Application Note
Materials

Measuring the Color of a Paint on Canvas

Direct measurement with an UV-Vis external diffuse reflectance accessory

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Introduction

Color measurement systems can translate the sensations, or visual appearances, into numbers according to various geometrical coordinates and illumination systems. The concept of "visual colorimetry" with a standard observer using a standard device as a method of color specification dates to around 1920. The first standardized color system was defined by CIE (Commission internationelle pour l'Eclairage) around 1931. One may regard the CIE system to be at the "heart" of all color measurement systems. However, for each painter, the use of colors is dictated by their personal inclination, cultural context and available materials. These are the reasons why sophisticated and portable instrumentation is needed to understand "the fine arts" and to find the best way for their conservation.

Measurements of colored materials in paintings are often difficult due to their size, shape and location. It is not possible to separate one type of paint into its individual components. Therefore, the collection of reflectance spectra and color data from a small spot of paint is needed to understand and classify the different colored materials within and to be able to remake them as similar as possible to the original.

The Agilent Cary 60 UV-Vis spectrophotometer with the remote fiber optic diffuse reflectance accessory (Figure 1) provides fast and accurate diffuse reflectance measurements on sample sizes around 2 mm in diameter. The Cary 60's highly focused beam makes it ideal for fiber optic work. It offers excellent coupling efficiency and high light throughput, which equates to better photometric performance. In addition, its room-light immunity enables sample measurements to be taken outside the sample compartment in any position.

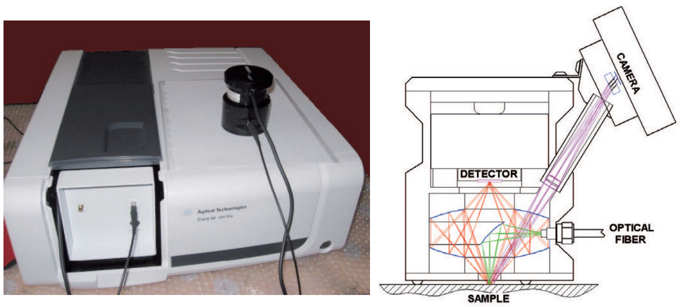

Figure 1. Agilent Cary 60 UV-VIS with the remote fiber optic diffuse reflectance accessory (DRA).

The Agilent Color software (Figure 2) is based on the CIE system. It is useful when performing "color-matching" experiments with a standard (or medium) observer. It transforms spectral data into systems of three coordinates named "Tristimulus Values". Tristimulus Values, generally, are related to color, hue and brightness. Today, we have the possibility of recalculating the spectral data with many "Standard Illuminants" and many color coordinates for a better evaluation of the color examined.

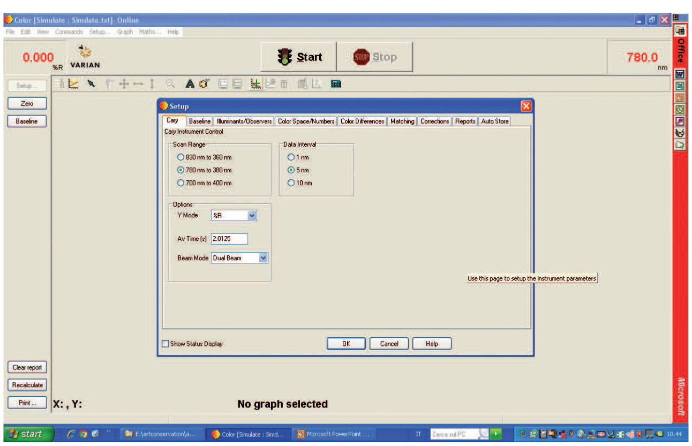

Figure 2. Setup page of Agilent Color software.

