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Tackling Water Quality Challenges with Compact UV Spectroscopy

As global concerns surrounding water quality intensify, safeguarding this indispensable resource becomes increasingly imperative. The impact of water quality affects many aspects of our lives, including our food systems, environment, and personal health. Unfortunately, factors such as the increasing population, intensified farming practices and industrial waste have all taken a toll on the purity of our water sources [2]. To tackle these challenges, Hamamatsu Photonics has just developed advanced UV spectrometers, offering innovative solutions for water quality management. Water quality monitoring is particularly pronounced in two key areas: environmental monitoring and drinking water quality monitoring.

Environmental monitoring

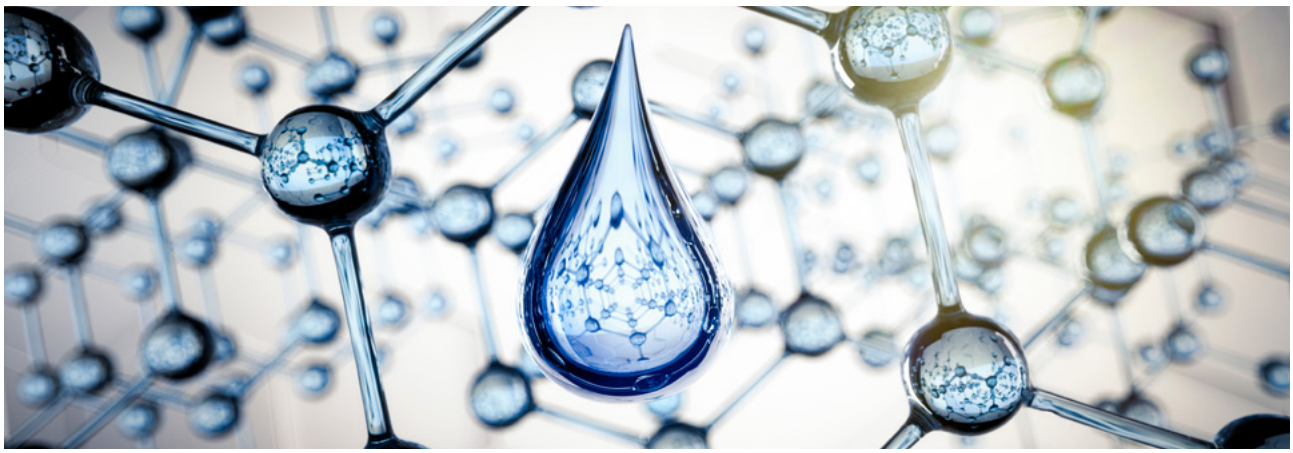
When a body of water becomes too rich in nutrients such as nitrogen and phosphorus due to the impact of human activities, the consequent reduction in oxygen levels causes the death of aquatic life. This poses a challenge to conservation efforts and our food supply [1,2].

Monitoring wastewater quality serves two purposes: early detection of pollution events and continuously ensuring compliance with regulations at treatment facilities[7]. For example, hospitals and pharmaceutical plants generate large amounts of concentrated antibiotic wastewater that needs to be treated and analyzed before being released into the environment [1,14].

Drinking water monitoring

Water utilities are committed to meeting the drinking-water standards which are often derived from the World Health Organization drinking water quality guidelines.

Water quality monitoring and treatment are two vital aspects of water quality management systems to detect hazards and events that can compromise its quality and provide operational control for assuring safe and reliable drinking water as preventive measures [3].



Conventional methods for water analysis

When it comes to monitoring water quality, a routine sampling program is typically utilized, which involves collecting and transporting water samples to a laboratory for analysis. However, this approach only partially explains water quality over time and may not accurately capture short-term fluctuations. Moreover, feedback from the laboratory is often delayed, making it difficult to respond quickly to any water incidents that may occur [4].

Currently, methods for assessing water quality parameters consist primarily of chemical, biological, and physical approaches [5]. The main chemical methods include titration analysis and electrochemical analysis, which are used to determine pollutant concentrations in a laboratory setting. However, these methods require bulky and expensive equipment and a large number of reagents which can result in secondary pollution.

Biological methods involve enrichment analysis and biosensor technology but suffer from lower accuracy and sensitivity compared to other methods. The results from the chemical and biological methods are also generally not provided in real time [6].

UV-Vis spectroscopy for online water monitoring

On the other hand, physical methods consist of spectral remote sensing technology in the UV and visible wavelengths. In fact, the principle of UV-Vis spectrophotometry relies on the correlation between the absorption of specific light wavelengths by a substance and its concentration [8].

Thanks to software particle compensation, spectrophotometry generally does not require sample filtrations, it is reagent-free and allows fast measurements of water quality in real time. This method has been increasingly utilized in the realm of rapid water quality assessment in recent years [6].

