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Fluorescent emission of varied shades of resin composites

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ABSTRACT

Objectives. The objectives of this study were to measure the fluorescent emission and the corresponding color difference by the inclusion and exclusion of the UV component of the standard illuminant D65 of varied shades of commercial resin composites, and to determine the influence of the color parameters and difference in color parameters by the UV component on the color difference caused by the fluorescent emission.

Method. Eight light-curing resin composites, a total of 41 shades, were studied. Color and spectral reflectance of specimens, 12 mm in diameter and 1 mm in thickness, were measured on a reflection spectrophotometer. An UV filter was adjusted to 100% or 0% location to include or exclude the UV component of the standard illuminant D65. From the spectral reflectance values, subtraction spectrum by the inclusion or exclusion of the UV component was calculated, and fluorescence peak height was determined. Color difference caused by the inclusion or exclusion of the UV component ($\Delta E^*_{ab} - \mathrm{FL}$) was calculated. Differences in color coordinates (ΔL^*, Δa^* and Δb^*) by the inclusion or the exclusion of the UV component were calculated.

Results. Fluorescence peak height and $\Delta E^*_{ab} - \mathrm{FL}$ were influenced by the brand and the shade of resin composites and there was a significant interaction between the variables based on two-way ANOVA ($p < 0.05$). $\Delta E^*_{ab} - \mathrm{FL}$ was correlated with the chroma component of the shade, and also with Δb^* [standardized partial correlation coefficient (β) = −0.699], ΔL^* ($\beta = 0.464$) and Δa^* ($\beta = 0.105$) based on multiple regression analyses ($p < 0.05$).

Conclusion. Fluorescent emission was influenced by the brand and the shade of resin composites. Fluorescent resin composites showed color shift to blue direction and increased lightness under the UV included illumination.

1. Introduction

Luminescence is a general term that describes any process in which energy is emitted from a substance at a different wavelength from that at which it is absorbed. It covers fluorescence, phosphorescence and triboluminescence. Fluorescence by definition is the absorption of light by a substance and the spontaneous emission of light in a longer wavelength within 10^{-8} s of activation [1]. In dentistry, it has been traditionally assumed that fluorescence is the absorption by a substance of ultraviolet (UV) light (black light) and the emission of visible light in the bluish spectrum [2,3].

Natural teeth emit a strong blue fluorescence under the action of the UV light. This property makes teeth whiter and brighter in daylight. In human enamel, three distinct luminescence peaks were observed in the regions of 350–360, 405–410 and 440–450 nm [4]. Fluorescence spectrum of natural enamel had the shape of a wide band whose maximum was at 450 nm

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and slowly decreased to 680 nm [5]. Study on the fluorescence of natural enamel and of dental ceramics showed the fluorescence of ceramics not containing rare earths decreased when the color saturation increases [5]. The fluorescence of samples of the same shade guide was not homogenous and some guides showed a strong green fluorescence [5]. When human dentin was irradiated with 365 nm light, blue fluorescence peak was observed at 440 ± 10 nm [6].

Ideal restorative materials should have similar properties of light reflection, scattering and fluorescence as those of natural teeth. If they are absent, the esthetic qualities of the restorations suffer under an UV illumination. The enhanced opalescence and fluorescence, combined with optical clarity, resulted in color-reactive porcelain that looked natural and esthetic in any light, and reacted to light in the same manner as the natural dentition [3]. It was found that many of the porcelain teeth and powders had strikingly different luminescence characteristics from those of natural teeth [7]. Fluorescence spectrum of direct anterior restorative materials such as silicate cements, acrylic resins and resin composites varied by the material [8].

Recently, the use of resin composites for the restoration of large defects in anterior teeth has been increasing, and layered resin composites with opaque dentin and translucent enamel shades are widely promoted for this purpose. These resin composites are used in direct restorative techniques that use layering to mimic the natural layering of dentin and enamel [9–11]. Since these composites are used for the restoration of large areas, fluorescent properties are important as in dental ceramics.

