Color stability against accelerated aging of alumina- and leucite-based ceramic materials

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Purpose: The purpose of the current study was to examine the effect of accelerated aging on color stability of the In-Ceram and Cergogold ceramic materials.
Materials and Methods: Ceramic samples with 1.0 mm in diameter and 1.5 mm in thickness were prepared in three commonly used shades. CIE Lab readings were recorded with a spectrophotometer prior to experiments and after 100-hour accelerated aging.
Results: The effect of ceramic type on the color change was similar for three shades (A1, A3, and A4). In-Ceram had less color change than Cergogold on every shade. When the shades of ceramic were compared, A1 shade had a greater color change than those of A3 and A4 shades ($p<0.05$).
Conclusion: Both In-Ceram and Cergogold ceramic materials had small color change with accelerated aging, although the changing was almost undetectable by human eyes. **(Int Chin J Dent 2007; 7: 49-52.)**
Key Words: accelerated aging, ceramics, color stability.

Introduction

All-ceramic crown possesses color-rendering properties and optical properties that simulate natural teeth.[1] Furthermore based on the excellent biocompatibility, strength, and surface texture of the material, it remains the material of choice for most clinicians. It is generally believed that ceramic crown has good color stability. A recent research, however, reported that the accelerated aging process may change the color of different kinds of heat-pressed ceramic materials.[2]

An objective evaluation for color differences requires an ordered system for the classification of color, and equipment capable of quantifying color differences. The most commonly used color classification system for research purpose was developed by the Commission International de I'Eclairage in 1978. Otherwise known as the CIE color system, it introduces three attributes to the perception of color named as L, a, and b. The letter L refers to the lightness variable and it is proportional to value in the Munsell Color System. The letters a and b are chromaticity coordinates, wherein a corresponds to the red-green axis, while b refers to yellow-blue axis. Although they do not directly correlate to hue and chroma, the respective numerals serve to determine numeric correlates for these attributes.[3]

Color stability of dental restorative materials was investigated by using accelerated aging in many articles.[4-7] Although the clinical relevance of accelerated aging on the color stability of ceramics was not studied, it seems that this method could be used to determine the color difference, which would probably occur over a long clinical period.[5,8] The purpose of this study was to examine the effect of accelerated aging on color stability of the In-Ceram and Cergogold ceramic materials.

Materials and Methods

Two brands of ceramic materials, In-Ceram (Vita Zahnfabrik GmbH, Bad Säckingen, Germany) and Cergogold (Golden Gate Degussa Inc., Darmstadt, Germany), were used in this study (Table 1).

Thirty disk shaped ceramic specimens (10 mm in diameter by 1.5 mm in thickness; Vita lumen shades A1=10, A3=10, and A4=10) were prepared with two materials according to the manufacturers' instructions.

Table 1. Ceramic materials assessed.

Trade name	Material	Composition	Lot number
In-Ceram	Core	Al_2O_3, La_2O_3, SiO_2, CaO	Powder 62983, Liquid 0899 Glass powder 6186P, 6436P, 6436O
In-Ceram	Dentin	Na_2O Al_2O_3 $6SiO_2$	4536, 4902, 4950
In-Ceram	Enamel	SiO_2, La_2O_3	4855
Cergogold	Dentin	K_2O Al_2O_3 $4SiO_2$	0021/9, 0031/6, 0021/1
Cergogold	Enamel	SiO_2, MgO, K_2O	Powder 0322/5, Liquid 0382/12

After firing and glazing procedures, color analysis of all ceramic specimens was undertake with a spectrophotometer (Datacolor, SF300/47-63HZ, Lawrenceville, NJ, USA). The spectrophotometer was calibrated according to the manufacturer's instructions before the analysis. Values were recorded in the CIE Lab color system. The L, a, and b values of each specimen were measured. Then, all ceramic specimens were subjected to an accelerated aging in the Weather-O-meter apparatus (M/s Atlas Electric Devices Co., Chicago, IL, USA). A 4,500-W xenon arc lamp was used to simulate D65 daylight. One hundred hours of weathering process was applied in 100% relative humidity and 37˚C temperature to all ceramic specimens. After the experimental procedures, color analysis was repeated for each of the specimens, as previously described. The pre- and post-experimental CIE Lab color values of each specimen were compared with each other by the following formula:

$$\Delta E = [(L_1-L_2)^2+(a_1-a_2)^2+(b_1-b_2)^2]^{1/2}$$

where L_1, a_1, and b_1 represent pre-experimental color values of each specimen, and L_2, a_2, and b_2 represent post-experimental color values of each specimen. Thus the degree of color change, ΔE is determined.

