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Blue and UV content of white LED light sources in comparison with fluorescent lamps, daylight and incandescent light

Monico et al. studied the degradation of specific yellow pigments in Van Gogh's paintings under a 175 W Cermax xenon lamp filtered by four different filters in the UV, blue and red spectral range [1]. They pointed out that UV and blue light advance the aging process of these yellow pigments more than red light, see Figure 5 in [1]. This means that these specific yellow pigments become fast brownish under UV and blue light. Several recent articles drew the false conclusion that, according to their supposedly large blue and UV content, white LED light sources would damage these paintings and the usage of white LEDs should be avoided in museums.

In this short communication, we would like to point out that white LEDs have significantly less radiation content in Monico et al.'s spectral ranges (defined on p. 861 in [1], "UV": 240 nm – 400 nm and "blue": 335 nm – 525 nm) than fluorescent lamps, incandescent light and daylight. To this end we considered the spectral power distributions of a comprehensive set of today's commercially available white LEDs (42 LED types with correlated colour temperatures ranging between 2600 K and 6400 K). We compared this set with a comprehensive set of fluorescent lamps (67 fluorescent lamp types with correlated colour temperatures ranging between 2500 K and 8000 K), with 4 phases of daylight (5000 K – 7000 K) and 5 Planckian (blackbody) radiators (2500 K- 4500K).

We computed the relative spectral content of radiation for these light sources (118 light sources altogether) in the two above mentioned spectral ranges in the Monico et al.'s study [1]. The relative spectral content in the "UV" range is designated by **a_uv_m** and the relative spectral content in the "blue" range is designated by **a_blue_m**. The two spectral ranges or "spectral windows" are depicted in Figure 1.

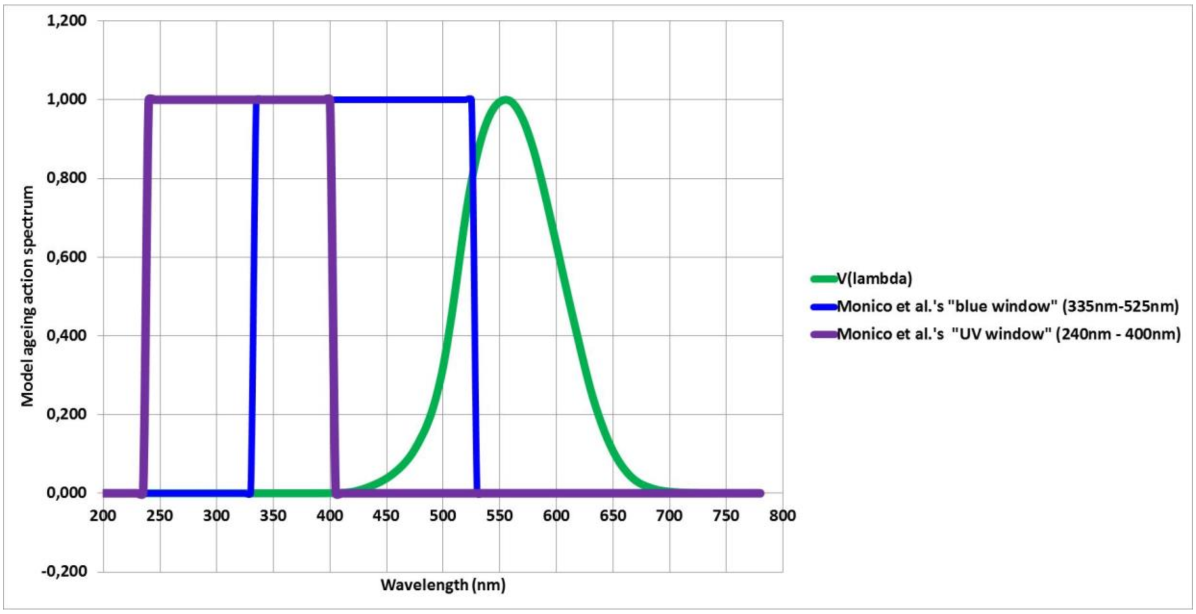

Figure 1. Monico et al.'s two spectral ranges or "spectral windows" (UV and blue) compared to the photopic luminous efficiency function $V(\lambda)$

