UV AOPs for Taste and Odor Removal: Test to Design to Full-Scale Operation

UV Treatment of RO Permeate for Potable Reuse at the Scottsdale Water Factory

UV Disinfection and Advanced Oxidation
Because clean water is a matter of trust: Think UV. Think Heraeus.

Contact us at: hng-uv@heraeus.com
www.heraeus-noblelight.com
Contents
Winter 2017

Features
4  UV AOPs for Taste and Odor Removal: Test to Design to Full-Scale Operation
   by Jens Scheideler, Xylem
8  UV Treatment of RO Permeate for Potable Reuse at the Scottsdale Water Factory
   by Keith Bircher, Calgon Carbon
12 UV Disinfection and Advanced Oxidation: A New Way of Tackling Old Problems
   by Patrick Bollman and Jon McLean, Evoqua Water Technologies
16 2017 IUVA World Congress recap

Departments
2  President’s Letter
2  From the Editor-in-Chief
21 IUVA and Other Related Events
22 UV Industry News
24 Calendar
24 Ad Index

Executive Operating Committee
Oliver Lawal
   President
Jutta Eggers, Ph.D.
   EMEA Co-Vice Presidents
Ian Mayor-Smith
   Asia Vice President
Kumiko Oguma, Ph.D.
   Americas Co-Vice Presidents
Jamal Awad, Ph.D., P.E.
Gary Hunter, P.E., Treasurer
Ron Hofmann, Ph.D., Secretary and President-Elect
Kati Bell, Ph.D., P.E.
   Past President

Editorial Board
Professor Ezra Cates,
   Clemson University
Christine Cotton, P.E.,
   ARCADIS
Samuel S. Jeyanayagam, Ph.D.,
   P.E. BCEE, CH2M Hill
Professor James P. Malley, Jr.,
   P.E., University of New Hampshire
Jennifer Pagan,
   AquiSense Technologies
Phyllis B. Posy,
   Atlantium Technologies
Harold Wright, Carollo Engineers

Editor-in-Chief
Jim Bolton
editorinchief@iuva.org

Associate Editor
Professor Jim Malley
assoceditor@iuva.org

IUVA News (print version) (ISSN 1528-2017) is published quarterly by the International Ultraviolet Association, Inc. An online version is posted on www.iuvanews.com.

IUVA News Editorial Office
628 Cheriton Cres. NW
Edmonton, AB, Canada T6R 2M5
780.439.4709

Published by:
Peterson Publications, Inc.
2150 SW Westport Dr., Suite 101
Topeka, KS 66614
785.271.5801

Managing Editor: Brittany Willes
Graphic Designer: Kelly Adams

Opinions expressed in this publication may or may not reflect the views of the Association and do not necessarily represent official positions or policies of the Association or its members.

Winter 2017
A Message

from the IUVA President

I am honored to take over stewardship of the IUVA from Dr. Kati Bell and a long line of giants of the UV world – most recently Prof. Karl Linden, who now ends his two-year period as past president. Karl and Kati have led the organization out of a somewhat difficult period into a position of renewed strength. Our executive director, Gary Cohen, and his support team have been effective in administering activities in a fiscally responsible manner. This has allowed the Executive Operating Committee, Board of Directors, various committees and working groups to focus on important issues affecting all aspects of ultraviolet technology. As the organization builds up to its 20th anniversary in 2019, I hope to continue the IUVA vision, namely: “To make the use of ultraviolet technology a leading technology for public health and environmental applications, and to position IUVA as the leading authority on the use of ultraviolet technology through advocacy to the education, industry, research and public policy sectors worldwide.”

In November, I was pleased to attend the two-day symposium jointly organized with the National University of Singapore and chaired by Professor Jiangyong Hu and Associate Professor Kumiko Oguma. The program delivered on its promise of discussing the latest UV technology advancements for the water environment with a distinguished list of speakers from academia and industry. This was followed by a technical tour of the impressive NEWater high-grade reclaimed water facility.

Our upcoming events in 2018 will offer an equally exciting opportunity to learn about and discuss the latest important issues in the field of UV technology. The America’s Conference will be held in Redondo Beach, California, in February and has attracted a strong list of abstracts that promises to deliver a unique program. Similarly, the specialist UV LED conference that will take place in Berlin, Germany, in April is shaping up to be the most comprehensive gathering of technical know-how of this exciting new area ever held. I am also pleased to announce that our 20th anniversary World Congress will be held in the Asia-Pacific region for the first time. Sydney is a great city with a strong tradition of the use of UV technology, and summer in February is always a bonus for Northern Hemisphere visitors.

