

Modern medicine faces the growing problem of bacterial resistance, one of the most pressing public health challenges worldwide. Bacteria's ability to develop resistance mechanisms against widely used antibiotics has led to reduced effectiveness in treating infections, resulting in an increase in difficult-to-treat infections and related mortality. Of particular concern are infections caused by biofilm-forming bacteria, which are significantly more resistant to known antimicrobial agents. Biofilms, structures composed of bacteria surrounded by an extracellular matrix, can shield bacteria from drug effects, enabling their survival under therapeutic conditions and contributing to chronic infections. Biofilms represent a highly resistant bacterial form that is challenging to eliminate with conventional antimicrobial agents, especially at clinically acceptable concentrations. The ability of bacteria to form biofilms on surfaces creates substantial obstacles in treating chronic infections and in preventing infections within healthcare facilities.

The project aims to develop new chemical compounds combining the properties of ionic liquids and antibiotics from the fluoroquinolone group. New ionic liquids (IL-API) will be more effective in combating bacterial biofilms and resistant strains of bacteria, while at the same time being characterized by lower toxicity and a more favorable safety profile. The problem of antibiotic resistance and biofilms, which constitute a natural protective barrier of bacteria, is one of the greatest challenges of modern medicine, requiring innovative solutions.

The research will include a detailed analysis of their stability in various environmental conditions, including variable pH, temperature and light values, physicochemical properties such as solubility or the ability to self-organize into micelles, and interactions with biological membranes. The biological activity of IL-API will be tested on various bacterial models, including planktonic and drug-resistant pathogens (e.g. MRSA, *Pseudomonas aeruginosa*). A key aspect is to test the ability of new compounds to penetrate bacterial biofilms, which are one of the main barriers to traditional antibiotic therapies. Cell migration tests are also planned to assess their effect on regenerative processes and wound healing, as well as blood-brain barrier permeability tests to limit potential neurotoxicity. The impact of new compounds on the intestinal microbiome will be analyzed using the *Bacillus subtilis* model. At the end of the project, a QSAR (Quantitative Structure-Activity Relationship) computational model will be created, which will allow for the prediction of biological properties of this class of compounds, supporting the design of new substances in the future.

It is expected that new ionic liquids will revolutionize the approach to combating antibiotic-resistant bacteria and biofilms, ensuring better efficacy and safety of therapy. Work on the QSAR model will allow for a more detailed understanding of the relationship between the structure and biological activity of IL-API, which will enable their further development. The project will also contribute to expanding knowledge about the use of ionic liquids in medicine, opening up new possibilities in the design of innovative antimicrobial therapies.