Smart Storm
Environmental Measurement & Control

What is UV254 and why is it important?

UV254 is the measurement of the absorption of light in the UV part of the light spectrum at 254nm. The absorption of light at this wavelength is an indicator of the organic species found in water and wastewater. The measurement is sometimes referred to as Spectral Absorption Coefficient (SAC).

UV254 is more sensitive to species of organic material that can cause the most harm. These are the aromatic organics with their double ring carbon structure. This makes them and thus UV254 is excellent at detecting the potential of chlorination disinfection by-products (DBPs) such as Trihalomethanes (THMs).

Organic water parameters such as TOC, DOC, BOD, and COD (see 3 letters acronym reference at the back of the document) can be correlated to the absorption UV light at 254nm. This allows for fast real-time and low-cost measurement of these surrogate parameters with UV254. It's important for regular calibration and verification of these parameters as the chemistry of the water may change over time.

Environmental agencies such as the EPA (method 415.3) use specific UV absorbance (SUVA) as a measurement for determining the disinfection by-product (DBP). The measurement is the ratio of absorption of UV254 to the dissolved organic carbon (DOC) concentration. The larger the SUVA the more of the total organic material is made up of aromatic organics. Aromatic organics are highly reactive with disinfectants and thus level of aromatics will greatly increase the risk of DBPs.

By monitoring and reducing the level of UV254 and thus the level Of DOC the amount of organic food for harmful microorganisms is reduced in the treatment water; and thus, the ability for organisms to enter water distribution networks and effluent receiving waters.

Measuring the level of BOD via surrogate measurement is important in the optimization of the oxygen levels in effluent water due to its effects on aquatic life. High levels of BOD can suffocate while low levels can stop the metabolism of aquatic life.

Key Reasons for UV254

- Provides a measurement of Natural Organic Material (NOM)

- Surrogate measurements of TOC, BOD, COD among others. Allows for real-time measurement without the need for expensive reagents

- Measurement allows water treatment sites to optimize and lower the cost of the treatment of organic material as well as the choice of coagulate
- Reduction of disinfection by-products such as Trihalomethanes (THM)
- UV254 is becoming a key parameter of measurement of water quality, along with the likes Hardness, Turbidity, and pH

Measuring UVA and UVT

Absorbance is a measure of the amount of light that is absorbed by the sample a transmittance is a measure of the amount of light transmitted through the sample.

In order to get a comparative value, the transmission value is first measured with a reference sample - typically distilled water.

The transmittance value for a sample is $T = \left(\frac{L_T}{L_R}\right) \times 100$, where L_R is the reference light value and L_T is the transmitted light value. % Transmittance is simply the transmittance shown as a percentage value: %T = 100T.

The absorbance value $A = 2 - log_{10}(T)$

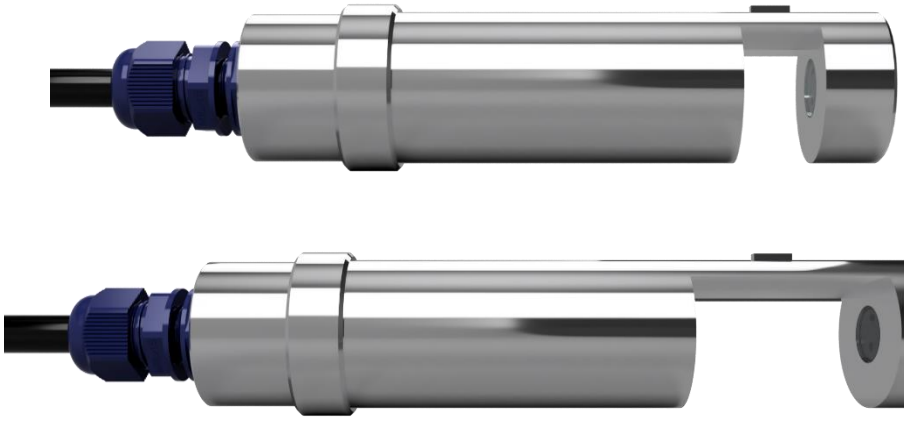
UVA and UVT are measurements of the absorbance and transmission of UV light at 254nm.

