Research project objectives

The goal of the research project is to construct a variety of multilayered nano- and microcarriers with antimicrobial function using newly synthesized polyelectrolytes decorated with different alkylene side chains and various types of naturally occurring antimicrobial agents. The designed polyelectrolytes decorated by antimicrobial function (PEs-DAF) will be used as the outer layer of fabricated particles forming functional coatings. The constructed carriers coated with PEs-DAF will provide the controlled release of antimicrobial compounds and longer antibacterial activity in time. This project aims to develop functionalized polyelectrolytes applied as building blocks for the formation of multipurpose nano- and microsystems with antimicrobial functionality. The research project will investigate the influence of such parameters as the type and structure of antimicrobial polyelectrolytes on the physicochemical and biological properties of designed carriers.

Description of the research

The proposed project involves the synthesis of poly(acrylic acid) and poly(diallyldimethylammonium chloride) decorated with various length of alkylene chains (dimethylene (C2) and hexamethylene (C6)) and different degrees of substitution of plant-derived antimicrobial agents including valuable flavonoids, such as galangin, apigenin and fisetin, as well as essential oils, such as thymol, carvacrol, and eugenol using mild reaction conditions i.e. Steglich esterification/amidation. The obtained polyelectrolytes will be characterized using advanced techniques, such as Fourier-transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR). The antimicrobial activity of synthesized polyelectrolytes will be examined on selected bacteria strains.
A variety of multilayered nano- and microcarriers with antimicrobial function will be fabricated using different techniques. For the construction of polymeric nanospheres the several methods will be used including nanoprecipitation, emulsification, and high-pressure homogenization (HPH). The HPH process will be optimized by the control of several condition parameters using design of experiment (DOE) approach, which allows to obtain an optimal carrier system for its further functionalization. For the formation of multilayered capsules coated with outer antimicrobial polyelectrolytes, the layer-by-layer (LbL) self-assembly technique will be applied. Various polyelectrolytes will be used as biocompatible building blocks of carriers such as synthetic polyelectrolytes i.e. poly(allylamine hydrochloride), poly(lactide-co-glycolide), poly(L-glutamic acid) and natural polyelectrolytes i.e. sodium alginate, hyaluronic acid, or chitosan. The model active substances will be encapsulated in fabricated carriers e.g. curcumin. The obtained nano- and microparticles will be examined using numerous techniques including dynamic light scattering (DLS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), FTIR, UV-Vis spectroscopy, quartz crystal microbalance with a dissipation (QCM-D) and spectroscopic ellipsometry. Additionally, antimicrobial activity of functionalized carriers will be studied.

Reasons of taking up the research topic

The matrix of administered drug carriers may contain the material sensitive to infection with dangerous bacteria, which causes strong side effects and limits the therapeutic application. For this reason, the construction of proposed nano- and microcarriers with natural-based antimicrobial coatings of various composition gives an opportunity of tailoring their physicochemical and biological properties to develop multifunctional systems which integrate the therapeutic drug activity and antimicrobial function improving disease treatment and supressing bacterial infection. Moreover, the synthesis of polyelectrolytes decorated with naturally occurring antimicrobial agents and their application in drug delivery systems have not yet been studied.

The most important expected effects

The research project will provide the formation of a variety of multipurpose nano- and microcarriers decorated with PEs-DAF, as functional coatings that release the antimicrobial agents in a controlled manner for long-term therapeutic applications. The construction of multifunctional systems with desirable physicochemical and biological features gives an opportunity to develop numerous tailor-made products. The highly novel and progressive research project will connect the field of chemical engineering, nanotechnology and biological science and guarantee publication of several articles in respected journals.