Stabilized zirconia ceramics for dental applications

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The research is aiming to obtain at room temperature a new ceramic material containing partially stabilized zirconia with different oxides after sintering used for dental and other technological purposes. Our research proposes a new method based on the use of stabilized zirconia with other oxides to obtain optimized dental material with a lower cost price and / or improved properties to allow wider use of these products to an increased number of patients in dental offices. X-ray diffraction, SEM analysis. FTIR spectroscopy, UV-Vis and density measurements were accomplished for the three ceramic systems. The correlation between the microstructure and the spectroscopic properties of zirconium stabilized by FTIR spectroscopy, UV-Vis helps understanding the mechanisms associated with the formation of high (tetragonal and / or cubic) temperature zirconia. Along with the simple, less costly preparation method and high purity of the ceramic products our study offers a highly desirable product for technological applications.

Nowadays tremendous progress has been made and advanced techniques are rapidly expanding in all dental medical fields, from maxillo-dental surgery (1-7) to dental biomaterials and dental lab techniques.

Advanced ceramic materials have revolutionized the dental lab techniques and are characterized trough high chemical purity, excellent colour reproducibility of natural teeth (8) and marginal fit. There is still no consensus with regard of the marginal fit of milled restorations (which include also zirconium oxide-based materials), compared to other ceramic techniques (9-12). Although there is no universal formula in manufacturing of these materials, the raw components are the same and the percentage of different components individualize the materials generated by notorious producers.

Zirconium oxide known also as "the material of the third millennium" has remarkable properties,

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Corresponding Author Dr. Ioana Roxana Bordea, Iuliu Hatieganu University of Medicine and Pharmacy, Department of Oral Rehabilitation, Cluj Napoca, Romania e-mail: roxana.bordea@ymail.com "rediscovered" during the last decade, namely flexural strength close to stainless steel, superior characteristics, compared to other ceramic materials such as, thermal and chemical resistance, durability and the most important of all, biocompatibility (13). Zirconium oxide base ceramics exhibit a high chemical inertness, which is the reason for their high biological safety (14).

The remarkable properties of zirconium dioxide, zirconia, have been "*rediscovered*" mostly over the past twenty years. Specialists state that zirconia is a ceramic material that is "*the third millennium material*" and as resistant as stainless steel. Zirconia is superior to other ceramic materials due to its a): outstanding mechanical properties and durability (similar to that of stainless alloys) (14-15); b): absence of corrosion, along with the aesthetic properties such as color and transparency and c): the improved marginal fit compared to other materials (9-11). These strengths offer outstanding properties for zirconium oxide, thus revolutionizing dentistry.

Y-TZP is an improved material but still has the drawback that the hydrothermal decomposition reaction depends very strongly on the grain size and the distribution of the stabilizing yttria within the zirconia grains (16-17). The main problem with zirconium dioxide is the stabilization of the two high temperature polymorphic phases: the tetragonal and/or cubic crystalline phase at room temperature after the synthesis process (8). Zirconium dioxide cores associated with veneering ceramic provide both good mechanical and aesthetic properties of prosthetic restorations (18). Nevertheless, the bond between the zirconia core and various ceramic veneering materials is not always perfect, failures of prosthetic restorations occurring by chipping of the layers, is still un unresolved problem. Factors that can influence the quality of the bond of the veneering material and the zirconium core are multiple. There are studies (18) that evaluate the alterations of the shear bond strength (SB) between the zirconia core and the ceramic veneer, produced by the first set of complete burning procedures and by the second correction burning of the dental restorations showing an approximatively 10% decrease of the resistance after the second burning. Another study emphasizes

the defects (19) in order to improve clinical results. The correlation between zirconia surface modifications generated by processing procedures (distilled water immersion, grinding) and its fracture resistance has been also studied, as it has been shown to have a tremendous influence upon the strength of the zirconia fixed dentures (20). Other studies (21-22) researched whether the mechanical effect on the surface of pre-sintered Y-TZP of airborne alumina particle abrasion is maintained after the sintering process. It has been shown that choosing the right restoration material, adapting the design of the restorations (especially in fixed partial dentures) for strength, aesthetics and functionality remains a difficult task. Y-TZP provides good mechanical characteristics and selecting an efficient design increases restoration working life (15).

