11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

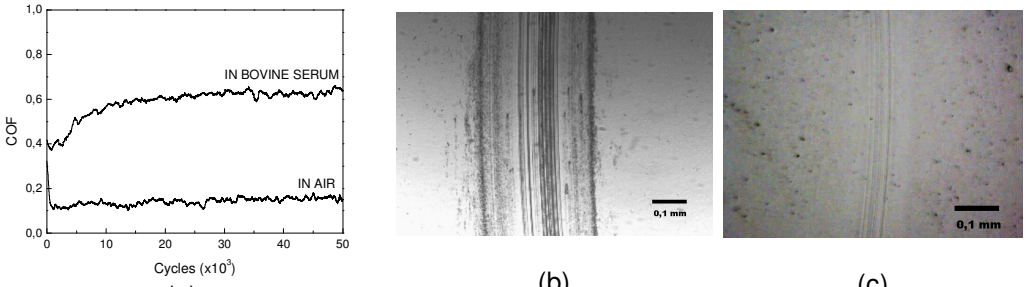
A qualitative study on wear behavior of Ti-doped carbon-based coatings by using ball-on-disk apparatus

E. Santos Jr.[(1)*], S.S. Camargo Jr.[(1)], M.P. Delplancke-Ogletree[(2)] and G.A. Soares[(1)]

(1) Metallurgical and Materials Eng., COPPE - Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil. E-mail: emanuel@metalmat.ufrj.br
(2) Chemicals and Materials Dept., Faculty of Applied Science, Université Libre de Bruxelles, Brussels, Belgium
* Corresponding author.

Abstract – In this work Ti-containing carbon-based coatings on Ti6Al4V alloy were produced. Reactive dc-magnetron sputtering was the deposition technique employed. X-ray diffraction results showed the presence of nano-TiC crystals in carbon matrix. Wear tests were carried out by ball-on-disk apparatus in two different media: in air and in liquid (fetal bovine serum). These results were qualitatively analyzed by optical microscopy. The higher coefficient of friction values were ~ 0.35 for tests in air. A little greater values were found for tests in liquid medium. Wear decreased for films with lower content of Ti. Results suggest that some of these films could be used as bio-coatings.

Over the past 20 years, the interest in carbon-based coatings has been growing due to their properties, such as biocompatibility, chemical stability and reduced coefficient of friction. The amorphous-like structure also provides the possibility to incorporate different elements in order to tailor their properties [1]. In fact, these films seem to be good candidates for improving tribological performance of orthopaedic prostheses (metal-metal paired), reducing the friction and wear. In this work modified carbon-based films were deposited on Ti6Al4V substrates mechanically polished. The technique used for depositions was reactive DC-magnetron sputtering under different conditions: mixed gas (Ar/CH_4) with mass flows of 190/30 sccm for bias voltages ranging from 0 to -800V. For the bias voltage -300V, different gas (Ar/CH_4) flow ratios were used: 170/50, 200/20 and 210/10 sccm. The deposition time was adjusted to produce films with thicknesses around 300 nm. A pure Ti target was used with a power density of 1.7 W/cm². Titanium interlayers were produced to improve the coating adhesion on Ti6Al4V. X-ray diffraction results showed the presence of TiC nanocrystals with sizes up to 6.2 nm in an amorphous carbon matrix. Tribological characterization, namely coefficient of friction (COF) and wear, was carried out with a ball-on-disk device using a 6.0 mm in diameter steel ball (AISI420), a load of 1N, a constant tangential speed of 0.07 m/s, and for 50,000 cycles (*f* around 1.8 Hz). These conditions lead to a maximum Hertzian contact pressure of 536 MPa, an order of magnitude higher than for a metallic hip prosthesis. Wear tests were performed in two different conditions at room temperature: in air, and in liquid medium using fetal bovine serum with a protein concentration of 20 mg/ml. The observed COF ranged from 0.1 - 0.35 in air. These values were a little increased in liquid medium due to the presence of wear debris between sliding surfaces. The tracks formed on the coatings and scars on the metallic balls were observed by optical microscopy. Despite having higher COF values in liquid medium, wear of the coatings appeared to decrease compared to tests in air (Fig. 1). It seems that these films can be *in vivo* tested as bio-coatings on load bearing surfaces.



(a) (b) (c)

Fig. 1 – Film deposited in Ar/CH_4 (190/30 sccm), bias voltage of 0V. (a) Coefficient of friction in different wear test media. Optical microscopy of the track formed on the coating in (b) test in air, and (c) in liquid medium. Magnifications of 50X.

Acknowledgements: CNPq (Project SWE 200654/2007-1), CAPES and FAPERJ Brazilian funding agencies.

References

[1] R. Hauert, Tribology International **37**, (2004) 991.