Current technological progress is causing an increasing energy demand. Traditionally, energy is obtained by fossil fuel combustion, which has resulted in a significant increase in the concentration of greenhouse gases in the atmosphere in recent decades. CO_2, which is one of the products of fuel combustion, is considered the main cause of the currently observed greenhouse effect and climate changes, and its concentration in the atmosphere increases significantly year by year. Therefore, great attention is focused on the development of innovative CCU (carbon capture and utilization) technologies, which involve capturing CO_2 and then transforming it into more useful products (synthetic fuels or products important for the chemical industry, such as alcohols). Among them, thermochemical CO_2 hydrogenation processes play an important role. However, these processes are challenging because CO_2 is a thermodynamically stable compound, and the efficiency of its transformation processes is often low. Additionally, currently used catalysts have relatively low selectivity to the desired products and are susceptible to deactivation under process conditions.

The project aims to develop and investigate a new, with a strictly designed, hierarchical architecture, high thermal stability, and tunable catalytic properties dedicated to the thermochemical valorization of CO_2 into more useful products. The catalysts will be obtained using an innovative synthesis method based on grafting the nanoparticles of double-doped cerium oxide (active metal and promoter), constituting the active phase, on an Al_2O_3 support with a specific hierarchical structure. The materials obtained in this way should also be able to regenerate the active phase after the catalytic process, using the phenomenon of self-regeneration.

To check the usability of the designed catalysts in CO_2 valorization reactions, the obtained catalysts' physicochemical properties will be extensively studied to precisely determine their chemical, structural, and morphological properties. The most promising, optimized catalysts will then be subjected to catalytic tests in a model CO_2 hydrogenation reaction to more useful products (e.g. alcohols). Among the research methods that will be used to analyze the physicochemical properties of the obtained catalysts, particularly important are modern *in situ* and *operando* methods, which allow the analysis of changes in the catalysts during the catalytic process at real reaction conditions.