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Hydroxyapatite Reinforced GIC Composites for Dental Implants

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Abstract:
*Glass lonomer Cements (GICs) are one of the most important dental restorative materials. Improvement of biological and mechanical properties of these materials has been taken into consideration. The aim of this work was to preparation and characterization of GICs by adding Hydroxyapatite on compressive strength of GICs. In this research, Hydroxyapatite were added to GICs in different weight percents (0, 4 and 8 wt %). These samples were prepared in laboratory at room temperature and capsule dies were used for the preparation of the samples.We heated sample for 2 day at 100 C. All the samples were taken for Scanning Electron Microscope(**SEM**), Surface hardness and Pin On Disc Tribometer (Wear). The phase analysis of GICs composite was carried out by X-ray Diffraction (**XRD**) technique.In SEM image observed that pure GIC has more crack in inner region whereas in 4% HA GIC some crack and 8% HA GIC strongly bond. Results of the Surface hardness showed that adding HA with the values 8% tly weight had good compressive strength of GICs. The final result of this research was GICs containing Hydroxyapatite with improved equivalent mechanical properties. The improvement of GICs properties in dentistry applications can be achieved by adding materials like Hydroxyapatite*

Keywords: *Glass ionomer cement(**GIC**), Hydroxyapatite, Scanning Electron Microscope(**SEM**), X-ray Diffraction (**XRD**)*

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I. Introduction

Glass lonomer Cements (GICs) are of the most important tooth colored restorative materials used in dentistry. Since the GICs were introduced to the dental profession by Wilson and Kent in 1972, the use of these materials has been increased due to their exclusive properties such as proper biocompatibility with body's hard tissue, long term fluoride release, the capability of absorbing and restoring fluoride, low thermal expansion coefficient, good adhesion to moist enamel and dentin without necessitating an intermediate agent and low cytotoxicity. Despite the above mentioned advantages, this group of substances has some disadvantages which mainly include low mechanical strength and sensitivity to humidity that limit their applications . Some efforts have been dedicated to improve the mechanical properties of conventional GICs which include reinforcement with metal powders, modification with resin. Incorporation with SiC whiskers/ short fibers , HA and fluoroapatite nanobioceramics , forsterite nanoparticles , etc.

Hydroxyapatite (HA) is one of the most important calcium phosphate bioceramics ($Ca10(PO4)6 (OH)2$, chemical formula: Ca/ P=1.67), and has a composition and crystal structure similar to apatite in the human dental structure and bone tissue. In recent years, a number of studies have tried to assess the effect of HA addition to the restorative dental materials such as GICs . It was found that glass ionomer cements were interacted with HA through the carboxylate groups in the polyacid. Hence, the incorporation of HA into GIC powder composition can not only improve the biocompatibility of GICs, but also increase the mechanical properties.

The investigated the physical properties of resin reinforced GIC modified with hydroxyapatite, and suggested that demineralization of enamel surface could be prevented by incorporating HA into GIC.

Therefore, the aim of this work was to Hydroxyapatite Reinforced GIC and HA particle size on the mechanical properties of GIC

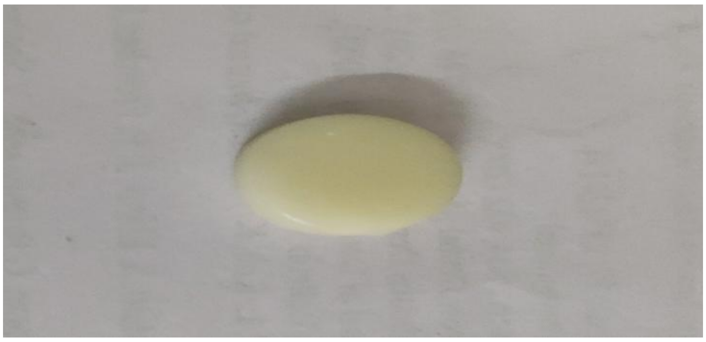
II. Materials and methods

Materials

Commercially available Glass ionomer cement**-** Restorative (TYPE II) were purchased from online market. Hydroxyapatite powder where purchased from (SRI JOTHI CHEMICALS ,TUTICORIN)

Sample preparation

Samples of Pure GIC were transferred to mixing pad plate and mixed with Hydroxyapatite powder with different weight percentage of 4% and 8% with GIC. These samples were separated in different pad plates to avoid errors.The liquid(Polyacrylic acid) were added slowly to the (calcium alumina flurosilicate glass) powders and transferred to the circular capsules to get shapes which will be comfortable for testing purposes. All the samples were prepared under lab condition with temperature ranges from 34±1°C.