The quantity **a_uv_m** was computed for each one of the 118 light sources in the following way: the spectral power distribution of the light sources was multiplied by the "UV window" in Figure 1 for every wavelength and the resulting numbers were summed up ("integrated") between 200 nm and 800 nm. This "integral" is designated by **I_uv**. Then, to obtain a relative value related to photopic luminance, the spectral power distribution of the light sources was multiplied by the V(λ) function for every wavelength and the resulting numbers were "integrated" between 200 nm and 800 nm. This "integral" is designated by **I_v**. Finally, **a_uv_m** was calculated as the ratio (**I_uv** / **I_v**). The quantity **a_blue_m** was obtained in a similar way by substituting the "UV window" by the "blue window" in the above calculation.

First, let us consider the relative spectral content of radiation in Monico et al.'s "blue window" (**a_blue_m**) for each one of the 118 light sources grouped by the type of light source, white LED (wLED), fluorescent lamp (FL), daylight and Planckian radiator, as a function of correlated colour temperature (CCT). This is depicted in Figure 2.

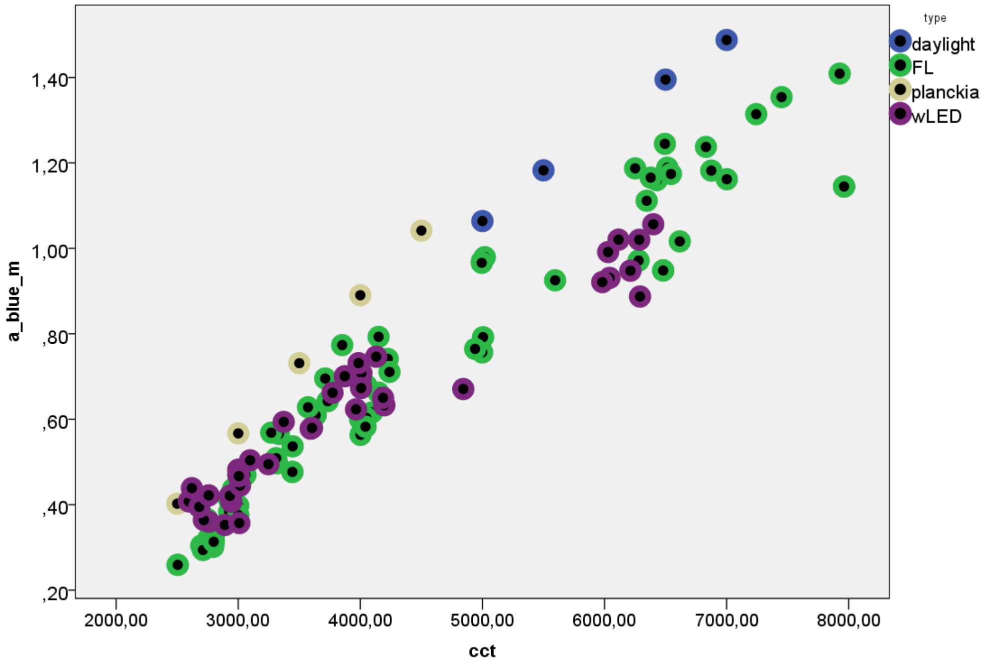

Figure 2. Relative spectral content of radiation in Monico et al.'s "blue window" (**a_blue_m**) for each one of the 118 light sources grouped by the type of light source, white LED (wLED), fluorescent lamp (FL), daylight and Planckian radiator, as a function of correlated colour temperature (CCT)

As can be seen from Figure 2, the value of the quantity **a_blue_m** for white LEDs (wLED, see the black dots in lilac circles) is generally less than for the fluorescent lamps, daylight or Planckian radiators. This tendency is especially significant for the light sources of high blue content i.e. for CCT≥5000 K.

Second, let us consider the relative spectral content of radiation in Monico et al.'s "UV window" (**a_uv_m**) for each one of the 118 light sources grouped by the type of light source, white LED (wLED), fluorescent lamp (FL), daylight and Planckian radiator, as a function of correlated colour temperature (CCT). This is depicted in Figure 3.

