

## Color Stability of Two Bulk-Fill Composite Resins

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### Abstract

**Objective:** Bulk-fill composites are a group of composite resins designed for easy and fast filling of large cavities. This study aimed to assess the color stability of bulk-fill composites subjected to xenon radiation and evaluate their color change ( $\Delta E$ ) following polymerization.

**Methods:** In this *in vitro* experimental study, 30 specimens (4mm in height and 8mm in diameter) were fabricated of x-traFil and Tetric N-Ceram universal color bulk-fill composites and A<sub>2</sub> shade of Grandio composite (as control). Bulk-fill composites were placed in the mold in 4mm thickness according to the manufacturers' instructions. In the control group, composite was applied to the mold in two layers each with 2mm thickness. Tetric and Grandio composites were cured for 20 seconds and x-traFil was cured for 10 seconds with a LED light-curing unit. A total of 15 specimens (five of each composite) were used for each test. For assessment of color change due to polymerization, L\*, a\* and b\* color parameters were measured before and immediately after polymerization and also 30 days after immersion in distilled water in an incubator at 37°C and 70% humidity using a spectroradiometer. For xenon test, the specimens were subjected to color analysis after 48 hours of storage in distilled water. Next, they were subjected to xenon lamp radiation in xenon environment chamber for 122 hours at 22°C and 25% humidity and then the color parameters were measured again. The mean and standard deviation (SD) of all values were calculated. One-way and repeated measures ANOVA were used to compare  $\Delta E$  and  $\Delta L$  among the groups. Tukey's HSD test was used for pairwise comparisons.

**Results:** The value of  $\Delta E$  immediately after polymerization was the lowest for Grandio (4.91) and the highest for Tetric (9.44). Thirty days after the polymerization,  $\Delta E$  was the lowest in Grandio (3.07) and the highest in Tetric (9.27);  $\Delta E$  showed a decreasing trend over time in all specimens. Under xenon light radiation, Grandio showed the lowest (1.50) and Tetric showed the highest  $\Delta E$  (11.15).

**Conclusion:** Following polymerization and under xenon lamp radiation,  $\Delta E$  of conventional composite was less than that of bulk-fill composites.

**Key words:** Spectroradiometer, Xenon, Color.

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## Introduction:

Combination of extrinsic and intrinsic stains determines the tooth color. Also, tooth color is related to the light absorption and scattering properties of enamel and dentin (1). Actual performance of dental materials is known after their placement in the oral cavity. Although color, translucency and other esthetic parameters can be judged quite rapidly, the long-term durability of composites is especially important and requires a longer time for evaluation (2). In most of the available bulk-fill composites, along the reduction in polymerization stress, the depth of cure has increased from 1-1.5 to 4-5mm. In some of them, the required time for curing has also decreased for faster performance (3,4).

The composite shade becomes lighter after polymerization due to the reaction of comphorquinone and formation of polymer chains. Clinically,  $\Delta E=3.3$  is clinically perceivable. Sabatini *et al.* in 2012 evaluated the color change of composites after polymerization. Discs with one and three millimeter thicknesses were fabricated of 10 different types of commercially available composites. Assessment of color change by colorimetry showed that following polymerization, clinically perceivable color changes occurred in the range of  $\Delta E=3.3$ ;

these changes continued for 24 hours and shifted the color towards lighter shades. At one month, insignificant changes in color ( $\Delta E<3.3$ ) were noted (5). Celik *et al.* and Barutçigil *et al.* in 2011 showed that color changes after polymerization were clinically perceivable and the final color no longer matched the shade guide (6, 7). Kim and Lee in 2007 evaluated the color changes after polymerization using spectrophotometry and showed that polymerization caused significant changes in brightness and chroma of color (8). By using spectrophotometry, Paravina *et al.* in 2005 demonstrated that in most composite shades, the polymerization-dependent color change was over 3.7 and the translucency parameter often increased following polymerization due to light activation (9). Therefore, this study aimed to assess the color changes of two commonly used bulk-fill composites immediately after polymerization, after 30 days of immersion in distilled water and after 122 hours of xenon light radiation.

## Methods:

Compositions of the study materials are shown in Table 1.

