ANODIZED TiO_2 COATINGS RESISTANT TO MICROBIAL COLONIZATION

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Introduction

In the recent development of biomedical engineering and biomaterials, there was observed an increasing need for the manufacturing of materials that would not only replace or heal the damaged parts of human body, but also block the microbial colonisation. Development of the way of how to inhibit the implants microbial colonisation has been considered as one of the very important aspects in biomaterials surface engineering. Among many approaches that allow to decrease adhesion of bacteria or fungi to materials there are protective coatings (diamond-like carbon, titanium dioxide etc.), immobilization of antimicrobial agents and particles onto surfaces and many others. Literature findings focus extensively on the use of TiO_2 layers for antimicrobial protection [1,2].

One of the popular, easy-to-implement and fast manufacturing techniques for TiO_2 is anodic oxidation. Anodization can be performed in various electrolytes, under desired voltages and currents. The change in the process parameters can lead to the creation of different oxide layers that could be porous, structurized or compact [3-5]. To obtain structurized TiO_2 coatings fluoride-based electrolytes can be used. These types of layers are known to possess excellent biological properties (e.g. increased osteoblast proliferation) [6]. However, they usually are not tested for microbial colonisation.

This work focuses on the dependence of the process parameters during titanium anodization on creation of structurized TiO_2 films and assessment of microbial colonization on their surfaces.

Materials and Methods

Substrates being titanium alloy Ti6Al4V disks were subjected to anodization in water-based electrolytes containing hydrofluoric acid as the oxidizing agent. Samples were manufactured with different approaches:

a) Different deposition times (10, 20 and 60 minutes)
b) Different deposition voltages (10, 20 and 100 V)
c) Changing the amount of hydrofluoric acid (0.25, 0.5, 1, 1.5 and 2 vol.% of the electrolyte)

The surface characterization based on scanning electron microscopy was performed. For the evaluation of microbial colonisation, bacterial (*Escherichia coli*) and fungal (*Candida albicans*) strains were used.

Results and Discussion

The topographical examination of prepared coatings showed that with the changing deposition parameters, there are changes in the complexity and structurization of coatings. The nearly-tubular structures that are the most desired for tissue regeneration near implant were obtained for titanium anodization in 2% vol. HF electrolyte.

The higher was the structurization of the coating, the higher was also the microbial colonisation. Not only the highest number of live bacteria cells were attached to surfaces possessing small structurization, but also almost a linear increase of total area occupied by bacteria with the increase of structurization is observed.

In the case of colonisation by *Candida albicans*, the situation is slightly opposite. The fungal attachment on surfaces is the smallest for the most complex TiO_2 coatings.

In both cases, all anodized samples exhibited the anti-microbial character due to lower attachment of bacterial and fungal cells in comparison to the control sample.

Conclusions

This study showed that the bacterial and fungal adhesion can be modulated by means of simple surface structurization. Not only the shape of the irregularities, but also the size of cells willing to inhabit those surfaces is important. What is more, the higher is the microbial colonisation of surface, the reduced could be the proliferation of human cells like e.g. osteoblasts. Thus, further modifications to manufactured surfaces like doping may be needed in order to reduce the possibility of microbial biofilm formation on anodized surfaces.

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