Contemporary development of chemistry is tending to create new methods of transforming simple chemicals into complex and attractive products using sustainable technologies, effectively consuming substrates, reducing production costs, eliminating reagents harmful to humans and environment, and limiting the amount of produced waste. Progress in this area is realized, among others by developing and using new catalytic systems. An essential part of this progress is research related to the precise knowledge of the structure, physicochemical properties and reactivity of these compounds, which enable to better understand of the catalytic processes and allow to find new directions for their use. In the last thirty years, a special place among such systems is occupying by chiral Shibasaki catalysts of the formula $[MM'_3(binol)_3]$ where M is rare earth metal, binolH - binaphthol and M' - alkali metal, used in asymmetric synthesis. The high efficiency of these catalysts is due to the synergies of the two metallic centers, whose mutual cooperation enables the transformation to be impossible with conventional catalysts. Examples of this type of interaction between at least two different metal centers are directly taken from nature where heterometallic clusters are active centers of many enzymes such as iron-molybdenum cofactor $\{Fe_7MoS_9\}$ of nitrogenase, $\{Mn_4CaO_5\}$ of photosystem II, and plays a significant role in the process of binding and activation of substrates or electron transfer.

The primary purpose of the proposed research is to develop new catalytic systems based on heterometallic alkoxides and aryloxides of the main group and transition metal ions, for the use in organic synthesis and cyclic ester polymerization processes. This task will be accomplished through the synthesis of properly designed complexes with catalytic properties that can be reasonably designed by selecting the appropriate metal centers and ligands according to their synthetic purpose. The commercially available functionalized alcohols and phenols, will be used as ligands with differentiated nature of donor centers, electronic structures and steric hindrances. The key stages of the project will be the structural and spectroscopic characterization of the received compounds, which allow the understanding of the self-organization processes occurring in solution and solids state at the molecular level. The results of these studies will be used to find correlations between the structure of these compounds and their catalytic activity, and to explain the interaction between the acidic metal centers and the transformed substrate molecules. These works are also intended to determine the synergies of heterometallic composition in the studied catalytic reactions.

The far-reaching end result of this study is the design and synthesis of new heterometallic catalysts (based on molecular precursors) where two or more metal centers acting in synergy will enhance catalytic behavior by increasing the efficiency and selectivity of the studied reactions with a simultaneous reduction of the reaction time and a decrease of the formation of byproducts as compared to conventional monometallic analogs.