Principal coordinates and illuminants of Color software

- Tristimulus
- Chromaticity
- CIE L*a*b*
- CIE L u v
- Metric coordinates
- Hunter Lab
- Whiteness
- Yellowness
- Haze
- Color difference

Illuminants:

A = Tungsten light

B = Direct Sunlight

C = Average Sunlight

D 65= Natural Daylight

Daylight and many other illuminants

- Observer angles:

  2 degrees, 10 degrees
- Photopic
- Scotopic
- Reference corrections

Instrumentation

- Cary 60 UV-Vis spectrophotometer
- Cary 60 Remote DRA
- Cary 60 Fiber Optic Coupler
- Cary Win UV Software
- Cary Win UV Color Software
- PTFE diffuse reference standard
- PTFE colors

Method

Data was collected using the Cary 60 Remote DRA and the Cary Win UV Scan application and/or Color application. All color traces were baseline corrected and run over the range 380 – 780 nm. The 100% reflectance baseline was collected using a white PTFE sample. A signal averaging time of 2 seconds was used.

Experimental

Red color spectra in a paint

The photos (Figure 3) show the red reference PTFE used and the red parts of the paint. The color o paint depends not only on the pigment color but also on the binding medium, surface absorbency, texture of the finish, size of particles, etc. The spectra (Figure 4) clearly show that clownr1 and clowncapelli are made of similar materials.

Figure 3. Red reference PTFE and red parts of the paint.

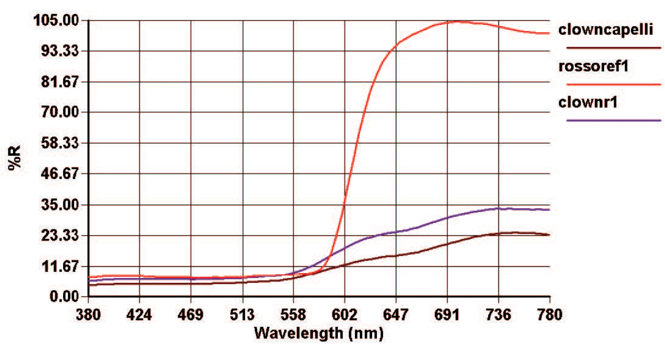

Figure 4. Spectra showing that clownr1 and clowncapelli are made of similar materials.

Red color data using color software

The spectra from Figure 4 were processed using the Color software with Illuminant C, observer angle 2 degrees in Tristimulus and Chromaticity coordinates. The CIE triangle Tristimulus and Chromaticity coordinates are shown in Figures 5 and 6.

Tristimulus and chromaticity data:

Sample: clownr1:	**Illuminant = CIE C**
Tristimulus: X = 14.2957	Y = 11.5510 Z = 7.9036
Chromaticity: x = 0.4236	y = 0.3422 z = 0.2342
Sample: clowncapelli:	**Illuminant = CIE C**
Tristimulus: X = 9.6948	Y = 8.1597 Z = 5.7750
Chromaticity: x = 0.4103	y = 0.3453 z = 0.2444
Sample: rossoref1:	**Illuminant = CIE C**
Tristimulus: X = 31.0238	Y = 18.5691 Z = 8.8005
Chromaticity: x = 0.5313	y = 0.3180 z = 0.1507

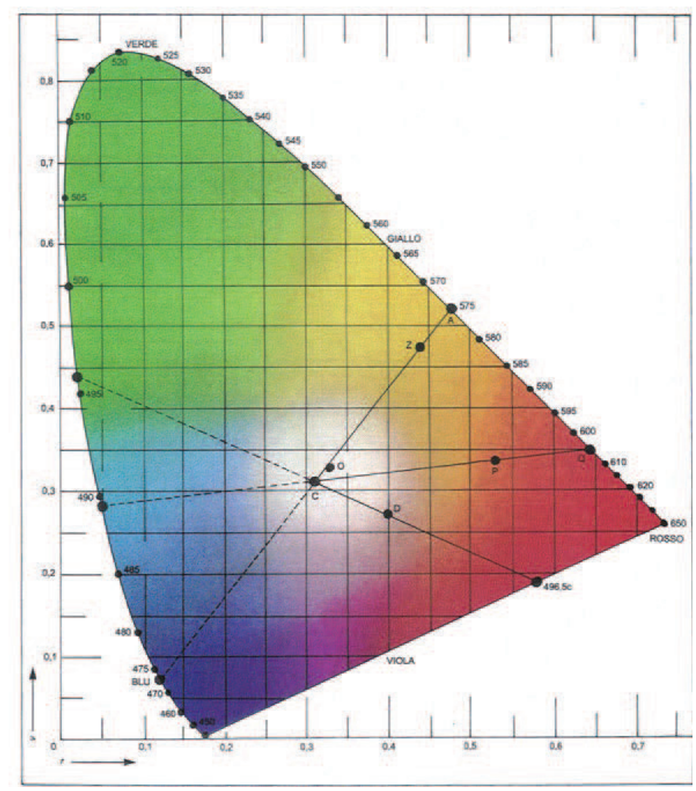

Figure 5. The (x,y) chromaticity coordinates identify color and hue. The z coordinate (not shown) is vertical to the (x,y) plane and indicates color brightness.

