# SURFACE MODIFICATION OF METALIC BIOMATERIALS WITH ANTIBACTERIAL COATINGS

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## Introduction

The first phenomenon that occurs after the introduction of the biomaterial into the biological environment is the creation of a biofilm on its surface. Biofilm is a form of aggregation of bacteria, fungi and other microscopic organisms in the form of thin deposits forming on various surfaces, contacting, for example, with body fluids. The natural bacterial flora of the patient is responsible for the formation of the biofilm. The presence biofilm can lead to the disappearance of the surrounding osseous tissue and, as a result, disturb the osseointegration process [1] Currently, prevention of bacterial infections is carried out using antibiotic therapy, however due to many problems associated with the way of administering the drug and its effective action, new method of administering the drug to the patient are still being sought. In order to limit those negative consequences, the physicochemical properties of the surface layer of implants are formed. As of today, different approaches are used to apply new biomaterial modification techniques [2]. So far, no satisfying study results were provided in this area of expertise. Numerous publications in the world literature (mainly in medical journals) confirm this activity. However, they most often present the most partial results of the research, which do not allow to fully assess the suitability of the produced coatings. In many papers, also the role of surface processing of metallic biomaterial is not emphasized. Therefore, the primary objective of the study is to observe the impact of physicochemical properties of the surface layers (bactericidal) on the processes occurring on the implants surface made of metallic biomaterials used in bone system.

## Materials and Methods

The study material was Ti-6Al-4V alloy in the form of disks of the following dimensions: diameter, d = 14 mm, thickness, g = 2 mm. The samples were subjected to metal finishing consisting of grinding and mechanical polishing and then coating with layer of TiN by means of PVD methods. Analysing the mechanical properties, adhesion of applied layers to the metallic base was examined. What is more, during physicochemical properties evaluation, the testing of surface wettability and corrosion resistance by means of potentiodynamic method was performed

Adhesion was tested using the scratch test, in accordance with the standard [3]. In order to determine the surface wettability of the selected samples, the wetting angle and surface free energy (SFE) were evaluated with the use of Owens-Wendt method. The wettability angle measurements were performed with two liquids: distilled water ($\theta w$) (by Poch S.A.) and diiodomethane (by Merck). Measurements with a drop of liquid and diiodomethane spread over the sample surface were carried out at room temperature (T = 23°C) at the test stand incorporating SURFTENS UNIVERSAL goniometer by OEG and a PC with Surftens 4.5 software to assess the recorded drop image.

The potentiodynamic tests were carried out as recommended by the ASTM F2129 standard [4]. The test set up consisted of the VoltaLab PGP201 potentiostat, the reference electrode (type KP-113 saturated calomel electrode SCE), the auxiliary electrode (platinum wire), the working electrode (test sample) and a PC with VoltaMaster 4 software. Evaluation of the pitting corrosion was carried out in the environment of Ringer solutions with the chemical composition recommended by the standard at the temperature T = 37±1°C, and pH = 7.0±0.2

## Results and Discussion

The first stage involved the assessment of electrochemical properties, under which potentiodynamic studies were carried out. Based on the obtained results, it was found favourable influence of mechanical polishing on corrosion resistance of Ti-6Al-4V titanium alloy without surface layer. Furthermore, an adverse effect of the applied TiN layer on the corrosion resistance was observed irrespective of the method of surface preparation. The conducted surface wettability tests for the samples in the initial state and with the applied titanium nitride coating showed that all samples are hydrophilic in relation to the contact angle values obtained, falling in the range below 90°. In addition, it was also found that the type of surface modification has a slight impact on its wettability, due to the similar values of the contact angle both for samples without a layer and with a TiN layer. The last study was to assess the adhesion of layers to the substrate by scratch test. On the basis of the obtained results, the influence of the method of preparing the substrate on the adhesion of the applied TiN layer was found. For a previously ground specimen, a higher critical force value was noted, causing delamination of the layer compared to a polished and grinding polished sample. During the test there was no acoustic emission signal, which indicates that the binding energy between the coating and the substrate was too low. The obtained results, however, indicate the need for further testing of the surface layers thus produced using PVD to determine their suitability for medical devices.

## Conclusions

The results may provide basis to develop more specific criteria for assessing the final quality of medical products used in osseous system, which will provide the required biocompatibility of implants and contribute to minimize the risk of postoperative complications. The obtained results will make a significant contribution to the explanation of processes occurring on implants surface using in osseous system.

## References

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