Every second of us in the elderly will carry an implant in the body. At the same time, several thousand people die annually due to post-implantation complications. Therefore, implant materials and their fabrications are central issues for our health and life. Besides metals and ceramics, polymers are the most commonly studied class of biomaterials. Special features of polymeric materials come from the ability to control, in a wide range, their physicochemical properties. This is due to the possibilities of designing and producing materials with a variable chemical composition of the mers, length and spatial arrangement of polymeric chains as well as the degree of crystallinity. The biggest advantages of polymeric materials include high mechanical strength, high resistance to chemical agents, biocompatibility as well as a production facility in complicated shapes of implants.

The project focuses on the knowledge-based design of functional surfaces of polymeric materials for medical applications. The main goal of the project is to develop and optimize an innovative method of embedment bioactive substances nanoparticles into the surfaces of various polymeric materials with the use of ultrasounds. The sonochemical method enables the one-step formation of nanoparticles of dissolved bioactive substance and simultaneous incorporation of them into biomaterial surfaces. The resulting hybrid material will be thus enriched with an additional function of the controlled release of bioactive substances (such as antibiotics, anti-inflammatory, anticoagulant agents). The research hypothesis put forward in the project assumes that the release kinetics of a specific bioactive substance can be controlled by adjusting the size of nanoparticles and depth of their embedment. The research strategy consists in the synergy between theoretical and experimental approach where molecular modeling is interlaced with experimental investigations. Understanding the molecular mechanisms of drug embedment and release is planned to be obtained from molecular dynamic simulations. In turn, the theoretical results will be used as guidelines for the development of the functionalized implant surfaces.

The pioneering nature of the project, besides the connection of the experimental and theoretical research, is due to the fact that there is no information in scientific reports on the impact of the sonochemical synthesis parameters on the size, morphology, and depth of nanoparticle deposition on polymer surfaces. To achieve the project goals, it is necessary to perform comprehensive studies combining the synthesis of nanoparticles, their thorough physicochemical characterization (using a wide range of spectroscopic and microscopic methods), and to establish functional correlations between sonochemical synthesis parameters and kinetics of the drug release process.

The proposed interdisciplinary project provides not only a fundamental knowledge in the field of design and engineering of polymer biomaterials but also practical rationales for the fabrication of a new generation of polymer surfaces with controlled drug release kinetics. The project is part of the current global research on the so-called ‘functional hybrid materials’. It should be emphasized that sonochemical synthesis does not require additional organic substances, therefore it does not generate chemical waste, in accordance with the green chemistry principles. The interdisciplinary project refers to current research trends, and its results, from a broader perspective, may have practical implications for a quality of life in aging societies.