The constantly increasing demand for pure and efficient syntheses boosts the development of catalytic strategies that offer increased efficiencies and lower production costs. Although transition-metal-based compounds play a special role in this field and they have innumerable applications: from pharmaceuticals and polymers to agrochemicals and electronics, that strategy raises some concerns regarding the scarcity, high cost, toxicity and environmental issues associated with their extraction and utilization. All these limitations have engendered studies on metal-free catalysts based on main-group elements that would be able to support – instead of transition metals – key industrial processes, especially activation and transformation of small molecules like hydrogen and greenhouse gases *e.g.* CO_2, N_2O or SO_2. This concept was termed "metallomimetics" and assumes that non-metallic systems should mimic the crucial features of transition metals to make them an effective catalyst.

In order to develop systems based on the main-groups elements that are capable of activating small molecules, we have turned to systems based on phosphorus – sustainable and abundant nonmetallic element. Taking into account our long-standing interest in the chemistry of phosphorus compounds, we decided to design and study phosphinophosphoranes – ambiphilic systems that behave as both Lewis acids and Lewis bases, and therefore, are supposed to imitate the reactivity of transition metals. The chemistry of phosphinophosphoranes is unexplored and there are no reports on activation of the most attention-grabbing molecules like H_2, CO_2, CO, SO_2 or N_2O. The synthesis of such species can be performed by readily-available reagents – we avoid using synthetically-demanding moieties to build these systems. All substrates can be obtained in efficient processes by using inexpensive reagents. Moreover, the reaction products may be easily applied as ligands in organometallic chemistry or may serve as substrates for the synthesis of more complex compounds that are difficult or impossible to obtain by other means. In relation to the binding of small molecules itself, phosphinophosphoranes offer an unprecedented approach in the field of metal-free catalysis that may trigger further developments in the way of facile fixation and functionalization of organic and inorganic systems. From the economic point of view, metal-free systems for small molecule activation are much more attractive than still commonly used catalysts based on noble metals. Furthermore, the results of the project can provide tools for reducing the emission of greenhouse gases such as CO_2, SO_2, and N_2O which is an important issue for society. We assume that rational P-based systems design together with an understanding of the crucial steps in the reaction mechanism may lead to a synthesis of unique main-group element systems capable of outperforming their transition metal counterparts.