Setting time

All the prepared samples were taken for setting time at room temperature of 34±1°C. The recorded setting time were listed in the table.

SL NO.	SAMPLE	SETTING TIME
1	**PURE GIC**	**223**
2	**4%HA +GIC**	**261**
3	**8%HA+GIC**	**311**

Heat Treatment

All samples are kept in direct sunlight for 3days.Due to present of moisture content,We heated the samples at 100°C for 4hrs in vaccum oven at International research center of sathyabama institute of science and Technology, Chennai.

Scanning Electron microscopy

These samples were tested in Carl ZEISS AG Brand Scanning electron Microscope made in Germany was available at VB'S Ceramic Research Center,Chennai.

X-ray Diffraction (XRD)

X-ray Diffraction (XRD) technique (Philips X'Pert-MPD system with a Cu Ka, 1.5418 A) was used to analyze the structure of the prepared glass ionomer powder and the GIC-HA composites. The diffractometer was operated at 40 kV and 30mA at a 20 range of 10-90° employing a step size of 5s per step at VB'S Ceramic Research Center,Chennai.

Pin On Disc Tribometer (Wear)
The wear examination of the samples was taken in pin on disc tribometer of DUCOM Instruments. The samples were tested under the frequency range of 1-30 Hz, stroke length of 30mm. This test was carried out in room temperature ranges 35±1°C.

Surface hardness
The surface hardness examination were done using Vickers Hard Wilson Wolpert - Germany make testing machine. The circular samples of 4mm diameter and 12mm height were used for the testing. Packs of three samples were maintained to produce the average results. Each pack includes a sample from pure GIC, 4% Hydroxyapatite reinforced GIC and 16% Hydroxyapatite reinforced GIC. The results were recorded and plotted with samples and hardness number.

III. Results

Scanning Electron microscopy
The scanning electron microscopic images were shown in Fig.1The GIC has many crack in inner region were in Fig .2.The 4% HA +GIC have some crack and bond with GIC in Fig 3.The 8% HA+GIC strongly bonded.

