ISSN: 2835-0448

International Journal of Dental Science and Dentistry Research (IJDSDR)

IJDSDR : Dental Publication

Available Online at: www.ijdsdr.com

Volume – 2, Issue – 2, March – April - 2023, Page No. : 10 – 15

A Solution to reprocess and recycle dental CAD/ CAM zirconia block from its waste residuals and evaluation of its surface properties

[1]Berry Dan Meyerbeer, Center for Innovative Dentistry, Yemen.

Correspondence Author: Berry Dan Meyerbeer, Center for Innovative Dentistry, Yemen.

How to Cite This Article: Berry Dan Meyerbeer, "A Solution to reprocess and recycle dental CAD/ CAM zirconia block from its waste residuals and evaluation of its surface properties", IJDSDR – March – April - 2023, Vol. – 2, Issue – 2, P. No. 10 – 15.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: To look for a solution that can renew and recycle zirconia blanks from its leftover waste and assessment of its surface attributes.

Materials and methods: White zirconia milled block waste residuals were first treated with 0.5 m nitric acid. Following dry pressing, these powders were pre-sintered into blocks at four different temperatures, namely 800, 900, 1000, and 1100 (n=16). As a control, leftover zirconia blocks from the same batch were used. These blocks were then exposed to the 1450-degree Celsius sintering advised by the manufacturer. After sintering, the elemental composition (by edx) and surface morphologies (by sem) were assessed.

Results: In both partially sintered and fully sintered recycled zirconia, only tetragonal phases were observed. According to sem findings, samples of pre-sintered zirconia had flat, smooth surfaces with evenly dispersed particles at 1000 degrees Celsius. Zirconia blocks from recycled and control samples had comparable elemental compositions.

Keyword: Zirconia, Celsius, Metallic Elements, Chemical Durability

Introduction

For more than a century, dentists have looked for the best materials for restorative dentistry. Despite being utilized with a fair amount of success, direct restorative materials like amalgam, composites, and restorative cements are not very helpful for multi-unit restorations. Because of its bio compatibility, long-term color stability, chemical durability, wear resistance, and capacity to be shaped into exact shapes, dental ceramics are appealing. over the past three decades, the field of dental ceramics has advanced quickly, and additional advancements are expected. Silicate glasses, porcelains, glass ceramics, or extremely crystalline solids make up dental ceramic. The widespread consensus is that dental ceramics' brittleness is the main cause of failure. Dental ceramics are non-metallic, inorganic materials that are generally composed of oxygen compounds with one or more metallic or semi-metallic elements. a silicate glass matrix phase and a crystal phase are common components of dental ceramics. The resultant structure has both covalent and ionic connections and is not tightly packed. In order to create high strength all ceramic dental materials, high performance ceramics are a good starting point. Yttria stabilized zirconia has been employed extensively in these materials. zirconia cannot be treated using conventional procedures in a dental lab, and producing tough, compact sintered zirconia takes a long time and puts a lot of strain on milling equipment. Therefore, prefabricated blanks are used frequently in the manufacturing of zirconia in order to create various dental constructions. To get the best mechanical strength, the structures are then sintered at particular high temperatures. Dental zirconia milling dust (30%) and block residuals (80%) as waste have been recorded, similar to all cad/ cam milling processes. Therefore, cost effectiveness would undoubtedly increase if such zirconia waste was properly reused. gonneia et.al attempted to recycle dental zirconia, but the recycled products can only be used in the jewelry industry.in this study, we aim to seek an easy and clean method to recycle dental cad/ cam zirconia white blank wastes that can be used effectively for dental prosthesis.

