Original Article

Comparison of Color Change of Silorane and Methacrylate-Based Composites Due to Bleaching

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Abstract

Background and Aim: Bleaching agents differently affect the color of composite restorations. This study aimed to assess the effect of two different bleaching agents on color change of silorane-based and two types of methacrylate-based composites.

Materials and Methods: This in-vitro study was conducted on 18 disc-shaped specimens measuring 10×2mm made of A3 shade of Z250, Z350 and P90 composites. The specimens were randomly divided into three groups (n=6). Group one or control samples were stored in distilled water. Groups two and three were subjected to bleaching with 16% and 35% carbamide peroxide (CP) (Kimia, Chemident, Iran). Color parameters of specimens were measured before and after bleaching using the CIE L*a*b* system and a spectrophotometer. Data were analyzed using repeated measures ANOVA and Tukey's HSD test for multiple comparisons.

Results: The mean and standard deviation (SD) of total color change (ΔE) of Z250 in distilled water, 16% carbamide peroxide and 35% carbamide peroxide was 3.48±1.43, 4.55±1.7 and 4.17±1.9, respectively. These values were 4.33±2.41, 4.94±2.23 and 4.25±1.65 for Z350 and 4.97±2.47, 5.28±1.67 and 3.41±2.26 for P90, respectively.

Conclusion: In general, the color change of microhybrid, nanofilled and silorane-based composites following bleaching with different bleaching agents was clinically perceivable.

Key Words: Bleaching, Silorane-based composite, Color, Methacrylate-based composite

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Received: 11 Aug 2014
Accepted: 20 Nov 2014

➢ **Cite this article as:** Hashemi Kamangar S, Kiakojoori K, Mirzaii M, Kharazifard MJ. Comparison of Color Change of Silorane and Methacrylate-Based Composites Due to Bleaching. J Islam Dent Assoc Iran. 2015; 27(2): 77-84.

Introduction

Due to the non-invasiveness of bleaching, demand for this esthetic treatment is high. At present, many different bleaching systems are available including the in-office and at-home bleaching systems as well as the bleaching kits available over the counter. Most of the available bleaching systems use hydrogen peroxide or CP. In-office bleaching is often performed by 30% hydrogen peroxide while at-home bleaching kits often contain 10% or higher concentrations of CP [1,2]. Since the introduction of bleaching treatment by Haywood and Heymann in 1989, use of bleaching agents for whitening of stained or discolored teeth has become highly popular. In this treatment, the tooth structure is repeatedly exposed to the bleaching agent and there is no way to prevent the exposure of dental restorations to the bleaching agent especially when home bleaching system is used [3]. The effect of bleaching on microhardness, surface roughness and color stability of methacrylate-based composites has been evaluated in many previous studies [4-7]. A question in this respect is that whether whitening the restorations with bleaching agents can result in an optimal color match with the bleached neighboring teeth without requiring restoration replacement. Studies have reported controversial results in this regard. Silva et al. [8] evaluated the effect of application of four different bleaching protocols on color and microhardness of nanofilled composites and showed that the total color change (ΔE) and Vickers hardness number (VHN) did not have significant differences among groups. Moreover, they demonstrated that nano-composites did not experience significant changes in terms of color or microhardness after the bleaching treatment. Therefore, the restorations did not need replacement after bleaching. Pruthi et al, [9] in an in-vitro study evaluated the effects of bleaching with 15% CP on color of composite restorations and showed that bleaching in all groups resulted in color change.

Silorane-based composites have been recently introduced as an alternative to methacrylate-based composites due to advantages such as low polymerization shrinkage attributed to the ring-opening polymerization mechanism of oxirane molecule and increased hydrophobicity due to the presence of siloxane molecule in their chemical composition [10-12]. Studies have attributed the effects of bleaching on color of composites to the type of resin matrix and type of filler [13]. Only a few studies have studied the effects of bleaching agents on color of silorane-based composites [14-16]. Al-Qahtani and Binsufayyam [15] evaluated color change of different types of composites after bleaching with 10% CP. Based on their results, ΔE was less than one and thus, color changes of silorane-based (P90) and methacrylate based (Z250, Z350, Valux Plus) composite restorations were not clinically perceivable.

