## Abstract

The main objective of the doctoral dissertation was to develop and analyze the effectiveness of bacterial cellulose (BC) bionanomaterials in preventing microbial colonization and eradicating biofilms of pathogenic microorganisms.

Bacterial cellulose (BC), also known as bionanocellulose, is a polymer with unique properties, used in many industries and fields of science. During the research, the reference strain of *Komagataeibacter xylinus* (ATCC 53524) was used for the biosynthesis of BC. The production process was carried out under stationary conditions. In order to obtain a modified BC with improved physicochemical properties, a cross-linking reaction method was developed, with the use of citric acid as a cross-linking agent and disodium phosphate, sodium bicarbonate, ammonium bicarbonate, and their mixtures as catalysts. As a result of the reaction, BC fibers did not collapse during dehydration, which allowed for obtaining bionanomaterials with a three-dimensional layered structure and numerous air spaces distinguishing them from dry, unmodified BC. Furthermore, analyses of the physicochemical parameters of the modified BC showed that this material was characterized by a significant improvement in the properties related to water absorption and retention compared to unmodified, dry BC, but also to specialized, highly-absorbing commercial dressings. In addition, the modified BC showed no cytotoxicity to fibroblast cells, which suggests that it can be successfully used in biomedical applications.

It was proven that modified BC materials functionalized by impregnation with an antiseptic based on octenidine dihydrochloride (OCT) are excellent dressing materials with high antimicrobial and anti-biofilm activity. Thanks to their structure, these materials were characterized by the prolonged release of OCT, increased ability to absorb exudate, good adhesion to the curved surfaces, and the possibility of long-term dry storage, combining the advantages of dry and wet BC.

Moreover, it was shown that the antimicrobial effect of OCT released from the BC-based carrier could be enhanced by the action of a rotating magnetic field (RMF), which influences the process of OCT release and penetration through subsequent biofilm layers. In addition, it was demonstrated that RMF affects the biofilm-forming cells by disturbing their morphology and changing the porosity and composition of the extracellular matrix. It was found that the RMF, at a low concentration of OCT and a short contact time of the OCT-impregnated carrier with biofilm, allows for a significant reduction in the viability of biofilm-forming cells. Therefore, combining BCs impregnated with antimicrobial substances with physical agents enabling their controlled release may be particularly promising in biofilm eradication, especially in hard-to-reach wound sites.

The widespread use of the BC is limited because of the high cost of ingredients used for the production medium. Therefore, the research also included the development of a new culture medium based on potato tuber juice, a significant waste of the starch industry. Due to the nutritional value of the potato juice, the obtained medium did not require any pre-treatment or supplementation. The BC synthesis efficiency using the potato juice medium was comparable to the process with a standard Hestrin-Schramm (H-S) medium. It was also shown that there were no differences in the structure, physicochemical parameters, and chemical composition between the BC synthesized with the potato juice and conventional H-S media.


07.10.2022

Daria Ciecholewska-Juśko