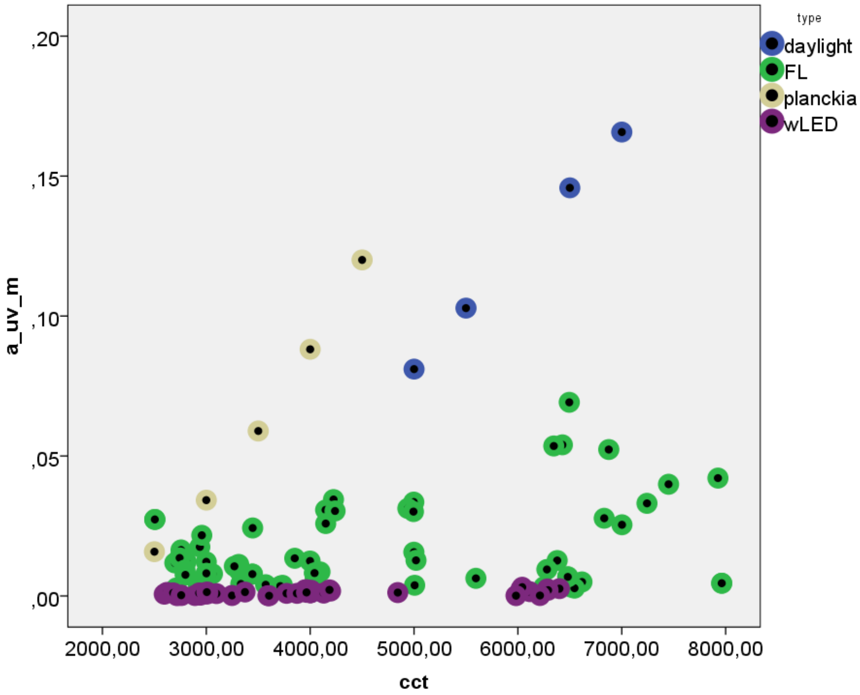

Figure 3. Relative spectral content of radiation in Monico et al.'s "UV window" (**a_uv_m**) for each one of the 118 light sources grouped by the type of light source, white LED (wLED), fluorescent lamp (FL), daylight and Planckian radiator, as a function of correlated colour temperature (CCT)

As can be seen from Figure 3, the value of **a_uv_m** for white LEDs (wLED, see the black dots in lilac circles) is generally much less than for the fluorescent lamps, daylight or Planckian radiators. This tendency is significant for all correlated colour temperatures.

The reason of the findings in Figures 2-3 is that a) white LEDs have no UV content and b) their blue radiation content is not higher than the blue radiation of the other light sources. Due to the fact that commercial white LEDs work with such blue LEDs that excite their phosphors efficiently (i.e. the blue peak wavelength is in the range of 450 nm – 460 nm), they do avoid some characteristic fluorescent short-wavelength maxima (404.7 nm, 407.8 nm and 435.8 nm). Latter maxima are obviously more dangerous for paintings than the longer blue wavelengths of commercial white LEDs at 450 nm – 460 nm. Due to their lack of UV radiation and their above mentioned longer blue wavelengths, **it can be stated that commercially available white LEDs are less dangerous in museums for the ageing of yellow painting pigments than other light sources, including fluorescent lamps and daylight.** The exact amount of ageing action of white LEDs on the yellow pigments and other pigments should be determined in a future study. It should be noted that white LEDs have a further advantage: their relative spectral power distributions can be designed very flexibly due to the different conversion phosphors. Hence white LEDs have the potential of brilliant, beautiful and easily variable museum illumination.

Literature

[1] Letizia Monico, Koen Janssens, Costanza Miliani, Geert Van der Snickt, Brunetto Giovanni Brunetti, Mariangela Cestelli Guidi, Marie Radepont, Marine Cotte, Degradation Process of Lead Chromate in Paintings by Vincent van Gogh Studied by Means of Spectromicroscopic Methods. 4. Artificial Aging of Model Samples of Co-Precipitates of Lead Chromate and Lead Sulfate, dx.doi.org/10.1021/ac3021592 | Anal. Chem. 2013, 85, 860−867.