Methane is currently used primarily to provide energy or heat via combustion. Almost 566 Tg methane per year is produced from anthropogenic sources, which constitutes 60% of annual global emissions. These, among others include the generation by the use of fossil fuels, landfilling and livestock farming. Increased emissions have negative consequences as methane is a greenhouse gas with approximately 20 times the impact of carbon dioxide. According to agreements from 2021 United Nations Climate Change Conference (COP26) at least 100 countries decided to reduce the methane emmissions in year 2030 by 30% compared to 2020 levels. Methane represents an enormous resource and can be treated as a platform chemical for conversion into a range of higher value products. This is especially encouraging when methane from sustainable sources like landfills or anaerobic digesters are used or otherwise sources that are not economical to process for conventional heating. These economic incentives and the changing attitude towards sustainable production of both fine and commodity chemicals results in the growing interest in the biological conversion of methane.

Potentially, cadaverine and terpenoids could be efficiently produced using methanotrophic bacteria platform and methane as a feedstock. Cadaverine is the key precursor of the new generation polyamide nylon 5X polymers. These polymers are materials with very good mechanical and physical parameters and can be used for production of quality plastics and chemical fibers. Terpenoids on the other hand comprise a vast group of organic compounds (more than 55000 compounds) that may be used in a number of commercial applications including: flavours, colorants, vitamins, farmecuticals or commodity chemicals. The sustainable, economical and efficient production process for both cadaverine and terpenoids is relevant for further development of these technologies. Recently, sugar and L-lysine are the only feedstocks producing cadaverine efficiently. Majority of terpenoids is still obtained by extraction from natural plant sources. Slow plant growth and low product content limits the commercial potential of these compounds. Moreover, some of these processes may compete with the food production and are expensive. Consequently, many research groups are investigating the potential of using a number of more sustainable substrates.

The general aim of the project is to synthesize novel terpenoids and improve substantially cadavarine production from methane, investigate molecular mechanisms determining yield of selected products in methanotrophic fermentations and explore the feasibility of novel approach for fermentation of gaseous substrates such as methane. Firstly, a new and/or improved methanotrophic strains will be established as cell factories. Moreover, environmental life cycle analyses will be performed in order to identify the most relevant methane sources and the bioproducts synthesized using methane platform. Genes necessary for cadavarine and terpenoid production will be introduced and performance of microbial conversion improved by enzyme and metabolic engineering. We aim the at improvement of cadaverine yield at least 50-100% when compared with the recent research.

In the long term, the outcome of the project will help to substantially improve methods for upgrading of methane into a range of renewable, environmenly-friendly products. The bio-upgrading of methane is still in its infancy and the number of possible products very limited at the moment. The application of the proposed strategy may constitute the basis for further development of technologies leading to production of a range of bioproducts from methane, whose wider adoption offers a potential solution to carbon sequestration and greenhouse gases (GHGs) reduction. In the future, it is also expected that results from this project will lay foundation for conversion of other methane-based gases, e.g. landfill or natural gas.