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Determining Color Difference (Delta E)

Introduction

Color matching and color consistency have become important quality control parameters in many markets. In the textile industry, a continuous swath of fabric moving through production equipment may be tested for variability, or different batches may be compared for consistency. In food quality control, the desired product color is carefully tuned to consumers' tastes, and the product must look the same despite being produced at different factories. In commercial lighting, bulb-to-bulb consistency to within the limits of human detection is extremely important. This is particularly true for banks of white light or colored LEDs, or any type of lighting array.

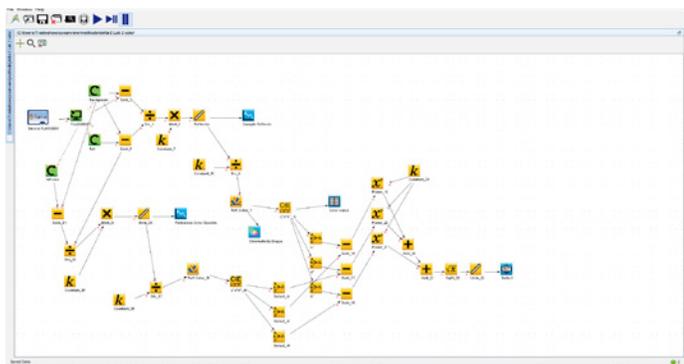
Measuring color is challenging, as the way our eyes detect color is not directly related to easily measured parameters such as light intensity. Color is dependent on the sample, on the illuminant and on subjective human perception. Spectral sensing, however, makes color measurement quantifiable, repeatable and consistent. Measuring the amount of light across the entire visible wavelength range brings real advantages when compared to traditional colorimetry due to the higher resolution and wider bandwidth of the measurement.

There are many different color coordinate spaces used to measure color (xyz, XYZ, RGB, CMYK). In one of the most common, CIE $L^*a^*b^*$, color differences between samples are quantified by a parameter called Delta E.

$$\Delta E_{ab}^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

A Delta E value between 1 and 3 is typically undetectable by eye. A Delta E of 1 is often referred to as the lowest detectable limit for someone who is trained in color matching. For a perceptible color difference for the average person, a Delta E of 2 or 3 is often used.

Importing Project Schematics



Not only are schematics useful for customizing your data acquisition, but they can also be saved and shared with others to allow them to replicate the same data acquisition process. Schematics are specific to the spectrometer used for development, but OceanView will walk you through the steps required to use them with a different spectrometer when you load the project.

In this experiment, you will measure the reflected color for similarly colored samples and determine the color difference for the samples using an OceanView project designed to calculate Delta E. The Schematic calculates Delta E by defining and measuring a "color standard," and then calculating Delta E for the sample by comparing to this color standard.

Materials

- FLAME-S-VIS-NIR spectrometer
- HL-2000 tungsten halogen light source
- R400-7-VIS-NIR 400 μm reflection probe
- RPH-1 reflection probe holder
- WS-1 diffuse reflection standard

- Computer with OceanView software installed
- Delta E OceanView Project (see [Instructor Notes](#))
- Similarly colored samples (e.g., paint samples, textiles)

Safety

Wear safety goggles and other appropriate safety gear during the experiment. Take all proper safety precautions when handling solutions and wear proper eye protection when working with UV light sources.

Determining Delta E

1. Connect the power cord to the HL-2000 light source. Turn the lamp on and allow it to warm up at least 15 minutes.
2. Connect the spectrometer to your computer using the USB cable and allow the spectrometer to warm up for at least 15 minutes.
3. Connect the reflection probe to the spectrometer and light source.
 - a. Connect the collection leg of the reflection probe to the spectrometer. The collection leg has a single fiber as shown in the diagram below.
 - b. Connect the illumination leg of the reflection probe to the light source. The illumination leg has 6 fibers as shown in the diagram below.
 - c. Reflection is measured with the common leg of the probe. The common leg contains all 7 fibers coming from the collection and illumination legs of the probe as shown in the diagram below.



NOTE: You can identify the collection and illumination legs of the probe by pointing the common leg of the probe at the overhead lights to light up the fibers. The collection leg will have a single fiber and the illumination leg will have 6 fibers as shown in the diagram above.

4. Start OceanView software. Click the **Start** button, then select **All Programs | Ocean Optics | OceanView | OceanView** or use the Desktop shortcut  created when you installed the software.

5. Select the **Load a Saved Project** option on the Welcome Screen.



6. Navigate to the location of the “Delta E Lab Color Difference” project that matches your spectrometer serial number and click **Open**.

7. Click **OK** to close the **Data Warning** dialog box that opens. This warning appears because the project contains outdated Reference, Background and Color Standard spectra that need to be updated before making new measurements. Follow the steps below to update these spectra.