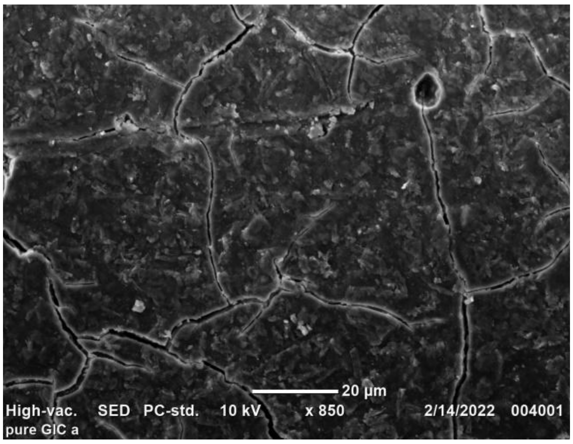


Fig.1 Pure GIC

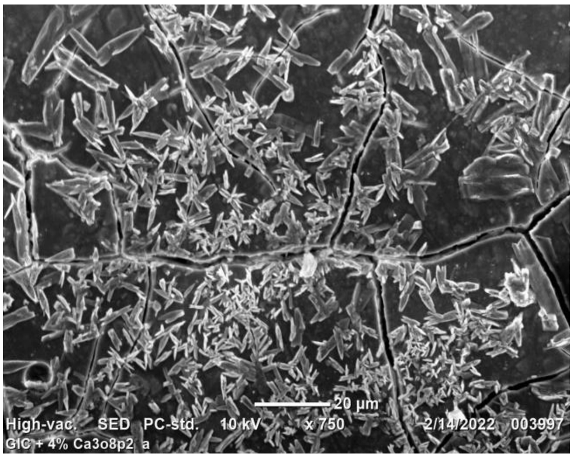


Fig.2. 4%HA+GIC

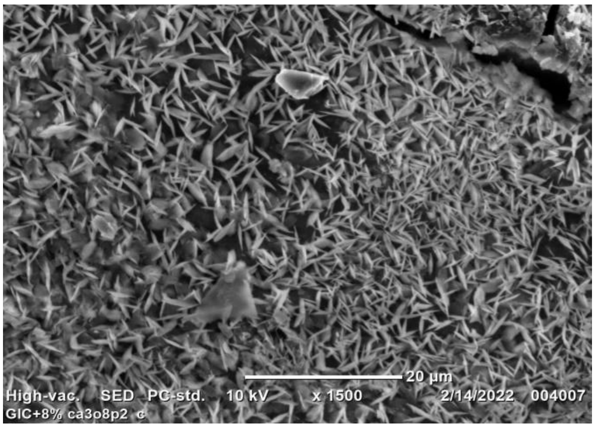


Fig.3.8%HA+GIC

X-ray Diffraction (XRD)
The XRD patterns of GIC powder,4%HA+GIC and 8%HA+GIC are shown in Figure 4. The pattern of GIC &4%HA+GIC (Figure 4a&b) did not contain diffraction peaks, indicated the internal disorder and the glassy nature of this material.
In addition, the XRD patterns 8%HA+GIC showed the peaks related to HA particles in glass ionomer structure (Figure 4c)These results had a good agreement with the results reported by Kotteshwaran(VB'S Ceramic Research Center.