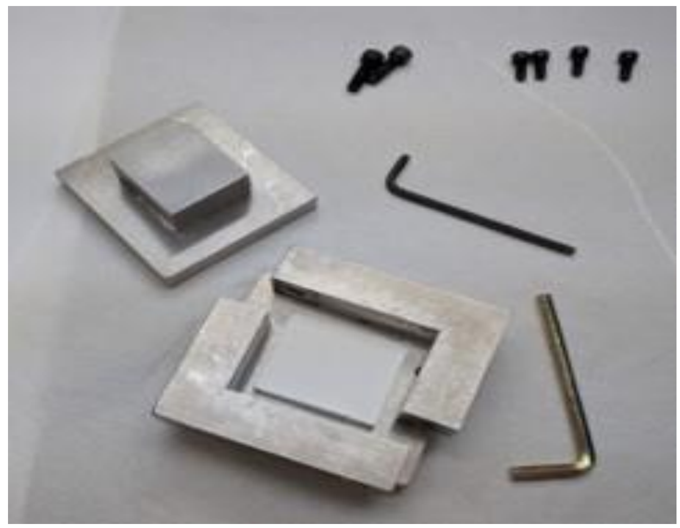
Materials and methods

Recycling pre-treatment of zirconia discs

Zir-x and upcera zirconia blanks' waste was gathered from internal labs. These leftovers were sieved using a 48 m screen after being first ground into a powder using a pulverizer at a speed of 10,000 rpm. The granules were thoroughly dissolved, combined, and agitated in 0.5 mol/l of nitric acid. The powders were stored in a drying oven after being carefully cleaned with distilled water.

dry pressing of white zirconia body

To create white recycled blanks, the dry pressing technique was employed. A rectangular mold (30mm*25mm*10mm) was filled with 10 gms of powder. To acquire the final size of the recycled white disc, the mold was compressed using a hydraulic press (80 kn). These were dried for 24 hours in a hot air oven.



sintering of recycled discs

In a furnace, recycled blanks underwent a pre-sintering process. By slowly heating the sample to 500 degrees celsius at a rate of 5 degrees celsius per minute, binders and other additives were eliminated. Next, for each pre-sintering tempera true, such as 800, 900, 1000, and 1100 degrees celsius.

Four blanks were heated to the desired temperature at a rate of 10 degrees celsius per minute starting at 500 degrees. It was allowed for the samples to cool to room temperature.(9,10)

Results

Sem analysis: An sem was used to study the surface morphologies of the blocks from each group. Photos at a magnification of 250 were taken of pre-sintered samples to analyze their surface roughness, and images at a magnification of 1000 were taken of fully sintered samples to assess their particle size distributions.

The surface topography variations between samples that were pre-sintered at various temperatures are visible in the sem pictures. The original block's surface was extremely smooth and flat, as can be seen.

After being fully sintered at 1450 °c, the control block is shown on the right with clearly uniform particle dispersion. other photographs display the surface morphologies of pre-sintering recycled zirconia blocks at temperatures of 800, 900, 1000, and 1100 °c, respectively. For instance, after being partially sintered at 800 °c, the surface was relatively rough compared to the surface of the control sample, and after being totally sintered at 1450 °c, the quality of the particle distribution was poor.

These non-uniform particle distributions were accompanied by a number of microscopic cracks and gaps between the particles.

The poor mechanical properties of the fully sintered products can be directly attributed to these undesirable chara cteristics of the surface structure. the zirconia blocks' surfaces smoothed down as the pre-sintered temperature rose, and the matching completely sintered bodies, whose photos are displayed on the right, had more evenly distributed particles and fewer cleavages between them.