**Table 1- Composition of materials used in this study**

Type of composite	Application	Manufacturer	Color shade	Filler content	Batch number	Layer thickness	Number
x-traFil	Bulk fill	VOCOG mbh, Cuxhaven, Germany	Universal	86wt% 70.1 v%	1242554	4mm	5
Tetric N-Ceram bulk-fill	Bulk fill	Ivoclar Vivadent, Schaan, Liechtenstein, Germany	IVA	77wt% 55v%	R52450	4mm	5
Grandio	Conventional	VOCOG mbh, Germany, Cuxhaven, Germany	A <sub>2</sub>	87wt% 71.4v%	1240413	Two layers, 2mm each	5

Using a Plexiglas mold (10), 30 discs were fabricated of each composite with 8mm diameter

and 4mm thickness. According to the manufacturer's instructions, a 2-mm thick layer

of Grandio conventional composite (control) was applied to the mold and cured for 20 seconds using a LED light curing unit (Demetron, Kerr, Orange, CA, USA) with an intensity of 850 mW/cm<sup>2</sup>. The second layer was then applied with 2mm thickness and light cured. Before curing, the light intensity was measured by a LED radiometer (SDI Limited, Bays water, Victoria, Australia). Tetric N-Ceram bulk-fill and x-traFil were applied as bulk with 4mm thickness and subjected to one-stage curing, which was 20 seconds for Tetric and 10 seconds for x-traFil. Composites were applied to the mold, which was placed on a glass slab. The surface of materials was then covered with a transparent Mylar strip and a glass slab was placed over it. Color of specimens was measured using CS-2000 spectroradiometer (Konica Minolta Inc., Tokyo, Japan) with 390-790 nm wavelength range, 1° measurement angle and ±2% brightness. CS-S10w data management software (Konica Minolta Inc., Tokyo, Japan) was used (11,12). After measuring the values and calculation of the three color parameters, the interventions were performed and after the required time interval, color parameters were measured again. Between measurements, the device was calibrated using a white tile. The value of ΔE of specimens was calculated using the formula below:

$$\Delta E^* = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

For assessment of ΔE after polymerization, 15 specimens were evaluated. Color of specimens was evaluated before curing. Curing was then performed and color assessment was repeated after curing. Next, the specimens were immersed in distilled water and stored in an incubator at 37°C and 70% humidity for 30 days. After completion of this time period, the specimens were removed from water, dried with air spray for 5 seconds and placed in the mold again for color analysis. For the xenon test, 15 specimens were immersed in distilled water and stored in an incubator for 48 hours. After color analysis, the specimens were placed in xenon environment metal chamber (NasajSanat, Yazd, Tehran) with a 500W xenon lamp (Osram HWL (MBFT), Berlin, Germany) at 22°C, 25% humidity (KM 918 digital thermo hygrometer, Kusam-Meco, India), 10-60°C range of temperature, ±1°C temperature accuracy, 20-95% range of humidity and ±8% humidity accuracy for 122 hours. The specimens were irradiated from 20cm distance and were subjected to color assessment again (13, 14).

## Results:

Table 2 and Diagram 1 show ΔE and ΔL values immediately and 30 days after polymerization.

**Table 2- The mean and standard deviation of ΔE and ΔL values immediately and 30 days after polymerization**

	Samples	Mean	Standard error
ΔE1 before and immediately after polymerization	x-traFil	6.61	0.35
	Tetric N-Ceram bulk-fill	9.44	0.34
	Grandio	4.91	0.59
ΔE2 immediately and 30 days after polymerization	x-traFil	4.80	0.37
	Tetric N-Ceram bulk-fill	9.27	1.12
	Grandio	3.07	0.43
ΔL1 before and immediately after polymerization	x-traFil	-4.79	0.25
	Tetric N-Ceram bulk-fill	-0.08	0.53
	Grandio	-1.39	0.09
ΔL2 immediately and 30 days after polymerization	x-traFil	4.59	0.27
	Tetric N-Ceram bulk-fill	7.67	1.34
	Grandio	2.21	0.81

To assess the effect of time and type of composite on  $\Delta E$ , repeated measures ANOVA was used. The results showed that the mean  $\Delta E$  and  $\Delta L$  significantly decreased immediately and 30 days after polymerization ( $p=0.012$ ). The interaction effect of time and type of composite was not significant either ( $p=0.239$ ). In other words,  $\Delta E$  had a similar decreasing trend over time in the three composites. However, the groups had statistically significant differences in terms of  $\Delta E$  ( $p<0.001$ ). Pairwise comparisons by Tukey's HSD test showed that x-traFil and

