

# Comparison of Color Stability of Conventional GIC, Calcium Oxide, and Magnesium Oxide Nanoparticle GIC After Immersion in Carbonated Beverages

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## ABSTRACT

**Introduction** One of the main aspects of dentistry is aesthetics, which involves repairing the damage in teeth and producing an end product which looks similar to the original tooth. Commonly used restorative materials include GIC, composite, resins, metal oxide modified GIC, etc and it is important that the material used has the property of color stability, despite chronic exposure to different fluids and drinks. The aim of this study is to compare the color stability of conventional GIC, calcium oxide, and magnesium oxide modified nanoparticle GIC after immersion in carbonated beverages.

**Materials and methods** 3 groups of samples were taken - conventional GIC, calcium oxide and magnesium oxide modified GIC nanoparticles. 12 disc shaped samples were prepared in total, 4 from each group having 10mm and 2mm in thickness as dimensions. Carbonated beverages of required amounts were taken in glass beakers and color stability was checked with the help of a spectrophotometer and one way ANOVA using SPSS software version 23.0 was used for statistical analysis.

**Results** It was observed that calcium oxide nanoparticle modified GIC had the maximum color stability with a  $\Delta E$  value of 8.52 and magnesium oxide nanoparticle modified GIC had the minimum color stability with a  $\Delta E$  value of 12.8. On analysis of p-value via one way ANOVA, it was observed that p-value is 0.13, which is greater than 0.05, meaning that it is not significant.

**Conclusion** On comparing the 3 groups, magnesium oxide nanoparticle modified GIC was the least color stable.

**Keywords:** Calcium oxide modified GIC, Carbonated beverages, Color stability, Conventional, Innovation, Magnesium oxide modified GIC, Nanoparticles, Sustainability

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## Introduction

Glass ionomer cement was first introduced in adhesive dentistry many years ago and is used

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mostly as a restorative material and occasionally as an intermediary base or liner [1,2]. GIC has numerous benefits which makes it a generically used restorative material, including adhesion to the enamel to prevent corrosion or leakage, sluggish release of fluoride ion through the years to hold dental fitness and its shade similar to human enamel [1,3]. However there is no dental material that has ideal properties of a dental application. GIC, too, has a few disadvantages, with some of them being brittleness, poor fracture, and wear resistance, [4] inadequate surface properties and sensitivity to moisture when placed in the oral cavity [5]. The oral surroundings, in particular, are a challenge to dentists and GIC manufacturers. After a GIC restoration, the cement is uncovered to saliva, oral microflora and coloured meals and carbonated beverages. The physicochemical properties of GIC, in particular the traditional type, are important during the early tiers and are significantly prompted with the aid of using the surroundings. The material's esthetic and mechanical properties are probably negatively inspired through the unfavorable surrounding situation to be able to finally affect its long time scientific performance [6].

Aesthetic issues may result from the GIC's surface degradation. According to several investigations, standard GI restoratives had the greatest color changes, particularly under acidic conditions [7,8]. 1830 was when carbonated beverages were first manufactured along with additional constituents such as a mixture of sweeteners and fruit flavor variations. The composition of carbonated beverages is 90% carbon monoxide gas water, 10% sugar, artificial or original coloring, [9] which increased solubility of the GIC restorative material [10,11]. A person, on average consumes 2.4 liters of carbonated beverages per year, and it increases annually by 4%. Research has proven that acids in carbonated beverages with pH of  $\pm 2.5$  can cause chemical reactions that dissolve the ion. The effect of these beverages on color varies depending on the intrinsic features of the restorative material, such as their chemical composition [12]. Systems, changes or materials with sizes ranging from 1 to 100 nm are the focus of nanotechnology.