Figure 1: original block

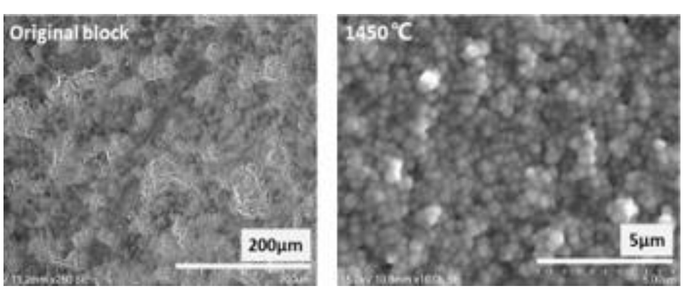


Figure 2: Pre-sintered at 800 degrees celsius

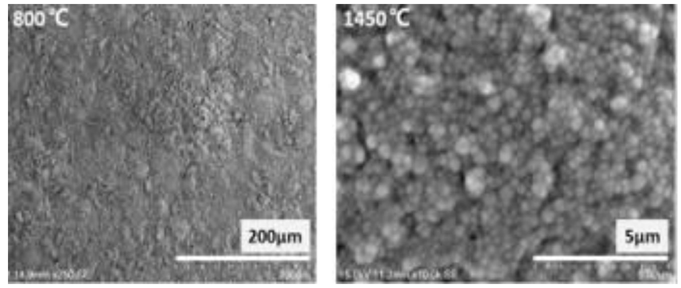


Figure 3: Pre-sintered at 900 degrees celsius

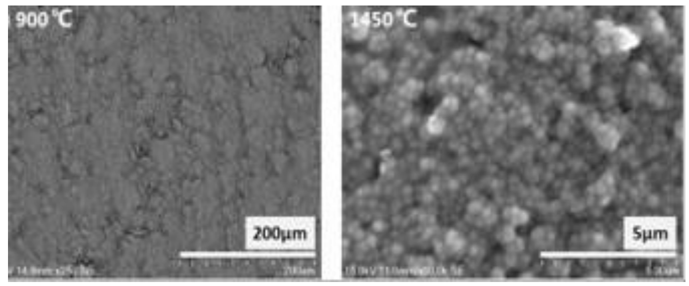


Figure 4: Pre-sintered at 1000 degrees celsius

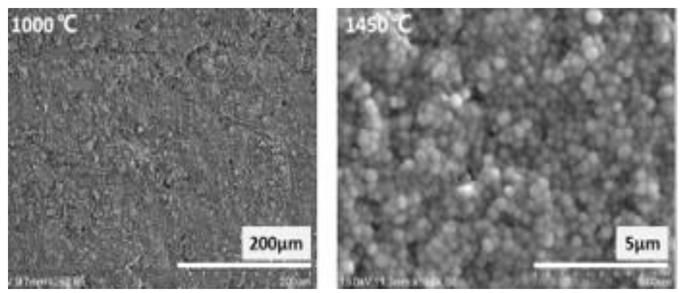
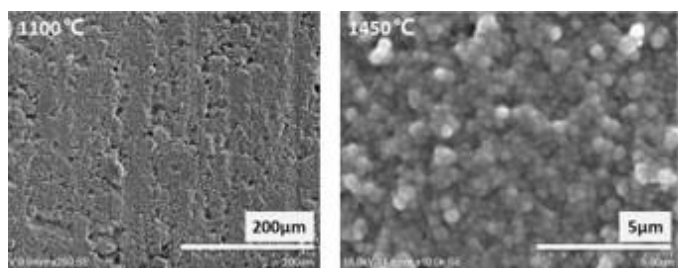


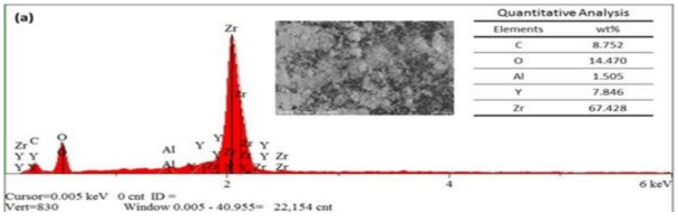
Figure 5: Pre-sintered at 1100 degrees celsius



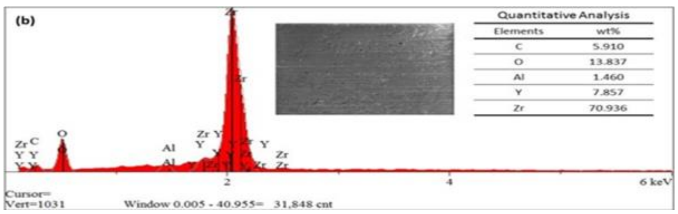
The surfaces appear denser for the samples that were pre-sintered at temperatures below 1000 °c, as shown in the photos, which could make further machining more challenging. In conclusion, the sem data show that 1000°c appears to be an appropriate temperature for pre-sintering the samples.

