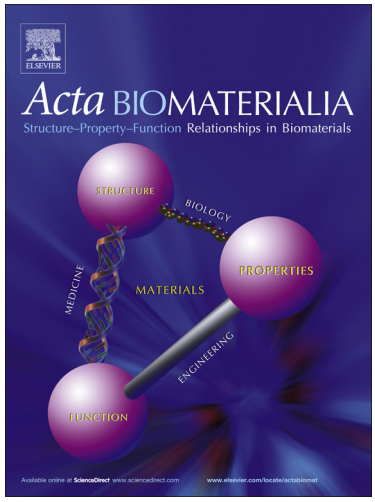

Full length article

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Sub-surface assessment of hydrothermal ageing in zirconia-containing femoral heads for hip joint applications

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Abstract

Zirconia-based materials have been used in orthopaedics since the 1980s, with large success, mainly thanks to transformation toughening. On the other hand, their main drawback is their potential sensitivity to hydrothermal ageing, *i.e.* tetragonal to monoclinic phase transformation on their surface in the presence of water. Hydrothermal ageing may result in roughness increase and microcracking of the surface. In this article the hydrothermal ageing behaviour of three medical-grade zirconia-based materials is assessed at high temperature and extrapolated to room or body temperature. The degradation is also characterized by FIB/SEM nano-tomography to better assess sub-surface evolutions. In both zirconia and alumina-toughened zirconia (ATZ), ageing results in the presence of a homogenous transformed layer of constant thickness whose growth rate is about 8 times slower in ATZ than in zirconia. Microcracking occurs in the entire transformed layer in zirconia, but was much less relevant in ATZ. Zirconia-toughened alumina (ZTA) is much less prone to ageing. In ZTA ageing results in a thin transformed layer in which the monoclinic fraction decreases with depth. No microcracking was observed in ZTA.

Statement of significance

This article details the microstructural evolution of the surface of three zirconia-based ceramics when exposed to water (hydrothermal ageing), and establishes a time-temperature equivalences of these evolutions. It shows that different zirconia-alumina composites do not degrade the same way: zirconia and alumina-toughened zirconia present a homogeneous degraded zone of constant thickness, whereas zirconia-toughened-alumina presents a gradient of transformation.

These new findings will help understanding better the hydrothermal degradation of zirconia based materials, and in particular will facilitate a better prediction of the durability of