Due to increased demand, dental material manufacturers supply a wide range of products to the dental market, which has resulted in confusion of dentists in selection of the most suitable product. Wide range and variability of Iranian and foreign made bleaching agents further emphasizes the importance of evaluation of the performance and effects of each product. Chemident Iran Company produces two types of bleaching agents containing CP under a general name of “Kimia”. One product contains 16% CP for at-home bleaching and the other product contains 35% CP and is supplied in the form of powder and liquid for in-office bleaching. Considering the need for assessment of the quality and efficacy of recently introduced Iranian products, this study aimed to assess the effects of two Iranian bleaching agents on methacrylate-based composites with different filler sizes (nano-filled and microhybrid) compared to a silorane-based composite.

Materials and Methods

This study evaluated the effects of a home bleaching system containing 16% CP (Kimia, Chemident, Tehran, Iran) and an in-office bleaching system containing 35% CP (Kimia, Chemident, Tehran, Iran) on a methacrylate-based microhybrid (Filtek Z250, 3M ESPE, St. Paul, MN, USA), a methacrylate-based nano-filled (Filtek Z350, 3M ESPE, St. Paul, MN, USA) and a silorane-based composite (Filtek P90, 3M ESPE, St. Paul, MN, USA). The composition of the materials used in this study is shown in Table 1.

Specimen preparation:

Discs measuring 2mm in thickness and 10mm in diameter were fabricated of A3 shade of composite resins using stainless steel molds. A total of 48 specimens were fabricated as such (n=18 for each composite). The mold was placed on a glass slab and a celluloid tape, carefully filled with composite, another celluloid tape was placed over it and a glass slab was placed on the top to eliminate voids and for the excess material to leak out. Light curing was done using a LED light-curing unit (Valo, Ultradent Products Inc., South Jordan, UT, USA) with an intensity of 1000 mW/cm^2 for 20 seconds from each side according to the manufacturer’s instructions. After removal of the celluloid tape, the specimens were polished by 1200, 1500, 2000, 2500 and 3000 grit silicon carbide abrasive papers (MARADOR, Yangzhong Lifeng Emery Cloth Co. China) by the same operator and immersed in distilled water in an ultrasonic bath for three minutes to wash out the debris. Next, they were stored in distilled water for 24 hours to allow completion of polymerization. Specimens in each group of composite were then divided into three groups (n=6) for immersion in distilled water (control group) or exposure to the two bleaching agents. In group two, specimens were exposed to 16% CP (Kimia, Chemident, Tehran, Iran) once a day for four hours for a duration of two weeks. In group three, specimens were exposed to 35% CP (Kimia, Chemident, Tehran, Iran) only once for 40 minutes. For exposure, the specimens were immersed in the bleaching gel. After each treatment, specimens were washed under running water using a soft brush for one minute. During the time intervals between treatments, the specimens were stored in distilled water in dark, screw top vials at room temperature. Distilled water was refreshed daily for all groups.

Color assessment:

The color of specimens was assessed using a spectrophotometer in the Institute for Color Science and Technology (ICST) of Iran according to the CIE L*a*b* system before and after bleaching. Color assessment in the control group was done before and after two-week immersion in distilled water. The specimens were placed on a plain white Leneta paper. The light source illuminated the specimen surface at a 45° angle relative to the vertical line and CS-2000 spectroradiometer (Konica Minolta Inc, Sensing Business Unit, Japan) was positioned at an approximate angle of 0° relative to the vertical line against the specimen surface with approximately one meter distance from it. The viewing angle of the device was set at 0.2° to yield a measurement area equal to the surface area of a circle with an approximate diameter of three millimeters at the center of specimens. Color measurement was performed in a laboratory at +20°C temperature. Color parameters were analyzed at D65/2° viewing conditions using CS-S10W software. The L* parameter indicated lightness, the a* parameter indicated redness-greenness and the b* parameter indicated yellowness-blueness. The C parameter indicated chroma and the H parameter indicated hue angle or coloration. The total color change (ΔE) was calculated using the formula below:

$$\Delta E = [(L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2]^{1/2}$$

Data were analyzed using SPSS version 18.0 (Microsoft, IL, USA). Repeated measures ANOVA was used to evaluate the effects of type of composite and type of bleaching agents as well as their interaction effect on color parameters and total color change. Given that the results of two-way ANOVA were significant, pairwise comparison of groups was carried out using Tukey's HSD test. Type one error was considered as 0.05.

