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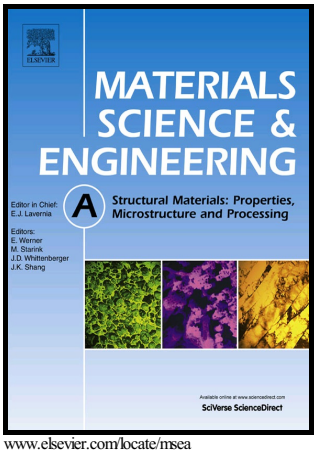

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Multi-functionality of Carbon Nanotubes Reinforced 3 mol.% Yttria Stabilized Zirconia Structural Biocomposites

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Abstract:

The effect of the addition of carbon nanotubes (CNT) on the densification, microstructural, mechanical, wear performance and biocompatibility of 3 mol.% yttria stabilized zirconia (3YSZ) have been investigated in the present study. The retention of high temperature phases (tetragonal and cubic) was found to increase with CNT addition in 3YSZ. Enhancement in the mechanical properties (hardness and elastic modulus) with CNT reinforcement is attributed to the refinement of grain size, enhanced densification and homogeneous distribution of CNT (up to 6 vol.%). Correspondingly, fracture toughness increased from 5 MPa.m$^{1/2}$ (in 3YSZ) to 10.1 MPa.m$^{1/2}$ with CNT reinforcement (for 12 vol.%) through energy dissipating mechanisms such as crack branching, CNT bridging, and crack-deflection, evidenced by the fractographs of 3YSZ-CNT composites. The toughening contribution with CNT reinforcement is observed to dominate over toughening contribution of $t \rightarrow m$ transformation by ~38 times, evaluated using a modified fractal model. However, this effectiveness decreased with CNT agglomeration. The physical damage of in the bacterial cell is observed to increase with CNT addition. The present findings promote 3YSZ-CNT as an optimal structural and antibacterial mutifunctional biomaterial.

Keywords: Yttria stabilized zirconia; carbon nanotubes; toughness; transformation toughening; anti-bacterial.

1. Introduction:

Tetragonal to monoclinic ($t \rightarrow m$) transformation in zirconia (ZrO_2) is martensitic in nature and, thus, reversible when heating or cooling through the transition temperature of ~1100 °C [1]. The existence of such a transformation and the associated volume expansion (~ 4.5 %) can be used to increase both fracture toughness and strength [2, 3]. 3 mol.% yttria (Y_2O_3) doping in ZrO_2 (3YSZ) stabilizes the tetragonal phase to room temperature ZrO_2 [4] and is one among the toughest ceramics (flexural strength, σ_f (~1 GPa) and fracture toughness, K_{IC} (~ 10 MPa.m^{½}) [5]). Being biocompatible, 3YSZ is also used in biomedical

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