APPLICATION NOTE

MEASURING THE COLOR INTENSITY AND SHADE OF RED WINE USING AN ABSORPTION CUVETTE AND FLOW CELL.

INTRODUCTION

The use of UV-Vis spectroscopy in the wine industry for evaluating wine physical and chemical properties is not recent. This non-destructive technique is routinely used by this industry to measure, among other properties, the color intensity of wine samples [1,2]. The color intensity of wine strongly depends on the concentration of anthocyanins and other phenolic compounds.

Other physical properties such as temperature, pH, and the amount of sulfur dioxide and oxygen also affect the color intensity of the wine. A large amount of dissolved oxygen can promote chemical reactions that results in oxidation of phenolic compounds [3].

UV-Vis spectroscopy is also a helpful technique to monitor wines of different geographical regions in terms of type and quality [3]. While red wine absorption spectra falls in the range of 250 to 800 nm, white wine falls in the range of 240 to 400 nm.

Keywords:

UV-Vis Spectroscopy;

DWHP Light Source;

FLEX Spectrometer;

Red Wine Color Intensity and Shade;

Standard Cuvette Holder;

Absorbance Flow Cell;

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Therefore, for the range of 400 to 800 nm, only red wine shows absorption bands that are associated with anthocyanins pigments [4]. The color intensity of red wine is usually determined by the sum of the absorbance values at 420, 520, and 620 nm. The ratio between the absorbance values at 420 and 520 nm defines the shade of the wine and gives a measure of the wine redness [2,3].

In this application note, we combine high-power deuterium and tungsten-halogen (DWHP) light source with a FLEX spectrometer to measure the color intensity and shade of three red wine samples. In order to evaluate the accuracy and flexibility of the configuration used here, the red wine color intensity and shade were measured using a cuvette holder and a flow cell, both set into an absorbance configuration.

MATERIALS & METHODS

Reagents

- Three commercially-available red wine samples;
- Distilled Water;

Instruments and Accessories (Figure 1):

- DWHP Light Source;
- Two Optical Fibers with 200 µm of diameter;
- Standard Cuvette Holder set into an absorbance configuration;
- FLEX Spectrometer (Slit: 10 µm; Grating: 600 grooves/300 nm; Detector: Sony 2048 pixel; Improved Sensitivity);
- 10 mm and 1 mm Quartz Absorption Cuvettes;
- 3 mm Absorbance Flow Injection Cell;

Figure 1 – Sarspec's light source (DWHP), spectrometer (FLEX), and accessories (Standard Cuvette Holder and Absorbance Flow Injection Cell). All these instruments were connected using optical fibers with a diameter of 200 µm.

EXPERIMENTAL PROCEDURE

Procedure for measuring the red wine color intensity and shade (with Absorbance Flow Injection Cell):

1. Introduce distilled water into a small container that contains a circulation pump connected to the absorbance flow cell;

2. Upon a continuous circulation of the distilled water for 5 minutes (it is important to remove the air bubbles inside the flow cell) and after performing the reference and dark measurements, carefully remove all the water from the container and add the red wine sample (after turning the circulation pump on with the red wine sample, it's important to avoid it's dilution with the distilled water inside the flow cell);

3. Measure the absorbance values at 420, 520 and 620 nm (the absorbance values can be divided by 0,3 for adjusting the measurements performed with the flow cell to a 10 mm optical path). Check the instrument settings used for this configuration on **Table 1**;

4. Calculate the wine color intensity (WCI) using the following equation:

$$WCI = A_{(420\ nm)} + A_{(520\ nm)} + A_{(620\ nm)} \quad (1),$$

where $A_{(420\ nm)}$, $A_{(520\ nm)}$, and $A_{(620\ nm)}$ is the absorbance value of the wine sample at 420, 520, and 620 nm, respectively. Calculate the shade (S) of the red wine sample using the following equation:

$$S = A_{(420\ nm)} / A_{(520\ nm)} \quad (2).$$

Table 1 – Instrument settings used for the experimental measurements with the flow injection cell.

Parameter	Value
Integration time (ms)	15
Average	100
Smoothing	6

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Procedure for measuring the red wine color intensity and shade (with Standard Cuvette Holder):

1. Introduce distilled water into a 1 mm quartz cuvette and use it as reference;

2. Introduce the red wine sample into a 1 mm quartz cuvette and measure the absorbance values at 420, 520 and 620 nm (the absorbance values should be divided by 0,1 for measurements performed with the quartz cuvette). Check the instrument settings used for this configuration on **Table 2**;

3. Calculate the color intensity and shade of the red wine sample using Eq. 1 and Eq. 2, respectively;

Table 2 – Instrument settings used for the experimental measurements with the standard cuvette

Parameter	Value
Integration time (ms)	20
Average	100
Smoothing	6

RESULTS

The absorbance spectra of the red wine samples obtained with the flow cell (3 mm optical path) are given in **Figure 2**.