Results

The L* parameter (ΔL*): The effect of type of composite ($p=0.72$), type of bleaching agent ($p=0.052$) and the interaction effect of the type of composite and type of bleaching agent ($p=0.75$) on ΔL* were not significant (Figure 1).

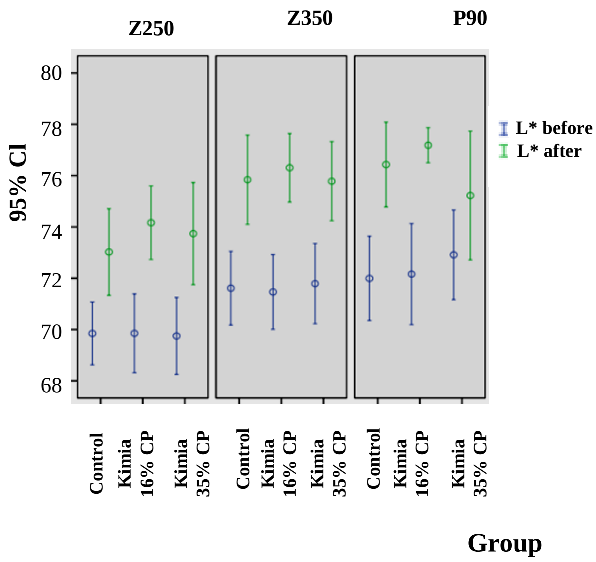

Figure 1. The mean and 95% confidence interval of L* color parameter before and after bleaching with different agents (CP: Carbamide peroxide)

The a* parameter (Δa*): The effect of type of bleaching agent ($p=0.19$) and the interaction effect of type of composite and type of bleaching agent ($p=0.55$) on Δa* were not significant but the type of composite had a significant effect on Δa* ($p<0.001$). Pairwise comparisons by Tukey's HSD test revealed significant differences between Z350 and P90 ($p<0.001$) and also between Z250 and P90 ($p<0.001$); but Δa* before and after bleaching was not significantly different between Z250 and Z350 groups ($p=0.99$) (Figure 2).

***The b* parameter (Δb*)*:** The effect of type of composite ($p=0.003$) and type of bleaching agent ($p=0.004$) on Δb* was significant but the interaction effect of the type of bleaching agent and type of composite was not significant ($p=0.08$). Multiple comparisons by Tukey's HSD test revealed no significant difference between Z250 and Z350 (p=0.81) in terms of Δb* but the differences between Z250 and P90 (p=0.004) and also Z350 and P90 (p = 0.03) were significant in this regard (Figure 3).

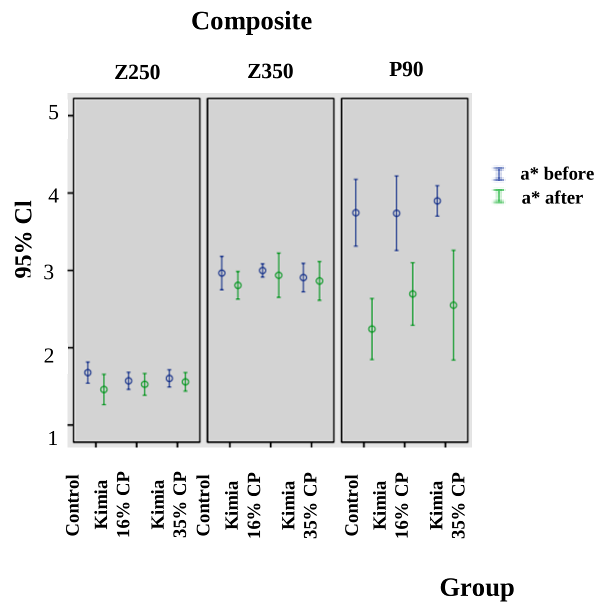

Figure 2. The mean and 95% confidence interval of a* color parameter before and after bleaching with Different agents (CP: Carbamide peroxide)

