Abstract

Nano sized ceria/yttria stabilized zirconia (CSZ/YSZ) and ceria/yttria stabilized zirconia toughened alumina (CSZ-TA/YSZ-TA) powders were synthesized by wet chemical method and subsequently consolidated to near full density following an optimized calcination and conventional pressureless sintering route. Average grain size of 4.3, 0.7, 1.7 and 1.2 μm with Vickers hardness up to 945, 1364, 1730 and 1800 were found for CSZ, YSZ, CSZ-TA and YSZ-TA systems, respectively. In case of CSZ system, accelerated ageing studied at 134 °C/0.2 MPa shows nucleation of orthorhombic zirconia phase after 25 h of hydrothermal treatment. Contrary to that, for YSZ, CSZ-TA and YSZ-TA systems; nucleation of monoclinic zirconia was observed. It is noteworthy that the rate of phase transformation (during ageing) is significantly reduced for ceria containing specimens. For CSZ-TA specimens, only about 1.5% monoclinic phase was found even after 50 h (equivalent to a minimum of 100 years *in vivo*) hydrothermal treatment whereas it was about 3.4% for YSZ-TA. Both these values are well below the recommendations made by ISO standard/manufacturer guidance and hence suitable for implant applications. Specimen's surfaces after hydrothermal treatment reveal partially/completely pulled out grains. However surface roughness does not alter much. The extent of such transformation and roughening were also higher for yttria containing specimens compared to ceria containing ones.

Surfaces after fretting wear show evidences of microcrack formation, grain pull outs and abrasion. Although the wear resistance property of YSZ is superior to CSZ specimens, CSZ specimens show better wear resistance after ageing.

Biocompatibility was corroborated from apatite like mineral layer formation on the surface of specimens while immersed in simulated body fluid at 37.5 °C. Calcium ortho-phosphate and hydroxyapatite (confirmed from EDS and XRD analyses) biomineral layer up to ~ 14-17 μm thick was found after 28 days. Differential rates of nucleation of minerals for alumina and zirconia specimens suggest that Zr-OH bond might have helped this accelerated nucleation of hydroxyapatite as compared to Al-OH bond. Multi layered interconnected human osteoblast like cells (MG63) were attached on the surface; cell proliferation and differentiation were satisfactory suggesting biocompatibility of the developed materials.

Keywords: Alumina-zirconia bioceramics, Rietveld refinement, ageing, fretting wear, *in vitro* osteoconduction, cell culture, biocompatibility.