Reflection and Transmission Measurements of a Chlorine Color Wheel

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Application Notes

Keywords

- Chlorine
- Water quality
- Test kit indicators

Techniques

- Reflection
- Transmission

Applications

- Feasibility testing
- Water analysis

In this application note, we describe the measurement of reflection and transmission characteristics of chlorine indicator materials being evaluated for use in a chlorine content test kit. The spectral data provided useful information on subtle differences among the chlorine indicators.

Introduction

Chlorine is a chemical element used in various industrial and consumer products, and is a commonly used disinfectant for drinking water, wastewater and industrial process water. Inexpensive test kits using a visual test method are available in different formats, including chlorine color wheels and test strips. Testing is a highly competitive market where speed and accuracy can be significant differentiators. By using spectroscopic techniques, test kit suppliers are able to continually refine chlorine indicator chemistries and help to maintain or expand market share.

Experimental Conditions

We evaluated a chlorine content color wheel having nine windows of varying shades of yellow, with a clear center window as the reference (Figure 1). Transmission and reflection measurements were performed for each window in the sample wheel.

Each sample window was analyzed using a USB4000-UV-VIS spectrometer, a tungsten halogen light source with color-correcting filter, and spectrometer operating software. For the reflection measurements a 400 µm reflection probe was mounted in an optical stage and positioned at 90° to the chlorine color wheel, at a distance of approximately 3 mm from the probe ferrule to the sample surface. A diffuse reflectance standard completed the setup.

Figure 1: Spectroscopic measurements are useful for evaluating characteristics of a chlorine color wheel.

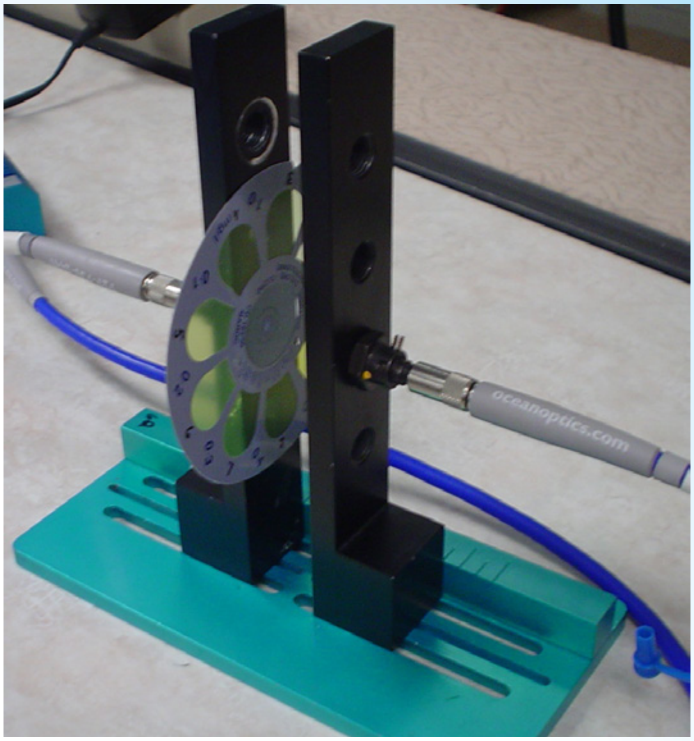

Figure 2: Optical fibers can be positioned for straight-through transmission measurements. Collimating lenses are screwed on to the end of the fibers and threaded into the optical fixture.

For transmission measurements we utilized the same modular spectrometer and light source, but with a pair of 300 µm optical fibers and an adjustable transmission stage as our sampling setup (Figure 2). The measurements were conducted using two different references. In the first experiment the clear center window was mounted in the transmission stage and a reference spectrum was captured. All of the subsequent window spectra were referenced to the central window spectrum.

In the second experiment the sample was removed entirely from the optical path and a free optical path reference spectrum was captured. Window spectra were captured for all nine windows and for the clear central window with respect to the free optical path reference.

Measurement parameters for the full series of experiments are shown in Table 1.

Table 1: Reflection and Transmission Measurement Parameters

Parameter	Reflection	Transmission (center reference)	Transmission (free path)
Integration Time	170 ms	30 ms	20 ms
Scans to Average	3	10	10
Boxcar	3	3	3
Correct for Electrical Dark	No	No	No
Correct for Nonlinearity	No	No	No
Correct for Stray Light	No	No	No

Results

Our testing revealed good correlation between the reflection and transmission data for the chlorine wheel (using the center window as the reference). Based on the setup of the reflection experiment, we would expect a similar spectral shape to the transmission data because of the diffuse reflection standard background (Figure 3). That's because the light source is transmitted through each window, reflects off the >98% diffuse reflection standard, is re-transmitted through the window, and is read by the spectrometer. As a result, the spectral shapes are essentially the same.

