

APPLICATION NOTE

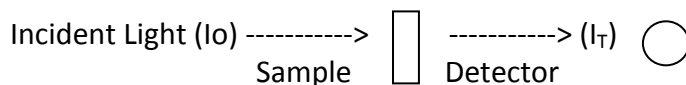
UV TRANSMISSION AND UV ABSORBANCE METHODS

UV Transmission (UVT) & UV Absorbance (A254) Methods

The Hach DR 5000 Spectrophotometer offers two methods using the UV/254 nm wavelength for measuring organic constituents in a water sample. At first glance, the methods appear to be complementary to each other. This is true as the UV/254 Transmission Method (UVT) measures the light transmitted or passed through a sample while the UV/254 Absorbance Method (A254) measures the amount of UV light that is absorbed by the sample.¹ However, while both methods are often referenced as measuring organic constituents, the use models for each method have different applications and it is important to understand the meaning and use of the value obtained.

Background

When light is passed through a sample, a portion of the light is absorbed or scattered by substances present in the sample. The amount of light energy exiting the sample is less than the initial incident light applied.



The light reaching the detector is the transmitted light (I_T) or transmittance. The ratio of the transmitted light (I_T) to the incident light (I_0) is the transmittance (T) expressed as %T.

$$\%T = 100 \times \frac{I_T}{I_0}$$

UVT as used in this application note will be assumed to mean the %T at 254 nm unless specifically noted otherwise.

The incident light that is absorbed or scattered by the sample is called the absorbance and expressed as (A). The absorbance and transmittance values are related by the logarithmic equation of $A = \log_{10} (1/T)$.

To determine which method to use, one needs to ask if you need to measure the amount of light reaching the detector (typical in a UV disinfection application) or if you are interested in measuring the properties of the sample that are absorbing the 254 nm light (typical in controlling disinfection by-products).

UV Transmission Method – UV Disinfection Applications

The UV Transmission Method (UVT) is used where there is a need to measure the amount of light reaching a detector or sensor. For example, this method would be used to determine the UV lamp

output settings on continuous-flow UV reactors. The UVT value is also used for the compliance monitoring of UVT analyzer calibrations and in the determination of UVT water quality characteristics for designing UV treatment facilities.² These applications require UVT values of the water to insure the UV light dose delivery is sufficient to inactivate pathogenic microorganisms and to insure that UVT analyzers are properly calibrated to insure the analyzers accurately measure and control the intensity of the UV/254 light being delivered. It is important to note that in these types of unfiltered samples, the UVT value is determined by the sample color, turbidity, particles and the soluble organic or inorganic compounds present in the water. A full list of interferences and additional precautions is given in the UV/254 Organic Constituents UV Transmission DR 5000 procedure.

UV Absorbance Method – Disinfection By-Product Control

The UV Absorbance Method (A_{254}) is commonly used to characterize the organic constituents in a water sample. Research has shown that organic compounds absorbing at 254 nm have a greater tendency to form chlorinated disinfection by-products (DBPs) when contacted with chlorine in the disinfection of drinking water. Source waters can be monitored with this method to predict the DBP formation potential or to signal major changes in source water quality. With this method the turbidity and particles in the water that absorb or scatter the 254 nm light are removed by first filtering the water through a 0.45-micron filter before making the absorbance measurement. A full list of interferences is given in the UV/254 Organic Constituents UV Absorbing DR 5000 procedure. It is important to note that Standard Method 5610B calls for adjusting the sample pH before measuring the A_{254} absorbance.³ However, when the A_{254} value is used for other UV disinfection applications, the water sample should be analyzed without filtering or adjusting the pH.

The UV/254 absorbance value is also used in the calculation of Specific Ultraviolet Absorbance (SUVA). SUVA is defined as the ratio of the A_{254}/cm to the total dissolved organic carbon (DOC) concentration in the filtered sample.⁴ The DOC is determined by running a Total Organic Carbon (TOC) test on the filtered sample.

$$\text{SUVA (L/mg-M)} = \frac{\text{Abs}(254)/\text{cm}}{\text{DOC (mg/L)}} \times 100 \text{ cm/M}$$

The SUVA value is a measure of the dissolved organic carbon concentration available to likely form disinfection by-products when chlorinated. The value is also used to determine compliance with the Disinfection/Disinfection By-Products Rule requirements for removing natural organic matter (NOM).⁵

Normalization Calculation

$\text{Abs}_{(254)}$ and UVT measurements are normalized to one cm and expressed as $\text{Abs}_{(254)}/\text{cm}$ or % UVT/cm respectively. The cm designation refers to the length of the quartz sample cell pathlength used to make the measurement. Measurements made on higher quality waters often have low absorbance or high transmittance levels. Longer pathlength 5 cm or 10 cm cells are often used to obtain better measurement sensitivity and accuracy. The DR 5000 method programs automatically normalize the linear absorbance and logarithmic transmittance values to equivalent Abs/cm or % UVT/cm values respectively, when the longer pathlength cells are used avoiding the need to manually do the normalization calculations.

References:

- ¹ Organic Constituents UV Absorbing (UV--254), Hach Method 10054; Organic Constituents UV Transmission (UV--254), Hach Method 10243
- ² Ultraviolet Disinfection Guidance Manual For The Final Long Term 2 Enhanced Surface Water Treatment Rule, USEPA, November 2006.
- ³ Standard Methods for the Examination of Water & Wastewater, 21st Edition, 2005, Part 5910 B. Ultraviolet Absorption Method.
- ⁴ Determination of Total Organic Carbon and Specific UV Absorbance at 254 nm In Source Water and Drinking Water, USEPA Document #: EPA/600/R-05/055, Revision 1.1 February 2005.
- ⁵ Enhanced Coagulation and Enhanced Precipitative Softening Guidance Manual, USEPA Document #: EPA 815-R-99-012, May 1999, page 2-9.

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