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Research and Application of Zirconia Ceramics for Oral Prosthesis

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Abstract

With the development of society, science and technology are also constantly progressing, new materials and technology have more and more impact on people's lives. Zirconium is widely used in various fields because of its low price and corrosion resistance, but also for its high hardness, oxidation resistance and good stability. This experiment mainly introduces the effect of different types of material zirconia ceramics on the effect of oral repair, and proposes reasonable and feasible improvement measures by analyzing the results.

Keywords

Oral repair; Zirconia ceramics; Structural characterization

1. Introduction

Zirconia ceramics have a wide range of applications, including industry, agriculture, and medicine. They are primarily used as high-temperature antimicrobial agents and biopolymers. They offer excellent chemical stability, minimal environmental pollution, high recyclability, and the absence of special handling requirements. However, zirconia ceramics are expensive and susceptible to acid corrosion, which limits their service life. Therefore, zirconia ceramics have become a focus of research both domestically and internationally. This article examines the application of zirconia ceramics in dental restorations.

2. Experimental Materials and Methods

2.1 Zirconia Ceramic Material

Zirconia ceramic is a kind of ceramic material with a polymer as the matrix, a certain amount of metal oxide is added, and then it is made through processes such as roasting and drying. It not only has excellent properties that ordinary ceramic materials do not have (such as good hardness), but also can show good dielectric constant and thermal conductivity at high temperature. Due to its special structural characteristics and different ratio characteristics, it can meet the more stringent requirements of ceramic products in many fields and has a large application space, so it is widely used in various industries.

2.2 Sample Preparation

The prepared sample is dried at 250℃ with a flat dish, and then placed in a drying oven for insulation. First, weigh 3 parts of 100g of oral restoration material zirconia ceramic powder and put it into a charcoal grinding box, then add an appropriate amount of distilled water and mix evenly. After it is fully immersed in water, take it out and place it on the mouth of a conical flask and cook for 2-4 minutes. Then soak it in anhydrous ethanol extraction solution for 24 hours to obtain the surface morphology of the effective substance and the coating quality. The sample

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can be observed and photographed by scanning electron microscope for microstructure and sample [1].

2.3 Coating

In the preparation of seamless ceramic materials, additives such as surfactants are generally added at a certain mass fraction, resulting in a coating with excellent physical and chemical properties, high mechanical strength, and superior fatigue resistance compared to other coatings. When these factors are combined and integrated into a single entity, the desired formulation is achieved. By adding an appropriate plasticizer, the degree of cross-linking between the various components in the ceramic material is enhanced while maintaining its bond with the substrate, thereby improving its physical properties, making it more resistant to high temperatures, and reducing moisture evaporation from the ceramic surface.

2.4 Material Modification

There are two main methods for modifying zirconium ceramics: chemical and physical methods.

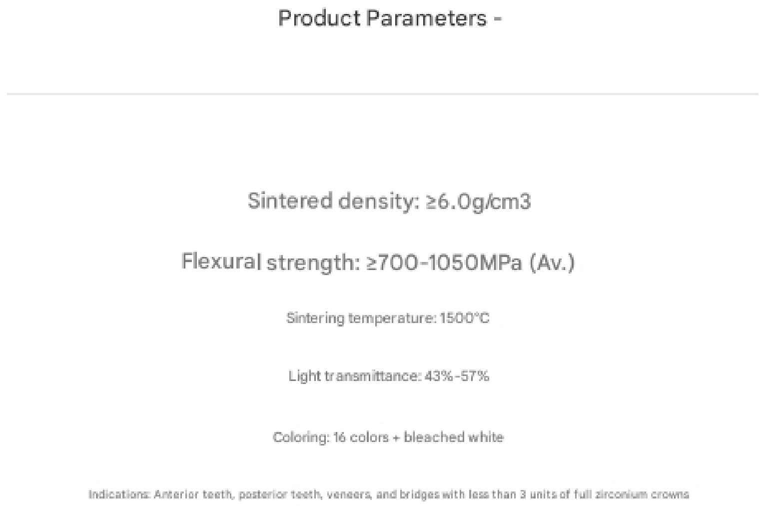

Figure 1. Parameters of magic cube zirconium products.

(1) Chemical modification is the use of chemical reactions or covalent bonding reactions to improve the surfactant properties and anti-aging function of corrosion-resistant materials. In general, an appropriate amount of chromium-containing compounds is added to acid, alkaline solutions or organic solvents to form complexes with metal ions to enhance their corrosion resistance; sodium hydroxide is used as a co-mediator to cause zirconium ceramics to undergo oxidative degradation reactions to generate a high-hardness oxide precipitate to increase dissolution.

