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**OPTICAL PARAMETERS COMPARISON OF DENTISTRY
OPERATION LIGHTS**

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OPTICAL PARAMETERS COMPARISON OF DENTISTRY OPERATION LIGHTS

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Abstract

This work presents spectral irradiance distribution, colour rendering index and chromaticity coordinate comparison of dentistry operating lights with LED light source and filament light source and evaluate this parameter according to ISO 9680:2014 requirements. Three different dentistry operation lights were compared where 2 of them use LED source and the other a filament source. The equipment chromaticity results are in agreement to the standard limits. One of LED light source equipment presented a colour rendering index above de standard limit, despite the ISO 9680:2014 excludes LED light source from the general colour rendering index requirement.

Keywords: Irradiance, Colour Rendering, Dentistry, Colour

1 Introduction

The recent publication of standard ISO 9680:2014 - Dentistry Operation Lights (ISO, 2014) changes the requirements for equipment colour performance according to the type of light source used. In this standard revision, equipment using LED light sources are excluded from colour rendering index (CRI) performance, although other types of light sources are not.

The use CIE colour rendering index (CIE, 1995) for general illumination colour comparison index is well established. In the medical field, this is a performance parameter for dentistry operation lights (ISO, 2014) and surgical luminaire (IEC, 2013). However, the CRI capability to correlate colour differences for LED source types was questioned for many works (Sándor et al., 2003; Guo & Houser, 2004; Sándor & Schanda, 2006). A CIE Report was published regarding the CRI limitation for generally application in colour rendering rank when white LED sources are used (CIE, 2007).

Although the CIE 177:2007 publication (CIE, 2007) effects could be perceived in the revision of the colour rendering index requirements from dentistry operation lights in the ISO 9680 (ISO, 2014), not all medical application followed its recommendation. The last edition of surgical luminaires standard (IEC, 2013) maintained the CRI performance requirement even for equipment using LED sources.

A recent CIE publication, CIE 224:2017, presents in detail the major reasons for CRI failures in colour rendering rank when LED sources are evaluated (CIE, 2017), which concerns non-uniformity in method spectral sensitivity and colour space adopted to CRI calculation. This CIE publication proposes new colour comparison index, colour fidelity index, to be used in international standardization.

Regarding the impact of colour comparison index in specific application fields, this work presents the colour characterization of dentistry operation lights according to current standardization requirements.

2 Methods

To characterized dentistry operation light concerning its colour aspects it is necessary to determine its spectral power distribution. A setup was built for spectral irradiance distribution measurement using a commercial spectroradiometer associated to a spectral irradiance certified reference lamp. The dentistry operation light spectral irradiance measurement

procedure was performed according to ASTM G138:2012 (ASTM, 2012) and CIE 63:1984 (CIE,1984). And the dentistry operation light configuration was conducted in conformity to ISO 9680:2014 (ISO, 2014).

The base of measurement arrangement was composed of a spectroradiometer model PR-705, manufactured by PhotoResearch, and a PTFE (polytetrafluoroethylene) plane diffuser. This base setup was calibrated by a 1000 W FEL-type spectral irradiance certified lamp and a low pressure mercury spectral lamp, using the measurement geometry of 0° incidence light and 45° measurement (0°:45°). The figure 1 presents a schematic diagram for the experimental setup.

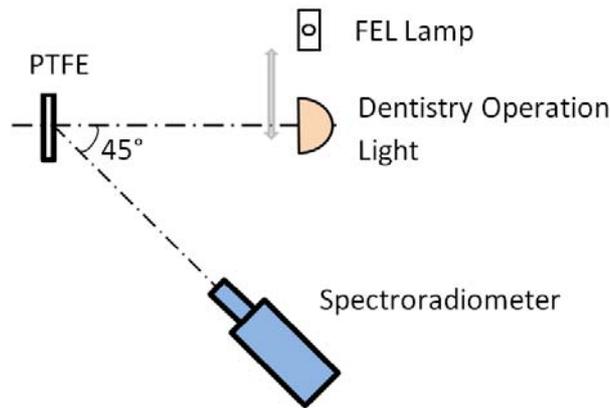


Figure 1 – Caption of Figure 1

The dentistry operation light spectral irradiance was measured at the same geometry used for the system calibration. Its colour rendering index and chromaticity coordinate were calculated from the spectral irradiance measurement using the software included in the publication CIE 13.3:1995 (CIE, 1995). The results of colour calculation were compared to the limits of standard ISO 9680:2014 (ISO, 2014).

3 Results and Discussions

The results from 3 different dentistry operation lights are obtained, which include 2 dentistry operation lights with LED source and one with filament source. The Figure 2 presents the normalized spectral irradiance for the measured equipment.

