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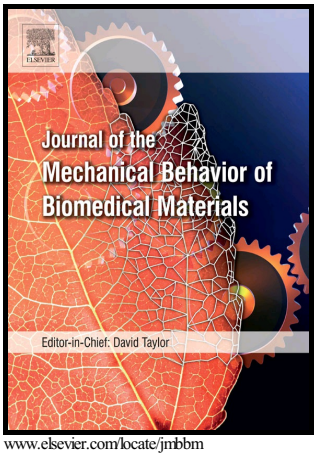

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Diamond-like carbon coatings with zirconium-containing interlayers for orthopedic implants

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Abstract

Six types of diamond-like carbon (DLC) coatings with zirconium (Zr)-containing interlayers on titanium alloy (Ti-6Al-4V) were investigated for improving the biotribological performance of orthopedic implants. The coatings consist of three layers: above the substrate a layer stack of 32 alternating Zr and ZrN sublayers (Zr:ZrN), followed by a layer comprised of Zr and DLC (Zr:DLC), and finally a N-doped DLC layer. The Zr:ZrN layer is designed for increasing load carrying capacity and corrosion resistance; the Zr:DLC layer is for gradual transition of stress, thus enhancing layer adhesion; and the N-doped DLC layer is for decreasing friction, squeaking noises and wear. Biotribological experiments were performed in simulated body fluid employing a ball-on-disc contact with a Si_3N_4 ball and a rotational oscillating motion to mimic hip motion in terms of gait angle, dynamic contact pressures, speed and body temperature. The results showed that the Zr:DLC layer has a substantial influence on eliminating delamination of the DLC from the substrates. The DLC/Si_3N_4 pairs significantly reduced friction coefficient, squeaking noise and wear of both the Si_3N_4 balls and the discs compared to those of the Ti-6Al-4V/Si_3N_4 pair after testing for a duration that is equivalent to one year of hip motion *in vivo*.

Keywords: N-doped diamond-like carbon; zirconium; wear resistance; squeaking noise; orthopedic implant; tribocorrosion.

1. Introduction

Despite a high number of studies on orthopedic implants, including new materials and designs, the revision rate of orthopedic implants is still high [1, 2]. During the last five years, the number of hip and knee replacements increased by a significant percentage (20 - 30%) worldwide [3, 4]. The demand for this intervention in younger patients (ages 45 - 64) is increasing; they require at least 30 years of functionality, but the average lifespan of an