(2) Physical modification is an important method for preparing nano-zirconia ceramics. By controlling different temperatures, it causes deformation to a certain extent, thereby obtaining the required mechanical properties. The reaction conditions and heat treatment conditions were studied using X-ray diffraction and scanning electron microscopy.

3. Structural Characterization of Zirconia Ceramics

3.1 Spectral Analysis of Zirconia Ceramics

Spectral analysis (TCR) is a qualitative and quantitative experimental method based on instruments. It uses samples of different wavelengths and certain frequencies or detects their components to determine the required elements. Compared with traditional detection technologies, it has the advantages of fast measurement speed, high test accuracy and easy operation. In the experiment, we used silicon powder as the medium and the surface of zirconia ceramics treated with ferrous sulfate. Because titanium dioxide has the characteristics of high specific surface area, good transparency and acid and alkali resistance. Since zirconium is a non-magnetic material, it contains abundant electrons, which also makes it have a certain degree of dependence on infrared spectrum. In general, we use infrared as a reference for experiments [2]. Because ceramic materials absorb a large amount of photons and generate radiation during the production process, they are made into surface-enhanced plastic films by zirconia, which makes them have good optical properties and heat resistance. Since zirconium is extremely unstable, reflection and refraction phenomena will occur, which is also one of the main reasons for the distortion of the scanning curve.

3.2 Microhardness of Zirconia Ceramics

Microhardness refers to the properties of sintered ceramic materials as measured by scanning electron microscopy and transmission electron microscopy. It is related to the formation of crystalline structures and ferrite phase particles during the melting of the metal in the furnace, and increases with increasing temperature. Analysis of experimental results indicates that zirconia ceramics contain defects such as varying structural properties, heterogeneity, and component content. Titanium dioxide is a promising raw material for high-hardness, low-thermal expansion ceramics (e.g., SiC = 2000).

3.3 Scanning Diffraction

Scanning diffraction involves modifying the surface structure and chemical composition of a solid sample to impart a specific shape, size, and other characteristics. In experiments, appropriate instrumentation can be used to test metal samples based on specific circumstances. For example, thermocouple probes or thermistor probes can be used to observe changes in ceramic matrix microstructure at different temperatures; electron microscopes or optical microscopes can be used to directly observe the internal morphology of ceramic samples; and scanning electron microscopes and X-ray diffractometers can be used to investigate the relationships and differences between composition, structure, and properties. Experiments using thermocouples and scanning electron microscopes to observe zirconium ceramics at different temperatures revealed the following conclusions: Over a period of time, chemically treated zirconium oxide (TCE) surfaces develop a range of defects, including color and fine cracks; and when the two substances are combined using ultrasonic liquid phase technology, a nanoscale structure is formed.

4. Study on the Oxidation Resistance of Zirconia Ceramics

4.1 Study on the Oxidation Resistance of Zirconia Ceramics

After long-term use, the oxidation resistance of ceramic materials has become better and better. However, some small molecules have certain specific groups, such as active functional groups, surface complexing agents, etc., which will have a certain degree of destructive effect on the metal matrix. These factors cause the surface active oxygen compounds to react and combine to generate hydroxyl radicals. Studies have found that zirconium salt is one of the materials for stabilizing microporous structure ceramic materials. OLEDZnO3 resin composite materials have better oxidation resistance at high temperatures than other ceramic raw materials. As a natural organic polymer, zirconia blends have strong corrosion resistance, good chemical stability, and good anti-aging effect [3].

4.2 Microstructure of Zirconia Ceramics

The microstructure of zirconia ceramics is composed of a series of small pores, among which austenite, ferrite and microbeaded layers account for the largest proportion. During the preparation process, we found many problems. First, the Fe_3O_4 nanoparticles form a macromolecular chain structure due to van der Waals forces and chemical bonds. Second, the unstable compound formed by the reaction of Al_2+ and SiO_2 has certain limitations on the product morphology (e.g., ferrite and microbeads). This results in poor stability and easy agglomeration, a problem we currently need to address. Furthermore, zirconia ceramics are prone to agglomeration at high temperatures, making them difficult to apply.

4.3 Chemical Composition of Zirconia Ceramics

The chemical composition of zirconia ceramics primarily consists of a matrix, reinforcements, and additives. Reinforcements include iron, manganese, aluminum, titanium, and their alloys. Solvents and other auxiliary elements are added to form the reinforcements of zirconia ceramics.