Recently, studies on the fluorescent properties of resin composites were performed. Three among five commercial resin composites showed fluorescent peaks around 440–450 nm, and the changes in color (ΔE^*_{ab}) caused by the UV component of the standard illuminant D65 were 1.6–2.4, and Δb^* values were from −2.2 to −1.5 in resin composites that showed fluorescent peaks [12]. Fluorescence of resin composites decreased or disappeared after surface sealant application and/or staining procedures [13]. The range of changes in fluorescent emission of resin composites after accelerated aging for 150 kJ/m^2 in ΔE^*_{ab} units was −1.2 to 0.2, and fluorescence was not detected after accelerated aging [14]. The influence of fluorescence on the masking effect of resin composites was also confirmed, although the degree of influence was very low [15].

Commercial resin composites are supplied with many shades and the optical properties vary by the shade and brand of materials. Color differences (ΔE^*_{ab}) between the different brands of resin composites of the same designated shade ranged from 2.1 (A2 shade) to 7.6 (D3 shade) [16]. Difference in the color of eight brands of A2 shade resin composites was determined, and was concluded that the color coordinates varied by brand [17].

Although fluorescent properties of resin composites have been determined previously, it is still unclear whether the shade of resin composites influences the fluorescent emission of resin composites. The null hypotheses of the present study were: (1) the fluorescence peak height and the corresponding color difference were not influenced by the brand and the shade of resin composites, (2) the color parameters did not influence the color difference caused by the fluorescent emission, and (3) the difference in color parameters did not influence the color difference by the fluorescent emission. The objectives of this study were to measure the fluorescent emission and the corresponding color difference by the inclusion and exclusion of the UV component of the illuminant D65 of varied shades of commercial resin composites, and to determine the influence of the color parameters and difference in color parameters by the UV component on the color difference caused by the fluorescent emission.

2. Materials and methods

Eight light-curing resin composites, a total of 41 shades, were studied (Table 1). Details are listed in the table.

Resin composites were packed into a polytetrafluoroethylene mold (12 mm in diameter and 1 mm in thickness) on a polyethylene terephthalate (Mylar) strip. After packing resin composite, another strip was laid on the top of the specimen, and pressed with a 5 kg load for 3 min to produce a uniform thickness. Five specimens were fabricated for each shade of material.

Specimens were light cured for 40 s in three overlapping areas with a light-curing unit (Spectrum 800, Dentsply/Caulk, Milford, DE, USA) with an intensity setting of 400 mW/cm^2. The output of the curing light was checked with a radiometer (SDS/Kerr, Orange, CA, USA). After curing, both strips were removed and color measurements were made after storage in 37 °C dry oven for 24 h.

Color was measured according to the CIELAB color scale relative to the standard illuminant D65 over a white standard tile (CIE $L^* = 82.3$, $a^* = -0.1$ and $b^* = -0.6$) on a reflection spectrophotometer (Color-Eye 7000A, GretagMacbeth Instruments Corp., New Windsor, NY, USA) with the specular component excluded (SCE) geometry. An UV filter was positioned to 100% or 0% UV including condition. The aperture size was 3 mm × 8 mm, and the illuminating and viewing configuration was CIE diffuse/8° geometry [20].

From the spectral reflectance values, the difference in reflectance by the inclusion (100% UV) and the exclusion (0% UV) of the UV component was calculated. With the following calculations, subtraction spectra were obtained. Preliminary subtraction spectrum from 400 to 750 nm (*i.e.*, the reflectance spectrum obtained with 0% UV condition subtracted at each wavelength from the reflectance spectrum obtained with 100% UV condition) was obtained. To eliminate the discrepancy of the illuminations by the inclusion or the exclusion of the UV component, the difference in reflectance spectrum at each wavelength of the white standard tile by the inclusion or the exclusion of the UV component was subtracted from the preliminary subtraction spectrum at each wavelength. Peak wavelength (nm) and peak height were determined. The unit for peak height was percentage because the reflectance values were measured in a percentage unit. Differences in color ($\Delta E^*_{ab} - \mathrm{FL}$) and color coordinates (ΔL^*, Δa^*, Δb^*, ΔC^*_{ab} and Δh°) by the inclusion or the exclusion of the UV component were calculated, where ΔL^* is the difference in lightness, Δa^* is the difference in red–green coordinate and Δb^* is the difference in yellow–blue coordinate. Chroma was calcu-