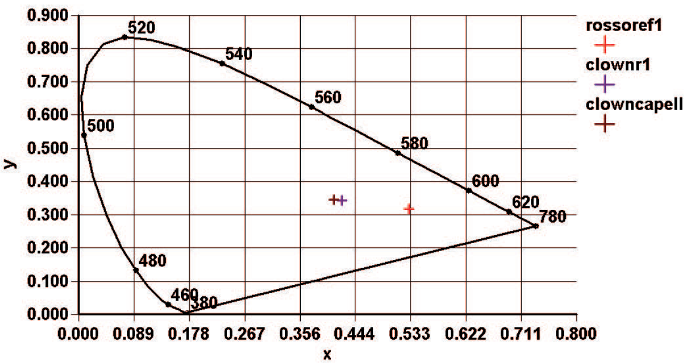

Figure 6. Chromaticity sample data in the CIE triangle graph.

As previously mentioned, clownr1 and clowncapelli are very similar in their spectra and color. Rossoref1 appears to be completely different.

Red color data in L*a*b*

From Tristimulus values (X,Y,Z), color software can recalculate the data in a different coordinate system, i.e. CIE L*a*b*. CIE L*a*b* is an "opponent type system" using rectangular coordinates where L*=lightness, a*=redness-greenness, b*=yellow-blueness (figure 7).

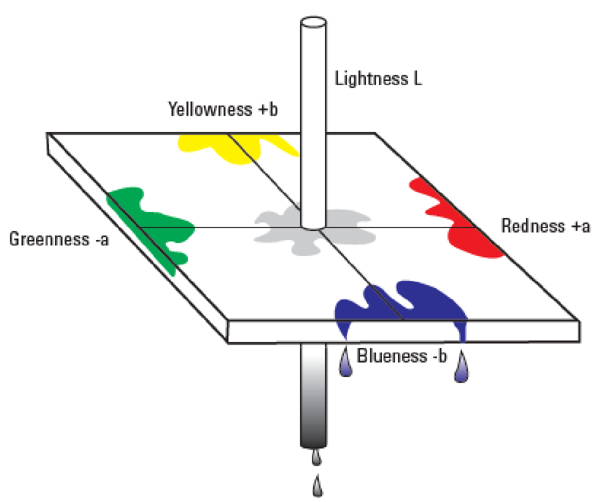

Figure 7. L*a*b* rectangular coordinates system.

The spectra recalculated in L*a*b* are shown in figures 8, 9 and 10. L*a*b* coordinates show that the red reference of Rossoref1 is very different from those of Clowncapelli and Clownr1.

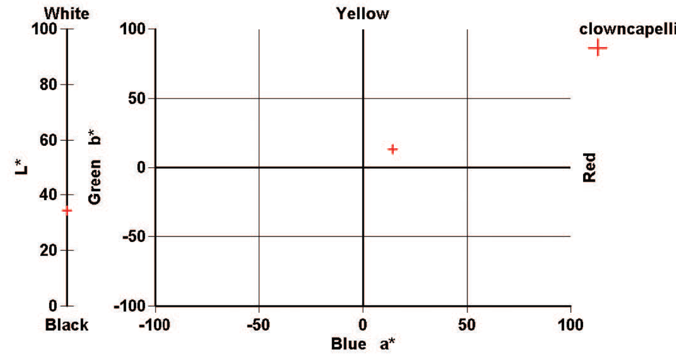

Figure 8. L*a*b* data for Clowncapelli: L*= 34.3133 a*= 14.3222 b*= 13.6369.

