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**Amr Nabil**
Department of Prosthetic Dentistry, Nahda University, Bani Sweif, Egypt

**Engy Adel Ahmed Farag**
Department of Fixed Prosthodontics, British University, Cairo, Egypt

**Corresponding Author:**
**Amr Nabil**
Department of Prosthetic Dentistry, Nahda University, Bani Sweif, Egypt

# The effect of two different types of mouthwashes on the color stability of a nano-hybrid CAD-CAM material

**Amr Nabil and Engy Adel Ahmed Farag**

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**Abstract**

**Objectives:** The color stability of dental restorative materials must be maintained over their functional lifespan to preserve the esthetic integrity of the restoration. However, the regular use of mouthwash may impact their color. Therefore, this study aimed to assess the effects of two commercially available types of mouthwash with different compositions on the color stability of nano-hybrid CAD-CAM blocks.

**Methods:** Thirty square samples of 1 mm thickness were constructed from nano-hybrid CAD-CAM blocks (CERASMART, GC, Tokyo, Japan). Samples were randomly divided into 3 groups (n=10) according to the oral rinse solutions; Control group: distilled water (DW), group I: Tantum Verde and group II: Hexitol. Samples were incubated for 24 hours in the investigated solutions. The alteration of color resulting from immersion in various solutions was assessed utilizing a spectrophotometer. The values of color change (ΔE) were subsequently calculated. Data were analyzed using one-way ANOVA ($\alpha$=0.05). Tukey's HSD post-hoc was used for pairwise comparison.

**Results:** There were significant differences in ΔE of CERASMART samples exposed to a range of immersion media ($p$<0.001). Tantum Verde showed the highest ΔE values. Both investigated mouthwashes showed non-significant differences when compared to each other. ΔE values for both mouth rinses showed a significant difference when compared to the control group.

**Conclusion:** Extended use of mouth rinses has the potential to induce color changes in hybrid composite CAD-CAM materials. Therefore, mouth rinses containing ethanol and alcohol should be advised with caution for daily use, especially with nano-hybrid CAD-CAM restorations.

**Keywords:** Benzydamine HCL, chlorhexidine, color change, mouth rinse, resin composite blocks

## Introduction

Utilizing computer-aided design and manufacturing (CAD-CAM) technology enables the creation of restorations with varying material compositions. Ceramic and hybrid materials are commonly chosen for tooth-colored restorations, offering popular alternatives in this regard [1].

Hybrid materials have emerged as an alternative to glass-ceramic blocks, blending the favourable attributes of ceramic and composite resins. Hybrid ceramics present superior mechanical and aesthetic qualities compared to composite resins, boasting increased fracture resistance and enhanced optical properties. Additionally, they exhibit higher abrasiveness than ceramics. These materials feature a polymeric matrix reinforced by nano-hybrid fillers, providing a versatile range of applications [2, 3].

Hybrid ceramics possess characteristics that fall between those of ceramics and composites, exhibiting moderately high fracture toughness, elastic modulus, hardness, and rigidity. They offer greater flexibility, affordability, and resilience against fractures compared to ceramics. Additionally, in comparison to both ceramic materials and composites, they lead to decreased abrasion of natural teeth opposing them, presenting a significant advantage over ceramics [4].

The CERASMART nanoceramic block was created by combining the advantageous properties of resin and ceramic technologies. This material, which is composed of 71% silica and barium glass nanoparticles and 29% resin, possesses a flexural strength of 238 MPa. It can be used in a variety of clinical scenarios including anterior, posterior, and implant restorations that require minimal preparation [5].

Effectively removing plaque deposits is crucial for preserving oral cavity well-being and health, as plaque has long been recognized as a significant contributor to the development of cavities, gingival inflammation, and chronic periodontitis [6]. Antimicrobial mouth rinses are recommended as additions to regular oral hygiene practices to enhance plaque removal. Regular usage of these mouth rinses, despite their antimicrobial attributes, has the potential to detrimentally impact the surface characteristics of dental restorations, possibly leading to discoloration of the materials used in the restorations. Mouth rinse formulations commonly comprise salts, organic acids, antimicrobial agents, dyes, and occasionally alcohol [7, 8].

Chlorhexidine is widely regarded as the most effective mouthwash for reducing dental plaque and combating pathogenic microorganisms like *Streptococcus Mutans*. In current literature, chlorhexidine is often considered the gold standard and serves as a positive control when evaluating the effectiveness of other products. However, drawbacks such as tooth discoloration and unpleasant sensations like mouth dryness and burning can deter patients from using chlorhexidine mouthwashes [9].

The mouth rinse Tantum Verde available on the market contains Benzydamine HCl. This compound is classified as a non-steroidal anti-inflammatory drug (NSAID) and possesses both systemic and locally applicable analgesic, antipyretic, and local anesthetic effects [10].