8. When the project loads, you will see:

- a. A **Sample Reflection** graph window showing a live reflection spectrum of whatever you are measuring with the probe
- b. A **Color Standard Reflection** graph window showing a static reflection spectrum for the color standard to which you will compare your samples
- c. A **Color Values** table showing the quantitative color values for your sample
- d. A **Chromaticity Diagram** window showing sample chromaticity characteristics
- e. A **Delta E Color Difference** window showing the Delta E value for your sample relative to your

color standard

9. Before you can update your Reference, Background and Color Standard spectra, you need to configure your reflection probe for diffuse reflection measurements by placing it in the RPH-1 reflection probe holder. Place the reflection probe in the 45 degree port of the reflection probe holder as shown in the image below. The edge of the probe should be flush with the opening on the bottom of the reflection probe holder so it will lie flat against the sample.



10. Place the reflection probe holder on the WS-1 diffuse reflection standard and confirm your spectrometer is not saturated by checking the indicator in the lower right corner of the software window. If the indicator is red, decrease your integration time in the **Acquisition Group Window** until the indicator turns green. Click the yellow light bulb button  in the **Sample Reflection** window to store a new a new reference spectrum.

11. Close the shutter on the light source or block the light from entering the spectrometer to store a new background spectrum. **Do not turn your light source off.** Click the gray light bulb button  in the **Sample Reflection** window to store a new background spectrum. Open the shutter or unblock the light source after you have stored your background spectrum.

12. Choose the sample you want to compare all the other samples to as your color standard. Place the reflection probe holder on the standard. Click the green button  in the **Color Standard Reflection** window to store a new color standard spectrum.

13. You are now ready to measure the $L^*a^*b^*$ and Delta E values for your samples.

14. Compare the spectral shape for two closely colored samples and record their L*a*b* color coordinates from the **Color Values** table in the **Data and Analysis** section.

15. Record the Delta E for the samples from the **Delta E Lab Color Difference** view in the **Data and Analysis** section, making note of which sample you used as your color standard reference.

Data and Analysis

Sample #	Sample Description	L*a*b*	Sample used as color standard	Delta E
1			Sample #	
2			Sample #	
3			Sample #	
4			Sample #	

Additional Tasks

Explore this **Schematic** in more detail to see how the nodes and connections are structured. Modify the **Schematic** to add another feature or create your own unique schematic and save the project with a new filename. Print a screenshot of your **Schematic** and graph views.

Instructor Notes

Contact info@oceanoptics.com to request the Delta E OceanView project discussed in this experiment.

Since the project was created with a different spectrometer than the one you will be using, OceanView will walk you through the steps necessary to swap in a new device. To save time, follow the steps below and save the project after you have swapped in the spectrometer the students will be using for their measurements.

1. Start the OceanView software. Click the **Start** button, then select **All Programs | Ocean Optics | OceanView | OceanView** or use the Desktop shortcut  created when you installed the software.

2. Select the **Load a Saved Project** option on the Welcome Screen.



3. Navigate to the location where you saved the “Delta E Lab Color Difference” project and click **Open**.

4. Since the project was created with a different spectrometer than the one you will be using, OceanView will walk you through the steps necessary to swap in a new device.

a. Select the device you will use with your measurements. Click **OK**.

b. Close the shutter on the light source or block the light from entering the spectrometer for your background measurement. Do not turn your light source off. Click the **Store Background**  button to store a background spectrum. Open the shutter or unblock the light source and click **Next**.

c. Place the reflection probe in the 45 degree port of the reflection probe holder for measuring diffuse reflection from the samples (see the image after Step 9 in the section **Determining Delta E**). The edge of the probe should be flush with the opening on the bottom of the reflection probe holder so it will lie flat against the sample.

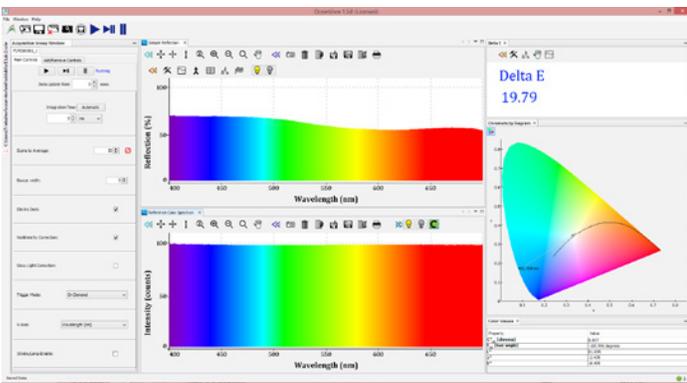
d. Place the reflection probe holder on the WS-1 diffuse reflection standard and confirm your spectrometer is not saturated by checking the

indicator in the lower right corner of the software window. If the indicator is red, decrease your integration time in the **Acquisition Group Window** until the indicator turns green.

e. Click the **Store Reference**  button to store a reference spectrum. Click **Next**.

f. Place the reflection probe on the color standard sample to which you will compare all the samples and click the **Store Overlay**  button to store the spectrum for your color standard. Click **Finish**.

g. When the project finishes loading, rearrange the windows as shown below.



h. Save the project with the serial number of the spectrometer in the filename by clicking the **Save Project** button  on the top menu so students can match their spectrometer to the appropriate OceanView project file.

Contact us today for more information on setting up your spectroscopy system from Ocean Optics.



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