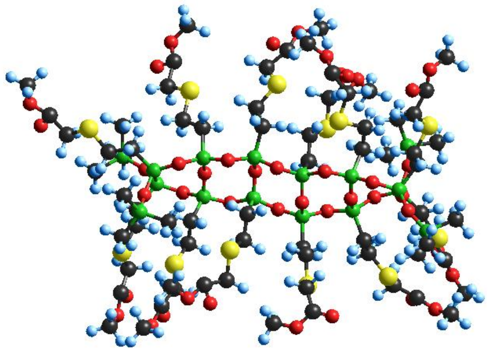
The unique properties and extensive applicability of polymer nanocomposites in modern technologies lead to an ongoing quest for most effective methods of their manufacture. Devices manufactured with advanced nanocomposite materials of novel properties and improved stability are more effective and durable. As a result, reduced energy consumption as well as a decreased amount of pollution generated during production and disposal can be noted, which has a very positive impact on the environment. Understanding the nature of physical and chemical phenomena occurring at the interface between the filler and the polymer is very important for the design of new nanomaterials. These phenomena, as well as the degree of dispersion of nanofillers, determine the properties of the nanocomposites. The species used so far as nanofillers, despite their obvious advantages, still have significant drawbacks, for example a tendency for progressive aggregation, which may cause phase separation and a significant deterioration of the performance of nanocomposites.

The innovative research approach proposed in this project is the use a functionalized linear oligosilsesquioxane ribbons of a ladder structure of the main chain (LPSQ) as a new platform for the synthesis of homogeneous polymeric nanocomposites, in order to maximize dispersion of the nanofiller phase (without progressive agglomeration) and improve its compatibility with polymer matrix (including multicomponent systems, also composed of immiscible polymers).



Functionalized LPSQ combine the properties of hybrid polyhedral silsesquioxanes (they are made of silsesquioxane structures) and layered silicates (two-dimensional shape of macromolecules owing to the presence of the rigid ladder structure of the main chain), but are well soluble in common organic solvents. LPSQ are gaining increasing importance in the field of new technologies and materials, but many of their potential applications is still under research. Quite unique is their ability for the formation of supramolecular systems, eg. thin polymer layers adsorbed on solid surfaces and nanomicelles in the liquid phase. These phenomena suggest that LPSQ could also bring in many valuable features as nanofillers in multi-component polymer systems. Functional groups in such nanofillers should not cause uncontrolled degradation of the polymeric matrix. The proper solution to this requirement is functionalization of LPSQ towards capability for the formation of non-covalent supramolecular interactions [hydrogen bonds, π-π, n-π^* interactions and electrostatic interactions] at the interphase between the polymer and the nanofiller.

The proposed research plan is focused on the development of efficient methods for the preparation of new hybrid nanocomposites based on the use of LPSQ ribbon nanoparticles with a very good solubility and compatibility with the chosen polymer matrix [e.g. poly(lactide), poly(styrene), poly(methyl methacrylate), poly(butadiene)]. The study on the nature of physicochemical interactions in the analyzed systems will be carried out by means of spectroscopic and calorimetric methods in solution and in the solid state. A comparative study will be carried out using model functionalized cyclotetrasiloxanes. Evaluation of the nature and stability of polymer-nanofiller supramolecular interactions is the aim of this study. The effects of supramolecular interactions will be distinguished from physical phenomena (e.g. plastification) and the effect of nanofiller on the ordering of polymer chains will be determined. Morphology of the obtained nanocomposites will be investigated in the solid state in order to assess the degree of homogeneity as well as characterize the changes in the physicochemical and mechanical properties of polymers due to the presence of functionalized LPSQ.