Research paper

Tribological characterization of a biocompatible thin film of UHMWPE on Ti6Al4V and the effects of PFPE as top lubricating layer

Bharat Panjwani, Nalam Satyanarayana, Sujeet K. Sinha*
Department of Mechanical Engineering, National University of Singapore, 9 Engineering Drive 1, Singapore 117576, Singapore

ARTICLE INFO
Article history:
Received 5 October 2010
Received in revised form
6 February 2011
Accepted 9 February 2011
Published online 17 February 2011

Keywords:
Ti6Al4V
Coating
UHMWPE
Friction
Wear
Tribology

ABSTRACT
Ultra-high molecular weight polyethylene (UHMWPE) thin film was coated onto Ti6Al4V alloy specimens using dip coating method. Tribological performance of this coating (thickness of 19.6 ± 2.0 µm) was evaluated using 4 mm diameter Si3N4 ball counterface in a ball-on-disk tribometer. Tests were carried out for different normal loads (0.5, 1.0, 2.0 and 4.0 N) and rotational speeds of the disk (200 and 400 rpm). UHMWPE coating formed in this study exhibits high hydrophobicity with water contact angle of 135.5 ± 3.3° and meets the requirements of cytotoxicity test using the ISO 10993-5 elution method. This coating shows low coefficient of friction (0.15) and high wear durability (>96,000 cycles) for the tested conditions. PFPE overcoat on UHMWPE has further increased the wear durability of UHMWPE coating as evaluated at even higher rotational speed of 1000 rpm.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction
Titanium and its alloys have been widely used in many biomedical and industrial applications due to their high specific strength, corrosion resistance and biocompatibility. However, high coefficient of friction and low wear resistance limit their usage in some applications (Budinski, 1991; Yildiz et al., 2009).

To improve the tribological properties of titanium alloys, various surface coatings and treatments have been explored. Plasma nitriding is one of the widely studied surface treatments for titanium alloys (Molinari et al., 1997; Yildiz et al., 2008). Ceramic coatings have also been investigated in many studies for improving the tribological properties of titanium alloys (Fei et al., 2009). In spite of these developments, there is a need to explore effective solutions for poor tribological properties of titanium and its alloys.

Recently, researchers have shown interest in polymer coatings for tribological applications due to its ease of fabrication, lower cost and impact loading performance (Demas and Polycarpou, 2008; Zhang et al., 2010). Application of polymer coatings in improving the tribology of titanium alloys has not been much explored. Among polymers, bulk UHMWPE exhibits high wear resistance (Sinha, 2002). Due to its superior wear resistance, UHMWPE coating may provide a suitable solution for boundary lubrication (or as a solid lubricant) of titanium alloys in biomedical and industrial applications. UHMWPE, as thin film coating, has shown low coefficient of friction and wear resistance in some studies (Abdul Samad et al., 2010; Minn and Sinha, 2008;