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The influence of stresses on ageing kinetics of 3Y- and 4Y- stabilized zirconia

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Abstract

Hydrothermal ageing is one of the most important limiting factors for the use of yttria-stabilized zirconia ceramics in contact with water-containing environments. It consists in the transformation of tetragonal phase to monoclinic phase, initiates on the surface of zirconia in the presence of water, and leads to roughening and potentially to micro-cracking and loss of integrity. The present work seeks to explore the influence of applied and residual mechanical stresses on the ageing kinetics of 3Y- and 4Y-TZP. Residual stresses were obtained by rough polishing. A subsequent Annealing step was employed for the preparation of samples free of residual stresses. All samples were submitted to *in situ* 3-points bending tests in water vapour atmosphere inside an autoclave at 134°C, allowing surfaces with a mechanical stress gradient to be exposed to hydrothermal ageing. The evolution of the monoclinic fraction with time and stress was then analysed using Mehl-Avrami-Johnson equation.

Keywords: zirconia; hydrothermal ageing; stress; nucleation and growth

Introduction

Since the failure events of Prozyr® femoral heads in 2001–2002 occurred, the studies of the ageing behavior of zirconia ceramics has become the topic of many works. Hydrothermal ageing (also called LTD for Low Temperature Degradation) is a low temperature tetragonal-to-monoclinic phase transformation (t→m) that occurs on the surface of zirconia ceramics in humid environment. This ageing process is strongly influenced by microstructural parameters (such as stabilizer nature and content, density, surface finish, grain size, cubic phase content, etc.) and mechanical stresses. This work focuses on the influence of both applied and residual stresses on the hydrothermal ageing behavior, which is not yet completely understood [1].