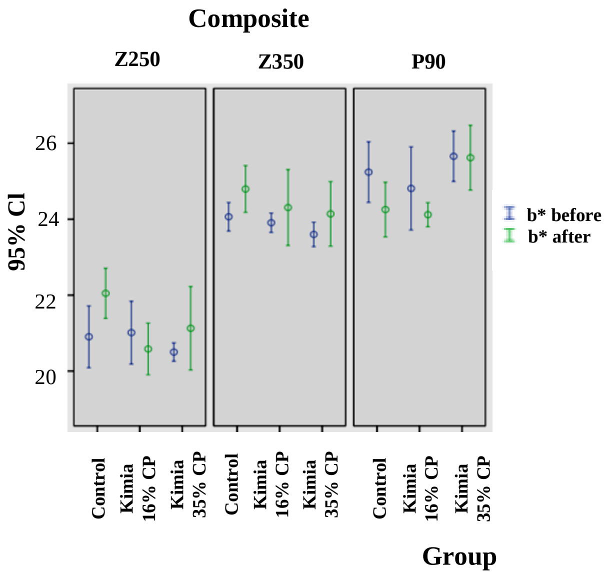

Figure 3. The mean and 95% confidence interval of b* color parameter before and after bleaching with different agents (CP: Carbamide peroxide)

The H parameter (ΔH): The effect of type of bleaching agent (p=0.06) and the interaction effect of type of composite and type of bleaching gent (p=0.43) on ΔH were not significant but the type of composite had a significant effect in this regard (p<0.001). Pairwise comparisons by Tukey's HSD test revealed significant differences between Z350 and P90 (p<0.001) and also between Z250 and P90 (p<0.001); but the difference in this regard between Z250 and Z350 was not significant (p=0.92) (Figure 4).

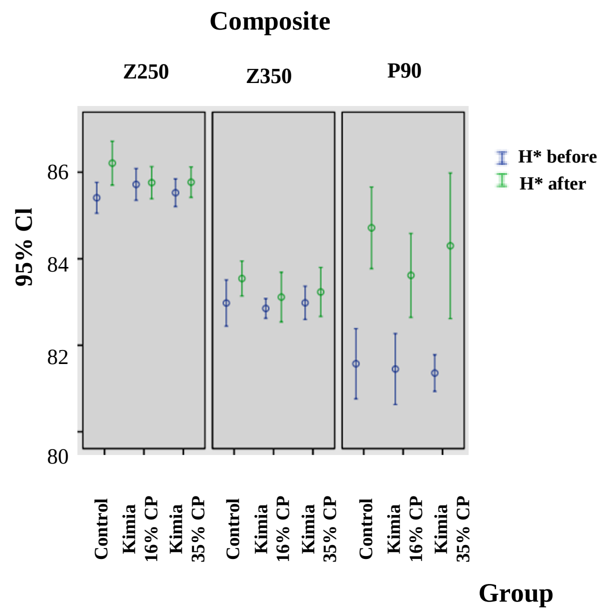

Figure 4. The mean and 95% confidence interval of H color parameter before and after bleaching with different agents (CP: Carbamide peroxide)

The C parameter (ΔC): The effect of type of composite (p<0.001) on ΔC was significant but the interaction effect of type of bleaching agent and type of composite was not significant (two way ANOVA, p=0.09). Also, according to multiple comparisons by Tukey's HSD test, the difference in ΔC between Z250 and Z350 (p=0.8) before and after bleaching was not significant but significant differences were noted in this regard between Z250 and P90 (p<0.001) and also between Z350 and P90 (p=0.006) (Figure 5).

