Comparative evaluation of the effect of Light Emitting Diode (LED) and Quartz Tungsten Halogen (QTH) light curing units on color stability of Filtek Z350 XT

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Abstract

Introduction: Discoloration of the resin-based composites is a common problem in restorative dentistry. There are many factors associated with the discoloration of dental materials in the oral environment. The purpose of this study was to evaluate the color changes in a nano-composite cured with a quartz-tungsten-halogen (QTH) and light emitting diode (LED) unit.

Methods: 80 disk-shaped specimens were prepared using Filtek Z350 XT. The specimens were cured with two LED units (Valo and BluephaseC5) and QTH (Astralis7) with two different energy density (400 & 750 mW/cm²). The color of the materials was measured before and after immersing in tea and artificial saliva. Color change value (∆E) were calculated and analyzed by 2-way ANOVA and Tukey’s test.

Results: In artificial saliva group, the composites cured with Astralis7 and BluephaseC5 showed significantly more color stability. In tea group, the composites cured with BluephaseC5 significantly had the least color change.

Conclusions: The type of light curing unit does not affect the color stability. Exposure time and interaction between light source and photoinitiator content in composite may be the most important factors affecting color stability.

Keywords: Dental curing lights, Nanocomposite, Spectrophotometry

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ارزیابی مقایسه ای اثر دستگاه‌های لایتکیور (QTH) و LED بر تیات رنگ کامپوزیت Filtek Z350 XT

چکیده
مقدمه: تغییر رنگ کامپوزیتهای رزینی یک مشکل عمده است. فاکتورهای بسیاری با تغییر رنگ مواد در محیط دهان ارتباط دارند. هدف از این مطالعه ارزیابی تغییرات رنگی پک نانوکامپوزیت است که با منبع نور کیو-وارتر-نتکستن-هاولزن (LED) و دیود نوری (QTH) به دو دستگاه متغیر (QTH) با استفاده از یک دستگاه (LED) به دو روش متفاوت (LED) و (QTH) مواد در روش‌های 80 نمونه به شکل دیسک با استفاده از کامپوزیت Filtek Z350 XT آماده شدند. نمونه‌ها mW/Cm² توسط دو دستگاه با استفاده از تیایی (Astralis7) QTH و (Valo) LED به دو دشت متفاوت (750,400) کیو شدند. رنگ مواد قبل و بعد از غوطه‌وری در محلول چای و برای مصوبه انسانی گیری شد. میانگین ∆E با استفاده از دو روش اماری ANOVA و تست Tukey یافتند. در نمونه‌های غوطه ور شده در برای مصوبه (Astralis7) QTH و (BluephaseC5) و در نمونه‌های غوطه ور شده در (BluephaseC5) با استفاده از بایوزومینیاتورات رنگی یک دارا بودند. نتایج گسترده: نوع دستگاه بروز نیروی بر تیات رنگ اثر ندارد. احتمالاً ذخایر ناشاب و تقابل بین نوع دستگاه بروز و آغاز توحید موجود در کامپوزیتهای سایپورهاهای موثر بر تیات رنگی هستند.

واژگان کلیدی: لایتکیور های دندانپزشکی، نانوکامپوزیت، اسپکتروفتوسکوپی

Introduction
The demand of aesthetic restorative materials has been increased after the introduction of resin-based composites (RBC) from late 1970s. Despite the many advantages of RBCs, they have a considerable disadvantage which related to their discolorations in the oral cavity after ages (1, 2).

Many factors affect color change of RBCs in oral cavity. Discoloration may occur by intrinsic or extrinsic factors. Extrinsic discoloration caused by adsorption or/and absorption of colorant agents contained in beverages, foods, tobacco and chromogenic bacteria. Intrinsic factors contain discoloration of material by itself which is determined by the quality of resin matrix, photoinitiators and inorganic filler (3). Numerous studies haveshown that adequate polymerization of RBCs is apparently influential on the physical and mechanical properties such as staining. One of the factors that influences polymerization is light curing unit (LCU), including spectral distribution, exposure time and intensity of light output (1, 4, 5).

