Enantioselective catalytic reactions are the main direction of modern asymmetric organic synthesis. Most of currently used selective catalysts contain environmentally harmful heavy metals, such as ruthenium, iridium, rhodium or palladium. Due to high toxicity, the content of these elements in the final product has to be very low (several ppm), what requires careful purification increasing costs. Therefore, the catalytic systems which exhibit a high catalytic activity and do not contain transition metals are intensively searched.

N-Heterocyclic carbenes (NHC) are by far the most studied members of the family of nucleophilic carbenes. They are generally known as exellent ligands for metal-based catalysts, but there is also an increasing interest in the role of nucleophilic carbenes as organocatalysts. Metal-free processes are interesting alternatives to classical organic transformations since they are often more economical. *N*-Heterocyclic carbenes are used as nucleophilic organocatalysts which promote the formation of new compounds by inversion of the polarity of reagents (umpolung). Beside their facile reactivity and selectivity, NHCs are also touted as environmentally safe whereby they tend to exhibit little to no toxicity and the reaction conditions in which they are used are often very mild.

The aim of our project is the exploration of important and challenging NHC-catalyzed enantioselective reactions, including cooperative (synergistic) catalysis. Special attention will be focused on the domino processes and the generation of multiple stereogenic centers.

Our investigations will include the following NHC-catalyzed reactions, representing different modes of activation of the carbonyl group, and dual activation strategy, integrating *N*-heterocyclic carbene (NHC) catalysis with Brønsted acids (BA) and transition metals (TM). The common use of two different classes of catalysts in a single reaction allows to carry out the chemical transformations unachievable in case of using these catalysts separately. Based on these strategies, methodologies for the synthesis of new chiral heterocyclic compounds derived from chromanone, uracil, flavone, tetrahydrofuran, pyrazolone, 1,2-diazepine, benzoazepinone, benzothiazine and pyridinone will be developed.

These structural motifs are present in a variety of biologically active natural products and numerous pharmaceuticals. Our research will develop new effective organocatalytic processes by using a dual synthetic strategy based on substrates activation *via* NHC in cooperation with Brønsted acids, Lewis acids, and transition metals.

The project is in line with the contemporary direction of research, and contributes to the national and international efforts to develop "asymmetric catalysis".