TECHNICAL NOTE

CHROMATICITY COORDINATES OF MICROCRYSTALLINE PHOSPHORS

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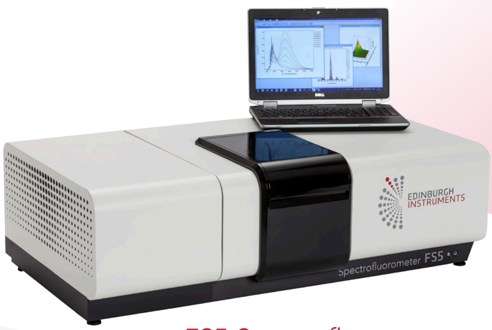
EDINBURGH INSTRUMENTS

INTRODUCTION

Luminescent materials used in lighting are standardised by the International Commission on Illumination (CIE). This standardisation is important for the lighting industry and is based on the illuminating conditions, the brightness and the observer[1,2]. In this technical note, a series of phosphors emitting across the visible range were characterised in an FS5 Spectrofluorometer and their chromaticity coordinates calculated in its integrated software package, Fluoracle®.



FS5 Spectrofluorometer

CIE CHROMATICITY COORDINATES

The tri-stimulus functions of an observer are defined as[1]:

$$X = \int_0^\infty I(\lambda)\, \bar{x}(\lambda) d\lambda,$$

$$Y = \int_0^\infty I(\lambda)\, \bar{y}(\lambda) d\lambda,$$

$$Z = \int_0^\infty I(\lambda)\, z(\lambda) d\lambda,$$

where $I(\lambda)$ is the spectral intensity of the material, while $x(\lambda)$, $y(\lambda)$, $z(\lambda)$ are the chromatic functions of the observer as defined by CIE[3]. It can be noted that the limits of the integrals can be any real integer. However, the functions are intended for standardisation in the visible range which corresponds to the photopic vision of a human observer, *i.e.* 380 nm to 780 nm.

Consequently, the normalised chromaticity x and brightness y coordinates are calculated according to CIE 1931 standard as[1]:

$$x = \frac{Y}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

According to the latest CIE 1976 standard the u' and v' coordinates are defined as[2]:

$$u' = \frac{4X}{X+15Y+32}$$

$$v' = \frac{9X}{X+15Y+32}$$

INSTRUMENTS & PROCEDURE

Spectral measurements were made in an FS5 Spectrofluorometer in its standard configuration, equipped with a 150 W xenon lamp and a single photon photomultiplier tube (PMT) detector (Hamamatsu, R928P). Phosphor powder samples were clamped in 2 mm demountable cuvettes and measured in a 45° front-face configuration with the SC-10 cassette of the FS5. This geometry closely matches the CIE recommended directional geometries[3]. Spectral correction was applied post-measurement to obtain the pure spectra of the phosphors. The chromaticity coordinates were calculated using the built-in chromaticity wizard of the Fluoracle® software package.

RESULTS

The emission spectra of the phosphors excited at 254 nm are displayed in Figure 1. From the spectra of Figure 1, the chromaticity coordinates could be directly calculated in Fluoracle®. The coordinates are displayed in CIE 1931 and CIE 1976 diagrams in Figures 2 and 3, respectively.

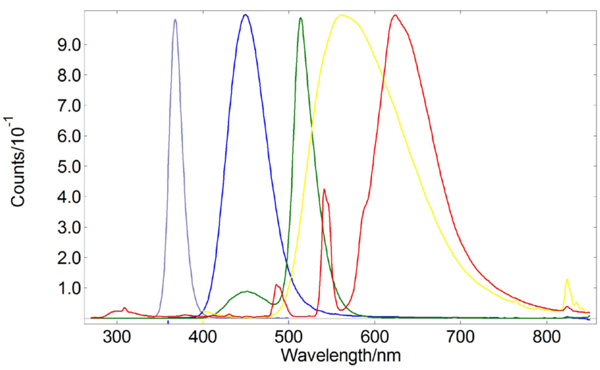
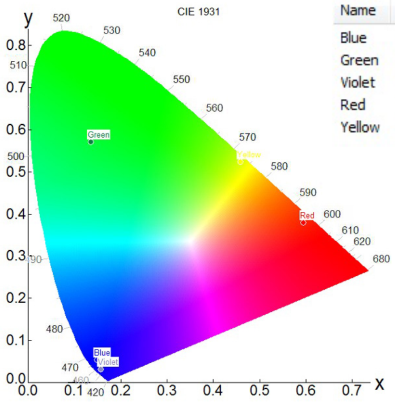
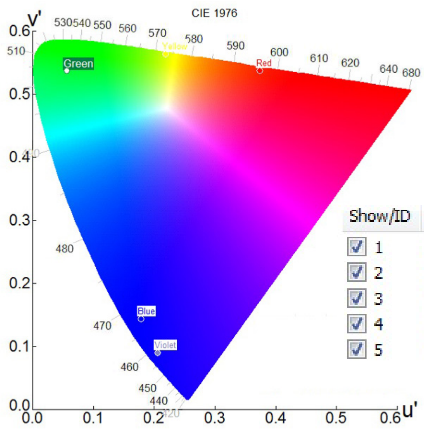


Figure 1: Emission spectra of six representative phosphors commonly used in LED. The measurement parameters were λ_{exc}=254 nm, step=1 nm, tint=0.5 s, while slit widths varied between $\Delta\lambda_{exc}$=0.3 nm - 1.5 nm and $\Delta\lambda_{em}$=0.3 nm - 1 nm.



Name	X	Y	I
Blue	0.14970	0.05319	1.099E-002
Green	0.13522	0.57091	4.096E-002
Violet	0.15714	0.03034	1.713E-005
Red	0.59514	0.37899	4.675E-002
Yellow	0.45940	0.52342	1.393E-001

Figure 2: Chromaticity diagram and coordinates of the phosphors of Figure 1 according to CIE 1931.



Show/ID	Name	U'	V'
☑ 1	Blue	0.17935	0.14337
☑ 2	Green	0.05646	0.53632
☑ 3	Violet	0.20610	0.08952
☑ 4	Red	0.37445	0.53651
☑ 5	Yellow	0.21975	0.56334

Figure 3: Chromaticity diagram and coordinates of the phosphors of Figure 1 according to CIE 1976.

CONCLUSION

Chromaticity coordinates, important for the characterisation of luminescent materials in the lighting industry can be fully characterised in an FS5 Spectrofluorometer. The coordinates are directly calculated in the operating software of the spectrometer, thereby simplifying and automating the measurement process. Additional geometries including excitation normal to the sample's surface or integrating spheres can also be readily used in the spectrometer for materials with extraordinary radiance patterns.

REFERENCES

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2. McLaren, K. XIII—The Development of the CIE 1976 (L* a* b*) Uniform Colour Space and Colour-difference Formula. Journal of the Society of Dyers and Colourists 92, 338–341 (1976).
3. Schanda, J. in Colorimetry (ed. President, J. S. S. of the C. V. P. chairs) 25–78 (John Wiley & Sons, Inc., 2007).

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