Until recently, quartz-tungsten-halogen (QTH) units have been used for polymerization of RBCs. Due to its shortcomings, new technologies introduced for light polymerization of RBCs (6). The Light Emitting
Diode (LED) technology was introduced in 1995 for polymerization of RBCs to overcome the shortcomings of QTH units. LEDs use junctions of doped semiconductors instead of the hot filament and have a lifetime 100 times greater than QTHs (7).

Nano-composites have been introduced recently. It has been thought that nanocomposites may have improvement in their physic-mechanical properties. Also, it has been claimed that low TEGDMA content in nano-composites may limit its water uptake and staining susceptibility (8). The purpose of this study was to evaluate the influence of the type of LCU on color stability of a nano-composite after immersing it in a colorant beverage (tea), compared to artificial saliva.

Methods

A nanocomposite, Filtek Z350 XT (3M ESPE, St Paul, MN, USA) of A2 enamel shade was used. 80 disk-shaped specimens, 8 mm in diameter and 2 mm in height, were prepared in a siliconer using Filtek Z350 XT composite. The specimens were divided into 4 groups (n=20). One millimeter glass slide was placed over the ring and pressure was applied until the slide touched the RBC completely.

The distance between LCU and specimen was standardized by placing the light-guide tip over the glass slide.

The specimens were cured by Valo (LED), BluephaseC5 (LED) and Astralis7 (QTH) (with two different light intensities) to compare the effect of low and high light intensity in color stability (LCUs) according to this formula (1):

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

The specimens were polished by silicone carbide paper of 220, 400, 600, 800, 1200 grit for 10 seconds. After measuring the baseline color, half of the specimens were immersed in tea (Yellow label tea; Lipton, London) which was prepared, immersing two tea bags (2.2 g) into 250 ml of boiling water for two minutes. The other half of the specimens were immersed in artificial saliva (biotene®). All specimens were incubated at 37 °C for 72 hours.

After 72 hours, the color values of each specimen were measured, and the color change value (ΔE*ab) was calculated from the differences of the values of L*, a*, and b* according to this formula (1):

\[
\delta^{*}ab = \sqrt{(\delta^{*}L)^2 + (\delta^{*}a)^2 + (\delta^{*}b)^2}
\]

The data were statically analyzed using two way repeated measures ANOVA and Tukey’s test with SPSS 17 software (p<0.05).

Table 1. Light curing units used in this study

<table>
<thead>
<tr>
<th>LCU</th>
<th>Type</th>
<th>Spectral distribution (nm)</th>
<th>Light Intensity (mW/Cm²)</th>
<th>Exposure Time (S)</th>
<th>Power Density (J/Cm²)</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valo</td>
<td>LED</td>
<td>430-490</td>
<td>500</td>
<td>32</td>
<td>16000</td>
<td>IvoclarVivadent</td>
</tr>
<tr>
<td>BluephaseC5</td>
<td>LED</td>
<td>395-480</td>
<td>800</td>
<td>20</td>
<td>16000</td>
<td>Ultradent</td>
</tr>
<tr>
<td>Astralis7</td>
<td>QTH</td>
<td>400-500</td>
<td>HIP: 750</td>
<td>22</td>
<td>16500</td>
<td>IvoclarVivadent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LOP: 400</td>
<td>40</td>
<td>16000</td>
<td></td>
</tr>
</tbody>
</table>

Results

The contribution of each basic color coordinates (L, a & b) is shown in figure1. Figure 2 shows the results of the influence of the type of LCU on color stability. The greatest change was found to be the value (L*) rather than chroma (a*, b*) in tea. There was statistically significant difference in color change between the specimens immersed in tea and those immersed in artificial saliva.
The specimens immersed in tea showed clinically perceptible color change and the specimens immersed in artificial saliva had color change which clinically were imperceptible (ΔE<3.3). In artificial saliva, specimens cured with Astralis7 (400mW/Cm²) and BluephaseC5 (LED) showed significantly more color stability. In tea, specimens cured with BluephaseC5 (LED) had the least color change and the other three groups had no statistically different color change.

L*(lightness), a* (the amount of red and green), and b* (the amount of yellow and blue)/ ΔL, Δa, Δb=differences of L*, a*, and b* prior to and after immersing. (Different letters used to show statistical difference between groups).

