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THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

Title of Thesis: The Effect of Water, Coffee, and Soft Drink on the Color Stability of a Smart-Matching-Shade Composite vs. a Conventional Nanocomposite

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The effect of water, coffee, and soft drink on the color stability of smart-matching-shade composite vs a conventional nanocomposite.

A manuscript

Presented to the Faculty of the Advanced Education in General Dentistry, Two-Year Program,

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And the Uniformed Services University of the Health Sciences – Post Graduate Dental College

In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Oral Biology

By

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May 2022

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Abstract

The effect of water, coffee, and soft drink on the color stability of smart-matching-shade composite vs a conventional nanocomposite.

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Introduction: Composite materials are evolving. For the past years, we have seen advent of so-called “smart-matching-shade composites.” These smart-matching-shade composites claims to blend with natural tooth color, whereby eliminating the shade-matching process with predictable color stability. Dentists can save time and cost by reducing number of composite inventories. In addition, by decreasing number of materials required to do restorative procedures, military dentists can greatly benefit and help with military deployments. Omnichroma is one such smart-matching composites. Color stability a composite can be affected by various extrinsic staining and affect perceived color change.

Objective: The objective of this study is to investigate an effect of different solutions, water, coffee, and Coke on the color stability of a smart-matching-shade composite, Ominichroma and a conventional nanocomposite, Filtek Supreme Ultra. The null hypothesis is that there is no measurable change in color stability between a smart-matching-shade composite and an A2-shade nanocomposite in different solutions.

Methods: A total of 150 specimens of Omnichroma and Filtek Supreme Ultra specimens are prepared using a resin mold with a glass slab. Each sample size has a diameter of 5mm and a thickness of 2mm. The prepared specimen is light cured for 20 seconds. 25 specimens of each Omnichroma and Filtek Supreme Ultra are placed into water, coke, and coffee. At 7th day, specimens are cleaned with distilled water and color change value, ΔE are recorded for all specimens using a spectrophotometer.

Results: The color stability of Omnichroma and Filtek Supreme Ultra in water and coke did not show statistically-significant differences. However, the both Omnichroma and Filtek Supreme Ultra in coffee solution show statically significant changes in color stability.

Conclusion: The study shows that coffee affected the color stability of Omichroma and Filtek Supreme Ultra whereas water and coke did not. Hence, the null hypothesis was partially rejected.

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Background

Composite materials are evolving. For the past few years, we have seen advent of various so-called “smart-matching-shade composites.” These smart-matching-shade composites claims to blend with natural tooth color, whereby eliminating the shade-matching process. Dentists can save time and cost by reducing number of composite inventories.

Color perception by human observers involves the spectrum of visible light entering the eye and stimulating color receptors in the eye’s retina². There are many models that can describe color. Munsell was the first to systemically illustrate that color can be modeled using a three-dimensional color space³. Hence, color stability of a composite is defined as its ability to maintain color renderings in three dimensions, described by Munsell and can be directly measured using the Commission of Internationale de l’Eclairage (CIE) developed a system for visual specification of signals. The CIE was recommended for widespread use in 1931⁴. CIE describes the color space with the following equation:

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

where ΔE is the total color difference; ΔL^* indicates lightness and darkness; Δa^* is the red-green coordinate; and Δb^* is the blue-yellow coordinate. Perceptibility threshold of color change depends on many factors, including test subjects, age, lighting, and distance. These factors contribute to inherent subjectivity of color detection by humans. Therefore, quantitative variable, such ΔE is useful in measuring color changes by reflectance spectroscopy.

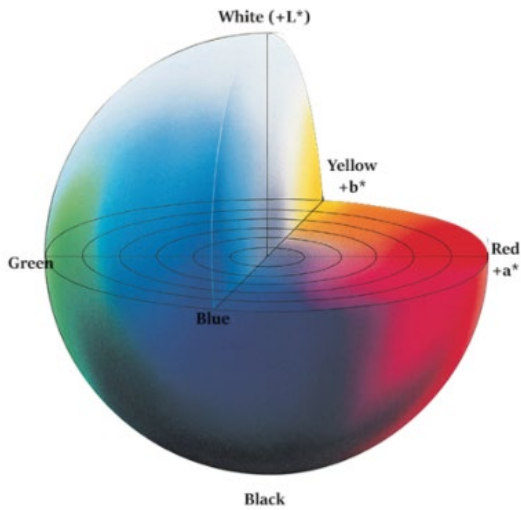


Figure 1. 3D Color space in Commission of Internationale de l'Eclairage (CIE)

Omnichroma claimed to be one of the first composite resin systems to match every color of tooth from A1 to D4. According to Tokuyama's research, a 260 nm spherical filler generates the red-to-yellow color necessary to match natural teeth. It concluded that variations in the size and shape of filler material ultimately affects the composite's shade matching ability. The organic phase of Omnichroma is made from monomers like urethane dimethacrylate (UDMA) and 1,9-Nonanediol Dimethacrylate. The inorganic phase of Omnichroma is composed of uniform sized supra-nano spherical filler (260nm spherical $\text{SiO}_2\text{-ZrO}_2$)¹. Omnichroma is a visible light-activated composite, utilizing camphoquinone as the photoinitiator for the initiation of free radical photo-polymerization. Camphoquinone is the most common photoinitiator and has an absorption peak near 470 nm, within the blue light region.

