A possibility of combining organic and inorganic components into one composite material is widely used nowadays in Materials Engineering. The majority of the current studies is focused on systems consisting of polymer matrix filled with inorganic particles characterize by one of their dimensions below 100 nm, called nanoparticles. When uniformly dispersed in the polymer matrix those particles can considerably improve the mechanical properties of polymers, increase their thermal stability, as well as change a number of other parameters (*e.g.* electric conductivity, permeability of gases and liquids). In order to avoid unfavorable agglomeration of nanoparticles their surface is additionally covered with organic compounds that constitute interphase between the composite's components. However, this method, called compatibilization, is not always effective. An interesting alternative could be the utilization of nanoparticles made of hybrid polymers – large chemical molecules in which organic groups are permanently linked with an inorganic core. In the case of such systems one can significantly affect both the size and shape of nanoparticles by a skillful planning of macromolecular structure and selection of the proper reaction conditions for its synthesis. As a result, one can obtain such morphologies as nanofibers, nanoplates or nanosphers. Later, both of those two factors have a great impact on the performance of composites. Nowadays, the possibility of a practical use of such systems still faces many limitations regarding mainly a high degree of complexity of their preparation methods and requirement for the usage of rather expensive reagents.

The authors of this project intend to develop rather simple methods for the synthesis of hybrid polymers based on the reaction of phosphoric acid esters with easily available derivatives of zinc, calcium and magnesium – oxides, hydroxides or salts. The comprehensive studies aimed at determining whether a proper selection of the reaction conditions and reagents one can control the way phosphoric acid derivatives bind to metal cations. In principle, the resulting products should first form linear chains or layers, and then self-organize into nanoparticles of a specific morphology (shape). The proposed investigations will include a characterization of structural transformations of those particles caused by temperature till their thermal degradation, evaluation of their interactions with solvents and classic organic polymers of various polarity, as well as measurement of mechanical properties and thermal stability of the resulting composite materials. These studies may contribute to the development of new substitutes of traditional polymeric materials ensuring the improvement of selected performance properties or widening of their application area. For example, some of the synthesized phosphate derivatives of zinc, calcium and magnesium may be used in the future as fire resistant materials capable of generating protecting ceramic layers.

Within the project attempts to permanently connect the obtained hybrid polymers with classic organic polymers will be undertaken. These actions should result in the formation of tridimensional networks or systems, in which organic chains grows from the single inorganic threads or layers, namely polymer combs or brushes. One could expect that the latter two types of systems will pave the way for a specific self-organization of inorganic and organic domains leading to the generation of materials showing laminar (layered) or other type of morphology and containing some elastic organic channels. A special attention will be paid to the preparation and characterization of solid or gel-like hybrid materials in which those organic channels will be able to fast transportation of lithium cations. In case of the synthesis of systems exhibiting good ion-conducting properties further electrochemical studies will be undertaken aimed at a verification of their suitability as novel electrolytes in lithium batteries.

The authors of the project are convinced that gaining a knowledge of the rules governing the course of the processes of self-organization in the studied systems will be essential for the better understanding of some processes that occur in living organisms and utilize natural esters of phosphoric acid (*e.g.* nucleic acids or phospholipids).