Pathlength and UVA/UVT

The absorbance of the water is not only proportional to the concentration of the material being absorbed but also the optical path length of the sample (beers law).

Thus, UVA and UVT measurements must be given for a certain path length. In general, the path length of 10mm/1cm is used and the absorption is reported abs/cm. This can be set to other values if necessary, such as abs/m.

Smart Storm UV254 systems come in with different optical paths. The measurement of the absorption is converted to abs/cm no matter what size the optical path. Also, the larger the optical path the more sensitive the measurement will be, whereas smaller optical paths are better suited to measuring higher UV254 absorption such as found in wastewater applications.

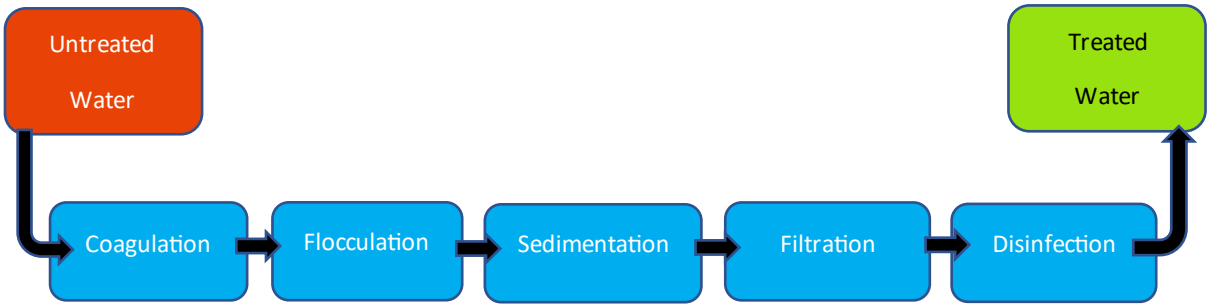


2-10mm optical path, better for higher absorption application such as waste water

20-50mm optical path, better for lower absorption application such as drinking water

Applications of UV254

Applications in Water Treatment Process

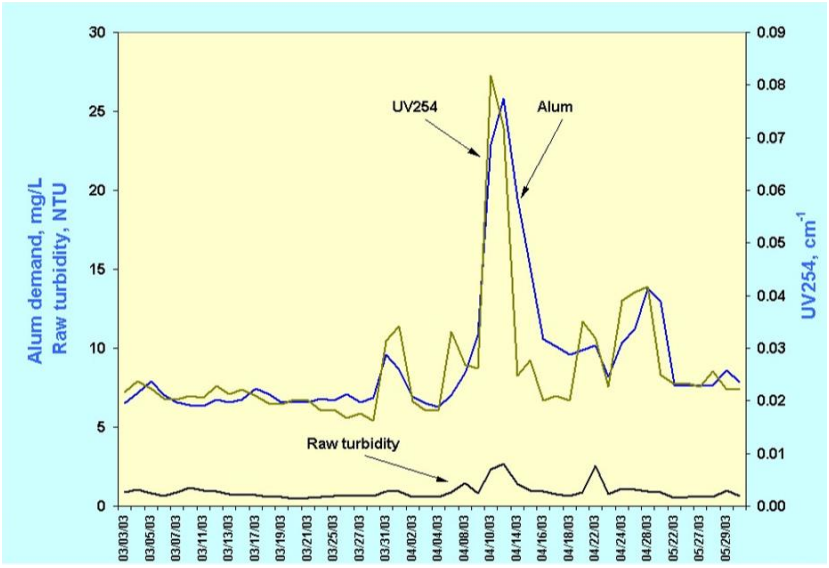


Coagulation Optimisation

In coagulation, polymers are used to clump small particulate matter together so that they can be easily separated from the water. The coagulation process also helps with the reduction of organic material that can cause disinfection by-products. Organics in water can absorb the polymers reducing the overall effectiveness of the process.

Monitoring the level of organics using UV254 absorption allows for the optimization of the coagulation process. This reduces the chemical polymer waste, sludge production and lowers potential disinfection by-products such as THM.

