Decreased bacteria growth on TiO_2 nanotubes grown on Ti alloys

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Statement of Purpose: Ti and Ti alloys are widely used in the manufacturing of biomedical devices like orthopedic and dental implants because they have improved biological and mechanical properties Titanium and its alloys have the chemical ability to form passive films in the form of TiO_2 when exposed to oxygen, which is rapidly formed on the surface when contact with the atmosphere. The formation of TiO_2 increases Ti bioactivity and osseointegration of the implant devices and provides a set of attractive properties including high corrosion resistance, good biocompatibility, high strength and a low elastic modulus. Despite these attractive properties, Ti based implants still suffer from limited functional lifetimes which need improvement. For this reason, the objective of the present was to create nanofeatures on Ti and determine bacteria responses, due to the growing need to formulate anti-bacteria Ti-based implants.

Methods and materials: The aim of this work was to determine the response of bacteria on substrates of Ti-35Nb with two different nanostructures (highly ordered nanotubes of TiO_2 and nanofeatures). TiO_2 nanotubes growth was carried out in an electrochemical cell by using a constant voltage of 20V in 0,1 and 0,25% HF electrolyte for 10 minutes on a Pontentiostat Autolab (PGSTAT 30). TiO_2 nanotubes and features were characterized using scanning electron microscopy (Zeiss-EVO/MA15). To determinate crystallization temperatures, samples were heated until 930°C to match phases with only anatase, a mixture anatase-rutile, and rutile. To characterize the surface chemistry, XPS analysis was tested by a spectrometer (VSW HA100) and water contact angles measurements (Easy Drop, model FM 40) were used. To assure bacterial biofilm formation, S. *aureus* (ATCC – 43300) was seeded at a density of $5x10^6$ colony forming units cm^{-2} in TSB solution under static conditions (4,5% CO_2 at 37°C) for 1 and 2 days. All experiments were completed in triplicate and repeated at least three times. Differences significant were determined using student-tests.

Results: The results suggest that the bacteria on two different nanostructures (nanotubes and nanofeatures) on Ti-35Nb alloys with different phases transformation of TiO_2 layers have different response. Nanotubes had a tendency to reduce bacteria after the first day on nanofeatures, after that a gradual growth occurred (Figure 1). For samples stabilized in the anatase phase, reduced bacteria growth on both nanostructures, while for the mixture of anatase-rutile and rutile phases, almost the same behavior was observed and the control samples promoted lower bacterial growth as compared to those stabilized phases**.**

Wettability measurements indicated that the anatase phase had higher contact angles, close to 70°. The rutile phase exhibited lower values and, thus, more hydrophilic characteristics.

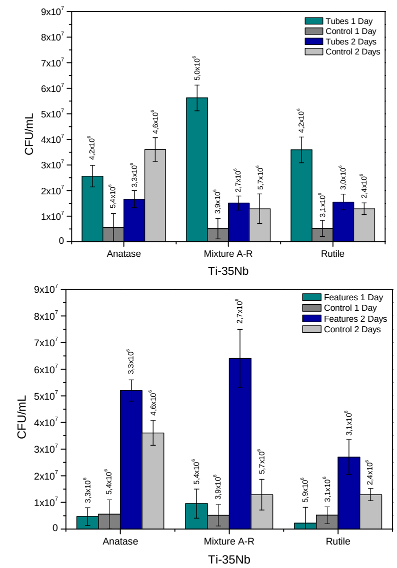

Fig 1. Bacteria experiments on TiO_2 (a) nanotubes and (b) nanofeatures stabilized at anatase, mixtures anatase-rutile and rutile.

Conclusions: In the present work, phase growth and anatase-rutile transformations using a heat method for Ti allows were determined followed by bacterial tests. XPS results showed that the anatase phase did not present Nb oxides and had the highest content of Ti and C on its surface and also presented the highest contact angle values. For bacterial analysis the chemical surface combined with stabilization of phase transformation on three different structures (anatase, mixture anatase-rutile and rutile) on nanotubes and nanofeatures affected bacterial behavior, resulting in lower bacteria growth for anatase phase while the mixture and rutile present right contents of bacteria growth compared with controls samples. Results showed increased bacteria growth on the nanofeatures after the first day and decreased bacteria growth on the nanotubes. For this reason, the results of this study show that Ti nanotubes should be further studied to decrease bacteria growth without the use of antibiotics. The criteria should be further investigated to decrease the infection of orthopedic implants.

References:

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