Biotribological Characterization of Laser Textured Ti6Al4V Produced by Addictive Manufacturing

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1. Introduction

Implantable medical devices used in human body as well as for dental purposes require biocompatibility with the surrounding tissues and organs, biomechanical strength and corrosion resistance. The body fluids constitute a hostile environment for the implant, which is also subjected to various loads. The implant can release particles due to corrosion, corrosion associated with fatigue, and even friction against implantable components, bones or other body parts. By coming into contact with body fluids, these particles can be placed in locations far from the removed source causing complications to the patients. Interaction between metallic implants and the human body can be affected by numerous factors such as the structure of the metal surface, its mechanical properties, size and shape. When in contact with the body tissues after implantation, metallic devices affect the intensity of stresses to which the whole human body is subjected the implant as well. Wear and corrosion processes are additional effects arising from the interaction between metallic biomaterials and the body tissues [1]. The micro-scale abrasion test (or ball-cratering wear test) is a practical method to analyze the wear resistance of biomaterials. The ball-cratering wear test has gained large acceptance at universities and research centers and is widely used in studies focusing on the abrasive wear behavior of different materials. Tests in micro and nano tribometers are used to investigate small regions and thin layers of different surfaces. The aim of this work was to evaluate the tribological behavior of Ti6Al4V textured by pulsed Ti: Sapphire laser, using ball-cratering wear tests.

2. Materials and methods

The tribological behavior of Ti6Al4V samples was assessed by wear tests conducted in a nanotribometer (Anton Paar - model NTR^2). The tests were performed in the air, at 25° C, with counter-body of chrome steel 52-100 rotating ball shape, 2 mm in diameter, during 10 minutes, with normal force of 100.0 mN, distance equivalent to 2.4 m, and scan speed of 4.0 cm.s^{-1}. Both laser-textured and pristine material were evaluated. Prior to the texturization stage, the samples were electrolytically polished in a solution of perchloric acid and ethanol.

3. Results

This work also analyzed the evolution of the friction coefficient by nanotribometer wear tests of the surfaces of these biomaterials with laser texturing treatment comparing with the blank specimen (without treatment). No direct relationship between wear volume and friction coefficient was observed, i.e., the highest value of wear volume was not related to the higher value of coefficient of friction. For the laser textured surfaces, Figure 6, the values of friction coefficient obtained were lower than those obtained in the samples without treatment by the laser beam (blank).

The friction coefficient values for the untreated specimen showed a rapid increase in the beginning of the test, and practically stabilized as the surface becomes less rough. In the case of the Ti6Al4V laser textured samples, the friction coefficient decreases primary, reaching a stabilization period up to the end of the running test. The variation of the coefficient of friction as a function of the test time was studied by Huang et al. [2]. They verified this effect on tribological properties in Ti6Al4V alloys with and without coatings ("laser clad"), for a running time of 3500 seconds in different rotation frequencies, at the end of the tests they verified that the coefficient of friction for the coatings was always inferior to the substrate.

4. Conclusions

The results indicated that the tribological behavior is influenced by the surface finishing parameters, and the wear rate is dependent of the normal force and the roughness of each sample. Therefore, it is necessary to constantly advance research on the use of femtosecond pulsed laser coatings on the biomaterial's surfaces produced by addictive manufacturing techniques.

5. References

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