Two-way analysis of variance (ANOVA) and Dunnett's T3 test at the 5% level of significance were used to examine the effects of ceramic types, shades, and the interaction of these two parameters on color stability. The statistical analysis was performed using SPSS 10.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The pre- and post-experimental L, a, and b as well as ΔE values of each of ceramics in their respective shades are listed in Table 2. The effect of ceramic type on the color change was similar for the A1, A3, and A4 shades ($p>0.05$). The In-Ceram material had less color change than the Cergogold material. When the shades of ceramic were compared, A1 shade had a greater color change as compared with A3 and A4 shades ($p<0.05$).

Table 2. The pre- and post-experimental L, a, and b values and degree of color change ΔE.

Material	L_1	SD	a_1	SD	b_1	SD	L_2	SD	a_2	SD	b_2	SD	ΔE
In-Ceram A1	74.75	2.42	0.95	0.05	13.06	1.47	73.23	2.72	1.10	0.11	13.24	1.47	1.54
In-Ceram A3	71.99	2.15	3.10	0.19	16.25	1.24	70.82	2.63	3.20	0.24	16.85	1.24	1.30
In-Ceram A4	65.52	2.36	4.40	0.15	20.58	1.23	64.49	2.54	4.60	0.24	20.70	1.23	1.06
Cergogold A1	75.20	2.13	0.75	0.12	13.82	1.14	73.39	2.38	0.80	0.01	13.84	1.12	1.81
Cergogold A3	71.89	2.25	1.55	0.23	19.75	1.25	70.39	2.47	1.65	0.24	20.02	1.42	1.52
Cergogold A4	65.60	2.47	0.20	0.14	20.59	1.34	64.49	2.45	0.28	0.35	20.73	1.25	1.12

To relate the amount of color change recorded by the spectrophotometer to a clinical environment, the data were computed to National Bureau of Standards (NBS) units.[9] With the NBS units, ΔE values can be described through the equation NBS unit = 0.92 x ΔE. According to the NBS units, these two ceramic materials except for the Cergogold with shade of A1 showed slight color change. The results of this conversion are shown in Table 3 along with the critical remarks of color differences as expressed by the NBS units.

Table 3. Color differences converted to the NBS units.

Material	ΔE	NBS unit	Remark	NBS critical remark	
In-Ceram A1	1.54	1.42	Slight	Slight	(0.5-1.5)
In-Ceram A3	1.30	1.20	Slight	Slight	(0.5-1.5)
In-Ceram A4	1.06	0.98	Slight	Slight	(0.5-1.5)
Cergogold A1	1.81	1.66	Noticeable	Noticeable	(1.5-3.0)
Cergogold A3	1.52	1.39	Slight	Slight	(0.5-1.5)
Cergogold A4	1.12	1.08	Slight	Slight	(0.5-1.5)

Discussion

With the great emphasis placed on aesthetics by modern society, the color stability of aesthetic restorative materials gains more critical importance. As a restorative material, ceramics has very good clinical properties at these topics. Traditional point of view was that ceramics has color stability in the clinical relevance environment. But there was no related experiment to test this theory. In this study an aging device was used to subject samples to both visible and UV light and 100% relative humidity at 37˚C. The manufacturer of the weathering instrument estimates 300 hours of aging is equivalent to one year of clinical service. This is applicable for specimens, which are in direct sunlight and located horizontally. However the oral environment is more complex. Razoog, et al.[10] stated that the greatest amount of color change occurred in the first 100 hours of accelerated aging. In our study 100 hours of accelerated aging was found satisfactory to demonstrate the early color change at ceramic materials. Although there were differences between the environments and the duration, this simulated aging treatment is useful for comparing different materials.

In this study, we used two types of ceramic materials. The In-Ceram uses a high strength core material and the Cergogold was heat-pressed ceramics. In the former system, low-translucency alumina is often used as the core material. This system has excellent strength but lower translucency. In contrast, leucite crystal used in the heat-pressed ceramics makes the restoration more translucent. Ceramic specimens were prepared in thickness of 1.5 mm which is similar to the thickness of the restoration at one third of middle labial of central incisor.

A spectrophotometer can measure color difference much smaller than that detected by human eyes. Therefore, the clinical relevance of color changes recorded by the spectrophotometer must be evaluated. According to CIE Lab specifications, color changes with a ΔE value lower than 1.5 could not be detectable by human eyes. In this study only one group of ceramic material showed a color change with ΔE value slightly higher than 1.5. The data for color differences was converted to NBS units, which is a practical way of determining the degree of color difference. With the use of NBS units, it was possible to determine what an observer might report regarding the color differences that in the ceramics. Comparison of the NBS units indicated that 100 hours of accelerated aging did lead to slight color change that can be detected clinically.

Causative factors that may contribute to change in color of aesthetic restorative materials include stain accumulation, water sorption, leakage, and wear of chemical degradation. Color changes of ceramic materials may also occur from metal oxide content. According to the findings of the present study, it may be concluded that both In-Ceram and Cergogold ceramic materials have small color change with accelerated aging, although the changing is almost undetectable by human eyes. However, long-term clinical evaluation of color stability of ceramics is necessary to substantiate these findings.

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