TiO_2 nanotubes for biomedical applications: morphological, structural and electrochemical characterization

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For their use in biomedical field, as orthopaedic implants, for example biocompatible titanium and titanium alloys surfaces need to be modified. A relevant process is the anodic oxidation, which, in the presence of fluorine ions, leads to the formation of self-ordered TiO_2 nanotubes arrays. Such surfaces provide interesting mechanical properties, high corrosion resistance, large specific surface area and good bioactivity.
Various sizes and morphologies of TiO_2 nanotubes were synthesized in organic electrolytes containing NH4F and 7.5 to 25 v.% of water by applying voltages ranging from 10 to 60 V, for 45 min to 1h. The resulting nanotubes morphologies were characterized by high-resolution Scanning Electron Microscopy observations (FE-SEM). Hence, nanotubes dimensions vary from 400 nm to 5 µm in length and from 45 to 130 nm in diameter with a length/diameter ratio between 5 and 40 and a specific surface area ranging from 30 to 140 cm² per geometric square centimetre.
X-Ray Diffraction (XRD) characterizations reveal that as-anodized TiO_2 nanotubes are amorphous while they crystallize into anatase phase under heat treatment in air at 450°C for 2h and into a mixture of anatase and rutile phases for annealing at 550°C.
The aim of this work was to determine the optimal nanotubes size and crystalline structure regarding both electrochemical and bioactive properties.
Potentiodynamic polarization measurements performed in simulated body fluid solution (SBF) revealed that the nanotube layer increases the corrosion resistance compared to titanium substrate and that crystallized nanotubes are much more corrosion resistant than amorphous ones.
Assessment of apatite deposition by immersion in SBF showed that annealing increases significantly TiO_2 nanotubes bioactivity. After 14 days of immersion, anatase TiO_2 nanotubes with small diameter (45 nm) and short length (400 nm) seem to constitute the most bioactive surface.

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