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Hydrothermally synthesized crystalline hydroxyapatite coatings on nanoporous titanium substrates for biomedical application

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High requirements for dental and orthopedic implants have pushed the research towards complex and intelligent biomaterials. To overcome the disadvantages of a single phase implant, such as low biocompatibility for metals and poor mechanical properties for ceramics, significant amount of research has focused on the development of their combination, i.e. covering load-bearing metallic implants with thin bioactive hydroxyapatite [HAp, $Ca_5(PO_4)_3(OH)_2$] films.

Titanium and its alloys, with excellent mechanical properties and high corrosion resistance, have been widely used as leading materials for hard tissue replacement. However, because of their lack of bioactivity, they cannot bond with surrounding tissues directly nor promote new bone formation on their surface at the early stage after implantation. Self-organized TiO2 nanotube arrays, fabricated by electrochemical anodic oxidation, have been reported to increase significantly the titanium surface area and enhance the formation of HAp and the bond strength between the substrate and the coating.

Herein, we investigate the effect of the nanoporous TiO_2 substrate on the morphology and uniformity of hydrothermally precipitated hydroxyapatite coatings. Nanotubular TiO_2 substrates were synthesized on a titanium plate by anodic oxidation and subsequently annealed at 500°C or 600°C to create the crystalline anatase and/or rutile forms of TiO_2. The substrates were further used for HAp growth under hydrothermal conditions. The hydrothermal method is based on a chemical precipitation from aqueous solution containing calcium and phosphate source, carried out in an autoclave at elevated temperature and high vapor pressure. The samples were then characterized with the XRD, Raman and SEM techniques. The results show that hydrothermal synthesis leads to formation of needle-like coating layer of HAp particles. The diameter and length of HAp crystals decrease with increasing annealing temperature of TiO_2 nanotubular arrays. Furthermore, we demonstrate that nanostructured surface of titanium oxide has beneficial influence on the HAp nucleation and coverage.

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