Required dosing level of the coagulate Alum can be seen in the figure following to trend well with UV254 in comparison to the more commonly measured Turbidity. Thus, UV254 provides an excellent tool in setting coagulate dosing levels.



Lake Michigan Filtration Plant, Grand Rapids, MI – Reference – Systemic Approach to Water Treatment Plant Process Optimization and Why Should Surface Water Treatment Plants Monitor UV254 in Source Water? Alex Yavich, Ph.D.,P.E. Optimization Solutions Environmental, LLC

Flocculation, Sedimentation, and Filtration

Previously for these steps, the amount of organic material was not being measured. The performance at these steps is measured via other indicators such as turbidity and/or ph. There is a trend to measure the UV254 thought out the process as this gives better information about the water quality than say turbidity.

For flocculation, the UV254 level drops with the optimization of charge neutralization and thus gives an indication of the flocculation performance. For sedimentation and filtration, the measurement is used to monitor the removal of organic material.

Chlorine Disinfection

Disinfection is an important part of the treatment of water in order to protect against waterborne infections and parasitic diseases. However, disinfection can produce harmful by-products such as carcinogens like trihalomethanes (THM). The by-products arise from generally harmless natural organic materials combined with cholerine.

Measurements before and after the disinfection process allow for real-time data on the performance, optimization, and reduction of disinfection by-products.

UV Disinfection

UV disinfection works by rendering viruses and bacterial ability to reproduce and infect. For this to happen the UV light needs to be above a certain intensity in order to reduce the photo repair of these organisms.

If the water has a high UV absorbance the effectiveness of the disinfection may be limited unless the intensity of the UV light is increased, or a secondary process is applied. As the main cost of UV disinfection is the cost of lamps it's important to monitor the UV absorption. This can be done with UV254 measurement. The UV254 measurement can be used to trigger a secondary process such as cholerization or increase the intensity of the treatment light when the absorption levels are high and thus the effectiveness of the disinfection is low.

Other applications include:

- Ultra-pure water for industrial processes- such as silicon wafer production
- Power Plants – water with high organic content causes fooling and degradation of equipment
- Effluent Water – Final check of the water quality in industrial processes before water is placed

back into the environment

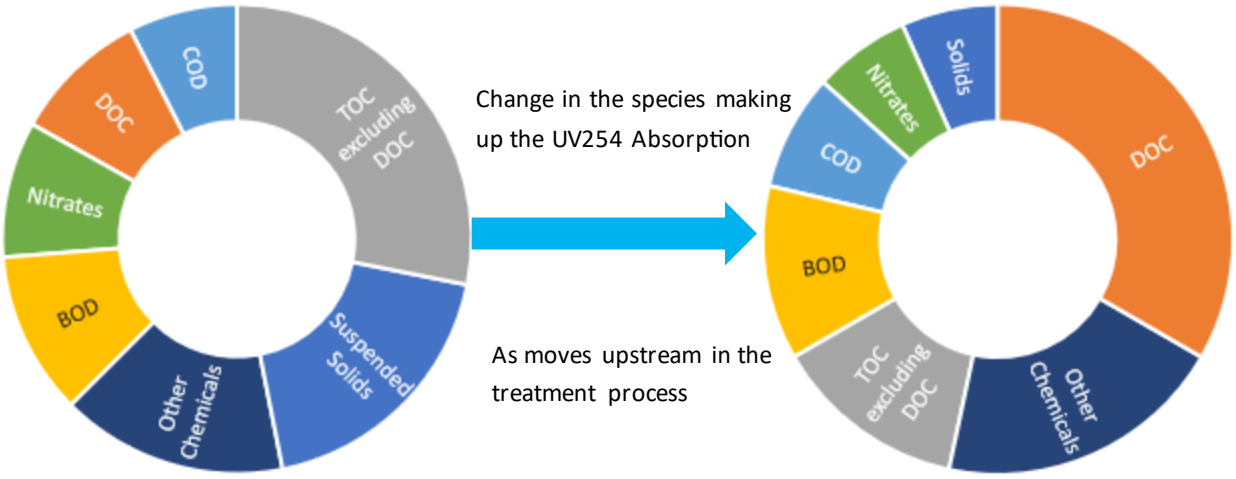
- Measurements of Disinfection By-Products and Organics in Rivers

Surrogate Measurements

The measurement of NOMs' can be correlated against the UV254 response in order to form surrogate measurements.

