Modern chemical industry cannot exist without catalysts. More than 80 % of the chemicals is synthesized by catalytic processes. These days catalysts are very complex solids, with a specific surface area of the order of several hundred square meters per gram and a complex morphology. In this "universe" the active centers are dispersed. They are the places where the catalytic reaction may occur. The purpose the catalyst is defined by the type, number, location and the strength of such active centers. Zeolites are one of the most prominent materials used in catalysis. They are the materials on which active centers the crude oil is transformed to gasoline.

Zeolites are named from Greek words which means "boiling stones" and they are crystalline microporous aliminosilicates. Zeolites are known as molecular sieves because they selectively adsorb molecules that fit the shape and size of their micropores of molecular dimensions (usually below 1 nm). The presence of Al creates a negative charge in the zeolite framework, which is compensated by an extraframework cation. Hydrogen forms of zeolites are strong solid acids able to catalyze many reactions, especially industrially important transformations of organic compounds, like mentioned above production of gasoline or Diesel oil.

Zeolites owe their unique and exceptional activity to the presence of active sites in their micropores, which is generally beneficial but also has a downside. Location of active centres in the channels or cavities with specific shape and size provides shape selectivity with regard to the incoming substrate, products or transition state molecules. On the other hand, the fixed size of micropores not only restricts access of large molecules to the active sites, but also may slow down the transport of smaller molecules to and from the active centres. Consequently, larger molecules can undergo reactions only on the centres located on the outer surface of crystals, while smaller ones may have effective access to only a small fraction of all the centres because of the long diffusion pathway in the micropores.

One of the methods for enhancement of the accessibility of catalytically active centers is generation of so-called hierarchical structures. In such materials wide meso- or even macropores are leading to active centers localized inside micropores, while the diffusion path through the micropores is as short as possible. This can be imagined as the building bypasses in the cities crowded by cars.

The present project focuses on using two-dimensional zeolite precursors with active layers to produce optimized catalysts with expanded structure by spatial arrangement of the layers. Two-dimensional (layered) zeolites open up new prospects for the development of catalysis, as they combine the high activity of the skeletal structures with the possibilities of construction of new materials, especially more open and with increased availability of active centers. To date, the number of two-dimensional zeolites does not exceed 10 % of all zeolitic materials, but each of them can be modified in variety of ways, so as to obtain even several final forms.

The proposed project consists of three interconnected parts – synthesis, physicochemical characteristics and testing of catalytic activity. In the first stage selected primary two-dimensional zeolite catalysts will be synthesized and, after initial studies of the structure and total acidity, screened for catalytic activity in the test reaction of alkylation of aromatic hydrocarbons with benzyl alcohol. The next stage will involve the assembly of three-dimensional catalysts, which will be constructed from the layers (similar to Lego bricks) of the primary two-dimensional zeolites, that already possess suitable activity. Despite significant advances in the capabilities of manipulation zeolite layers, there are still great opportunities for innovation, e.g. synthesis of materials with active pillars, intergrown house-of-cards structures or delamination with high yield.

Assembly of two-dimensional zeolites can bring opportunities for the preparation of novel highly active and stable zeolite-based catalysts and might be a promising way for obtaining either new zeolite frameworks or materials with already familiar structure but with different chemical and structural properties that can either improve current technologies or lead to applications in new processes. Such innovations may become necessary, since it is required by law to produce materials with minimized adverse effects on environment and to preserve the quality of life.