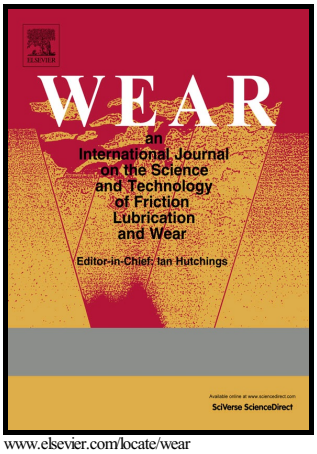

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Multi-length Scale Tribology of Hydroxyapatite Reinforced with Ceria and Silver

Aditi Pandey[1], *Vinod Kumar Nigam*[2], *Kantesh Balani*[1, $]

[1]Biomaterials Processing and Characterization Laboratory, Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, Uttar Pradesh, India.

[2]Department of Bio-Engineering, Birla Institute of Technology, Mesra, Ranchi -835 215, Jharkhand, India

Abstract

In order to control the inflammatory reaction and bone resorption due to wear debris and obtain a multi-functional composite with superior mechanical and tribological properties, antioxidant ceria (CeO_2) and antibacterial silver (Ag) nanoparticles are synergistically reinforced in hydroxyapatite (HA) matrix. Enhanced hardness (5.3 to 8.6 GPa), elastic modulus (120.8 to 167.9 GPa) and fracture toughness (0.21 to 0.90 $MPa.m^{1/2}$) and reduced brittleness index (24.8 to 9.6 $\mu m^{-1/2}$) of HA-CeO_2-Ag composite were achieved, when compared to that of HA. A multi-length scale tribological study (by dissimilar damage mechanisms in fretting and scratch) is presented. Observed herein, that enhanced mechanical properties elicited a wear resistance of 89% (by fretting) and 13% (by scratch), with synergistic CeO_2 and Ag reinforcement. Compression during fretting over a localized length (100 μm) resulted in the closure of pores, whereas micro-scratching exposed a higher number of interfaces (by an order of magnitude), reducing wear resistance at higher length scales. In summary, HA-CeO_2-Ag composite restricts tribological damage effectively over multi-length scales, thereby serving as an optimal substrate with efficient load-bearing capacity for orthopedic applications.

$ Corresponding author from IIT Kanpur: Email: kbalani@iitk.ac.in, Ph: +91-512-259-6194.