Color change of a restorative material can be assessed using different instruments and utilizing different techniques. Among them, spectrophotometric technology is the most commonly used approach in dental color research due to its optimum and exact procedure for qualitative color measurement [11]. In the (CIE L*, a*, b*) system, L* denotes the lightness of the sample, a* indicates the position on the green-red axis (negative values represent green, positive values represent red), and b* indicates the position on the blue-yellow axis (negative values represent blue, positive values represent yellow). Additionally, it is feasible to compute the overall color alteration (ΔE*ab) by taking into account the variations in L*, a*, and b* [12].

Although mouth rinses are being increasingly utilized, research on their effects on CAD/CAM hybrid ceramic blocks remains controversial. Limited studies have explored the color changes in hybrid ceramics associated with the use of mouth rinses [13, 14].

Hence, this study was to evaluate the color stability of CAD/CAM CERASMART hybrid ceramic blocks after immersion in chlorhexidine and Tantum Verde mouthwashes. The null hypothesis tested in the present study was that daily use of mouth rinses does not affect the staining ability of hybrid ceramics.

## Materials and Methods

CAD-CAM blocks of nano-hybrid ceramic (CERASMART A2-HT; GC, Tokyo, Japan) were cut into square samples with 1 mm thickness using an Isomet precision cutting device (Low-Speed Saw, Buehler Lake Bluff, IL, USA) operated at low speed and cooled with water by the same operator. A total of 30 samples were obtained and were cleaned in distilled water for 10 minutes.

To simulate clinical conditions, chairside polishing was conducted using a polishing kit (CeraMaster polishing kit, Shofu Dental Corp, Kyoto, Japan) at 20,000 rpm, with a low-speed handpiece and light hand pressure for 30 seconds per step.

Baseline measurements (L*, a*, b*) were conducted using a spectrophotometer (Vita Easyshade V; Vita Zahnfabrik, Bad Sackingen, Germany). For each sample, 3 readings were recorded and averaged to obtain the mean color coordinate for more collected data reliability. Color measurement was assessed using the Commission Internationale de l'Eclairage (CIE Lab) system. Prior to each sample measurement, calibration of the spectrophotometer device was conducted. All measurements were consistently performed at the center of the samples by the same individual.

The samples were randomly divided into three groups (n=10) based on the immersion media: the control group, which was immersed in distilled water (DW); group I, which was exposed to Tantum Verde a Benzydamine HCl-based mouthwash (EIPICO, Cairo, Egypt) and group II, which was exposed to Hexitol mouthwash Chlorhexidine HCl-based mouthwash (Hexitol, Arab Drug Company, Cairo, Egypt). The list of materials used in the current study is shown in Table 1. Each group was submerged in 30 ml of the respective mouthwash for 12 hours, which was deemed equivalent to a twice-daily mouth rinsing for 12 months.[11] To simulate oral cavity conditions, the mouth rinses were stored in a dark environment at 37 °C ± 1 °C. To ensure uniformity, the solutions were stirred every 3 hours. After the designated immersion duration, the specimens were removed and transferred to distilled water. Following that, the color values of each specimen were re-examined, and the color change value ΔE was computed using the following formula: $\Delta E=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$.

**Table 1:** Different materials used in the study

| Product | Composition | Manufacturer |
|---|---|---|
| CERASMART | Filler: 71% silicon dioxide ($SiO_2$) and barium glass nanoparticle<br>Polymer: BisMEPP, UDMA, DMA. | GC Corp, Tokyo, Japan. |
| Tantum Verde | 0.15% Benzydamine Hydrochloride, Methyl Paraben, Quinoline Yellow, Patent Blue V, Ethanol, Mint Flavor. | EIPICO, Cairo, Egypt. |
| Hexitol | Chlorhexidine HCl, Glycerin, Propylene Glycol, Alcohol 96%, Anise Oil, Peppermint Red, Cremophor, RH 40, Purified Water. | Arab Drug Company (ADCO), Cairo, Egypt. |

Bis-MEPP: Bisphenol A ethoxylates dimethacrylate, UDMA: Diurethane dimethacrylate, DMA: Dimethacrylate, RH40: PEG-40 Hydrogenated Castor Oil

Data was checked for normality using Shapiro-Wilk test and showed normal distribution. One Way ANOVA was employed to compare among the tested groups for the change in color parameters after immersion in the investigated solutions followed by Tukey's HSD test for pairwise comparisons. A significant level was set at $\alpha=0.05$.

## Results

Color parameters changes mean values are presented in Table 2. Tantum Verde showed the highest significant ΔL values compared to the distilled water group. Meanwhile, ΔL between Tantum Verde and Hexitol showed non-significant differences. For Δa, Tantum Verde showed the highest significant values when compared to the distilled water group. There was no significant difference between both tested mouthwashes. For Δb, Tantum Verde showed the highest values with insignificant differences amongst the tested groups. For the ΔE, Tantum Verde showed the highest values. The Tantum Verde and Hexitol values were significant when compared to the distilled water groups. Both types of mouthwash showed insignificant differences when compared to each other.

