APPLICATION NOTE

MEASURING THE CIELAB COLOR SPACE OF TWO FABRICS USING AN INTEGRATING SPHERE

INTRODUCTION

Color is the visual perception mediated by a variety of mechanisms in the retina as well as the brain to light emitted, reflected, or transmitted by an object, in the visible region (from 400 to 700 nm). Since 1976, the International Commission on Illumination (CIE) recommends the CIELAB color space to provide a uniform description of the size and direction of the color coordinates and predict the color appearance of objects under specified lighting conditions [1,2].

The dimensions in this color space are the luminosity L* and the two color components a* and b*, which specifies the color hue and saturation along the green-red and blue-yellow axis, respectively, see **Figure 1** [1,2].

Keywords:

Tungsten Halogen Light Source

FLEX Spectrometer

Diffuse Reflection

Integrating Sphere

CIELAB Color Space

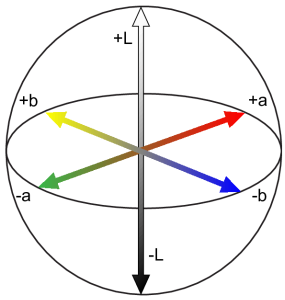

Figure 1 – CIELAB color chart.

One way of measuring the color of an object is to use reflectance spectroscopy. For this measurement, a spectrally smooth light source and highly reflective standard are required. Comparison measurements between the reference and our sample are made under identical experimental conditions and allow for the determination of our sample reflectance spectrum, from which the color can be mathematically obtained.

From the relation between the reflectance spectrum, illuminant (A, C, F2, D50, D55, D65 or D75) and standard observer (2-degree observer, for CIE 1931, or 10-degree observer, for CIE 1964) derives the tristimulus values of XYZ [1-4]. The L*a*b* coordinates are mathematically obtained from the tristimulus values of XYZ [2,5].

In this application note, we combine our high-power tungsten-halogen (W20) light source and FLEX spectrometer with our new integrating sphere to measure the reflectance spectra and obtain the precise color coordinates of two different color fabrics.

MATERIALS & METHODS

Materials

- Two Fabrics with different colors;
- Dark Reference;
- Diffuse Reflectance Standard (Optical PTFE, 98 % Nominal Reflectance);

Instruments and Accessories:

- W20 light source;
- Optical Fibers with 600 μm of diameter;
- Integrating Sphere (Diameter: 50 mm, Optical PTFE);
- FLEX Spectrometer STD Vis/NIR;
- Slide System (support for the integrating sphere and slide supports for both diffuse reflectance standard and fabrics);

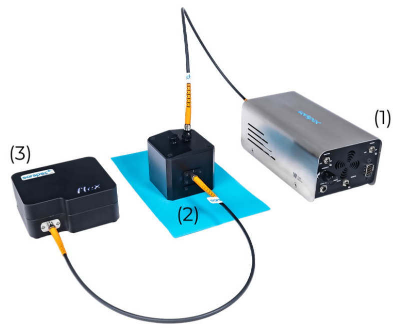

Figure 2 – Setup employed in this experiment: W20 light source (1), Integrating sphere (2), and FLEX spectrometer (3) were used to obtain the reflectance spectra and measure the color of two fabrics.

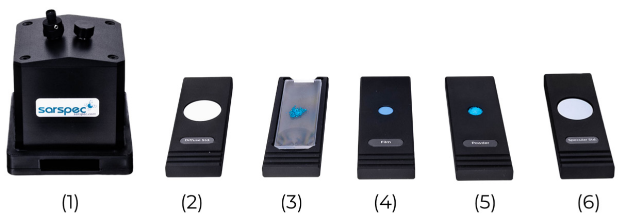

Figure 3 – Sarspec's slide system used in connection with our Integrating Sphere. (1) support for the integrating sphere; (2) slide support for diffuse reflectance standard; (3) slide support for microscope slides; (4) slide support for films; (5) powder slide support; (6) slide support for specular reflectance

EXPERIMENTAL PROCEDURE

1. Perform the reference measurement by placing the diffuse reflectance standard slide support on the slide system with the integrating sphere;

2. Perform the dark measurement by placing the dark reference in the slide support for films on the slide system with the integrating sphere;

3. Place the fabric sample in the slide support for films and insert it in the slide system with the integrating sphere to obtain the reflectance spectra and measure the L*a*b* color coordinates. For each fabric, a total of a six samples were measured, see **Figure 4**.