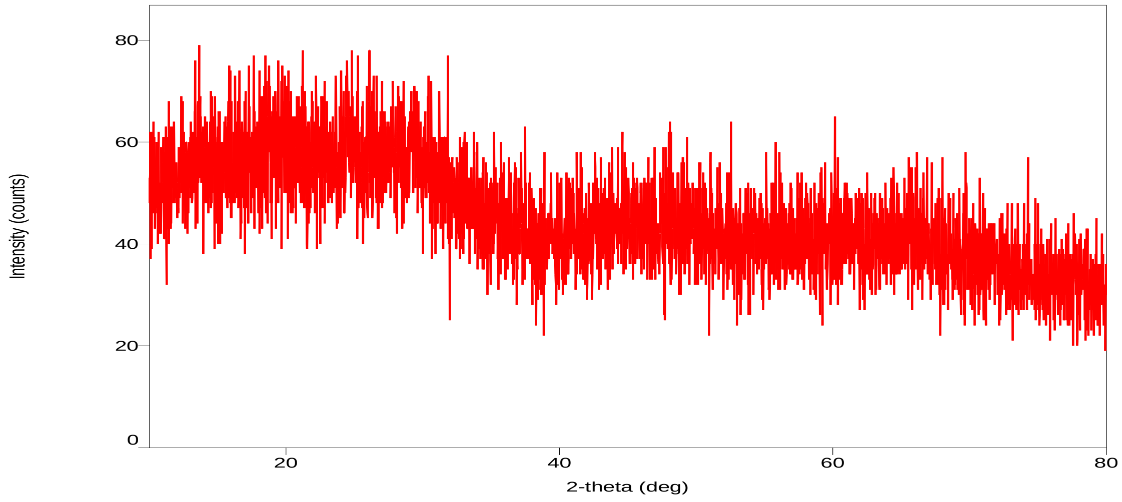


Fig 4(a) pure GIC

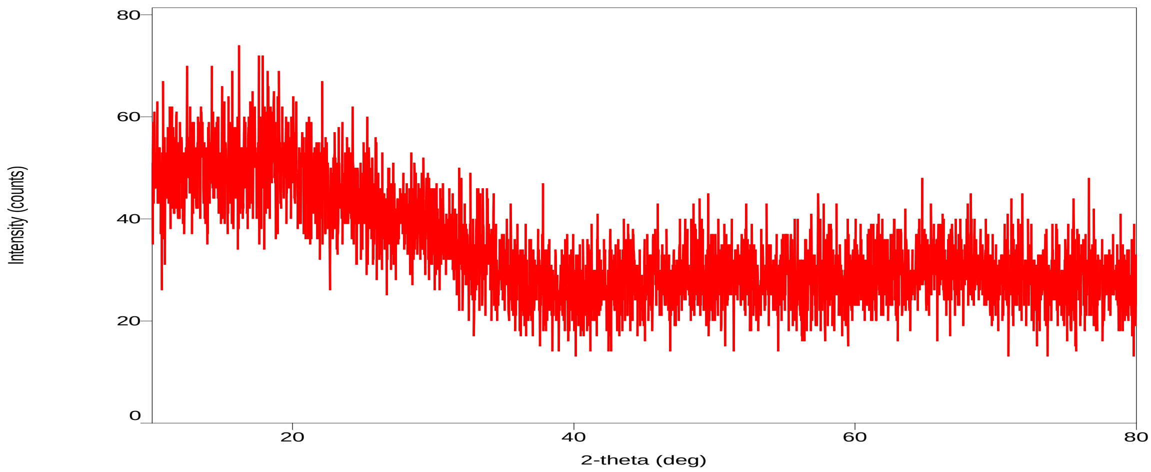


Fig 4(b) 4%HA+ GIC

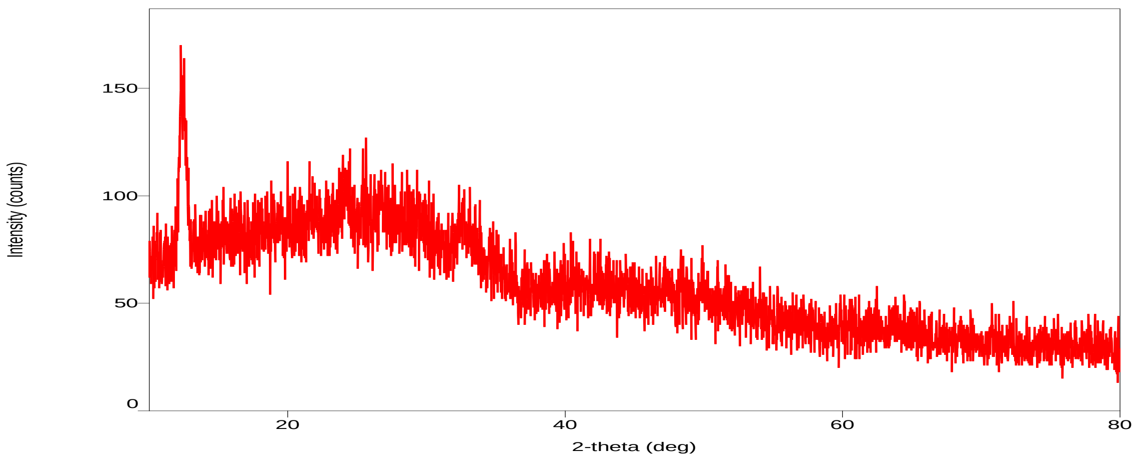


Fig 4(C) 8%HA+ GIC

Pin On Disc Tribometer (Wear)

Pin On Disc Tribometer results were plotted.At the beginning, it increases up to a peak value and then decreases. Successively, it starts increasing again up to a second peak, and then progressively decreases down to the steady-state value. The increase in concentration of HA is acting as a protective layer of the dentin and reduces the wear rate. In continuation with the reduced concentration of HA the percentage of reinforcement with GIC is poor and increasing linearly with the rate of wear.