The advantage in the correlation depends on the species that is being measured; for example, this could be: fast real-time measurement, lower-cost instrumentation, lower operational cost (no need for chemical reagents or consumables), and the ability to measure a number of parameters at the same time.

Importantly though, as the chemical make-up of the water changes so does the percentage of species that make up the complete UV254 response. For instance, the percentage of dissolved organic carbon (DOC) making up the overall UV254 response should increase throughout the treatment process as suspended organic material is removed. Thus, the correlation at one point of the treatment process will be different at another.



The above figure is for illustration proposes, as such illustrating how the components that make up the overall UV254 signal may change as one move upstream in the treatment process.

TOC - Total Organic Carbon

TOC in water comes from a number of sources such as decaying Natural Organic Material (NOM) and synthetic sources such as detergents, pesticides, and other industrial chemicals. Knowing the level of TOC is important in estimating the number of NOMs, as NOMs react with the chloride during the disinfection process to produce harmful by-products.

Examples of Instruments/Methods of measuring TOC between 1-10,000mg/L (Require range of drinking and wastewater) other than UV254

UV254 advantage

The main advantage the UV254 surrogate measurement has over the above is the speed of measurement and operational cost. The Smart Storm online UV254 can take input from the slower TOC analysers to update the UV254 surrogate measurement of TOC and thus, allow for the end-user to combine both methods for fast real-time calibrate TOC measurements. This makes the overall system less likely to miss TOC upsets.

DOC – Dissolved Organic Carbon

Dissolved organic carbon is part of the TOC found in the water and is the part that is smaller than 0.45µm.

DOC is the part of the TOC that combines with chlorine causes harmful disinfection by-products.

DOC acts as a food source for bacterial and other microorganisms. Thus, levels need to be kept at a minimum in order to produce biologically stable water at the treatment effluent entering distribution systems and water networks (such as rivers).

Other methods of measurement of DOC other than UV254.

Infrared measurement of CO_2 after Oxidation same as that used in TOC but the suspended organic carbon is removed first using a 0.45 µm filter. For online/inline measurements the filters can be placed at the inlet to the device.

For the laboratory
The reagent test requires that the water sample is passed through a 0.45 filter and the measurement procedure takes 2hours.

UV254 advantage

The main advantage the UV254 surrogate measurement has over the above is the speed of measurement and operational cost.
The Smart Storm online UV254 can be purchased with a filter before the flow cell to remove the suspended organic material and allow for better surrogate measurements of DOC.

BOD – Biochemical Oxygen Demand

Biochemical oxygen demand is a measurement of the amount of dissolved oxygen that is needed for aerobic biological organisms in a volume of water to break down an amount of organic material at a given temperature over a certain time period. The measurement is commonly expressed at mg/L of oxygen consumed in a 5-day period at 20°C.

The measurement of BOD is not a precise measurement but is widely used for the indication of the quality of water.

For water going back into the environment, the level of BOD is important for aquatic life. Too low and there isn't enough oxygen for these organisms to carry out metabolic processes. Too high and the organism become stressed and suffocate.

Other methods of measurement of BOD other than UV254.

By measuring the dissolved oxygen via optical luminescent the BOD value can be calculated the following instruments perform such measurement:

UV254 advantage

The main advantage the UV254 surrogate measurement has over the above is the speed of measurement.