TetricN-Ceram, Tetric N-Ceram and Grandio ( $p<0.001$ ) and x-traFil and Grandio ( $p=0.034$ ) had statistically significant differences and Grandio showed the lowest and Tetric showed the highest  $\Delta E$ . The value of  $\Delta L$  significantly increased over time ( $p<0.001$ ). Also, the mean  $\Delta L$  was significantly different among the three groups ( $p<0.001$ ). Pairwise comparison of groups showed that x-traFil and Grandio had the lowest  $\Delta L$  with no significant difference ( $p=0.611$ ); whereas, Tetric had a higher  $\Delta L$  than x-traFil and Grandio ( $p<0.001$  for both).

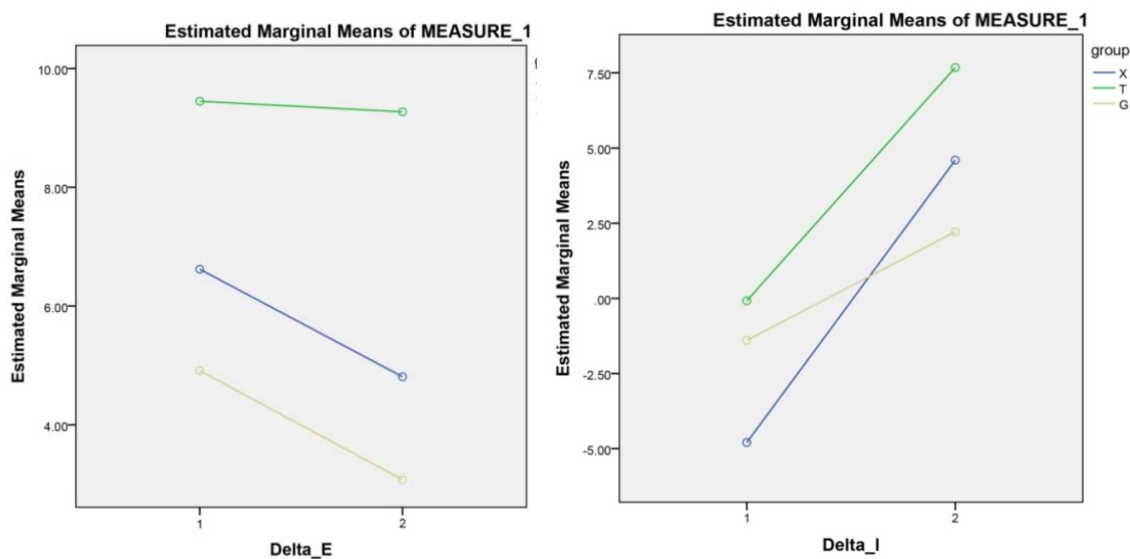


Diagram 1- Changes in values of  $\Delta E$  and  $\Delta L$  immediately (1) and 30 days (2) after polymerization

Table 3- The mean and standard deviation of  $\Delta E$  and  $\Delta L$  after placement in xenon environment chamber

Samples		Mean	Standard error
$\Delta E$ before and after placement in xenon environment chamber	x-traFil	2.55	2.55
	Tetric N-Ceram bulk-fill	11.15	11.15
	Grandio	1.50	1.50
$\Delta L$ before and after placement in xenon environment chamber	x-traFil	-0.26	-0.26
	Tetric N-Ceram bulk-fill	-0.21	0.21
	Grandio	-0.49	-0.49

Xenon test results are shown in Table 3. One-way ANOVA was used for the comparison of  $\Delta E$  and  $\Delta L$ . The difference in  $\Delta E$  was significant among the three groups. Pairwise comparison of groups in terms of  $\Delta E$  by Tukey's HSD test showed that Grandio had the lowest and Tetric had the highest  $\Delta E$ . Also, the differences in this

regard between Grandio and Tetric ( $p=0.02$ ), Grandio and x-traFil ( $p<0.001$ ) and Tetric and x-traFil ( $p<0.001$ ) were statistically significant.

