Abstract of doctoral dissertation

Despite the availability of numerous clinically approved active compounds, modern pharmacotherapy still faces significant limitations related to the bioavailability, selectivity, and systemic toxicity of currently available drugs. In response to these challenges, nanoscale drug delivery systems are being intensively developed to improve the stability of active substances, control their release, and enhance therapeutic efficacy while minimizing adverse effects. Particular attention has been devoted to core-shell nanostructures, which represent promising platforms for biomedical applications due to the synergistic combination of the properties of their individual components.

The aim of this doctoral dissertation was to design, synthesize, and comprehensively characterize core-shell nanostructures based on the Au@SiO_2 system as potential carriers for biologically active compounds. A synthesis strategy enabling the preparation of stable nanostructures with uniform morphology and favorable physicochemical properties was developed. The obtained materials were subsequently subjected to detailed characterization, including the evaluation of morphology, colloidal stability, surface properties, and structural parameters. An important part of this work involved the assessment of the functional properties of Au@SiO_2 nanostructures. The studies demonstrated no penetration through a model skin barrier and confirmed high biocompatibility toward human skin cells (HaCaT and HDF). Furthermore, the nanostructures exhibited antioxidant properties and showed no interaction with DNA, indicating a favorable biological safety profile.

The experimental studies also investigated the potential application of Au@SiO_2 nanostructures as a universal carrier platform for biologically active compounds with diverse physicochemical properties. Mupirocin, amoxicillin, and levodopa were loaded onto the nanostructures, and their immobilization efficiency and release profiles were evaluated. Particularly promising results were obtained for hydrophobic mupirocin, for which preserved antimicrobial activity was observed. The possibility of functionalizing the nanostructures with levodopa was also demonstrated, which confirmed the universality of the developed system as a platform for immobilization and delivery of various medicinal substances.

The final stage of the study involved the incorporation of Au@SiO_2 nanostructures into hydrogel matrices based on hyaluronic acid and hydroxyethyl cellulose. The obtained hybrid

systems enabled effective release of nanostructures and positively influenced skin hydration parameters while reducing transepidermal water loss, with the most promising results observed for hyaluronic acid-based formulations.

The obtained results confirm that Au@SiO_2 nanostructures constitute a stable, biocompatible, and functional platform with high application potential for the development of advanced delivery systems for biologically active compounds with therapeutic, dermatological, and cosmetic applications.