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Modified nanoporous titanium dioxide layers for drug delivery and cell culturing

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Statement of the Problem: Now-a-days, most of implants are made of titanium and its alloy. However, the process of chemical bonding between the biomaterial and surrounding bones is long-lasting. In addition, periprosthetic joint infections and insufficiency of the conventional antibiotic therapies may lead to the implant failure.

Method: The Anodic Titanium Dioxide (ATO) layers were synthesized via a three-step anodization process in an ethylene glycol-based solution. They were alkali treated by immersing in a 0.5 M sodium hydroxide solution. In order to obtain the anatase phase the samples were annealed at 400 °C. The non-annealed and annealed NaOH-modified layers were functionalized with different silane derivatives, (3-aminopropyl)triethoxysilane (APTES), (3-glycidyloxypropyl)trimethoxysilane (GPTMS) and (3-mercaptopropyl) trimethoxysilane (MPTMS). The modified samples were characterized by using scanning electron microscopy and X-ray photoelectron spectroscopy. Ibuprofen was used as a model drug in the drug delivery studies. The drug was loaded inside the nanopores and released in a phosphate buffer solution at 37 °C. The Desorption-Desorption-Diffusion (DDD) model was fitted to the obtained drug release profiles. For biological studies the osteoblast-like cell line MG-63 was used. The number of viable cells after 2, 24 and 72 hours were determined by the MTS (3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium) assay. The morphology of adhered osteoblast-like cells line MG-63 was investigated using fluorescence and scanning electron microscopies.

Findings: The modification of anodic TiO_2 layers inhibited the drug release process. In addition, the functionalization led to the improvement of the cell response. The release process from annealed samples was slower than from non-annealed. However, the number of viable cells was higher on the non-annealed layers.

Conclusion: The modification of nanoporous titanium dioxide layers affects the drug delivery process and cell response. It is possible to improve both aspects by the two-step modification of amorphous TiO_2 samples with NaOH and silane derivatives.

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