

Fabrication of Porous Al_2O_3 and t- ZrO_2 Ceramics and Evaluate their Biocompatibility

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INTRODUCTION: Recently, yttria stabilized zirconia (t- ZrO_2) and Al_2O_3 have been considered as a typical bioceramics for implants such as prostheses, dental materials and femoral heads due to their excellent biocompatibility, as well as desirable material properties such as strength, chemical stability and wear resistance [1]. However, the pore size, shape and porosity are also important factors to consider improving the compatibility of ceramics for implants because they are closely related to cell attachment, growth behavior and bond strength between the tissue and the artificial implant in the human body [2]. Suitable pore sizes for implants were reported to be approximately 100-150, 140-160 and 200-1000 μ m in diameter [3].

METHODS: To fabricate the continuously porous Al_2O_3 and t- ZrO_2 bodies, the starting ceramic powders /EVA/ stearic acid with a 50/40/10 volume fraction, were homogeneously mixed using a shear mixer. This mixture was used to produce tubes by warm press. On the other hand, to make the rod, a pore-forming agent (carbon, Aldrich Chemical Company, USA), polymer and stearic acid (volume fraction 50/40/10) were also mixed using a shear mixer at 120°C for 1hr. The tubes and rods were assembled together to prepare a feed roll and extruded at 120°C to make the 1st passed filaments with a diameter of 3.4 mm. The 1st passed filaments were cut 80mm in length and reloaded into the extrusion die and re-extruded to make the 2nd passed filaments. To remove the polymer binder (EVA) and pore forming agent carbon, the 1st and 2nd burnout was performed at 700°C and 1000°C, respectively. Finally, the pressureless sintering process was carried out at 1450°C-1600°C for 1 hr in flowing air.

RESULTS: Fig.1 (a) and (b) are SEM and TEM images of porous Al_2O_3 bodies and (e) (f) are SEM images of t- ZrO_2 bodies. The pore sizes of the 2nd passed samples were 260 μ m, in diameter. The average grain sizes of Al_2O_3 and t- ZrO_2 bodies were about 0.8 μ m and 0.7 μ m in diameter, respectively. In case of Al_2O_3 porous body, in pore

frame region also many fine pores less than 100nm in diameter were clearly observed. Figure 1(c) and

(h) are the light microscopic images of osteoblast cells grown behaviour of porous t- ZrO_2 and Al_2O_3 bodies, respectively. The spindle shape osteoblast cells grew well in both samples and most of the cells went down through the pores. On other hand, the pebble stone appearance osteoclast cells fully covered the pore frame region with in 12 days as shown in Fig. 1(d) and (h).

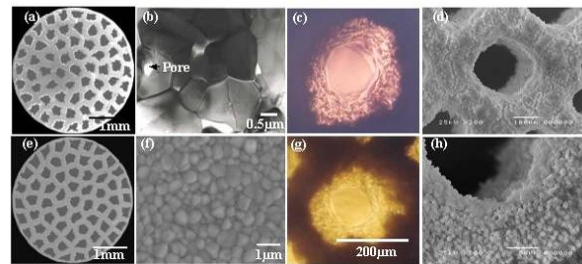


Fig. 1: SEM (a), (e), (f) and TEM (b) images of porous Al_2O_3 and t- ZrO_2 and their grown behaviour of osteoblast (c), (g) and osteoclast (d), (h) cells.

DISCUSSION & CONCLUSIONS: Continuously porous Al_2O_3 and t- ZrO_2 ceramics were fabricated by multi-pass extrusion process using commercial Al_2O_3 and t- ZrO_2 powders. The pore forming agent and binder were successfully removed during the burn out process and fabricate the continuously porous Al_2O_3 and t- ZrO_2 bodies. Their biocompatibility was evaluated through in-vitro investigation. All kinds of cells were grown well on top and bottom surface as well as inside the surface of the porous bodies. The growth of osteoblast cells showed spindle shape, three-dimensional and network type structures. In contrast, osteoclast revealed the growth behavior like pebble stone in appearance.

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