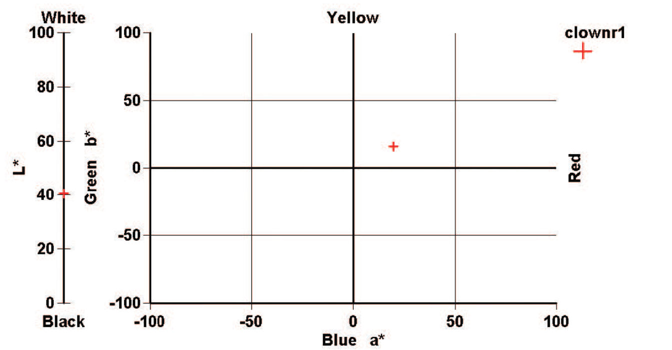

Figure 9. L*a*b* data for Clownr1: L*= 40.4934 a*= 19.6363 b*= 16.2313.

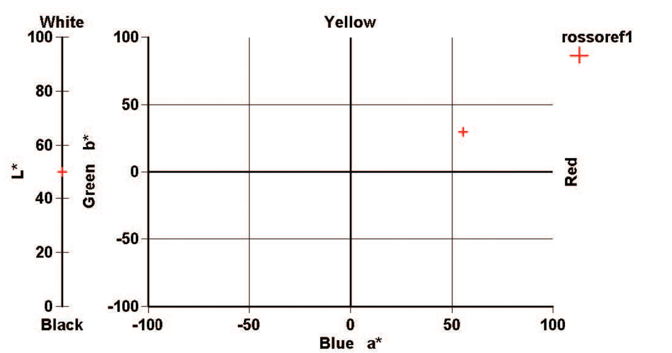

Figure 10. L*a*b* data for rossoref1: L* = 50.1792 a* = 55.4309 b* = 29.9696.

Red color data in delta Lab mode

Another useful color software tool is the "Matching application". This application compares two samples in L*a*b* coordinates, one is set as the standard and the other as the sample. Clownr1 has been set as the standard and Clowncapelli as the sample. A Delta LAB tolerance of 1.00 has been used in order to have an idea of the surrounding equal color space for each color dot (sample). The data is as follows:

The results are:

	Standard	Sample	Diff
L*	40.493	34.313	-6.180
a*	19.636	14.322	-5.314
b*	16.231	13.637	-2.594
DE*ab 8.554			

The data indicates the total difference (DE*ab) between the two samples and the difference for each single color coordinate.

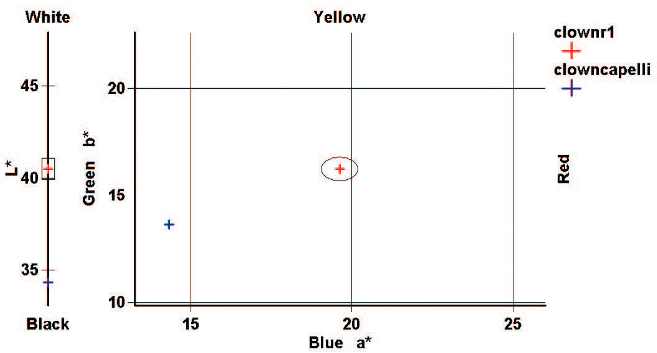

Figure 11. Comparison of Clownr1 (standard) and Clowncapelli (sample) L*a*b* coordinates (zoomed in figure).

The sample and standard are in the yellow-red part of L*a*b* system (Figure 11). This indicates that Clowncapelli has less yellow and blue pigments in comparison to clownr1, and less lightness (or brightness).

Conclusion

The Agilent Cary 60 UV-Vis spectrophotometer with Remote DRA and Color software is an ideal tool for the fast analysis of samples that must not be damaged. In a short space of time, it is possible to make color measurements in many color coordinate systems to compare and verify the information obtained from spectra, irrespective of observer personal vision, brain color perception and room illumination. As an example, we have shown some color data using different coordinate systems but only for illuminant C. If desired, it is simple to recalculate all the data with other illuminants of interest. This application is also applicable in many others areas, such as art restoration and conservation and is not restricted to analyzing a particular material. It would be useful for any material needing a single color analysis including paper, plastics, coated metals and wood.

References

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