Investigation of antibacterial activity and synthesis of zirconia meso-porous nanoparticles by soft molding

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Abstract

Daily increase of antimicrobial resistance in microorganisms is a major concern for human health. This requires the search for new unconventional antimicrobial agents. Nano-material technology, makes us hopeful to fight infectious diseases by using nanoparticles with antimicrobial activity. Among various metal oxides, ZrO_2 is used in various implant devices due to its good mechanical properties and biocompatibility. As a ceramic, ZrO_2 has several advantages such as corrosion resistance, mechanical strength, abrasion resistance, fracture toughness and chemical stability. In this paper, the evaporation-induced self-assembly (EISA) method is used for synthesis meso-porous zirconia. In addition, Pluronic F127 is applied to achieve a greater surface area. The results show that aging and calcination temperature are effective parameters to increase the specific surface area and pore size reduction. Various analyzes such as XRD, TEM and absorption/desorption analysis of nitrogen was carried out in order to determine the specific surface area, pore size and volume, phase structure and morphology of the synthesized meso-porous material. It was observed that there is a high surface area of about 184.66 m^2g^{-1} with pore size of 3.05 nm at calcination temperature of 400$^{\circ C}$. Agar Diffusion method was used to investigate the antibacterial activity of zirconia meso-porous nanoparticles. In this method, the gram-positive (S.aureus) and gram-negative (E.coli) bacteria were used, according to their clinical significance, and it was found that zirconia meso-porous nanoparticles have a high antimicrobial activity against S.aureus bacteria relative to E. coli bacteria.

Keywords: meso-porous zirconia, high surface area, antibacterial

Introduction

Humans come always in contact with various microorganisms such as bacteria, viruses, fungi and etc., in their living environment. Therefore, a lot of research has focused on synthesizing materials with antibacterial property[1] .In comparison to organic materials, nanoparticles offer better antibacterial properties. One of its reasons is the high ratio of the surface area to the volume and thus, the presence of a large fraction of surface atoms in nanometer-sized materials. Therefore, a large fraction of surface atoms together with the effect of the shape and size of the very fine grain nanoparticles cause nanoparticles to be differentiated from a material in the mass format and pave the way to fight bacteria[2].

Zirconium oxide or zirconia (ZrO2) is an interesting and useful metal-oxide, in many different application fields, thanks to its good mechanical, thermal, functional and sometimes unique properties. These materials are commonly used as thermal barrier coatings (TBCs), dental and bone prostheses, high resistance laminates, solid oxide