Our various committees, councils and working groups continue to work hard on the pressing issues of the day. Whether that be regulatory issues in ballast water treatment applications or detailed review of the draft EPA document, “Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems,” the many hours of volunteer work carried out, all contribute to the protection of human health and the environmental well-being.

I hope that you are as proud as I am to be known as a member of the IUVA. Over the coming two years, I am seeking ways to extend the influence of our vision. This can be by increasing accessibility to regulators, end users and students, or by offering a forum to those working in health care or other emerging applications. As an organization we hold an unparalleled wealth of experience and knowledge that can positively influence many aspects of this beautiful planet (and beyond).

Thanks, everyone, and I look forward to hearing from you. Feel free to contact me directly at oliver.lawal@aquisense.com or +1.859.869.4700.

Oliver Lawal, IUVA president
President and CEO, AquiSense Technologies

A Message

from the Editor-in-Chief

With this issue, we are starting a series of “theme” issues. The theme for this issue is Advanced Oxidation. The theme for future issue are: (spring 2018) UV LEDs; (summer 2018) food and beverages; (fall 2018) reuse water; and (winter 2018) air and surface treatment. This IUVA News issue features three articles illustrating various applications of Advanced Oxidation technology.

Advanced Oxidation technologies (AOT) involve the oxidative treatment of organic contaminants in water where the process is driven by highly reactive oxidants, such as hydroxyl radicals (·OH) or chlorine atoms (Cl·). These intermediates can be generated either by the absorption of UV photons or by chemical generation (e.g., O$_3$ plus H$_2$O$_2$).

If you would like to submit a paper for one of these theme issues, please send it to me at editorinchief@iuva.org. The deadlines are 15 March 2018 for the spring 2018 issue and 15 May 2018 for the summer 2018 issue.

IUVA News is your quarterly ultraviolet magazine, so please take some time to read it through, and don’t forget the ads. The ads make it possible to publish the magazine, so please support our advertisers by clicking through to their websites or contacting them for further information. If you are a marketing manager in a UV company, I encourage you to advertise. You will not only attract direct sales but also enhance your image in the UV community. Send me an email at editorinchief@iuva.org, and I’ll send you the IUVA News Media Kit. Also note that IUVA News publishes short Application Notes highlighting novel and ground-breaking applications of a UV company’s technology. Also, IUVA Corporate Members are welcome to contribute short announcements to the UV Industry News column.

Jim Bolton, IUVA News editor-in-chief
AQ Series UV water treatment units provide effective bacteria and virus protection in residential, and commercial applications, from soft drinks to shampoo - especially where resistance to chemical treatment exists.

- Thousands of standard and custom units in use
- Simple and more economical than sophisticated industrial systems
- Won’t change color, odor or taste of water
- Flow rates from 2 to 100 GPM

Contact American Ultraviolet today about ways to purify your water. It’s really that simple.

THE BEST ELECTRONIC LAMP DRIVERS FOR MEDIUM PRESSURE UV LAMPS 12KW

CLEAN WATER FOR THE CITY OF ROTTERDAM. THE BIGGEST DRINKING WATER PLANT IN THE NETHERLANDS HAS A YEARLY CAPACITY OF 100 MILLION M³ DRINKING WATER.
UV AOPs for Taste and Odor Removal: Test to Design to Full-Scale Operation

Jens Scheideler, Global Advanced Oxidation Process (AOP) manager
Xylem, Boschstrasse 4, 32051 Herford, Germany; email: jens.scheideler@xyleminc.com

Abstract
Implementing UV AOPs for the control of taste and odor involves several steps that need to be followed carefully to assure proper design and cost-efficient operation.

Introduction
The taste and odor of drinking water is one of the most important indicators to assess if water is safe to drink. Ironically, most chemicals that can be harmful, even in low concentrations, do not influence either the taste or odor. On the other hand, 2-methylisoborneol (2-MIB) or geosmin, which are produced by cyanobacteria during an algae bloom, are not harmful in their natural occurring concentrations. Their impact on the taste and odor (T&O) of potable water, however, is so strong that utilities are faced with serious complaints or even exposure in the media when these compounds are present in concentrations of >5 ng/L. Therefore, utilities must implement treatment solutions that maintain consumers’ trust in their drinking water supply.

