Abstract

Development in various areas of our daily life, including medicine, involves the extensive use of new technologies. An example of this is implantology, which is developing at a noticeably high pace and requires the use of more complex and multifunctional materials to allow the restoration of tissue function, e.g. bones. In order to achieve a durable implant–bone connection, materials are sought that, in addition to appropriate physicochemical, mechanical as well as tribological properties, will stimulate and accelerate bone tissue regeneration and stimulate osteogenic cells. Among the materials used in the production of, for example, orthopaedic and dental implants, metallic materials play a particular role, especially titanium and its alloys. Despite the numerous favourable properties of titanium materials, such as low specific weight, high corrosion resistance and good biocompatibility in tissue and body fluid environments, these materials exhibit poor osteoinductive properties, which are necessary to achieve a durable and stable bond between the implant and bone tissue. One of the factors limiting their use is their high elastic modulus, which significantly exceeds that of the cortical layer, which can lead to bone loss around the implant. A good solution seems to be the production of a hydroxyapatite coating on the surface of metallic implants. This solution should improve the biocompatibility of the implanted material to the bone tissue, as well as significantly prolong the service life of the implants. In addition, such coating should improve abrasion resistance of the implant, as well as function as an additional barrier by reducing the release of metal ions from the substrate material. Currently, the obstacle to the wider use of these coatings is their very low adhesion to the titanium substrate.

My research focused on modifying the surface of Ti6Al4V alloy implants that can be produced using i.a. 3D technology (laser sintering of titanium powders for medical devices). It was assumed that the main outcome of the carried out research and development would be the preparation for introducing a prototype of dental and orthopaedic implants to the market, which would have an active layer to promote bone regeneration, suitable for subsequent application of a stem cell–rich fraction. The stated purpose was achieved in two stages of the research. In the first stage, surface modifications of Ti6Al4V alloy samples were carried out, leading to titanium oxides with different morphology, structure and mechanical and biological properties (articles **P1**, **P2**, **P3**). In the second stage, highly biocompatible oxide nanolayers (produced as part of stage I) were used as intermediate layers (ILs) and fabricated Ti6Al4V/IL/HA systems. The intermediate layers were the link between the hydroxyapatite coating and the Ti6Al4V alloy substrate (articles **P4, P5**). Their aim was to improve the bonding

strength between the metallic substrate and the hydroxyapatite coating while maintaining the relevant physicochemical and biological properties of the system.

In conclusion, the study presents the physicochemical, mechanical and biological characterisation of thirteen diverse TiO_2/titanate nanolayers. Twenty–four hydroxyapatite–coated systems were characterised in terms of their physicochemical as well as mechanical properties, and then the biological activity of three selected systems was evaluated. The result of the research is the development of a method for the two–stage modification (TNT5/HA) of a Ti6Al4V alloy implant, which represents an innovative solution ready to be used in the production of a new generation of dental and orthopaedic implants. The proposed implant can be safely steam–sterilised, which is an additional advantage in terms of simplicity of clinical use. Implants with a bioactive surface layer enriched with the patient's stem cell–rich fraction will be suitable for a wider range of recipients, including diabetics, immunocompromised patients, the elderly, as well as children.

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