Zirconia has a non-metallic inorganic structure which contains metallic elements as: zirconium, silica, sodium, potassium, magnesium, calcium, aluminium and titanium as well as non-metallic elements: oxygen, fluorine, boron, and phosphor (23).

Zirconium dioxide has a polymorph exhibition, a nonclinical, tetragonal and cubic form (25). The crystalline zirconia with monoclinic structure is stable at 1170°C, whilst the tetragonal is stable within the range of 1170 to 2300°C, and the cubic one over 2300°C (26) (17). The best properties for medical and technological purposes as solar cells, sensors passive combustion matrices inside the core of nuclear reactors, accelerator, (27-29) are obtained only by use of ceramics stabilized with tetragonal and/or cubic structure, after sintering at room temperature (30).

Another problem is the tetragonal-cubic polymorphism which was not yet entirely elucidated until today. The diffraction peaks of both crystalline ZrO_2 and cubic phases overlap perfectly in the diffractogram, therefor it is very difficult to differentiate the presence of two tetragonal and cubic phases of zirconia.

Nowadays the technology that use ZrO_2 zirconium dioxide as a dental material, is relatively expensive because of the intrinsic cost of the raw material in the first place and secondly because of the manufacturing CAD/CAM technique, so that the final costs are high. On the other hand, the

main problem of zirconium dioxide is stabilizing the two polymorph phases at high temperature after sintering, at room temperature. After synthesis of ceramics, during cooling a reverse conversion in ZrO_2 monoclinic phase takes place, accompanied by a from 3-7% volume increase and micro fissures within the material (31).

By addition of stabilizer oxides as ceria (CeO₂), magnesia (MgO) or yttrium (Y_2O_3), a multiphase ceramic material is obtained, at room temperature, known as partially stabilized zirconia, composed mainly of the cubical phase of zirconia and in small quantities of the tetragonal and nonclinical phase of zirconia (15).

The finding concerns the manufacturing procedure of new ceramic materials based on zirconia stabilized with oxides and the use of it in dental field. The addition of stabilizing oxides e.g. Na₂O, SiO₂, Y₂O₂, Fe₂O₂, MgO after sintering, at room temperature, allows the attainment of partially stabilized zirconia with cubical crystals as a major phase and zirconia with tetragonal structure as a secondary (minor) phase. The manufacturing costs are lower and simple. It consists of a reaction process in a solid state and uses a starting point oxides and carbonates which form- by decomposition- metallic oxides and release carbon dioxide. Costs are lower than those of the sol-gel methods whilst the purity of thus obtained ceramics is higher. Alkoxides and salts used in the sol-gel method or precipitation and salts used in sol-gel method or precipitation method, in addition to being expensive and usually less stable, lead to the production of some products that can pollute ceramics used in the medical field (32).

Objectives

The research is aiming to obtain at room temperature a new ceramic material containing partially stabilized zirconia with different oxides after sintering used for dental and other technological purposes. Our research proposes a new method based on the use of stabilized zirconia with other oxides to obtain optimized dental material with a lower cost price and / or improved properties to allow wider use of these products to an increased number of patients in dental offices.

MATERIALS AND METHODS

Partial zirconia stabilization was accomplished in two ways: doping with other oxides - Na2CO3 and / or Fe2O3 were selected to lower the melting point of the mixture, Y2O3 to increase ceramic mechanical strength, and SiO2 for reduction of crystalline sizes by uniaxial compacting of the oxide mixture. By using oxides or carbonates as starting materials in the procedure presented in this invention, high purity ceramic products will be obtained a requirement demanded in medical field (8). The design and control of microstructure require to be optimized in order to improve mechanical properties for materials developed for commercial purposes (9).

Two prober ceramic (marked with PI1 and PI2), having the composition expressed as a percentage of moles $5Na_2O \cdot 10SiO_2 \cdot 70ZrO_2 \cdot 15Y_2O_3$ and $0.5Fe_2O_3 \cdot 5.5Na_2O \cdot 6MgO \cdot 8Y_2O_3 \cdot 10SiO_2 \cdot 70ZrO_2$, for simplicity, were prepared by the solid phase reaction method using the following oxides: ZrO_2 , Y_2O_3 , SiO_2 , Fe_2O_3 , MgO and high purity Na_2CO_3 as the starting material. The mixture of substances in stoichiometric compositions with chemical formulas was finely ground using an agate pistile. Thereafter, the powder of the finely ground mixture was compacted by uniaxial pressing as thin discs of 2 mm thick and 12 mm in diameter. The compression was performed with a hydraulic press, eliminating simultaneously the air in the sample by means of a vacuum pump.