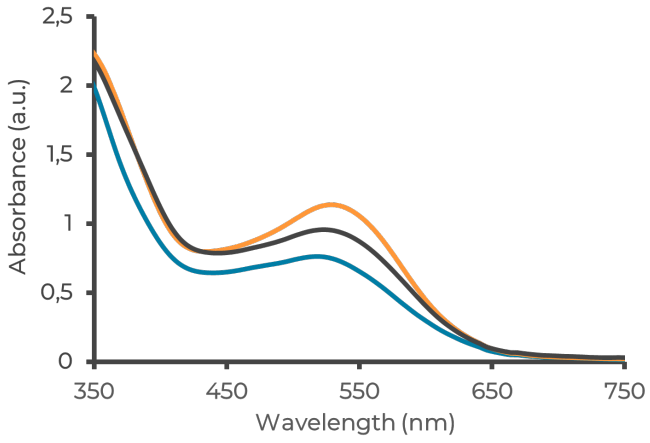

Figure 2 – Absorbance spectra of red wine samples using the flow cell. The blue line corresponds to sample 1, the black line corresponds to sample 3 and the orange line corresponds to sample 2.

According to the absorption spectra, presented in Figure 2, all red wine samples have the same characteristic spectral features, despite showing different absorbance values. The wine color intensity and shade values of the red wine samples were calculated using Eq. 1 and Eq. 2, respectively, and are given in **Table 3**.

Table 3 – Results of the color intensity and shade of red wine samples using the flow injection cell.

Red Wine	Absorbance @ 420 nm	Absorbance @ 520 nm	Absorbance @ 620 nm	WCI[1] (a.u.)	S (a.u.)
Sample 1	0.657	0.759	0.170	5.29	0.866
Sample 2	0.812	1.13	0.251	7.32	0.716
Sample 3	0.827	0.962	0.237	6.75	0.860

[1] The WCI was corrected for an optical path of 10 mm.

As expected, high absorbance values at 420, 520 and 620 nm results in a high color intensity. This reflects a higher concentration of anthocyanins and other large phenolic compounds in the red wine.

In order to show the great flexibility of our absorption configuration, the wine color intensity and shade of red wine samples were measured and calculated using a more common absorbance setup, with a standard cuvette holder.

The red wine samples were measured against distilled water in a 1 mm optical path quartz cuvette (the wine color intensity calculated for the red wine samples were corrected for a 10 mm optical path, see the experimental procedure section). The absorbance values measured at 420, 520, and 620 nm for the configuration with the standard cuvette holder are given in **Table 4**.

Table 4 – Results of the color intensity and shade of red wine samples using the standard cuvette holder.

Red Wine	Absorbance @ 420 nm	Absorbance @ 520 nm	Absorbance @ 620 nm	WCI[1] (a.u.)	S (a.u.)
Sample 1	0.217	0.260	0.048	5.22	0.83
Sample 2	0.274	0.393	0.069	7.35	0.70
Sample 3	0.274	0.330	0.066	6.67	0.83

[1] The WCI was corrected for an optical path of 10 mm.

The wine color intensity values obtained using the 1 mm quartz cuvette and the standard cuvette holder (**Table 4**) are very similar to those values obtained using the 3 mm flow cell (**Table 3**).

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On the other hand, the shade values are lower than those obtained using the flow cell (**Table 3**), with this difference better than 5 % for both red wine samples 1 and 3.

In addition to the absorbance measurements with the standard cuvette holder at 420, 520, and 620 nm, the color of red wine samples was also investigated using the tristimulus method, a feature that is integrated into the LightScan software.

After measuring the transmittance spectra of each sample in the whole visible wavelength range, it is possible to define the L*, a*, b* color space parameters that are defined in the CIE standard colorimetric system, see **Table 5** [5]. This method makes it possible to acquire color-related information that cannot be obtained by the single-point method.

Table 5 – Results of color using the CIE standard colorimetric system, obtained with standard cuvette holder and a the 1 mm quartz cuvette.

Red Wine	L*	a*	b*	Color
Sample 1	83.6	17.0	6.16	
Sample 2	77.2	25.2	3.62	
Sample 3	79.2	20.8	5.61	

The color obtained from the CIE coordinates using the LightScan software (**Table 5**) follows the wine color intensity, given in **Table 4**.

CONCLUSIONS:

An absorption configuration with experimental approaches (cuvette and flow cell) was used in this application note to determine the color intensity and shade of three different red wine samples.

The color of each sample was estimated using the absorbance values, which allow for estimating the wine color intensity and shade values, and the tristimulus method, which allows for determining the visual color through the CIE coordinates.

This application note highlights the great accuracy and large flexibility of Sarspec spectrometers and accessories, with regard to measuring the absorbance of solutions in both a small quartz cuvette (1, 5, or 10 mm optical path) or in large containers, where the solution can be set into a continuous circulation through a flow cell.

REFERENCES

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