**Figure 1. The contribution of each basic color coordinates**

![Figure 1. The contribution of each basic color coordinates](image)

**Figure 2. Mean ΔE obtained for specimens cured with QTH or LED sources**

![Figure 2. Mean ΔE obtained for specimens cured with QTH or LED sources](image)

**Discussion**

In this study, color changes of Filtek Z350 XT in two different environments with four different light intensities and LCUs have been calculated. Specimens cured with lower intensity units showed significantly more color stability. Many factors have effect on color changes of RBCs. Resin matrix, dimensions of filler particles, depth of polymerization, oxidation of unreacted carbon-carbon double bonds, degree of conversion and coloring agents may affect the color stability (9, 10).

Color changes of RBCs can be evaluated by visual or instrumental techniques. Spectrophotometry is the most reliable technique in evaluating discoloration of dental materials (11). Instrumental techniques generally use two color systems: the Munsell Color System and Commission Internationale de l’Eclairage (CIE) Color System (12).

Color evaluation in this study has been evaluated by Vita Easyshade which is a spectrophotometer using CIE L*a*b* system. The high reliability of this device in comparison to the laboratory spectrophotometer has been proven in recent studies (13, 14).

According to the individual ability of the human eye, three different intervals of ΔE were used: ΔE<1—imperceptible by the human eye; 1<ΔE<3.3—perceptible only for skilled person; ΔE>3.3 easily observed. ΔE<3.3 is clinically acceptable (15).

In the current study, The color change of specimens in artificial saliva were clinically imperceptible (ΔE<3.3) but those in tea were perceptible (ΔE>3.3), and the difference were statistically significant.

The staining susceptibility of RBCs has been attributed to the hydrophilicity and degree of water sorption of the resin matrix. Water sorption cause expansion and plasticization of the resin component, hydrolyze the silane, and consequently make micro-crack or interfacial gaps at the interface between filler and matrix. These gaps allow stain penetration and discoloration (12, 16).

Thus, color changes of specimens in artificial saliva, which contain water as the basic component, is provable. Moreover, clinically imperceptible discoloration may be attributed to the presence of no pigment in artificial saliva.

If RBCs can absorb water, then they can also absorb other beverages such as tea (12). Discoloration of the RBC in tea was clinically perceptible, similar to previous studies. This color change may be attributed to yellow colorants existing in tea (12, 16). Nasimand et al. (10) claimed that stain ability of tea may be due to...
tannic acid. In artificial saliva, specimens cured with Astralis 7 (400mW/Cm²) (QTH) and Bluephase C5 (LED) significantly showed more color stability. Also, in tea, specimens cured with Bluephase C5 significantly had the least color change.

The degree of conversion affects solubility and color stability of RBCs (9, 10, 12, 17). Some studies reported that time may be the most important factor influencing the degree of conversion (2, 17, 18, 19). The result of this study was similar to those studies. Bluephase C5 and Astralis 7 (400mW/Cm²) had the longest curing time (32 and 40 s).

This may be one of the reasons that caused better result for these two LCUs. On the other hand, recent studies have reported that LED technology polymerizes RBCs as well or better than some QTH lights (20, 21-23). Also, in accordance to previous studies, light emitted by LED lamps allows a reduction of the exposure time from that recommended by RBC manufacturers for QTH curing lights (24, 25).

In this study, Bluephase C5 as LED showed the result as similar as the referred studies but Valo was another LED that did not conform to those results. Therefore, other factors might be responsible for better polymerization.

Filtek Z350 XT contains camphorquinone as photo-initiator, (peak absorption at 468 nm) (20, 26, 27). In this study, Bluephase C5 had the narrowest spectral range (430-490 nm) which matches with the optimum absorption wavelength for the activation of the camphorquinone, which is in agreement with our study. However, spectral distribution of LCUs may be another factor affecting on the degree of conversion and subsequently, on color stability.

Conclusions
Specimens cured with LED and QTH did not have difference in color stability. But, exposure time and interaction between LCU and photoinitiator contained in composite may be the most important factors affecting color stability. It is suggested to evaluate the effect of different energy density and influence of heat production after light curing, on the stain susceptibility of RBCs.

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Conflict of interest: There was no conflict of interest.

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