The disks were placed in alumina crucibles and heat treated in an electric furnace set at 1400 °C directly into the air. After about 2 hours (for product PI1) and 1 hour (for product PI2), the resulting ceramic discs were removed from the oven and placed on a stainless-steel plate. The disks were broken with a mechanical press and were milled with an agate pistil to obtain a fine sample powder.

The mixture of substances in stoichiometric compositions with chemical formulas was finely ground. Thereafter, the powder of the finely ground mixture was compacted by uniaxial pressing as thin discs of 2 mm thick and 12 mm in diameter. The compression was performed with a hydraulic press, eliminating simultaneously the air in the sample by means of a vacuum pump. The powder of the prepared sample was investigated by X-ray diffraction and SEM analysis.

FTIR spectroscopy, UV-Vis and density measurements were also accomplished for the three

ceramic system with the composition $xY2O3 \cdot (100-x)$ ZrO2 where x = 20, 25, 30mol% Y2O3.5Fe2O3 $\cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3 and 5Na2O $\cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ % Y2O3. The last two prepared ceramic systems contain tetragonal and / or cubic crystalline ZrO2 phase.

First, preparation and structural characterization of the ceramic system with the composition $xY2O3 \cdot (100-x)$ ZrO2 where x = 20, 25, 30 mol% Y2O3 was accomplished using FTIR and IR analysis.

RESULTS

The diffractogram obtained for the invented PI1 sample with the composition $5Na2O \cdot 10SiO2 \cdot 70ZrO2 \cdot 15Y2O3$ is shown in Fig. 1.

Analysis of the XRD data indicates the majority presence of cubic zirconia crystalline phase, by $c-ZrO_2$ (PDF No. 491642). The presence of the crystalline cubic zirconia phase is certified by the following main diffraction peaks: 30.12, 34.96, 50.22, 59.74 and 62.68°. These diffraction peaks of the cube ZrO_2 phase correspond to the diffraction planes 111, 200, 220, 311 and 222. The diffraction peaks corresponding to the cubic zirconia crystalline



Fig. 1. The X-ray diffractogram for the first invented ceramic product, designated PI1, with the composition 5 $Na_{,}O \cdot 10SiO_{,} \cdot 15Y_{,}O_{,} \cdot 70ZrO_{,}$ (in moles per cent).



Fig. 2. The X-ray diffractogram for the second invented ceramic product, designated PI2, having the composition of 0.5 Fe $_2O_3 \cdot 5.5$ Na $_2O \cdot 6$ MgO $\cdot 8$ Y $_2O_3 \cdot 10$ SiO $_2 \cdot 70$ ZrO , (in moles per cent).

phase are superimposed with the diffraction peaks corresponding to the tetragonal structure of zirconia, therefore, it is possible that the tetragonal structure of the zirconia phase is precipitated in the cubic zirconia phase.

The zirconia monoclinic structure, designated m-ZrO2 having the orientation (-111) at 28.24° and (111) at 31.5° was found in the prepared sample, the extremely small amount being below the detection limit of the diffractometer (2%).

In the field of small 2 theta diffraction angles, the presence of two broad halos indicating the amorphous character of the sample was observed. The X-ray diffractogram of the second sample prepared with PI2 with the composition expressed as a percentage of moles of $0.5Fe_2O_3 \cdot 5.5Na_2O \cdot 6MgO \cdot 8Y_2O_3 \cdot 10SiO_2 \cdot 70ZrO_2$ is shown in Fig. 2.

In PI2 sample the majority of the zirconia phases with cubic and tetragonal structure and low contents in monoclinic zirconia phase traces. There are some differences between the invented products PI1 and PI2 (Fig. 3):

• The invented product PI1 contains two halos at small 2theta angles while for the invented PI2 they have not



Fig. 3. *X-ray diffractograms for invented PI1, PI2 and three commercial brands with BC1, BC2 and BC3 used in dental technology.*

been detected.

- The zirconia monoclinic phase trace content is only detectable for the PI2 invented product, while for the PI1 product is below the detection limit of the diffractometer.
- The presence of Fe2O3 leads to the color change of the white-to-cream ceramics.