The alteration of implant surfaces is one of the notable uses of nanotechnology in dentistry, creation of reinforced polymeric composites using nanoparticles and prevention of dental caries [13] [14][15]. Recent research suggests that adding nanoparticles to dental restorative materials like resin composites can enhance their mechanical qualities [16]. Similar techniques have been used to try and enhance the mechanical and physical properties of GIC [17]. Based on studies such as this, our team has previous citations that have been published as quality articles [18–27]. Thus, the aim of this study is to compare the color stability of conventional GIC, calcium oxide and magnesium oxide nano GIC after immersion in carbonated beverages.

### Materials and method

#### Preparation of specimen

For this investigation, three different kinds of GIC were used: conventional, magnesium oxide nanoparticle, and calcium oxide nanoparticle. 12 disc-shaped samples in total, 4 of each type were taken. According to the manufacturer's directions, these GIC specimens were made by pouring the powder and liquid in the right amounts, loading them into PTFE (polytetrafluoroethylene) molds, and letting them cure. After they had dried and hardened, they were removed from the molds, and any extra flash was removed and smoothed out using a polishing bur and micromotor. The experiment was only carried out on specimens that were determined to have smooth surface finishes.

#### Preparation of staining or immersing solutions

Necessary amounts of carbonated beverages were weighed and poured into a beaker.

#### Immersing method

Four samples from each group were placed into glass beakers containing carbonated beverages. After that, they were rinsed with distilled water and tested with a Vita simple shade advance spectrophotometer for color stability.

#### Calculation of color stability

In order to determine color stability, a spectrophotometer of reflection time based on the Commission Internationale de l' Eclairage lab

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(CIELAB) system was employed in 1976 to measure color variations (E). The L\*a\*b color space is another name for CIELAB. Perceptual lightness, abbreviated L\*, refers to values of lightness to darkness that range from 0 to 100. a\* and b\* for the four distinct colors that the human eye can distinguish, where a\* stands for the range of green to red, b\* expresses the blueness to yellowness and has values ranging from -127 to +128. Prior to immersion, the color values of the specimens were used as a baseline. The Vita EasyShade Spectrophotometer was used to determine the L, a, and b values for color stability. The E values were determined to ascertain how much the color changed at certain stages. Then, using SPSS software version 23.0, pre and after immersion values were compared and examined. The formula used is

$$\Delta E(L^* a^* b^*) = [(\Delta L^*)^2 + (\Delta a)^2 + (\Delta b)^2]$$

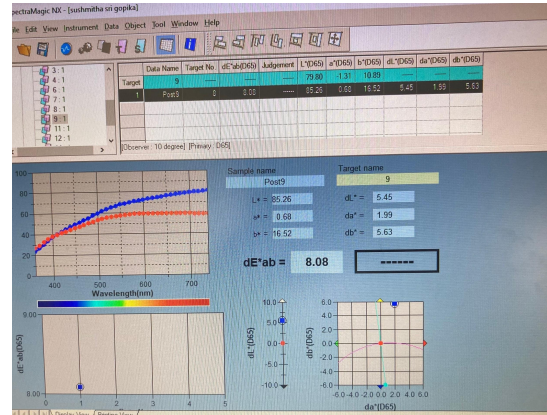
### Results

The mean and standard deviations were calculated by descriptive statistics and the groups were compared using ANOVA test. The p-value was taken as significant when <0.05. Table 1 shows the comparison of mean values, standard deviation of the 3 different groups and the significance. The p-value is 0.13, meaning that it is not significant. Figure 1 represents data from a spectrophotometer using SpectraMagic NX software, which is the standard tool for measuring color changes in dental materials. It represents a direct comparison between a Target (the baseline color) and a Sample (the color after experimental immersion).

The Mean values represent the average total color change for each material, where CaO nano particle group showed the best performance. CaO-modified GIC showed a numerically lower mean color change, the ANOVA test confirms that there is no statistically significant difference in color stability between Conventional GIC, CaO-modified, and MgO-modified GIC when exposed to carbonated beverages. All three materials failed to maintain a stable color, as all means were well above the clinical perceptibility threshold of 3.7.