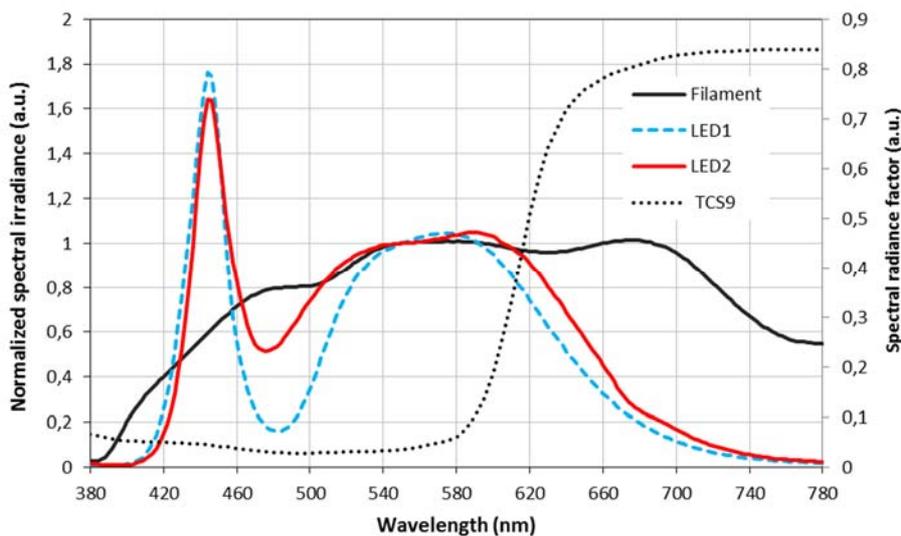


Figure 2 – Normalized spectral irradiance at 550 nm (right side). Spectral radiance factor for test colour sample 9 (TCS9) from CIE 13.3:1995 (left side).

The filament source type spectral irradiance distribution does not match the shape of an illuminant A which is mainly associated to head reduction elements included in the equipment optics. The LED source type spectral irradiance distribution presents the maximum irradiance in blue part of spectrum.

The general colour rendering index (R_a), special rendering index number 9 (R_9), correlated colour temperature (CCT) and the corresponding ISO 9680:2014 limits for all dentistry operation light are presented in Table 1. The measured chromaticity coordinates and its limits are presented in Figure 3.

Table 1 – Measured colour rendering index and the ISO 9680:2014 limits for dentistry operation light.

	Limits of ISO 9680:2014	Lamp Type		
		Filament	LED1	LED2
CCT (K)	4 500 K to 6 400 K	4 400	4 995	5 165
R_a	> 85	94,5	72,3	87
R_9	-	77,1	-16,0	32,2

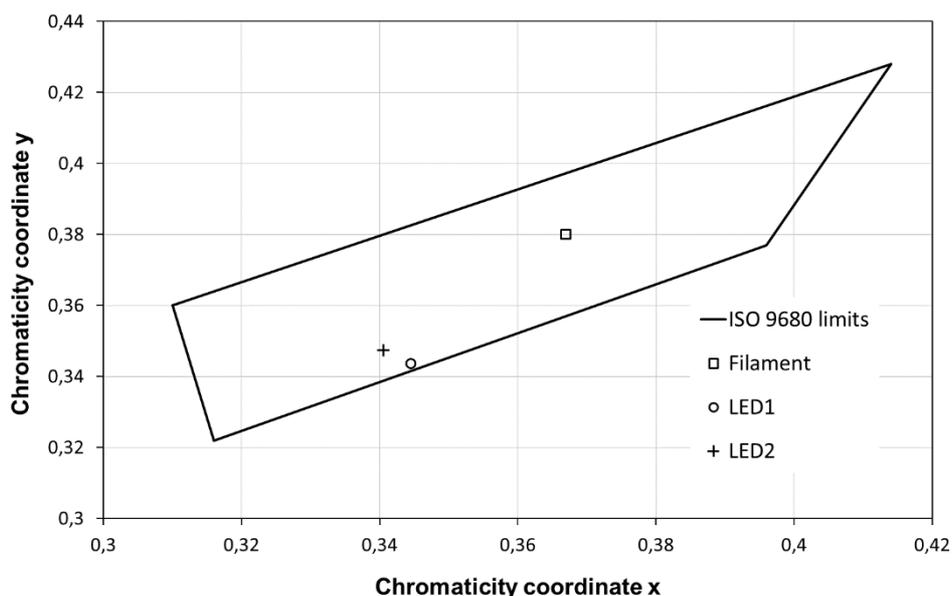


Figure 3 – Measured chromaticity coordinates and its ISO 9680:2014 limits.

The CCT limit presented in Table 1 is only a recommendation for dentistry operation light. The major restriction for colour is the chromaticity area (ISO, 2014) indicated in the Figure 3. It is possible to note that all equipment accomplish with the limits of chromaticity, however this does not occur to R_a limits in Table 1. The ISO 9680 does not state limits for R_9 , but this is one of test colour samples that cause more problem in CRI calculation due to intense light emission of LEDs in the blue part of spectrum. In some case, the R_9 can be negative as presented in Table 1. The spectral radiance factor for test colour sample 9 (TCS9) used to calculated R_9 is presented in the Figure 2 to show that the LED intense emission occurs in the spectral range that TCS9 has the lower spectral radiance factor which can cause wide colour shift in comparison to illuminat A. Despite of ISO 9680:2014 excludes dentistry operation light using LED sources from R_a requirements, the results in Table 1 shows that equipment using LED sources can fulfil the R_a .

4 Conclusions

The majority of general colour rendering index obtained from the evaluated dentistry operation lights are above the ISO 9680:2014 requirement of $R_a > 85$. The chromaticity coordinate of LED1 is at the border limit of ISO 9680:2014 requirement, but far enough for equipment conformity to the standard.

Although the ISO 9680:2014 excludes LED light source from the general colour rendering index requirement it is observed that there are dentistry operation lights in the market fulfilling this standard requirement.

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Note: Specific firms and trade names are identified in this paper to describe the experimental procedure adequately. Such identification does not imply recommendation or endorsement by the author, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.