As lights pass through the composite, Omnichroma is able to attenuate photons by using proprietary uniform sized supra-nano spherical fillers such that the reflected light closely mimics the red-to-yellow structural color of surrounding tooth¹.

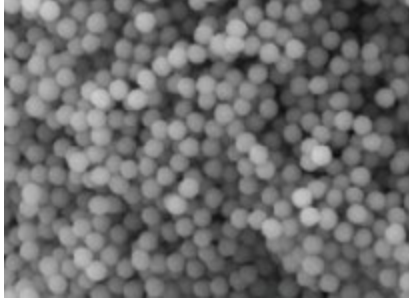


Figure 2. Scanning electron microscope image of OMNICHROMA at x20,000 magnification¹

The objective of this study is to investigate an effect of different solutions, water, coffee, and Coke on the color stability of a smart-matching-shade composite, Ominichroma and a conventional nanocomposite, Filtek Supreme Ultra. The null hypothesis is that there is no measurable change in color stability between a smart-matching-shade composite and an A2-shade nanocomposite in different solutions

Methods and Materials

A total of 150 specimens of Omnichroma and Filtek Supreme Ultra were prepared using a resin mold using a 3D printer and a glass slab. Each sample size had a diameter of 5mm and a thickness of 2mm. The prepared specimens were light cured for 20 seconds, using SDI Radii Plus LED curing light at 5mm from each sample. Afterwards, 25 specimens of each Omnichroma and Filtek Supreme Ultra are placed into distilled water (Aquafina purified water), Coke, and coffee (Kirkland Signature Colombian Cold Brew). At 7th day, specimens are cleaned with distilled water and color change value, ΔE are recorded for all specimens using a VITA Easyshade Compact spectrophotometer.

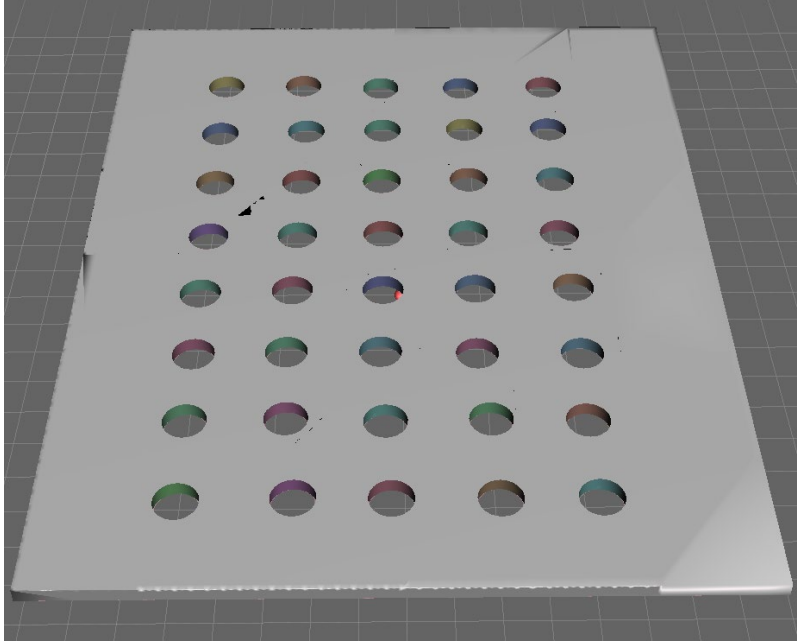


Figure 3. 3D printout of sample resin molds



Figure 4: Spectrophotometer, Vita Easyshade Compact

Mean ΔE values were compared using repeated measures of analysis of variances (ANOVA) and comparison of all pair using Tukey HSD. Therefore, data was analyzed with nonlinear regression and ANOVA/Tukey ($\alpha = 0.05$).

Results

The color change, ΔE was greater in Omnichroma than in Filtek Supreme Ultra across all three solutions. The highest color change was observed in Omnichroma, Coffee solution with mean of 2.56 whereas the lowest color change was observed in Filtek, water solution with mean of 1.224. The color stability of Omnichroma and Filtek Supreme Ultra in water and Coke did not show statistically-significant differences. However, the both Omnichroma and Filtek Supreme Ultra in coffee solution show statically significant changes in color stability.