**Table 2:** Mean color parameters differences as a result of immersion media

| | ΔL | | Δa | | Δb | | ΔE | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Distilled water | 0.11a | 0.34 | -0.15a | 0.17 | 0.30a | 0.34 | 0.56a | 0.18 |
| Tantum Verde | -1.90bc | 1.41 | 0.47b | 0.57 | 0.38a | 0.47 | 2.28b | 1.04 |
| Hexitol | -1.61c | 0.26 | 0.23ab | 0.36 | 0.05a | 0.80 | 1.80bc | 0.34 |
| *p*-value | 0.020* | | 0.053 | | 0.576 | | >0.001* | |

Different letters within each column indicate significant differences.

## Discussion

The null hypothesis was rejected when different mouth rinses showed a significant effect on the color stability of the hybrid resin ceramic material used in the study.

The hydrophobic or hydrophilic properties of the resin matrix affect how easily it discolors. Research indicates that hydrophilic materials tend to be more prone to discoloration compared to hydrophobic materials when exposed to coloring solutions [15]. According to studies, urethane-dimethacrylate (UDMA)-based composite resins outperform other dimethacrylates in their resin matrix in terms of staining resistance and water sorption levels under standard curing circumstances [16].

Mouth rinse solutions consist of a variety of components, including antibacterial agents, salts, organic acids, colors, and occasionally alcohol. Alcohols, which include hydroxyl groups, have the ability to react with cations present in resin materials including $Zr^{+4}$, $Si^{+4}$, and $Zn^{+2}$. This reaction causes the dissolution of the cations in the fluid and results in the loss of the material. Salts can undergo similar reactions, as they also react with these cations. In addition, mouth rinse solutions and beverages such as tea and coffee can transfer their color to restorative materials because of the organic dyes they contain. These dyes have the ability to enter the tiny holes in ceramics and polymers or stick to the surface, causing a change in color by moving the scattering of ultraviolet light to higher or lower values within the range of colors that can be seen [17].

The observed staining effect of chlorhexidine in this study aligns with findings from previous research that has documented discoloration of dental restorative materials after being exposed to chlorhexidine mouth rinse. Three mechanisms have been proposed to elucidate this discoloration: The three processes involved are A. non-enzymatic browning reactions, often known as Maillard reactions, B. the creation of colored sulphides of iron (Fe) and tin (Sn), and C. the reaction of dietary chromogens with chlorhexidine [18].

In the current study, no noticeable color difference was noticed following immersion in distilled water. This finding contrasts with the results reported by Lee *et al*. [14] and Gürdal *et al*. [19], who observed more significant color changes after immersion in distilled water compared to chlorhexidine-containing and other mouth rinses.

In the Tantum Verde group, substantial color changes were observed in the hybrid ceramic material, likely due to the presence of ethanol in the solution. Ethanol exhibits a capacity to dissolve composite materials that absorb water. Mouth rinse solutions containing ethanol may therefore soften prosthetic materials. Tantum Verde, characterized by a very high ethanol content (95 vol %), resulted in the most pronounced changes in both color and surface roughness in this study. Tantum Verde contains a high volume of ethanol (95 vol %) along with methyl parabens, saccharin, quinoline yellow, and patent blue, which impart a greenish color to the material. This greenish hue may stem from a combination of yellow and blue components in the solution, which are absorbed onto the material's surface [17].

In the current investigation, color was measured using spectrophotometry. Many investigations have demonstrated the device's instrumental dependability [20]. The CIELAB system was employed in this investigation, therefore color change was determined using a particular formula based on the differences in L*, a*, and b* values [21].

It is worth to mention that change in color of dental restoration values (ΔE) greater than 1.22 were considered perceptible but still clinically accepted in dental practice, whereas values greater than 2.66 were considered clinically unacceptable, according to the defined perceptibility and acceptability thresholds [22]. The finding of our current study showed that both mouth rinses caused a perceptible color change which was still clinically accepted when simulating the constant use of tested mouth rinses 2 times per day for 1 year.

Limitations of our study encompass the constraints posed by *in vitro* conditions to completely replicate the oral environment, and the possibility that the ageing method employed may yield varying results in terms of color change values. Additionally, factors such as surface finishes, material type, and thickness can influence color changes. We did not consider other potential factors influencing color changes, such as dietary habits or abrasion. Hence, it is advised to interpret the results cautiously and complement them with further *in vivo* and *in vitro* investigations.

## Conclusion

Clinicians should consider the possibility of Chlorhexidine and Tantum Verde discoloring effects when prescribed for routine use to their patients, especially with nano-hybrid restorations.


## Acknowledgement

Not applicable.


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