4. The LightScan software was used with the instrument's settings specified in **Table 2**;

Figure 4 – The reflectance spectra and L*a*b* color coordinates were measured for six samples of the two fabrics.

Table 1 – Instrument settings used for diffuse reflectance measurements.

Parameter	Used Settings
Integration time (s)	2
Average	10
Smoothing	4

RESULTS

The reflectance spectra (obtained by averaging the reflectance spectra of the six samples) of the two fabrics are presented in **Figure 5**.

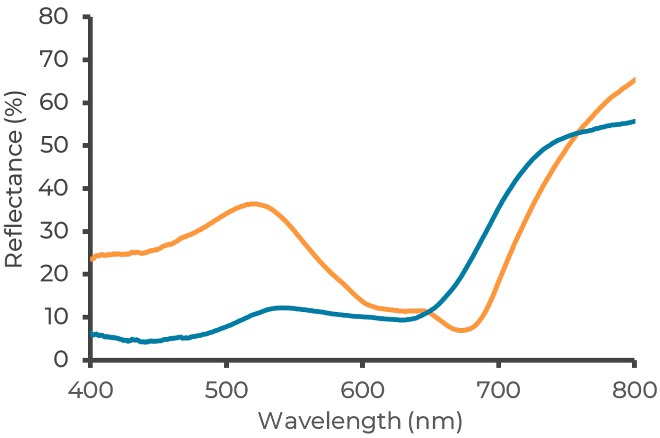

Figure 5 – Reflectance spectra of the two fabrics (**fabric 1** and **fabric 2**).

The averaged reflectance spectra of both fabrics have a broad structure with a low light reflection below 750 nm. **Fabric 1** has the lowest reflectance percentage around 675 nm while **Fabric 2** has an almost constant reflectance for wavelength below 650 nm.

The CIELAB color coordinates of the two fabrics were obtained using the Color Mode included in the LightScan 2.0 software. The L*a*b* coordinates of these two fabrics are presented in **Table 2**.

Table 2 – – CIE 1976 L*a*b* coordinates of the two fabrics samples (the values here presented correspond to an average of the six samples). The illuminant used was the D65 while the observer was the 10-degree.

Fabric	L*	a*	b*	Color	Fabric Photo
1	57.5 ± 0.4	-27.1 ± 0.6	-1.5 ± 0.4		
2	38.7 ± 1.4	-4.7 ± 0.1	19.6 ± 0.7		

The integrating sphere provides a precise measure of the color of both fabric and yields a great match between the L*a*b* color coordinates obtained using the LightScan 2.0 software and the color perceived by the observer. The fabrics used in this application note are very challenging because they have a non-uniform surface, which can result in artifacts when measuring the reflectance spectra and color coordinates. The integrating sphere is therefore a fundamental accessory to perform these measurements because all the light reflected by the fabric is spatially integrated, resulting in less artifacts and more accurate reflectance and color measurements.

CONCLUSIONS

The setup used in this application note is ideal for a precise color matching between the color obtained from the reflectance spectra and the color perceived by the observer visual sense. This is especially important within industries that analyze non-uniform samples such as textiles and paint production.

The integrating sphere is an fundamental accessory for measuring the reflectance non-uniform surfaces with high precision. Performing the color analysis of fabrics, testing solar-protective clothing, automotive paints for their resistance to UV radiation and coatings characterization and quality control are some of the most common applications that make use of integrating spheres.

REFERENCES

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