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Avg. ΔE</i>	<i>Variance</i>
Filtek (water)	25	30.6	1.22	0.43
Filtek(Coke)	25	33.7	1.35	0.73
Filtek(Coffee)	25	49.7	1.99	0.77
Omnichroma(Water)	25	44	1.76	0.68
Omnichroma(coke)	25	45.3	1.81	0.67
Omnichroma(Coffee)	25	64	2.56	0.71

Table 1: Summary of color changes for Filtek and Omnichrom in three solutions

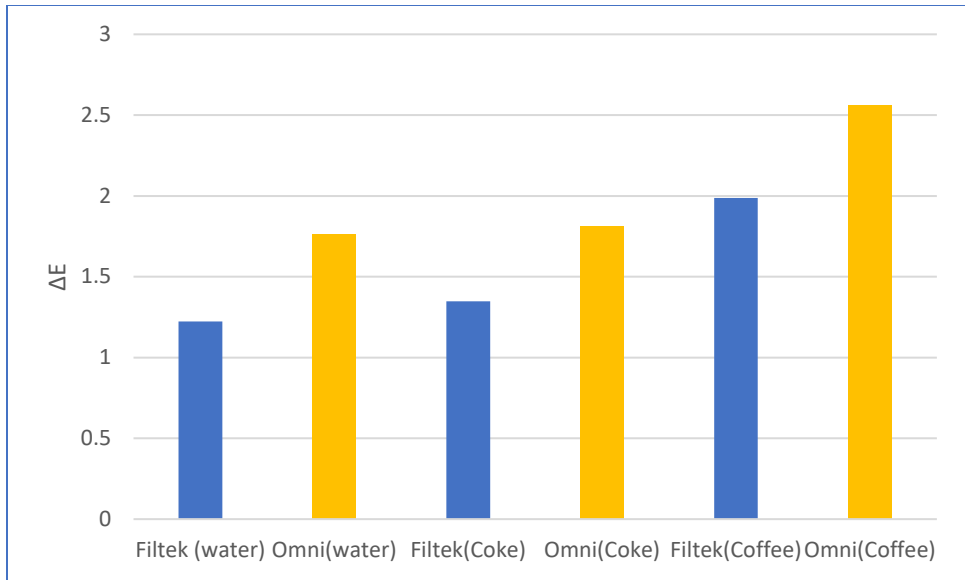


Figure 5: Average color change, ΔE

ANOVA						
Filtek						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8.41	2.00	4.20	6.54	0.0024	3.12
Within Groups	46.23	72.00	0.64			
Omnichroma						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	10.02	2.00	5.01	7.32	0.0013	3.12
Within Groups	49.27	72.00	0.68			

Table 2: Summary of ANOVA statistical analysis

Filtek			
comparison	abs. mean diff	Tukey HSD	significant
water v coke	0.12	0.54	no
coke v coffee	0.64	0.54	yes
water v coffee	0.76	0.54	yes
Omnichroma			
comparison	abs. mean diff	Tukey HSD	significant
water v coke	0.05	0.56	no
coke v coffee	0.75	0.56	yes
water v coffee	0.80	0.56	yes

Table 3: Summary of Tukey HSD statistical analysis

Discussion

The color changes for both composites were statistically significant in coffee solution and not in water or coke. This could be due to coffee staining affecting the color reading of spectrophotometer.

Although color changes were greatest in coffee group for Omnichroma, $\Delta E=2.56$ and Filtek Supreme Ultra, $\Delta E=1.99$, the color changes would be hard to perceived by human eyes. Past dental publications found ΔE of 2.7⁵ and 3.3⁶ to be 50:50 acceptability thresholds. This threshold means that 50% of observers would be able to discern color changes while 50% would not.

Conclusion

The study shows that there was statistically significant color change in coffee solution for both Omichroma and Filtek Supreme Ultra whereas water and coke did not. Hence, the null hypothesis was partially rejected. There were several limitations with the study. First, the study is a bench-top study and hence applicability to clinical setting is limited. All composite samples were light cured in a dental laboratory against a grey background. Hence, the masking effect of

Omichroma, utilizing adjacent teeth is greatly reduced. Second, although the curing time and distance from light source were constant, some samples may have been exposed to the light source longer than others. This is due to the resin template used to manufacture composite samples were in close proximity to each other. For future study, conducting research under more realistic clinical-setting would be ideal. One such study can be done by using composite samples on extracted teeth and have observers detect color changes across multiple time periods.

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