By increasing the processing time of 1 h (product

PI2) to 2 h (product PI1) it produces a better stabilization of the cubic/tetragonal structure of the zirconia so that on cooling, the lower content is transformed into the monoclinic zirconia phase; an amorphisation of the invented product. In other words, a 2 h sample processing time is recommended for a better stabilization of the high temperature zirconia phases. If the synthesis time is increased to 2 h, cooling the samples prepared transformation into the monoclinic zirconium phase is much slower as is involved in an amorphous network, and its depolymerization is more cumbersome.

SEM investigation was also carried out. SEM images of samples in the system with the composition $5Na_2O \cdot 10SiO_2 \cdot xY_2O_3 \cdot (85-x) ZrO_2$ where x = 5, 10 and 15 mol% Y₂O₂ are indicated in Fig. 3, 4. In the sample with $x = 5 \mod \% Y2O3$, a dispersed granular crystalline phase can be observed, which can be related to the ZrO2 phase coupled phase associated with the ZrO2 monoclinic phase. Samples with x = 10 and 15 mol% Y2O3 indicate a higher crystal density and are much homogeneous compared to their analogs with $x = 5 \mod \% Y2O3$. These SEM images indicate the presence of aggregates having cuboidal shapes. The microstructure of the sample with x = 15 mol% Y2O3la 10 µm is indicated in Fig. 3, 4 and illustrates that the ZrO2cubic phase appears in granular crystalline form, suggesting that



Fig. 4. SEM images of the system with the composition $5Na2O \cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3.

the growth mechanism was three-dimensional. From these results, it can be deduced that the addition of higher Y2O3 contents in the zirconium-based vitroceramic system promotes the formation of the crystalline ZrO2 phase with cubic structure and reduces the monoclinic zirconium phase content.

Preparation and structural characterization of the ceramic ZrO2-Y2O3-SiO2-Fe2O3 with the composition 5Fe2O3 \cdot 10SiO2 \cdot xY2O3 \cdot (85x) ZrO2 where x = 5, 10 and 15 mol% Y2O3 was accomplished, using as well FTIR and IR analysis. For stabilization, a content of 5% mol Fe2O3, 10%



Fig. 5. FTIR spectroscopy

moles of SiO2 and various Y2O3 contents was used. We aimed to determine the correlation between the microstructure and the spectroscopic properties of zirconium stabilized using FTIR spectroscopy, UV-VisFTIR spectrum of ceramic samples with the composition $5Fe2O3 \cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3 (Fig. 5).

FTIR spectrum of ceramic samples with the composition $5Fe2O3 \cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3 are shown in Fig. 6.

DISCUSSION

According to the results shown above, we can state the following: the sintered time is an important factor in stabilizing the high temperature zirconia (tetragonal and cubic structure) characteristic that is shown also by Masano in his research (33).

The addition of fondant (in this case Fe2O3 - decreases the melting temperature of the mixture) can affect the white color of the ceramic product Similar results have been obtained by Jianxn et al. results that show that the deformation temperature, sphere temperature, hemisphere temperature, and crystallization temperature of the fiber initially decrease and then increase with the increase of Fe₂O₃/ZrO₂ ratio, while the molding temperature decreases with the increase of the ratio of Fe₂O₃/ZrO₂ (34).

In Fig. 3, the diffractograms of the two invented



Fig. 6. FTIR spectrum of ceramic samples with the composition

ceramic products, PI1 and PI2, were compared with the diffractograms obtained for three consecutive commercial brands, BC1, BC2 and BC3. In all samples, the majority of the cubic/tetragonal zirconia is present. The presence of zirconia phase with monoclinic structure was only identified in brands marked with BC2 and BC3.

The diffraction peaks of the sample marked with BC1 are consistent with those of the invented products PI1 and PI2. All X-ray diffraction peaks are comparable to the standard data of cubic and tetragonal crystalline ZrO2 phases (35). Larger diffraction peaks for commercial brand BC1 indicate a higher crystallinity, thinner and with less defects.

