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A Note on Synthesis Zirconia as a Dental Biomaterial

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Description

The development of the dental crowns is highly concerned with the optimum mechanical properties, superior esthetic appearance and biocompatibility. In order to meet the requirements, structural ceramics has been improved and has become increasingly more popular in the dentistry. Among from the dental ceramics, zirconia is the dental restorative material most commonly used in the dental restoration. This material has some unique characteristics, such as high fracture toughness, biocompatibility, and the color approximating the natural tooth color. However, that zirconia is too opaque, which reduces the esthetic appearance for the restoration. This paper reviews zirconia as a dental material with their potentials for further use in the ceramic dentistry.

Introduction

Bones Ceramics are very important in the science for dental biomaterials. Among all the dental ceramics, zirconia is evidence as a dental biomaterial and it is the material of choice in contemporary restorative dentistry. Zirconia has been applied as structural material for the dental bridges, crowns, inserts, and implants, mostly because of its biocompatibility, high fracture toughness, and the radiopacity. However, the clinical success of restorative dentistry has to be considering the adhesion to the different substrates, which has been offered a great challenge to dental zirconia research and development. This study characterizes zirconia as a dental biomaterial, presenting the current consensus and challenges for its dental applications.

The most popular dental ceramic systems are like silica-, leucite-, lithium disilicate-, alumina-, and zirconia-based on materials. Currently, zirconia-based ceramics are the most studied and challenging researches for the different reasons. Zirconia (zirconium dioxide, ZrO_2), also named as "ceramic steel" has been optimum properties for dental use of superior toughness, strength, and fatigue resistance, in the addition to the excellent wear properties and biocompatibility. Zirconium (Zr) is a very strong metal with the similar chemical and physical properties to titanium (Ti). Incidentally both Zr and Ti are 2 metals commonly used in implant dentistry, mostly because they do not have the inhibition for the bone forming cells (osteoblasts) which are essential for Osseo integration [1-5].

Dental zirconia is the most modified yttria (Y_2O_3) tetragonal zirconia poly crystalline Yttria is added for stabilization the crystal structure transformation during firing at an elevated temperature and improves the physical properties of zirconia. While heating, the monoclinic phase of zirconia starts transforming to the tetragonal phase at 1187°C, peaks at 1197°C, and finishes at 1206°C. During cooling, the transformation from the tetragonal to the monoclinic phase starts at 1052°C, peaks at 1048°C, and finishes at 1020°C. The zirconia tetragonal-to-monoclinic phase transformation is known as a martensitic transformation. During the zirconia phase transformation, the unit cell of the monoclinic configuration occupies about 4% more volume than the tetragonal configuration, which is relatively large volume change. This can be result in the formation of ceramic cracks if no stabilizing oxides were used.

Ceria (CeO_2), yttria (Y_2O_3), alumina (Al_2O_3), magnesia (MgO) and calcia (CaO) have been used as stabilizing oxides. So as the monoclinic phase does not form under normal cooling conditions, the cubic and tetragonal phases are retained and cracked formation due to the phase transformation is avoided. It is also very important to consider the stabilization of the tetragonal and cubic structures requires different amounts of dopants. The tetragonal phase is the stabilized at lower dopant concentration than the cubic phases. However, the way of stabilizing the tetragonal phase at the room temperature is to decrease the crystal size. This effect has been attributed to the surface energy differences. Consequently, zirconia-based upon ceramics used for the biomedical purposes typically exist as a metastable tetragonal partially stabilized zirconia (PSZ) at the room temperature. Metastable means that trapped the energy still exists within the material to drive it back to that monoclinic phase. It turned out that the highly localized stress ahead for a propagating crack is sufficient to trigger the zirconia grains to transform in the vicinity of the crack tip. In this case the 4% volume increases becomes beneficial, essentially squeezing the crack for closing and increasing toughness, known as transformation toughening.

Conflict of Interest

The authors declare that there is no conflict of interest associated with this manuscript.

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