Energy dispersive x-ray spectroscopy

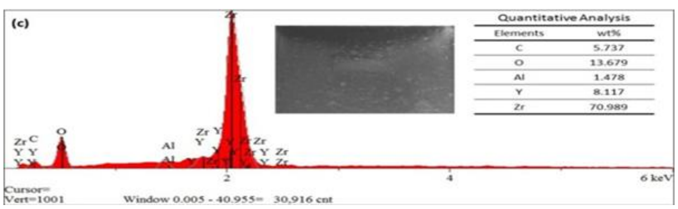
After the sem imaging, edx measurements were performed on chosen regions of the zirconia powder and block samples. The selected areas had their magnifi cation set to 100 times. According to the quantitative examination of the edx data, the recycled blocks and the control block and powder both had roughly the same amounts of important elements like zirconium, yttria, aluminum, and oxygen.



Graph 1:



Graph 2:



Graph : 3

Discussion

Dental zirconia waste residual blocks were successfully recycled in this study with satisfactory qualities, as shown by the experiment findings. In order to be appropriate for dental applications that demand a certain level of flexural strength and the quality in surface topography, pre-sintering of the dry-pressed blocks at temperatures in the range 950–1000 °c was specifically judged necessary. Two factors influenced the decision to use the dry pressing process in this study: (1) its high production rate; and (2) its tiny dimensional tolerances, which improved tolerance control.one of the simplest methods for compacting powder is dry pressing. The creation of non-uniform density distributions, as documented in the literature, is this method's biggest drawback. However, when a large mold is utilized for pressing, this behavior mostly manifests. Therefore, a smaller mold might not be much impacted by this technique.

As various additives or impurities may be present in the green body, it is well recognized that melting, decomposing, and volatilization of those additives or impurities could cause deformation or crazing in the ceramics, which should be avoided. In reality, a pretreatment with acid that was not picked up by the edx result efficiently eliminated a number of contaminants. It is important to note that the carbon content of 5.7-8.7 wt.% found in the edx data came from the carbon tape used to secure the zirconia sample to the sem/edx mount. In addition to temperature, heating rate and time should also be important factors in defining the ultimate quality of the ceramics as well as the process of removing the binder. This could be explained by the possibility that a faster heating rate could reduce the time needed for crystallization, which would prevent the excretion of pores between the grains. when the sintering temperature was below 500°c, stages of mean weight loss began to show, followed by a strong physicochemical reaction and a change in state. During this time, any binders or additional additives were also taken out. A slower heating rate of 5 °c/min was established from room temperature to 500 °c to avoid the possibility of volatilizing gasses expanding too quickly and compromising the mechanical properties of the ceramics. In conclusion, this research describes a technique for recycling dental zirconia ceramic wastes from old blocks that is particularly well suited for usage in dental laboratories and by zirconia producers. This recycling method may benefit from its quick production cycle, high efficiency, and economical nature. Additionally, it only requires a straightforward production process, and the recycled blocks compare favorably to the control sample in terms of their physical and chemical characteristics. However, more advancements are needed to make recycled samples that are thicker and larger. Additionally, the creation of a universal sintering strategy appropriates for many dental zirconia ceramic types. Additionally, a uniform quantitative measurement technique needs to be created for the sliced surfaces. Additional research is required to study the effects of aging, the presence of faults and fissures in bulk materials, and clinical tests of restorations built from recycled materials.

Conclusion

We have created a reasonably easy, clean, and quick technique for recycling dental zirconia. Conclusion: with optimum pre-sintering temperatures in the range of 950 to 1000 °c, it is possible to recycle dental zirconia cad/ cam waste residuals from the used blocks.

References

1. Ferreira, G., Lopez-Sabiron, A.M., Aranda, J., Mainar-Toledo, M.D., Aranda-Uson, A., 2015. Environmental analysis for identifying challenges to recover used rein- forced refractories in industrial furnaces. J. Clean. Prod. 88, 242e253.