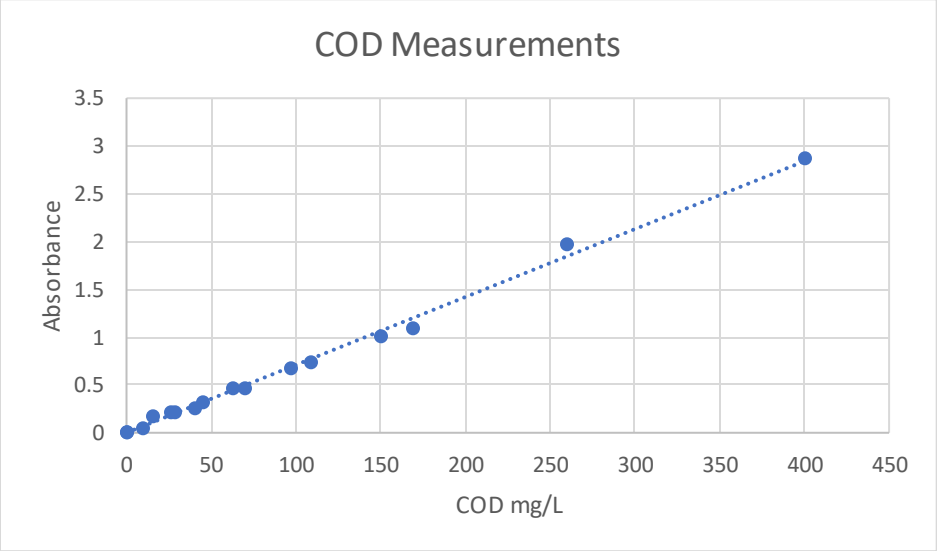
The Smart Storm online UV254 can take input from these analyzers, allowing the combined system to provide real-time calibrated measurements.

COD – Chemical Oxygen Demand

Similar to BOD, chemical oxygen demand is the amount of oxygen consumed over a given volume given in mg/L. Where they differ is that COD is an organic compound that can be chemically oxidized.

The measurement of COD is important for the aeration of water during the treatment process. This is to optimize the levels of oxygen needed to treat and reduce negative effects on effluent. If the COD is too high then the receiving waters can be stripped of their oxygen levels and damage aquatic life.

The figure below shows the correlation of UV254 absorption and COD as measured with the smart storm UV254 probe.



Other than UV254, the measurement of COD for online applications is performed by the combustion process and measuring the oxygen using an IR sensor. This type of measure can take several minutes

For laboratory measurements, there are a number of reagent-based measurements that in general

require a slow incubation period for the detection chemistry to complete.

UV-254 Probe

Stainless Steel Probe with 50mm pathlength

Plastic Probe with 20mm pathlength

With Smart Storm, the UV254 probe takes control of Natural Organic Materials (NOMs) in your process water with real-time surrogate measurements of TOC, BOD, and COD without the need for expensive reagents. Measuring UVA, UVT, and SUVA for responsive detection of aromatic organic material allows you to act on disinfection by-products such as Trihalomethanes (THM).

Long-life UV LED and highly sensitive optical system reduces the need to replace the illumination source which has an expected life of greater than 10 years.

The 39mm diameter small footprint probe with a selection of optical path lengths to match the sensitivity requirements of your application.

Water or Waste Water?

Choose a probe material: plastic, aluminum or stainless steel, depending on your application. For wastewater add Ultrasonic Cleaning to ensure continuous operation of the probe by removing fouling of optics.

Connect to Smart Storm Control Unit for real-time data and alarming. With all data being stored to SD card for easy export of results. 4-20mA output to relay back to the SCADA system.

Parameter	1mm path length in mg/L	2mm path length in mg/L	5mm path length in mg/L	10mm path length in mg/L	20mm path length in mg/L	50mm path length in mg/L
COD	0-2800	0-1400	0-560	0-280	0-140	0-56
BOD	0-1400	0-700	0-280	0-140	0-70	0-28
TOC	0-1200	0-600	0-240	0-120	0-60	0-24
DOC	0-1000	0-500	0-200	0-100	0-50	0-20

For the UV254 Probe Drinking water 10-50mm, Waste Water 1-5mm

Ranges for the UV254 Probe

Accuracy for the UV254 Probe

Parameter	1mm path length in mg/L	2mm path length in mg/L	5mm path length in mg/L	10mm path length in mg/L	20mm path length in mg/L	50mm path length in mg/L
COD	4	2	0.8	0.4	0.2	0.08
BOD	2	1	0.4	0.2	0.1	0.04
TOC	2	1	0.4	0.2	0.1	0.04
DOC	2	1	0.4	0.2	0.1	0.04

Ranges will depend on the water source