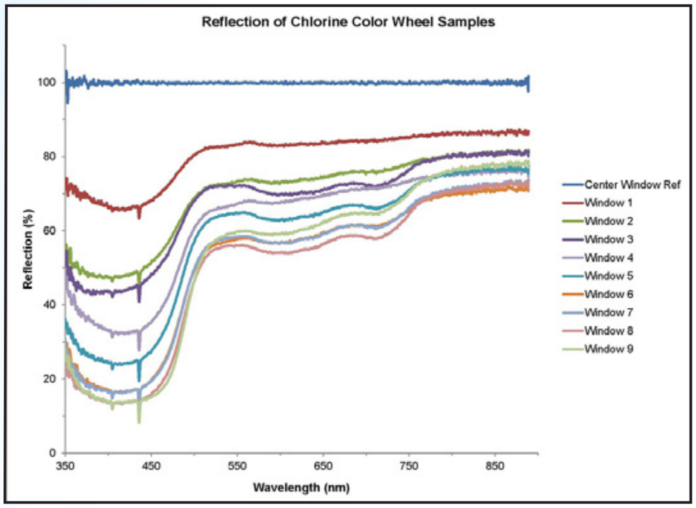

Figure 3: Reflection measurements were conducted using a diffuse reflectance standard (>98% reflectivity) as the reference.

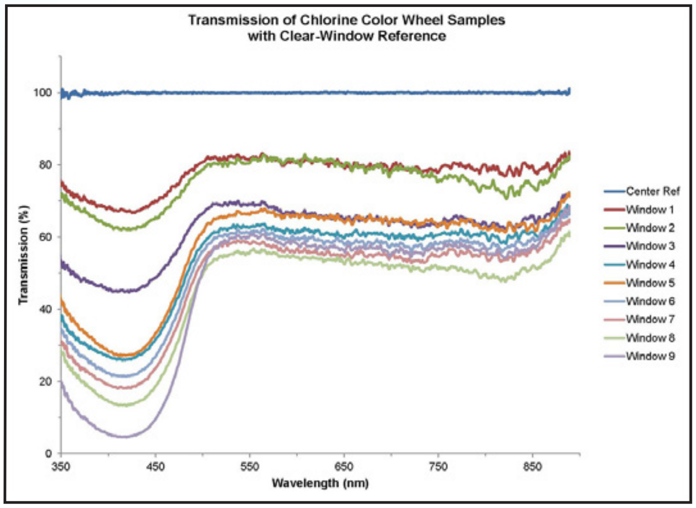

Figure 4: With a clear window as the reference, transmission measurements of chlorine color wheel windows revealed spectral differences from 350-500 nm.

In comparing the two sets of transmission data (Figures 4-5), we observed that using the data obtained with the clear center window spectrum as a reference is most advantageous for identifying the subtle differences in sample window characteristics. This is primarily due to the nature of the clear center window in the region from 350-500 nm (Figure 4). The center window spectrum has more pronounced spectral features in that region and is the most useful region for classifying the sample windows.

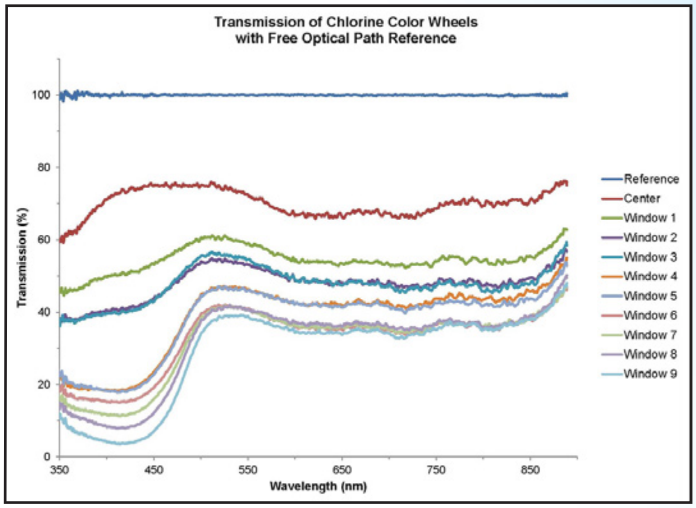

Figure 5: Differences in transmission spectra of chlorine color wheel samples were not as pronounced using air (no wheel) as the reference.

Conclusion

Reflectance and transmission measurements are useful for distinguishing chlorine color wheel samples, with selection of a relevant reference standard a key element of the experiment setup. Spectroscopic techniques are valuable in qualifying product characteristics, where even subtle improvements can drive the difference between market success and parity.

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