2. Ozkan, A., Günkaya, Z., Tok, G., Karacasulu, L., Metesoy, M., Banar, M., Kara, A., 2016. Life cycle assessment and life cycle cost analysis of magnesia spinel brick production. Sustainability 8, 662.

3. Johnston, W.M., Kao, E.C., 1989. Assessment of appearance match by visual obser- vation and clinical colorimetry. J. Dent. Res. 68, 819e822.

4. Lüthy, H., Filser, F., Loeffel, O., Schumacher, M., Gauckler, L.J., Hammerle, C.H.F., 2005. Strength and reliability of four-unit all-ceramic posterior bridges. Dent. Mater. 21, 930e937.

5. Oh, G.-J., Yun, K.-D., Lee, K.-M., Lim, H.-P., Park, S.-W., 2010. Sintering behavior and mechanical properties of zirconia compacts fabricated by uniaxial press form- ing. J. Adv. Prosthodont. 2, 81e87.

6. Takatsui, F., De Andrade, M.F., Neisser, M.P., Barros, L.A.B., Loffredo, L.D.C.M., 2012. CIE L*a*b*: comparison of digital images obtained photographically by manual and automatic modes. Braz. Oral Res. 26, 578e583.

7. Rekow, E.D., Silva, N.R.F. a, Coelho, P.G., Zhang, Y., Guess, P., Thompson, V.P., 2011. Performance of dental ceramics: challenges for improvements. J. Dent. Res. 90, 937e952.

8. Cattani-Lorente, M., Scherrer, S.S., Ammann, P., Jobin, M., Wiskott, H.W.A., 2011. Low temperature degradation of a Y-TZP dental ceramic. Acta Biomater. 7, 858e865.

9. Guess, P.C.; Selz, C.F.; Steinhart, Y.N.; Stampf, S.; Strub, J.R. Prospective clinical split-mouth study of pressed and CAD/CAM all-ceramic partial-coverage restorations: 7-year results. Int. J. Prosthodont. 2013, 26, 21–25.

10.Chirumamilla, G.; Goldstein, C.E.; Lawson, N.C. A 2-year retrospective clinical study of enamic crowns performed in a private practice setting. J. Esthet. Restor. Dent. 2016, 28, 231–237.

11.Augusto, M.G.; Borges, A.B.; Pucci, C.R.; Mailart, M.C.; Torres, C.R.G. Effect of whitening toothpastes on wear and roughness of ormocer and methacrylate-based composites. Am. J. Dent. 2018, 31, 303–308.

12.Alencar-Silva, F.J.; Barreto, J.O.; Negreiros, W.A.; Silva, P.G.B.; Pinto-Fiamengui, L.M.S.; Regis, R.R. Effect of beverage solutions and toothbrushing on the surface roughness, microhardness, and color stainability of a vitreous CAD-CAM lithium disilicate ceramic. J. Prosthet. Dent. 2019, 121, 711.e1–711.e6.

13.Tribst, J.P.M.; Dal Piva, A.M.O.; Borges, A.L.S.; Anami, L.C.; Kleverlaan, C.J.; Bottino, M.A. Survival Probability, Weibull Characteristics, Stress Distribution, and Fractographic Analysis of Polymer-Infiltrated Ceramic Network Restorations Cemented on a Chairside Titanium Base: An In Vitro and In Silico Study. Materials 2020, 13, 1879.

14.Flury, S.; Diebold, E.; Peutzfeldt, A.; Lussi, A. Effect of artificial toothbrushing and water storage on the surface roughness and micromechanical properties of tooth-colored CAD-CAM materials. Prosthet. Dent. 2017, 117, 767–774

15.Giudice, R.L.; Lipari, F.; Puleio, F.; Alibrandi, A.; Giudice, F.L.; Tamà, C.; Sazonova, E.; Giudice, G.L. Spectrophotometric evaluation of enamel color variation using infiltration resin treatment of white spot lesions at one year follow-up. Dent. J. 2020, 8, 35.