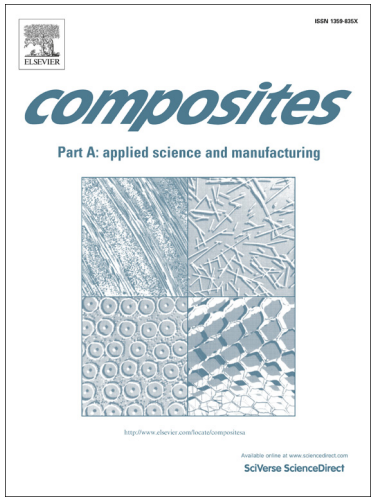

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Effects of Carbon Nanotube Aspect Ratio on Strengthening and Tribological Behaviour of Ultra High Molecular Weight Polyethylene Composite

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Abstract

Carbon-based nanomaterials are great choice as reinforcement to ultra-high molecular-weight polyethylene (UHMWPE), with potential use in orthopedics. While high in-plane-stiffness and strength of these nanomaterials help in toughening, their weaker out-of-plane integrity offers lubrication. Present study investigates effect of aspect ratio of carbon nanotubes (CNT) on toughening and solid-lubrication efficiency of UHMWPE-matrix. A nominal 0.05–0.1wt.% of CNT addition increases hardness and elastic modulus of UHMWPE by 3-45% and 8-42%, respectively. Higher aspect ratio (HAR) CNTs are found more effective in improving hardness and modulus of UHMWPE. Wear rate and friction-coefficient also increase by 530% and 220%, respectively, while reinforced with HAR CNTs. Thermal analysis shows slight increase in crystallinity and stability of composite. HAR CNTs improve interfacial bonding with matrix, due to their morphological similarity to polymer chains, as compared to low aspect ratio CNT. Aspect ratio of CNTs significantly dominates strengthening and tribological behavior of UHMWPE.

Keywords: A. Polymer- matrix composites (PMCs), B. Wear, B. Mechanical properties, D. Thermal analysis.

1. INTRODUCTION

Ultra-High Molecular Weight Polyethylene (UHMWPE) has been extensively used in various joint replacement applications (artificial hip cups and tibial inserts), with articulating counteract surfaces made of metals or ceramics [1, 2]. UHMWPE has been chosen over other commercial polymers because of its superior toughness, impact strength, low friction and abrasive sliding wear resistance. In addition, easy fabrication ability and superior biocompatibility of UHMWPE in the physiological environment makes it even suitable for the above mentioned application [3]. However, tribological behavior of UHMWPE lining plays a critical role in deciding life span of modular acetabular cup in total hip implants [4]. Though UHMWPE is in clinical application for long time, its performance in extended period has been limited due to its inherent low yield strength, leading to permanent deformation, severe wear and ultimately premature failure of implant. Relative motion between the metal/ceramic