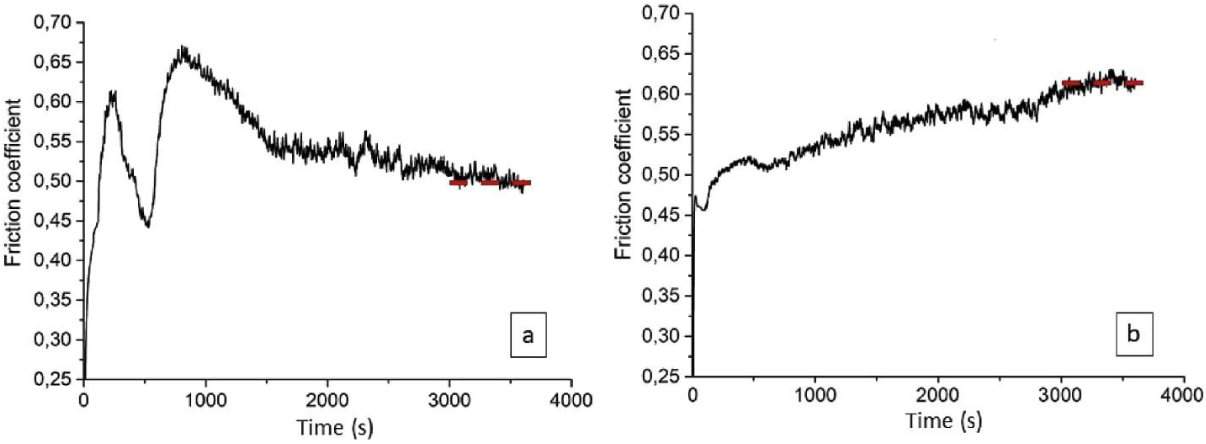


Fig 5:(a)8%HA+GIC(b)4%HA+GIC

Surface hardness

The surface hardness results were plotted for three trials with the recorded values. The results were shown in graph. It is observed that the surface hardness results of pure GIC ranges from (79.5-81.2), where 4% HA reinforced GIC shows the surface hardness of (30.2-38.7). in another hand 8% reinforcement of HA with GIC shows greater improvement of surface hardness (53.5-66.5).This is due to the impact of reinforcement in higher concentration with the GIC.

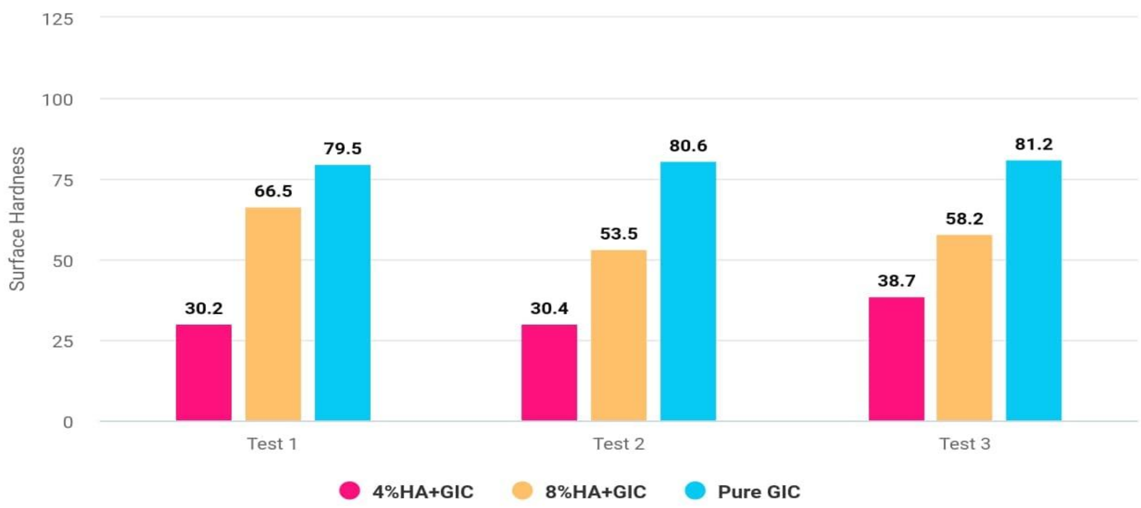


Fig 6 Surface Hardness

IV. Conclusions

The addition of 4% and 8%HA into prepared conventional composition of GIC enhanced the surface hardnes of the resulting cements.Therefore considered promising additives for glass ionomer restorative dental materials.Whereas 8% addition of HA to glass ionomer has some good improvements in terms of wear resistance, surface hardness result which is greater than the 4% addition of HA. These 8% addition of HA found less cracks and very strong bonding with the glass ionomer.

However,Setting time & Heating has greater impact with the material properties. Factors like environmental conditions, mixing time, proportion of resin may influence directly in the mechanical properties of the materials.

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