Influence of the structural, physical and chemical characteristics of titanium surface oxide layers on its tribocorrosion behaviour in contact with an artificial saliva solution

A.R. Ribeiro[1,2], R. Maribondo[2], E. Martinelli[2], C. A.Junior[3], J-P.Celis[4], J.R. Gomes[1], L.A. Rocha[1]

1 Research Centre on Interfaces and Surfaces Performances, University of Minho, Guimarães, Portugal

2 Federal University of Rio Grande do Norte, Dept. Mechanical Engineering, Natal, Brazil,

3 Federal University of Rio Grande do Norte, Labplasma, Natal, Brazil,

4 Katholieke Universiteit Leuven, Dept. of Metallurgy and Materials Engineering, Leuven, Belgium

Titanium has been widely used for dental implant applications because their attractive properties such as low Young modulus, good fatigue strength, excellent corrosion resistance and biocompatibility. However it cannot meet all clinical requirements. [1-2] When inserted in the oral environment, dental implants are submitted to a complex degradation phenomena occurring due to the interaction of tribological and corrosive phenomena which can result on its failure. In fact, most of the failures are a result of the combined action of mechanical solicitations (sliding or abrasive wear, erosion, impact, fretting or fatigue processes) and chemical solicitations as a consequence of contact with saliva, cells or bacteria. Consequently, dental implants become part of a tribocorrosion system, and the investigation of the tribocorrosion mechanisms in such systems becomes essential. [3] Recent work has shown that wear resistance of titanium might be improved selectively using the appropriate surface treatment, such as plasma oxidation, which is also often used to enhance the osseointegration process. [4-5]

The main aim of this paper is to study the influence of the characteristics of the oxide layers obtained by plasma oxidation on the tribocorrosion behaviour of c.p. Ti intended for the fabrication of dental implants. The plasma oxidation treatment were performed at three different temperatures (300, 450 and 530ºC) and a detailed study of surface topography (Fig. 1), thickness, structure and chemical composition of the oxidized layers was performed.

Tribocorrosion experiments were performed using a reciprocating motion pin-on-plate tribometer with an alumina pin as a counterface material in the presence of Fusayama solution. The applied normal force used was 3N, the stroke length 1mm and the displacement frequency was 1Hz. During rubbing the friction coefficient was monitored. Electrochemical techniques were used to follow the evolution of the system during sliding. Each experiment involved an in situ surface cleaning by a cathodic polarization at -900mv during 3 minutes, and after that a potentiostat was used to impose a passive potential to titanium samples. This experiment allows in situ and in real time following of the corrosion kinetics through current measurements. It is important to refer that electrochemical impedance spectroscopy was also used before and after rubbing in order to evaluate the protective character of the oxide film.

The influence of the thickness of the oxide layer and of surface roughness on the wear-corrosion behaviour of the material is discussed in detail. Results clearly showed that plasma oxidation treatments have a strong influence on the tribocorrosion behaviour of titanium. Both the corrosion and wear performance of the samples are improved by the increase of the processing temperature. In relation to friction profile no significant differences were found between all samples tested (μ remains between 0.35 and 0.45). Results show that electrochemical techniques yield useful results.

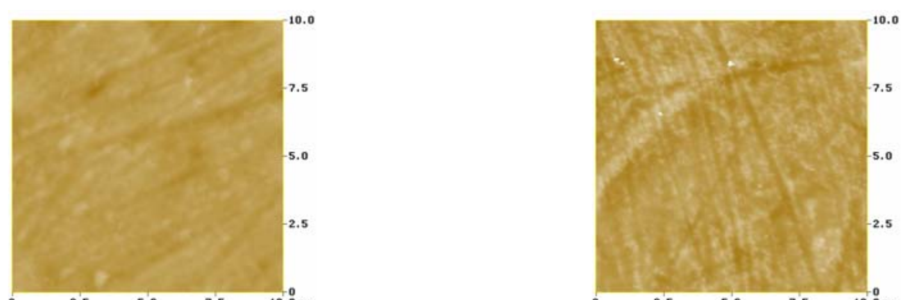

Fig.1. AFM images of Ti after plasma oxidation at (a) 300ºC and (b) 450ºC.

References

[1] F.H. Jones, Surfaces Science Report. 75-205, 42 (2001).
[2] J. Qu, P.J. Blau, T.R. Watkins, O.B. Cavin, N.S. Kulkani, Wear. 1348-1356, 258 (2005).
[3] A.C. Vieira, A.R. Ribeiro, L.A. Rocha, J.P. Celis, Wear. (2006) in press.
[4] X. Liu, P.K. Chu, C. Ding, Materials Science and Engineering. 49-121, 47 (2004).
[5] M. Morra, C. Cassinelli, G. Bruzzone, A. Carpi, G. Di Santi, R. Giardino, M. Fini, Int. Oral Maxillofac Implants. 46-52, 18 (2003).