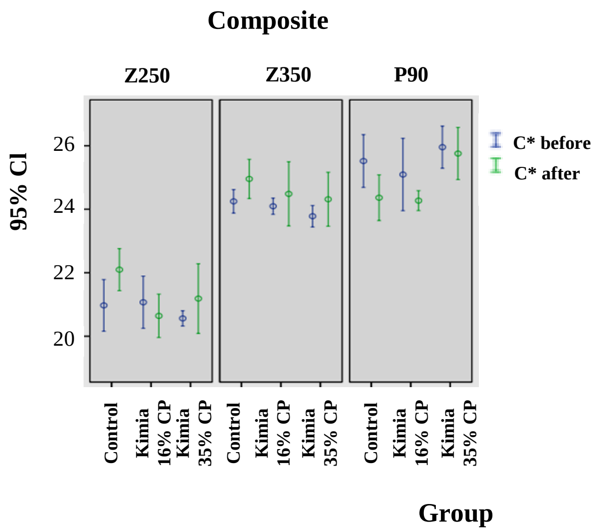

Figure 5. The mean and 95% confidence interval of C color parameter before and after bleaching with different agents (CP: Carbamide peroxide)

The ΔE color parameter: The effect of type of composite (p=0.624), type of bleaching agent (p=0.093) and their interaction effect (p=0.936) on ΔE were not significant. In other words, the understudy composites were not significantly different in terms of total color change due to the effect of bleaching agents. The mean and SD of ΔE of Z250 was 3.48±1.43, 4.55±1.7 and 4.17±1.9 in the control, 16% carbamide peroxide and 35% carbamide peroxide groups, respectively. These values were 4.33±2.41, 4.94±2.23 and 3.25±1.65 for Z350 and 4.97±2.47, 5.28±1.67 and 3.41±2.26 for P90, respectively (Table 1).

Discussion

Surface hardness is defined as resistance of a material against indentation following load application by an indenter [17]. Chemical agents values indicate redness) and b* indicative of

Table 1. The mean and standard deviation of changes in color parameters (ΔE, ΔH, ΔC, ΔL, Δa and Δb) after bleaching in different composites using different bleaching agents

Composite/Color parameter		Δa	Δb	ΔL	ΔC	ΔH	ΔE
Z250	16% CP	-0/05±0/19	-0/43±1/27	4/31±1/89	-0/43±1/26	0/04±0/48	4/55±1/7
	35% CP	-0/05±0/12	0/63±1/06	3/99±1/93	0/63±1/07	0/24±0/28	4/17±1/9
	Control	-0/22±0/08	1/15±0/31	3/18±1/65	1/13±0/3	0/8±0/26	3/48±1/43
Z350	16% CP	-0/06±0/32	0/4±0/91	4/84±2/24	0/39±0/93	0/26±0/59	4/94±2/23
	35% CP	-0/04±0/18	0/54±0/94	3/99±2/0	0/54±0/95	0/25±0/31	4/25±1/65
	Control	-0/16±0/27	0/73±0/65	4/23±2/39	0/71±0/64	0/57±0/68	4/33±2/41
P90	16% CP	-1/04±0/18	-0/69±1/25	5/02±1/56	-0/82±1/27	2/17±0/28	5/28±1/67
	35% CP	-1/35±0/49	-0/04±1/29	2/31±2/92	-0/2±1/26	2/94±1/31	3/41±2/26
	Control	-1/5±0/46	-0/97±0/99	4/44±2/66	-1/16±1/03	3/14±0/85	4/97±2/47

with softening effects on restorations decrease their hardness and compromise their durability and clinical service [18].

Color analysis is done using CIE L*a*b* standard system in accredited studies. This system can quantitatively assess the changes in color parameters. In this system, color is measured and reported in three axes of L* (indicative of lightness, ranges from white to block), a* indicative of greenness-redness (negative values indicate greenness and positive blueness - yellow-ness (negative values indicate blueness and positive values indicate yellowness) [19]. The total color change (ΔE) is also calculated using the above-mentioned parameters [19].

