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Synthesis and testing of dental ceramic

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ABSTRACT
Zirconia has been recently introduced in prosthetic dentistry for the fabrication of crowns and fixed partial dentures, in combination with CAD/CAM techniques. Zirconia stabilized with Y_2O_3 has the best properties for these applications. This project aims at producing cast Zirconia blocks primarily for dental application that is more cost effective and biocompatible in comparison to the commercially available zirconia. A simple co-precipitation method was used to produce the zirconia powder; simple, inexpensive and indigenous method of uniaxial compression was employed to cast the zirconia pellet. Further studies have to be carried out to study and improve the densification behaviour, biocompatibility, aesthetics and resistance to masticatory force.
Keywords : Zirconia, Zirconium Oxy chloride, Slip casting, compaction pressing, sintering

I. INTRODUCTION

The recent introduction of zirconia-based ceramics as restorative dental materials has generated considerable interest in the dental community. The mechanical properties of zirconia are the highest ever reported for any dental ceramic. This may allow the realization of posterior fixed partial dentures and permit a substantial reduction in core thickness. These capabilities are highly attractive in prosthetic dentistry, where strength and esthetics are paramount. [1] This project aims at producing cast Zirconia blocks primarily for dental application that is more cost effective and biocompatible in comparison to the commercially available zirconia.

This report discusses preparation of Zirconia powder from Zirconium Oxy chloride Solution by precipitation technique and its stabilization using Yttrium Nitrate.[2] [3], Shaping of the powder by compaction pressing[4]. Comparison of densities of samples subjected to sintering and pre sintering (900^oC) [5]. CNC milling of samples to check the machinability of samples.

II. EXPERIMENTAL WORK

Experimental work done in this project can be broadly be summarized as 1) Synthesis of Zirconia powder from Zirconium Chloride Solution by precipitation technique, 2) Compaction pressing. 3) Comparison of densities of samples subjected to sintering and pre sintering (900^oC) 4) CNC milling of samples to check the machinability of samples.

2.1 PREPARATION OF POWDER

The Zirconia powder were prepared using basic co precipitation method Zirconium oxychloride ($ZrOCl_2 8H_2O$), ammonia (NH_3) solution and Yttrium nitrate ($Y(NO_3)_3$) were used for making of powder.

This procedure led to the formation of a white precipitate. The precipitate recovered was washed several times using distilled water. The washed precipitate was dried in an oven for 1 hour. This was followed by heating the dried mixture in a furnace at 900^oC[2] [3].


Fig.1 Zirconia powder preparation using simple co precipitation method.

2.2 COMPACTION PRESSING


Fig.2 Pellet casting using compaction method

Another method that was used for sample preparation was the compaction pressing method [4]. In this method zirconia powder was mixed with steric acid solution and Poly Vinyl Alchohol to form a moist mixture, this mixture was weighed and fed into die. The pressing was carried out gradually at a load of 80kN.

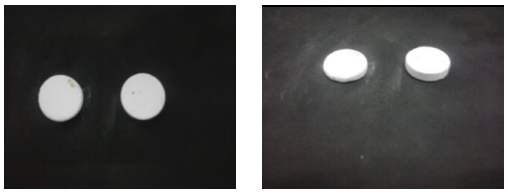

Fig.3 Samples obtained after compaction pressing

2.3 SINTERING

The samples obtained by compaction pressing method were in the form of circular disc of 25.5 mm dia. Two samples were subjected to sintering process above 1350oC and two samples were heated at 900^{o}C

Fig.4 Low temperature heating at 900^{o}C

2.4 CNC MILLING

All the samples were subjected to milling operation on CNC Milling machine.

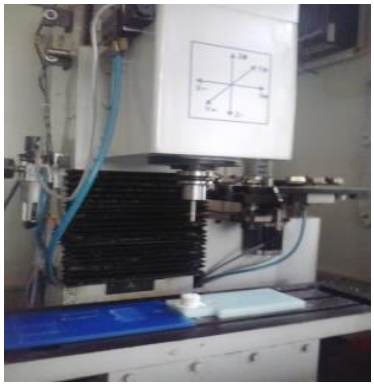

Fig.5 CNC milling

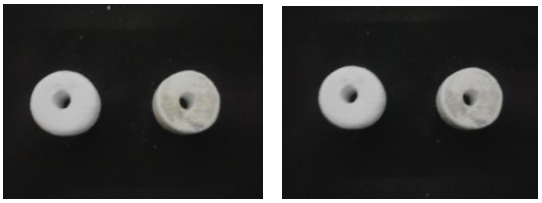

Fig.6 Samples obtained after CNC milling.

III. RESULTS

The samples were subjected to sintering process at a temperature of 1350^{o}C. Several changes with regard to its dimensions, weight and density were recorded before and after sintering

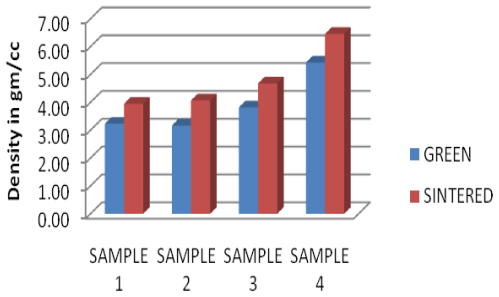

Fig.6 Figure showing changes in densities in green and sintered state.

The theoretical density of Zirconia is 5.56gm/cc whereas the densities of above samples lie between 3.65 - 5.43gm/cc. average density of the samples is 3.80gm/cc

VI. CONCLUSIONS

Zirconia was successfully produced using a simple precipitation technique which has a potential to be used as dental implant. The average density of the sintered zirconia pellets obtained was 3.80gm/cc which is approximately 67.26 % of theoretical density. The compaction of the powders was easily possible. The powders were machinable which is an added advantage for it to be used for dental applications. Further studies are needed to check the biocompatibility of the powders prepared.

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