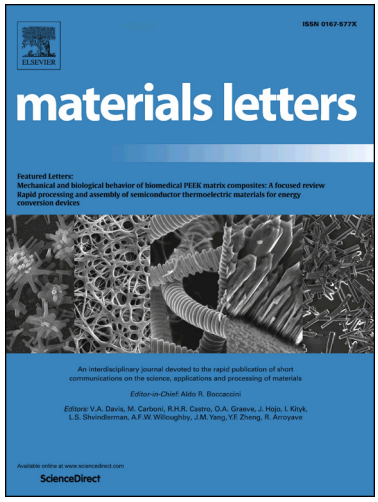

Comparative analysis of the tribological characteristics of canine joint cartilage and UHMWPE-based biomimetic materials

A.V. Maksimkin, D.I. Chukov, F.S. Senatov, A.I. Salimon

PII: S0167-577X(16)31991-7
DOI: http://dx.doi.org/10.1016/j.matlet.2016.12.107
Reference: MLBLUE 21919

To appear in: *Materials Letters*

Received Date: 13 December 2016
Accepted Date: 28 December 2016

Please cite this article as: A.V. Maksimkin, D.I. Chukov, F.S. Senatov, A.I. Salimon, Comparative analysis of the tribological characteristics of canine joint cartilage and UHMWPE-based biomimetic materials, *Materials Letters* (2016), doi: http://dx.doi.org/10.1016/j.matlet.2016.12.107

Comparative analysis of the tribological characteristics of canine joint cartilage and UHMWPE-based biomimetic materials

A. V. Maksimkin[1]*, D. I. Chukov[1], F. S. Senatov[1], A. I. Salimon[1]

[1] National University of Science and Technology "MISIS", Moscow 119049, Russia
*Corresponding author: Aleksey Maksimkin, e-mail address: aleksey_maksimkin@mail.ru

Abstract
We report the results of pin-on-disc friction and wear testing for canine shoulder and knee joint cartilages and UHMWPE-based biomimetic composites against stainless steel counter-body. The values of the friction coefficient for natural cartilage against carbon steel were found to lie around 0.01 for shoulder and 0.015 for knee joints. The orientation treatment and the incorporation of fluorinated carbon nanotubes applied to isotropic bulk UHMWPE caused both the reduction of the friction coefficient from ~0.09 to ~0.05, and as well as the decrease of wear rate down to 3 times.

Keywords: Cartilage; Tribology; Polymers; Nanocomposites; Carbon nanotubes; Biomimetic

1. Introduction

Total joint replacement is possibly the most widespread surgical intervention in the world that accounts for up to 1 000 000 operations annually [1]. The hip and knee prostheses are highly demanding tribological applications that require not only delivering frictional pairs of low resistance and high durability, particularly in view of the production of harmful wear debris in the friction pair that may cause periprosthetic osteolysis at the bone-implant interface that may ultimately lead to the final failure of the replacement joint. Currently the mostly widely used friction pair is the metal-on-UHMWPE combination [1]. Therefore, the improvement of UHMWPE tribological characteristics is the primary specific challenge that is critical for improving prostheses reliability. A number of methods have been put forward to modify the properties of UHMWPE, including nanoparticle reinforcement [2], macromolecular cross-linking [3] and the enhancement of the degree of crystallinity [4]. A potentially impactful approach is the application of orientation treatment, since a promising combination of mechanical properties has been reported for commercially available highly oriented fibres: Young's modulus up to 140 GPa, tensile strength up to 3.9 GPa, and the friction coefficient lying in the range of 0.04-0.05 [5,6].

We have compared the tribological behavior of the friction pair constituted by the dog's cartilage and oriented bulk UHMWPE. We therefore conclude that UHMWPE modified by orientation treatment offers an efficient route for the improvement of components for hip and knee prostheses.

2. Materials and Methods

The bone-cartilage combination of tissues from a dog shoulder and knee joint cartilage samples taken from an adult dog of bullmastiff breed were extracted to obtain cylindrical samples of 6.3 mm diameter and 10 mm height and mounted in the pin-on-disk tribo-testing rig (CETR UMT-3, Bruker, CH) illustrated in Fig. 1. Samples of UHMWPE material were molded using the process that has been previously described elsewhere [7,8]. Samples in different states were considered, namely, bulk isotropic UHMWPE, oriented unfilled UHMWPE, and bulk oriented UHMWPE-based nanocomposite doped with 1%wt fluorinated multiwall carbon nanotubes (FMWCNT). The parameters of tribological evaluation were chosen to correspond to standard testing conditions for cartilage [9,10], namely, frictional contact against carbon steel disc with the