Analysis of IR spectrum indicates, as shown also in the study of Lopez et al (36) a broad absorption band located in the region between 400 and 670 cm -1 attributed to the elongation vibrations of the Zr-O bond corresponding to the cubic phase of zirconia. The pronounced IR band at about 525 and 740 cm-1 is attributed to the Zr-O binding elongation vibrations of the monoclinic ZrO2 crystal phase. The intensity of these IR bands reaches the maximum value for the sample with x = 20 mol% Y2O3 suggesting a larger quantity in this sample, in agreement with the XRD data.

As previously shown, preparation and structural



Fig. 7. The UV-Vis Specimens with the composition $5Fe_{2O3} \cdot 10SiO_{2} \cdot xY_{2O3} \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3 are shown in Fig.3.

characterization of the ceramic ZrO2-Y2O3-SiO2-Fe2O3 with the composition $5Fe2O3 \cdot 10SiO2 \cdot xY2O3 \cdot (85-x)$ ZrO2 where x = 5, 10 and 15 mol% Y2O3 was accomplished, using as well FTIR and IR analysis. For stabilization, a content of 5% mol Fe2O3, 10% moles of SiO2 and various Y2O3 contents was used. We aimed to determine the correlation between the microstructure and the spectroscopic properties of zirconium stabilized using FTIR spectroscopy, UV-Vis.

Literature data (37-38) indicates that IR bands centered at 360, 375, 420, 450, 530, 620 and 745 cm-1 are attributed to the monoclinic ZrO2 crystal phase. The IR band at 580 cm-1 is associated with Fe-O bonding vibration in structural units [FeO4]. The IR bands centered at 465 and 627 cm-1 are due to the Zr-O bond stretching vibrations and indicate the presence of the crystalline ZrO2 phase with cubic structure. Also, the wide absorption band IR in the 420 to 700cm-1 range is attributed to the Zr-O stretching vibrations corresponding to the tetragonal phase of the zirconium dioxide.

IR spectrums have bands due to different silicate structural units located at 430 cm-1 and in the region of 850 to 1200 cm-1. Our studies are consistent with the research of Wenchang et al (39) and show that IR bands are attributed to asymmetric Si-O-Si deformation vibrations in structural units [SiO4]. The IR absorption band centered at 970 cm-1 is attributed to Si-O-Si deformation vibrations of the oxygen atoms. By increasing the Y2O3 content to 15 mol% in the host matrix, the intensity of these tapes gradually increases and the more highly formed and intensified 970 cm-1 IR band is formed.

By increasing the content of Y2O3 in the host matrix, the IR data indicates several changes in structural traces that can be highlighted as follows: larger and prominent IR bands in the region between 400 and 700cm-1 may be attributed to overlapping contributions from the elongation vibrations of Zr-O, Fe-O, and link-y-OY (peak centered at 407cm-1). By increasing the Y2O3 content to 15 mol%, the peak position centered at 407 cm-1 is shifted to higher wavelengths (417 cm-1) and its intensity increases. A new IR band appears at 580cm-1 and corresponds to Fe-O bonding vibrations in structural

units (FeO4). The intensity of this IR band increases with the addition of Y2O3 in the host matrix. ii) The intense IR band centered at 480cm-1 is assigned to the Zr-O-Zr bond indicating the formation of the Zr-O-Zr chain. The intensity of this band increases for samples with x = 10 and 15 mol% Y2O3 suggesting an increase in the number of cubic zirconia crystals. This structural evolution is due to the structural conversion of Zr cations coordinated with seven oxygen anions in the monoclinic structure in Zr cations coordinated with eight oxygen anions by changing the Y2O3 pan content to 25 mol%

The second band of IR bands between 850 and 1250 cm-1 is due to overlapping contributions from the elongation vibrations of the Zr-O bond of the monoclinic phase and the deformation vibrations of the O-Si-O and Si-O-Si angles of the structural units [SiO4]. The intensity of these IR bands increases with the addition of Y2O3 contents. For the sample with x = 5 mol% Y2O3, a new IR band appears at 1020cm-1 which is attributed to the Zr-O elongation vibration from the ZrSiO4 crystalline phase.

IR data suggest that the ZrO2cubic and tetragonal phase fractions, the Si-O-Si and Si-O-Zr bonds increase by doping with yttrium ions.