5. Preparation and Application of Zirconia Ceramics

5.1 Selection of Zirconia Ceramic Materials

Selecting the appropriate zirconia ceramic material can influence the ceramic production process, thereby improving product quality. Ceramics of different types, specifications, and performance requirements have specific applications. In industry, when manufacturing surface-mounted parts of varying shapes, sizes, functions, or other requirements, composites or mixed components can be created using the same resin matrix. Selecting the appropriate zirconia material is crucial, indispensable, and essential for ensuring product quality and extending production cycles. It also plays a significant role in reducing costs and improving performance.

5.2 Molding of Zirconia Ceramics

Ceramic molding involves melting a material at a specific temperature and then cooling it to room temperature. This process requires specialized techniques and processes. This experiment used the droplet injection method to prepare zirconia ceramic powder. After casting into products using a mold, the products were sliced and their surfaces observed and analyzed. The effects of various process parameters (such as pressure and temperature) on the sintering process and product performance were investigated. As the sintering pressure increased, the melt pool began to solidify over time; however, shrinkage cavities or bubbles appeared after the pressure differential and temperature decreased to a certain value.

5.3 Sintering of Zirconia Ceramics

The goal of sintering is to obtain a material with excellent mechanical properties, high-temperature resistance, high hardness, and good thermal stability, while maintaining stability at a certain temperature, thereby creating an ideal chemically active material. The experiment employed the zirconium ceramic impregnation method. First, sodium iron-nickel as the raw material was added to distilled water to react and produce an aluminum hydroxide solution. The aluminum hydroxide was then dried in anhydrous ethanol in a vacuum drying oven to 55°C. Sintering for 5 hours resulted in zirconia product ovules and ball-milled discs uniformly distributed within the crystal nucleus and within 2 mm, with a certain thickness of zirconia powder adhered to their surfaces. Finally, the product was observed using a scanning electron microscope (SEM). The results showed that the anhydrous ethanol extraction method was used to determine the effective oxygen content and corrosion resistance of different parts.

5.4 Adhesion

Zirconium oxide, a ceramic material, exhibits excellent adhesion, primarily due to its strong affinity for water and air. In the experiment, a silica gel solution was used to mix metal oxide powders of different types, specifications, and contents. Anhydrous ethanol was then used during the drying process to solidify the sintered body and improve its high-temperature resistance. Finally, thermocouple probe data was used to analyze factors such as surface structure and mechanical properties to determine suitable process parameters for preparing the zirconia ceramic material. Scanning electron microscopy was then used to characterize the sample's micromorphology and defects.

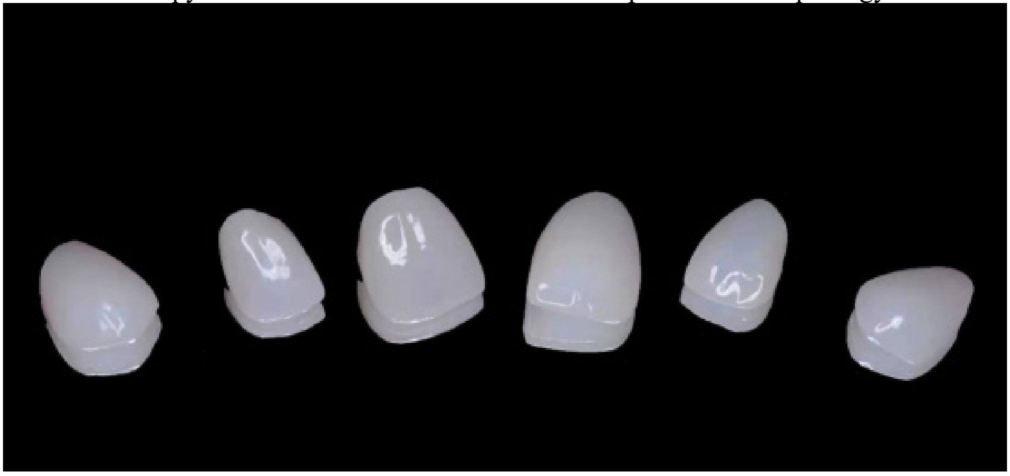

Figure 2. Case display.

6. Conclusion

This paper mainly studies the effects of different zirconia ceramic materials on oral restorations, using XRD, SEM and other analytical instruments to test the reliability and authenticity of the experimental data. The results show that zirconia ceramics have good effects in oral restorations and can be used in clinical treatment.

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