Polyurethanes (PUs) belong to the crucial class of polymeric materials which are used almost in every brunch of industry e.g. automotive, medicine or building industry. In the chemical structure of PUs is presented the urethane group which is formed in the reaction of hydroxyl and isocyanates groups derived from polyols and isocyanates, respectively. To obtain specific form of polyurethane materials, as a foam or cast materials, also crosslinking agents or chain extenders are added, respectively, which affect the chemical formula. By the changes at the polyurethane composition it is possible to manipulate their unusual shapes and enhance industrial and consumer products. In general, polyurethanes are produced by using petrochemical based monomers. For instance, isocyanates in the industrial scale are produced with the use of high toxicity phosgene what is the main disadvantage of their production. The scientific studies also show that some commercially available diisocyanates have an unfavorable impact on human health (like asthma) because of high volatile. Moreover, some of them, are suspected of carcinogenic influence for humans.

Nevertheless, because of growing interest in an environmentally friendly polymeric materials, new trend at the chemistry related with sustainability and renewable resources usage during chemical synthesis is observed through last few decades. Nowadays, there are commercially available first polyols from monomers with natural origin, which is the result of the growing interest in the idea of green chemistry and sustainable development in the polyurethane industry. As the examples of monomers from renewable sources intended for polyurethanes preparation the biggest part constitute plant based polyols (vegetable oil-based polyols), chain extenders and crosslinking agents. Less scientific studies are related with dicarboxylic acids based polyols and significantly less dicarboxylic acids based isocyanates what will be the main issue of this project.

The global production of PUs is growing every year what corresponds also to growing amount of PUs waste. Ones from the methods of polymer waste utilization are mechanical and chemical recycling which allow to return the polymer wastes to the new processing cycle or synthesis of new polymer, respectively. Moreover, some from PUs give a new possibility for developing of their recycling by improved potential to biodegradation.

Recent sustainable chemistry concept has promoted investigations using various renewable resources for synthesis of novel bio-PUs. However, these novel PUs should be carefully designed considering not only bio-based origin of raw-materials but also understanding of relationship between PU synthesis, chemical structure, physical properties and (bio)degradation behaviour. This multidisciplinary approach is considered in this project, which deals with the enzymatic and chemical synthesis of polyols and isocyanates using only renewable monomers, the preparation of bio-PU casts and foams, the degradation behaviour and recycling of the produced bio-PUs using enzymes and microwave radiation, and by determining the sustainability / environmental impacts of these bio-PUs using life cycle assessment.

Project is divided into 4 main steps. According to the definition of ‘sustainable’ the project involves design novel types bio-based monomers, polyurethanes materials (as thermoplastics polyurethane elastomers TPUs and polyurethanes foams), their processing and recycling by using physical, chemical and biological methods. Investigation of the circulation of monomers of natural origin in a closed cycle, from the synthesis of intermediates to recycling of products, will enable a life cycle assessment (LCA). The expected results of the project implementation will provide information on the life cycle analysis of monomers of plant origin, their synthesis processes and the synthesis of polyurethane materials using them, as well as various methods of recycling polyurethane materials, which will allow to estimate the impact of sustainable PU on the environment.