Modes of interaction between rare 2D MXene phases and bacteria cells

One of the most important problems of the present socjety is bacterial immunity to amtimicrobial agents, which is associated with a decrease in the effectiveness of bactericidal compounds and an increase in the side effects of their use. Therefore, there is a great demand for the development of new solutions and materials that have selective, effective and, above all, targeted biocidal activity in relation to microorganisms. Therefore, there is a strong demand for the development of new solutions for selective and effective microbial targeting. Advances in nanomaterials technology nowadays provide many opportunities for the development of alternative therapies and bioactive agents. As a result, the development of new nanomaterials with unique bioactivity is now one of the fastest growing fields of nano-science. Two-dimensional (2D) nanomaterials also have gained a lot of attention due to their outstanding antimicrobial activity. In this area, the MXenes phases are of interest, due to their unique physico-chemical properties and structure, enabling easy modification and design of, among others, hybrid structures.

Phases MXenes is a new family of 2D materials that attracts attention thanks to its intriguing properties. These materials are carbides and nitrides of early transition metals, which were first described in 2011. The term 'MXenes' reflects the stoichiometry of the material, i.e. $M_{n+1}X_n$, where M is the early transition metal, X is carbon or nitrogen, n = 1, 2 or 3. The MXenes phases are obtained from the respective MAX phases by etching with concentrated hydrofluoric acid. During this process, metal A coming from group 13 or 14 of the periodic table of elements is removed. The structure created in this way resembles the structure of expanded graphite. As a result of the reaction of the MAX and HF phases on the MXenes phase surface, there are surface groups such as -OH, = O and -F, thanks to which the MXenes phases have their specific properties such as e.g. antibacterial properties or bio-adsorption to bacterial cells.

The scientific and cognitive aim of the project is to present potential toxic mechanisms of rarely investigated, new members of two-dimensional (2D) MXenes family towards bacterial cells in context of (i) specific interactions of the physicochemical nature between 2D MXenes and cell surface and its interior, as well as (ii) bacteria cell functioning on molecular level.

The project will investigate the rare two-dimensional nano-crystals of 2D carbides of early transition metals, with varying stoichiometry and chemical composition, characterized by unique features that are intriguing in the search for potential innovative bioactive agents. The planned basic interactions of nano-crystals 2D phases of MXenes in the aspect of their in vitro toxicity in the direction of interaction with bacterial cells will enable obtaining the necessary information about the impact of their properties on the observed mechanisms.