

For many decades, alkenes (such as ethylene, propylene, and butenes) have been the most important chemicals in terms of production scale in the chemical industry. They are universal intermediates in the large-scale organic synthesis and building blocks (monomers) included in ubiquitous plastics used in everyday life. Due to the production scale of nearly 400 million tonnes per year, there are a number of technologies for the alkene production, which could be generally divided into non-selective and selective (on-purpose). The two most important industrial sources of alkenes are olefin pyrolysis and catalytic cracking, which are non-selective technologies, because both processes produce a complex mixture of products, including the aforementioned alkenes and other chemicals from different refinery feedstocks. An important group of technologies for obtaining alkenes are processes aimed solely at the production of specific alkenes, the so-called on-purpose technologies. This group of processes includes the high-temperature dehydrogenation of alkanes to alkenes, alkene metathesis, and other less important technologies. The latter technologies have an advantage of obtaining a specific alkene without a production of by-products at the same time.

This project aims to combine two selective alkene production technologies, namely, dehydrogenation and conversion of the resulting alkenes each other (so-called metathesis). We intend to join these two technologies in a single reactor where they will be cycled in the presence of one solid catalyst, i.e. dehydrogenation followed by metathesis. Such a combination should allow for the conversion of alkanes to alkenes and alkenes to each other in one line, to maximize the production of scarce alkenes (for example propylene nowadays). We are going to conduct both reactions in the presence of a solid molybdenum catalyst. In addition, we expect that during high temperature dehydrogenation of alkanes (usually above 500 °C), new active sites will be created on the catalyst surface for the metathesis reaction to be carried out even at room temperature. Few reports in the literature and our preliminary work indicate that high-temperature treatment of molybdenum-containing catalyst with alkenes/alkanes causes an increase of 1-2 orders of magnitude of the metathesis reaction rate in relation to a catalyst pretreated in air or inert atmosphere (e.g. nitrogen).

The proposed combination of both reactions performed in one reactor over one catalyst can give great advantages, in particular for the metathesis reaction. Dehydrogenation will provide alkenes not only for the metathesis reaction, but they will also generate a large number of active sites. In consequence, the metathesis reaction will be able to be carried out at a satisfactory rate already at room temperature, in which the participation of side reactions (unwanted, e.g. isomerization or oligomerization) is negligible.

In summary, the combination of cyclic dehydrogenation and metathesis in one reactor may turn out to be a favourable solution in terms of consumption of energy and raw materials. At this stage, however, research is necessary to optimize conditions of the dehydrogenation process in such a way as to match this stage with the metathesis process. It is essential to gain knowledge on the mechanism of formation of active sites on the catalyst surface, where both reactions can occur, and the way of catalyst deactivation both in the high-temperature dehydrogenation and the low-temperature metathesis.