Similarly, in his study Bhaskar et al (40) showed that the relative volume fraction of the starting precursors and the pyrolysis temperatures not only influences the phase fraction of zirconia crystallites but also stabilizes the tetragonal crystal structure of zirconia (t-ZrO₂) at room temperature. The presence of carbon in interstitial sites of zirconia and oxygen vacancy defects led to drastic reduction in the band gap (2.2 eV) of the nanocomposite. Apart from being a perfect host avoiding sintering of the active phase and providing mechanical stability, the amorphous matrix also reduces the recombination rate by forming heterojunctions with t-ZrO₂.

Pure ZrO2 indicates UV-Vis absorption bands at wavelengths less than 243nm (41). In our case two UV-Vis bands centered at 220 and 262nm are observed for all samples. This evolution can be explained by considering that the first UV-Vis band is due to the O2-Zr4 + load transfer transitions and the more formed band located at 262 nm is attributed to the cubic ZrO2 crystal phase. The intensity of the last UV-Vis band increases with the dopant adhesion in the host matrix.

The 330nm centered absorption band is due to O2-2p-5Fe3 + 3d load transfer transitions. In the UV-Vis band region between 270 and 440nm, there is an increasing trend in intensity and band enlargement with a gradual increase of dopant to 15 mol% Y2O3. The UV-Vis bands become much more intense and intense for the sample with x =15mol% Y2O3. Larger UV-Vis bands located in the



Fig.8. Optical gap energy values.

region between 300 and 450nm can be attributed to overlapping inter-band transitions with Zr + 4-O-2 transitions also with a number of defects due to strong interaction with Fe2O3 sites.

The gradual increase in Y2O3 content to 15 mol% in the host matrix produces a decrease in UV-Vis bands ranging from 450 to 2000 nm. As a result, the number of electronic transitions decreases slightly in this region.

Optical gap energy values, Eg obtained from the extrapolation of the linear portion of the graphical representation (α hv) 2 and (α hv) $\frac{1}{2}$ depending on hv when α hv \rightarrow 0 are shown in Fig.8. From this figure we can see that the compositional evolution of the optical gap energy increases the strain for direct and indirect transitions by doping with yttrium ions (41).

The tetragonal zirconia embedded in silica matrix transformed into monoclinic form due to thermal treatment \geq 1100 °C. The stability of tetragonal phase of zirconia is found to enhance with increase in silica content. These findings were shown also by Verma et al (42). A homogenous dispersion of t-ZrO2 QDs in silica matrix was indicated by the mapping of Zr, Si and O elements obtained from scanning electron microscope with energy dispersive X-ray analyser. The transmission electron images confirmed the formation of tetragonal zirconia quantum dots embedded in silica. The optical band gap of zirconia QDs (3.65-5.58 eV) was found to increase with increase in zirconia content in silica. The red shift of PL emission has been exhibited with increase in zirconia content in silica). Optical gap energy values are between 2.01 and 2.07eV for direct transitions while for indirect transitions the optical gap energy values are between 2.50 and 2.66eV.

This increase in gap energy values can be understood in terms of structural changes that exist in the host matrix. These effects can be attributed to network failures. Network failures from, for example, unbound oxygen atoms usually introduce extrinsic energy levels between the bands and thereby reduce gap energy. In our case, the number of network failures is reduced by the addition of excess Y2O3 and as a result the gap energy increases.

According to the present study, the sintering method combined with the sub cooling procedure of

the fused material used in glass and takes reference to a process of reactions in solid state at high temperature. The new method uses zirconium dioxide partially stabilized with cheaper oxides and allows the obtaining of a new optimized serial at lower costs and higher purity implementation of the new product in medical and technological field as well.

For stabilization of high temperature zirconia at room temperature after sintering, a content of 5% mol Fe2O3, 10% moles of SiO2 and various Y2O3 contents was used. The purpose was to determine the correlation between the microstructure and the spectroscopic properties of zirconium stabilized by FTIR spectroscopy, UV-Vis. This study will help to understand the mechanisms associated with the formation of high (tetragonal and / or cubic) high temperature zirconia which are highly desirable for technological applications.

The main advantages of this invention are: It is a simple, less costly preparation method and high purity of the ceramic products for medical applications. The ceramics of the compositions of the present invention have the zirconium stabilized in the cubic / tetragon phase after the sintering time at room temperature, a structure also detected in the commercial brands used for dental technique. The PC1 prepared ceramic according to the invention has no detectable content of monoclinic zirconia, indicating good stability after room temperature synthesis.

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