## Discussion

Polymerized composite resins have higher

diffuse reflectance than un polymerized composite resins. This change indicates an increase in the refraction coefficient of the matrix phase following the conversion of monomer to polymer; whereas, the refraction coefficient of filler phases remains unchanged (8,15). In the current study, all specimens had A<sub>2</sub> shade. Lee and Powers in 2001 fabricated 2mm thick specimens (16) but in our study bulk-fill composite specimens had 4mm thickness as recommended by the manufacturers. Conventional composite was applied to the mold in two layers, each with 2mm thickness and cured. A spectroradiometer was used for analysis of color parameters (11, 12) at 30 days (5,6). Studies have demonstrated greater color change in higher thicknesses of specimens (8). However, some other studies have reported greater color change in thinner specimens (17). In composites with a base of Bis-GMA, degree of polymerization varies between 45-85%. It has been reported that in composites with a base of Bis-GMA and UDMA, degree of polymerization is 20% lower compared to other monomers (18). This monomer was present in all three types of composites in our study. Low degree of polymerization decreases the color stability and can intensify discoloration due to the release of products such as methacrylic acid and formaldehyde (18, 19). Considering the fact that the filler content of Tetric composite is lower than that of the other two composites, Tetric had a lower degree of polymerization. This explains the greatest color change in Tetric immediately and 30 days after polymerization. On the other hand, due to higher volume of matrix phase in Tetric, it may have a higher water absorption and greater color change compared to the other two composites. At 30 days after polymerization,  $\Delta E$  significantly decreased in the three groups, which is probably due to the continuation of polymerization as dark cure in dark jars and water sorption of the resin component.

In the current study,  $\Delta L$  significantly increased over time in the three composites. Paravina *et al.* in 2005 evaluated the color change due to polymerization of 28 different composites and showed an increase in translucency following polymerization; that is, an increase in L\* parameter (9). Sabatini *et al.* in 2012 and Celick *et al.* in 2011 also reported an increase in L\* parameter following polymerization (5, 6). However, Lee *et al.* in 2001 showed that depending on the type of material and its shade, lightness (CIE L\*) may increase or decrease following polymerization (14). Based on the results of the current and the above-mentioned studies, it can be concluded that most composite resins show a relatively wide range of optical changes due to polymerization (6). In the xenon test, Grandio showed the least color change following aging while Tetric showed the highest color change (20, 21). Intrinsic factors such as size, percentage and type of filler particles as well as the type of initiator and its chemical composition affect the color stability of composites. Since the xenon environment mainly affects the polymer component of composite and its carbon bonds, it can be concluded that the lower the filler content the greater the color change. This was especially true for Tetric. On the other hand, Tetric, in contrast to the other two composites in the current study, has two photo initiators namely comphorquinone and Lucirin, which may be responsible for greater color change of this composite. Albuquerque *et al.* in 2013 showed that type of photoinitiator in composites may affect their color stability. They showed that composites with Lucirin TPO had higher color stability than composites containing bisacyl phosphine oxide (BAPO) or the comphorquinone-amine system (22). However, Da Costa *et al.* in 2003 evaluated the effect of type of photoinitiator on the color stability following xenon aging and reported that type of photoinitiator (phenyl propanedione and

comphorquinone) had no significant effect on the color stability of composites (23). Tetric also contains filler that serves as a stress reducing agent in the composite due to its low modulus of elasticity and yields up to 4mm of curing depth. This filler does not exist in the other two composites evaluated in our study. Therefore, this filler may also be responsible for lower color stability of Tetric. Catelan *et al.* in 2011 reported color changes within the acceptable range following 252 hours of UV irradiation (20). Kolbek *et al.* in 2006 also reported the same results (34). However, Stober *et al.* in 2001 demonstrated unacceptable color changes ( $\Delta E > 3.3$ ) after 24, 96 and 168 hours (21). Considering all the above and since  $\Delta E > 3.3$  is perceivable by the human eye and results in dissatisfaction of patients, the best suggested strategy is that the clinician applies a piece of composite on the tooth under restoration or the neighboring teeth and cure it in order to ensure

color match after polymerization (6). On the other hand, based on the results of the current study, change in  $\Delta L$  after polymerization indicates change in lightness of restoration over time; this calls for greater attention of clinicians to shade selection and giving a higher priority to the value of color.

### **Conclusion:**

Color change immediately and 30 days after polymerization was the lowest in Grandio and the highest in Tetric composites;  $\Delta E$  had a descending trend over time in all specimens. Following xenon radiation, Grandio showed the lowest and Tetric showed the highest color change.

### **Conflict of Interest: “None Declared”**

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