Among the parameters that can be measured using UV-Vis spectrophotometers, we can commonly find color, nitrate, Depleted Oxygen Content (DOC), Total Oxygen Content (TOC) and the spectral absorption coefficient SAC254 (sometimes referred to as UV254). In recent years, additional parameters have been included in water quality monitoring using online UV-Vis spectrophotometers [8], such as measurements of dissolved organic matter [9], chemical oxygen demand (COD) in water bodies [10], and disinfectant in drinking water [11].

Single-wavelength and multiwavelength detectors

There are mainly two types of spectral sensors used in water analysis: Single Wavelength (SW) sensors and spectrophotometers.

SW sensors generally consist of a bandpass-filtered single photodetector (Silicon Photodiode

or Avalanche Photodiode) and a light source that emits in the targeted wavelength and is absorbed by the substance to be detected. However, spectrophotometers use a broadband light source, a diffractive grating that separates light into its wavelengths components and directs it towards a linear array photodetector.

Online SW UV-Vis instruments can determine concentrations of a specific water parameter (most typically UV254, nitrate, or nitrite) based on the absorbance of a selected single wavelength [12]. In comparison, UV-Vis spectrophotometers measure the absorbances of a certain wavelength band. These sensors produce spectral fingerprints which are used to determine concentrations of water quality parameters based on the instrument's built-in algorithms [13].

Generally, when comparing the performance of full-spectrum and SW sensors, the latter can measure parameter variations during certain periods but may not compensate for the particle effect accurately, specifically when comparing the results with the standard laboratory procedures and measurements. On the contrary, spectrophotometers provide better particle compensation and can be calibrated to specific locations with higher accuracy. They are better for precise applications, such as real-time water and treatment process monitoring [13].

Introducing Hamamatsu's latest compact UV spectrometers for real-time water quality monitoring

We are thrilled to announce the launch of Hamamatsu's new innovative UV-Vis spectrometer, designed meticulously to meet the demands of modern water quality monitoring. This cutting-edge solution seamlessly blends advanced technology and practicality, ensuring accurate and efficient real-time analysis.

Key features and advantages

Ideal wavelength range

Our UV-Vis spectrometers exhibit exceptional sensitivity across a wavelength range spanning from 190 to 400 nm. This wide coverage allows for precise measurement of critical water quality parameters, thereby enabling comprehensive insight into water composition.

Unmatched compact design

The distinctive compact form factor of our spectral sensors facilitates seamless integration into miniature and handheld instruments. Moreover, these sensors can be effortlessly incorporated directly within water pipelines, underscoring their adaptability and ease of deployment.

Exceptional dynamic range

Hamamatsu's UV spectrometers boast an unparalleled dynamic range, ensuring dependable measurements even amidst dynamic environmental conditions. This exceptional attribute makes them ideal for dependable operation in outdoor settings, where fluctuations are inherent.

Enhanced Signal-to-Noise Ratio (SNR)

Our new UV spectrometer achieves an impressive SNR of up to 20,000. This remarkable capability enables the early detection of even the most subtle fluctuations in water quality, facilitating preemptive alarms and swift corrective actions.

Precise stray light suppression

By meticulously curbing crosstalk among different wavelength readings, the accuracy of Hamamatsu's UV spectrometers is significantly enhanced. This design detail ensures the production of reliable and consistent measurements, critical for meaningful analysis.

The UV-Vis spectrometer series: tailored to your needs

Hamamatsu Photonics offers a variety of compact UV-Vis spectrometers meticulously crafted to meet the diverse demands of various applications. The C16767MA Mini-spectrometer head is our latest release. However, you will find many more products here: Mini-spectrometers | Hamamatsu Photonics [15]

New C16767MA Mini-spectrometer head

The spectral head model present the most compact yet powerful solutions for situations requiring portability and efficiency. Ideal for direct installation into water pipelines or complex monitoring configurations, its streamlined design encapsulates advanced functionality within a diminutive form factor.

C16767MA fingertip size

- Size: 20.1 × 12.5 × 10.1 mm
- Weight: 5 g
- Spectral response range: 190 to 440 nm
- High sensitivity
- Spectral resolution: 5.5 nm (Typ.)
- Stray light suppression: -25 dB
- Supports synchronized integration (electronic shutter function)
- For integration into mobile measurement equipment
- Wavelength conversion factor is listed on final inspection sheet

Navigating the future of water quality with UV technology

Hamamatsu's cutting-edge UV spectrometers offer a vital solution to the escalating global water quality challenges. From addressing nutrient imbalances jeopardizing aquatic ecosystems and food supplies to ensuring stringent drinking water standards, these spectrometers cater to diverse concerns. Unlike traditional methods with delayed responses, Hamamatsu's compact UV spectrometers employ real-time UV spectroscopy to measure water quality with sensitivity from 190 to 400 nm, seamless integration, unmatched dynamic range, improved signal-to-noise ratios for early detection, and precise measurements through stray light suppression. The new lineup of Hamamatsu's compact UV spectrometers transcends mere instrumentation—it signifies a commitment to elevate water quality management and secure the purity of our vital water resources.

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