Color gamut of a typical display for the color reproduction of effect coatings

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1. Introduction

In recent years, technological innovation in all areas has led, among other things, to the appearance of new materials such as metallic and pearlescent objects developed from special-effect pigments that produce goniochromatic effects, i.e. they depends strongly on the illumination and detection geometries, giving them a very appealing appearance [1-3]. As a consequence, these pigments are used in many industrial activities, such as automotive coatings, cosmetics, plastics, security inks, building materials, etc.

Effect coatings consist of a transparent medium containing traditional absorption pigments and flake-shaped effect pigments. Refractions and reflections of light at and within these layers cause interferences that yield certain colors in an attempt to replicate natural colors seen in lesser animals such as butterflies and insects.

To completely characterize the color of these coatings under any illuminant and for any illumination/detection geometry, their spectral Bidirectional Reflectance Distribution Function (BRDF) should be measured for a large number of measurement geometries, thus providing all information required to characterize the color shift. In addition, another important issue is to combine the large number of measurement geometries in order to replicate and render these color appearances in current color reproduction technologies for computer graphics.

The aim of this article is to investigate what extent the various colors fall inside the color gamut of a typical display to evaluate, in a first step, the guarantees of a good color reproduction.

2. Method and materials

GEFE, the gonio-spectrophotometer developed at the *Instituto de Óptica* in CSIC (IO-CSIC) was used to measure the spectral BRDF at any geometry, including out-of-plane and retro-reflection angles following a normalized procedure. We selected polar angles with respect to the sample normal to vary from 0^o to 70^o in steps of 10^o, both for illumination (θ_{ill}) and detection (θ_{det}) directions. The azimuthal angle of the detection direction (ϕ_{det}) was varied from 0^o to 180^o in steps of 30^o, assuming symmetry with respect to the incident angle [4].

Six special effect coatings were analyzed in this work. Three of them are commercialized by Merck and the other three are prototypes from BASF Coatings. Their descriptions and types of interference pigment are related in Table 1.

Code	Company	Description	Type of pigment
MCS1	Merck	T20-04 WNT Lapis Sunlight	Colorstream
MCS2	Merck	T20-02 WNT Arctic Fire	Colorstream
MXi	Merck	Light Yellow & Solaris Red	Xirallic Al2O3/TiO2
BASF1	BASF	Burgundy & Olive Green[2]	Colorstream
BASF2	BASF	Laurel Green & Greenish Blue[2]	Colorstream
BASF3	BASF	Light Blue & Pale Turquoise[2]	Colorstream

[2] Visual description by authors.

Table 1 Special effect coatings studied in this work.

The samples were plotted in the CIELAB color space to be compared with the color gamut of a typical display. Based on the measurements of spectral BRDF, the CIELAB values were calculated by taking the CIE 1964-XYZ standard observer and the D65 illuminant into account. The color gamut of the display was obtained by assuming the sRGB color space following the international standard IEC 61966-2-1:1999.

3. Results

As said before, three-dimensional CIELAB diagrams are shown to analyze if the different colors obtained by the color shit of effect coatings fall inside the color gamut of a typical display. In the next figures, only in-plane and non-specular measurements are shown. The color dots are the samples associated with each measurement geometry. The color corresponds to the real color samples calculated by transforming the XYZ tristimulus values into sRGB values. In addition, the projection on the CIE a*-b* diagram is plotted by using grey dots. On the other hand, the color gamut of the display is plotted by constant lightness profiles (from L* = 0 to L* = 100 in steps of 5) for better visualization.

Figure 1 shows the color gamut of the samples used in this work. It can be seen the strong color travel of these effect coatings, that is, the lightness, chroma and hue shift along the measurement geometries. It is noteworthy that for high lightness values, the color samples are outside the color gamut of a typical display, not only for a lightness value higher than L* = 100, if not, some of them are more colorfulness but with lower lightness. In particular, the sample MXi falls outside the color gamut of a typical display for many measurement geometries implying that it would very difficult to reproduce the real color shift of this sample on a typical display.

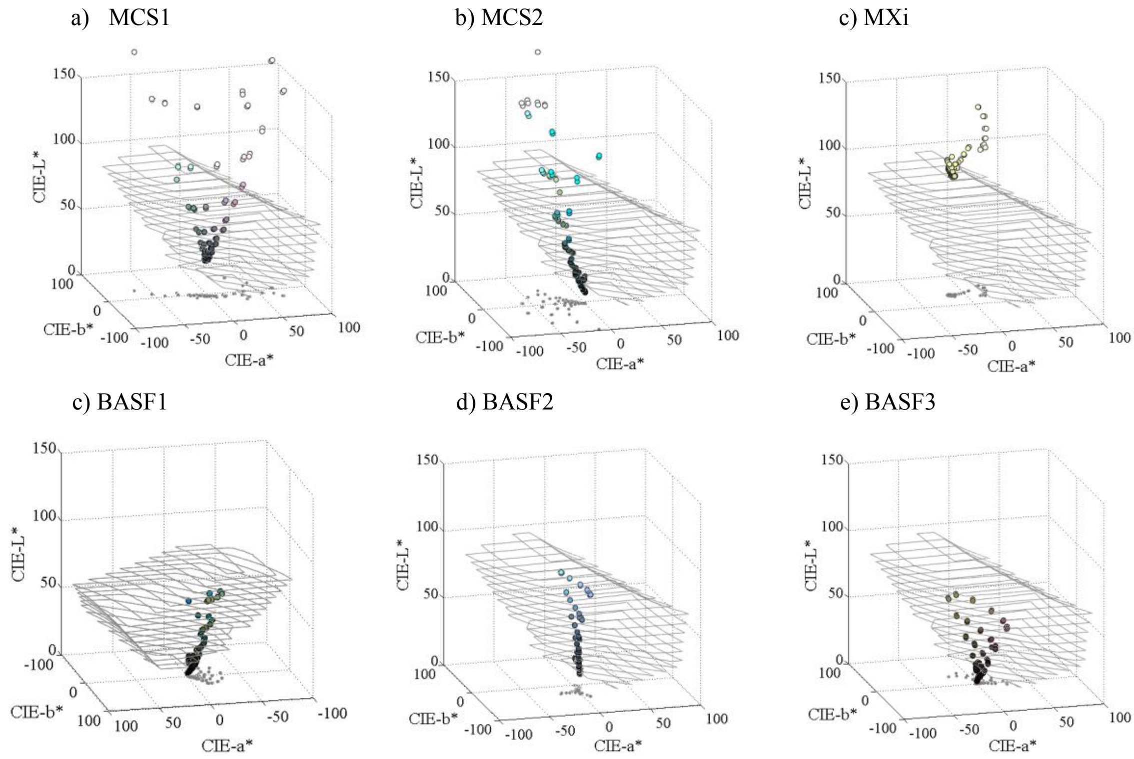

Figure 1 Three-dimensional CIELAB diagrams for the samples used in this work.

Other interesting question, it would be to evaluate the color gamut of new displays such as OLED, LED and multi-primaries technology in order to know if the color gamut of these new displays is enough large to obtain a good color reproduction of effect coatings.

4. Conclusions

In this work, we evaluated the color gamut of a typical display to replicate and render the color appearance of effect coatings. We measured the BRDF of 6 samples under 448 measurement geometries and it is shown that for many geometries, the resulting colors fall outside the color-gamut of an electronic display.

Consequently, it would be more interesting in future to work in some gamut-mapping algorithms, or new extended RGB color spaces, or even in multi-primaries displays, to reproduce more faithfully the colorimetric values of goniochromatic materials.

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