Groups	Mean	Std deviation	Significance
Conventional GIC	10.225	1.0047	0.13
CaO nanoparticle modified	8.52	2.0113	0.13
MgO nanoparticle modified	12.835	4.111	0.13

**Table 1 : Table represents the mean, standard deviation and significance of the 3 groups after being immersed in carbonated beverages.**



**Figure 1 : Figure represents the spectrophotometric analysis to measure color stability**

### Discussion

In dentistry, especially in fields of aesthetic and pediatric dentistry, long time shade balance of restorative substances is an essential aspect mainly to the achievement of dental remedy because it contributes to the patient's delight and confidence. One of the major failures of restorative resins is due to color instability due to its prolonged and constant exposure in the oral cavity against various types of drinks with pigments, bacteria, carbonated beverages, food with spices, etc [28].

In the current study conducted it can be observed that CaO nanoparticle modified GIC showed maximum color stability and MgO nanoparticle modified GIC showed minimum color stability. In a similar study conducted in 2016, it was concluded that traditional GIC had most color change in all immersion media and maximum ΔE, in aerated liquids accompanied by ice candy, fitness drink and least in mineral water.[29].

Similarly, a study additionally confirmed that carbonated drinks showed the highest color change amongst various immersion media [30]. This could

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have been due to the difference in the surface roughness and low pH which led to the increased adsorption of color from the beverage [31].

In a study that examined the effects of color stability and degree of conversion of nano and micro hybrid composites, the results showed that nano composites showed highest  $\Delta E$  values when exposed to coffee solutions and showed less color stability although they have a higher degree of conversion [32]. A recent study conducted in 2021 observed that all types of soft drinks resulted in unacceptable discoloration of composite and GIC materials and this was maximum with a micro hybrid immersed in iced tea [33].

An invitro study checking for the susceptibility of restorative staining by beverages such as tea, coffee and cola noted that  $\Delta E$  value was higher for polyacid-modified composite resin immersed in coffee and tea compared to cola [34]. Similarly, a study conducted in 2020 observed that the highest color change was seen in a high viscosity glass ionomer cement when immersed in cola. However, nanohybrid composite resins were resistant to external coloration and hardness change [35].

In similar studies that studied GIC, it was observed that GIC brand Shofu has higher flexural strength compared to D-Tech. Flexural strength was decreased for both the GIC groups when immersed in grape juice [36]. Another study conducted in 2025 observed that 10% phyto-mediated Ch-Ti-Zr-HA nanocomposite-modified GIC excels in antibacterial activity, compressive and flexural strength, microhardness, and solubility outperforming conventional GIC and showing potential for enhanced dental applications [37]. Similarly another study found that Green-mediated nano-enhanced GIC caused less inflammation and upregulated healing genes compared to conventional GIC, suggesting better integration and improved clinical outcomes [38]. The findings of another this study indicate that incorporating nanotechnology is a valuable approach to enhancing the clinical performance of GIC. 5% and 10% nanoformulated GIC containing Ch-Ti-Zr-HA demonstrates significant potential as a restorative

material, offering microleakage resistance superior to conventional GIC [39].

Usage of small sample size and less immersing solutions used for comparison are the limitations of this study. Further studies based on large sample size is to be done to study the effect of carbonated beverages on the restorative materials. In vivo studies can be carried out in the future to check for further effectiveness. Thus, from the articles mentioned above it can be said that carbonated beverages and other drinks such as coffee and tea have a negative effect on color stability with regards to restorative materials and nanoparticle modified GIC.

### Conclusion

The current study evaluated the influence of carbonated beverages on 3 types of GIC with respect to color stability and on comparing the 3 groups it was concluded that magnesium nanoparticle modified GIC was least stable with respect to color stability, after immersion on carbonated beverages.

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### Conflict of interest

The authors hereby declare that there is no conflict of interest in this study.

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