Based on the results of the current study, ΔE of all composites was over 3.4. Controversy exists regarding the clinically perceivable ΔE value. Some have reported values between one and two to be clinically perceivable and have stated that ΔE over one is perceivable by half the individuals [7]. Some others have reported the clinically perceivable color change to be values over three and even 3.7. Moreover, one study reported ΔE>3.3 to be clinically perceivable [20]. Some authors believe that ΔE>3.3 is not clinically acceptable and such restorations must be necessarily replaced [21]. Considering the values reported in our study, we may conclude that changes caused by bleaching with different agents were all clinically perceivable and all composites experienced significant color change by bleaching.

The mechanism of color change of dental restorative materials following the use of bleaching agents has yet to be fully understood. Free peroxyl radicals (HO^2-) probably cause oxidative cleavage of polymer chains and the free radicals eventually generate water and oxygen, which enhance the hydrolytic degradation of composites. On the other hand, this process results in color change and thus, composites with higher resin content are more susceptible to degradation and subsequent color change [22]. Following application, CP is converted to hydrogen peroxide and urea; the urea also breaks down into ammonia and carbon dioxide [7]. Hydrogen peroxide is also a strong oxidizing agent, which breaks down into water, oxygen and free radicals. Free radicals bleach the pigments responsible for discoloration by oxidizing them [6]. Moreover, the filler particles used in dental composites have variable refractive indexes and thus factors such as filler size, shape and content affect the color change of composites [23]. Color change following the application of different bleaching agents may be due to the structure of composite matrix, filler volume and type of filler in different types of composite resins [24].

Assessment of the clinical significance of statistically significant color changes is difficult. When the teeth are whitened by the bleaching agents, composite restorations may also undergo discolorations in line with the teeth. Thus, color changes after bleaching depend on color change of both the tooth and the composite. Based on the results of the current study, the effects of type of composite, type of bleaching agent and their interaction effect on ΔE were not significant; although the effects of type of composite on Δa*, ΔC and Δb* was statistically significant.

The L* parameter indicates luminosity of color and the human eye observes and perceives this parameter more clearly because the quality of rod cells, which are responsible for detection of black and white colors is much higher that that of cone cells, which are responsible for color vision [19]. The L* parameter in all groups in our study increased after bleaching and indicated lightening of all composites due to bleaching. In our study, before bleaching, the a* and b* values of all composites were within the positive range i.e. red and yellow. Following bleaching, the a* parameter remained unchanged in the methacrylate-based composites but redness decreased in P90 (a* value). The numerical value of b* in the composites remained within the positive range after bleaching; but it increased in some and decreased in some other groups. The increase in b* parameter in some studies has been referred to as becoming chromatic [25].

Considering the limited number of studies on color stability of silorane-based composites, a definite conclusion has yet to be drawn. AlQahtani reported that bleaching with 10% CP for 14 days did not cause a significant color change in microhybrid, nanofilled or hybrid methacrylate-based and silorane-based composites [15]. Their findings are different from ours. Pruthi et al, also showed that following bleaching with 15% CP, significant changes occurred in color of Z350, which is in line with our results [9].

Mohammadi et al. evaluated the effects of 15% CP bleaching gel and reported limited color change of microfilled and Giomer composites after bleaching [22].

Variability in the results of different studies may be attributed to different bleaching protocols, duration of exposure to bleaching agents, variable concentration of bleaching agents or different types of composites used. Bleaching may result in degradation of composite and can cause micro-cracks. Thus, it can adversely affect the long-term clinical service of composites [24].

Therefore, clinicians must be well aware of the color change of composites subjected to bleaching treatment. When using hydrogen peroxide for bleaching, patients must be informed that this process may accelerate aging of their composite restorations or may cause color changes that will require restoration replacement.

Conclusion

Within the limitations of this in vitro study, total color change of microhybrid, nanofilled, and silorane-based composites following bleaching with different bleaching agents was clinically perceivable.

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