Advanced oxidation processes (AOPs) have become widely accepted and commonly used treatment options to address issues related to harmful algae blooms (HABs). AOPs present a robust barrier against T&O compounds, as well as the toxins released by the cyanobacteria. This article provides guidance and examples for the implementation of UV-based AOPs for full-scale T&O applications.

Testing
As hydroxyl radicals (·OH) can react with almost all water constituents, the feasibility and efficiency of a UV-based AOP treatment should be tested prior to design. Modeling techniques have developed rapidly over the last decade leading to more precise predictions of the performance by incorporating the chemistry of the water to be tested. However, to eliminate uncertainties and the risk of over or under designing a system, a collimated beam test (CBT) is still the best way to develop the optimum design.

CB testing
To carry out a CB test, the utility needs to provide a sample of expected water quality during algae bloom season. Ideally the water should contain the target compounds (2-MIB or geosmin) in sufficient levels to allow demonstration of the required log reduction target. If the concentration of naturally occurring T&O compounds is too low, the best practice is to spike the sample with powdered 2-MIB. Note that the use of methanol dissolved 2-MIB standards is not recommended, since methanol is an ·OH radical scavenger influencing the results heavily. During the CB test, different UV and hydrogen peroxide doses should be trialed to develop dose response curves while also identifying the optimal balance between UV dose (energy costs) and hydrogen peroxide doses (chemical dosing and quenching costs).

As an alternative, the CB test procedure can be adjusted to determine the OH radical scavenging potential using the Methylene blue method or PCBA as a surrogate for ·OH radical specific reaction kinetics (Rosenfeldt et al., 2007). The advantage of this approach is that the handling of powered 2-MIB is not required, and the analytics may be less costly than 2-MIB specific analytics. The principal disadvantage, however, is that this method is indirect, and the customer does not get a specific demonstration of how the target contaminant is degraded, which may decrease trust and confidence in the proposed technology.

Figure 1 shows a typical CBT experiment set-up using a petri dish filled with sample water, which has been spiked with 2-MIB and hydrogen peroxide. Typical volumes necessary for one test set range between 100-500 mL.

Figure 1. Typical CBT experiment set-up

Onsite testing
An alternative to CBTs is onsite pilot tests, which are especially recommended when the water quality fluctuates during the bloom season. An advantage of an onsite pilot is the
demonstration of the technology in a 24/7 operation and the opportunity to educate operators and owners about the technology and to identify training needs for the reliable operation of a full-scale treatment system.

As the results arising from the pilot are the base of the design for the full-scale reactor it is necessary to deploy UV reactors that have known applied UV dose distributions under the conditions of the pilot. For this, two approaches have been found applicable:

1. Validation using a “chemical-assay”
   The reactor must be operated in parallel to a CB device to develop UV dose response curves and to determine the reduction equivalent dose (RED) of the reactor. Once this is done, the exact applied UV dose is known and can be compared to existing modeling tools to extrapolate when parameters, such as flow rate or ultraviolet transmittance (UVT), are outside of the validated envelope.

2. Modeling using Computational Fluid Dynamic (CFD)
   This approach uses computer based modeling tools to predict the applied UV dose considering UV intensity inside the reactor, as well as the hydraulic profile. It has been found that these REDs predicted by modeling tools are very close to the REDs measured in the field using approach number one (Scheideler et al., 2016).

The figures in the next column show how the chemical-assay must be set up to develop the design criteria for a full-scale UV AOP system by evaluating the Reduction Equivalent Dose (RED) of the pilot UV reactor.

**Design**

Once the bench or pilot scale tests have been completed and dose response curves have been developed, the full-scale system can be designed considering the following important items:
- Flow rate and turn down requirements
- Duration of the T&O event
- Maximum log removal target
- Space available
- Local costs for electricity and hydrogen peroxide
- Potential quenching costs
- Water quality and fluctuations

UV-based AOPs are always a balance between the input of electrical energy (UV dose) and the costs for chemical dosing. As a rule of thumb, it can be assumed that doubling the hydrogen peroxide dose will result in a 50% lower UV dose, which will result in space, capital expenditure (CAPEX) and energy savings but significantly increases the costs for quenching and dosing. It is, therefore, recommended to perform a detailed life cycle cost analysis to identify the “sweet spot” between those two factors and at the same time ensuring that the system can react and be modified to changing conditions without the need for cost intensive upgrades. The graphs below show the outcome of such an analysis, comparing a design with a high hydrogen peroxide dose and a low hydrogen peroxide dose in correlation to how many days the system is operated in AOP mode. For the analysis a hypothetic water treatment plant with the costs and flows given in Table 1 was considered:

**Table 1. Costs and flows**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate</td>
<td>m³/h</td>
<td>3,000</td>
</tr>
<tr>
<td>UVT</td>
<td>%</td>
<td>92</td>
</tr>
<tr>
<td>Energy costs</td>
<td>$/kWh</td>
<td>0.14</td>
</tr>
<tr>
<td>Hydrogen peroxide costs</td>
<td>$/kg</td>
<td>1.4</td>
</tr>
<tr>
<td>Sodium hypochlorite costs</td>
<td>$/kg</td>
<td>0.8</td>
</tr>
<tr>
<td>Depreciation time</td>
<td>Y</td>
<td>20</td>
</tr>
</tbody>
</table>

The quenching of residual hydrogen peroxide was simulated by dosing with a conventional sodium hypochlorite solution.

![Onsite pilot reactor test with CBD in parallel to assess the RED](image-url)
Figure 3. Impact of hydrogen peroxide dose and UV dose balance depending on the run time on operational expenditures (OPEX)

From this analysis, it can be concluded that for short run times, a smaller UV system with a higher hydrogen peroxide dosing is favorable, whereas for longer run times, the lower hydrogen peroxide dosing option is more economical.

Once the optimum level between UV and hydrogen peroxide doses is established, the full-scale UV reactor must be designed. In the past, up-scaling was done using the electrical energy per order ($E_{EO}$) approach, which simply considers the energy consumption of the pilot reactor for a one log removal of the target contaminant and extrapolates this to the total power requirement of the full-scale system. This approach works well when the pilot and the full-scale reactor are from the same manufacturer and the same product line using the same geometry and UV lamp technology.

Nowadays, however, more sophisticated approaches can be applied by using the UV dose determined by the CB tests, or onsite pilot tests to upscale to different styles of UV reactors and lamp technologies, or even to different manufacturers. This offers many advantages to the engineer or customer as the most suitable reactor geometry can be considered, benchmarking different vendors becomes easier, and the most efficient AOP system can be identified, resulting in potential CAPEX and OPEX savings. Table 2 shows the difference between a UV AOP system being up scaled by the $E_{EO}$ and the UV dose approach. Using the EEO approach does not allow giving credit to a more energy efficient reactor, and, by this, potential costs savings are missed.

Table 2. $E_{EO}$ vs. the UV dose approach

<table>
<thead>
<tr>
<th>$E_{EO}$ Approach</th>
<th>UV Dose Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reactor A</td>
</tr>
<tr>
<td><strong>UV Dose (mJ/cm²)</strong></td>
<td>600</td>
</tr>
<tr>
<td><strong>Electrical Energy Demand (kWh/m³)</strong></td>
<td>75</td>
</tr>
</tbody>
</table>

It is important that the engineer and manufacturers consider how best to upscale using the UV dose approach to ensure optimum design while avoiding an over designed UV AOP system with limited turn down capabilities. To address this either purely mathematical (Point Source Summation – PSS) or modeling (CFD) tools can be used to size the full-scale system. Both methodologies are well understood and have become industry standards for UV disinfection systems but are still relatively new for AOP applications. However, full-scale systems that have been designed using these methods have demonstrated their performance successfully in the field (Scheideler et al., 2016).

Another design aspect to be considered is the potential need for a hydrogen peroxide quenching step. Since only 10% of the added hydrogen peroxide is consumed in the AOP, there is often the need to quench the residual to avoid interference of the hydrogen peroxide with downstream treatment processes. Two methods have been found to be applicable using chlorine dosing or activated carbon for quenching. Whereas the quenching with chlorine purely removes the residual hydrogen peroxide, the downstream filtration using granular activated carbon that often becomes biological active offers several benefits for the overall treatment. Besides, effective quenching oxidation by products that have been formed during the AOP are effectively adsorbed and metabolized by the microorganisms leading to a true removal of the organic micropollutants (Wang et al., 2016).

Operation

Once installation and commissioning are complete it is time to plan the full-scale performance tests to confirm the design and operational set-points while also collecting data for potential optimization of the full-scale system to improve overall life cycle costs. If 2-MIB or Geosmin are not naturally present, it is possible to dose powdered 2-MIB. However, this is a very cost-intensive option, especially for large flow rates,
and may be associated with environmental safety, security and health (ESH) concerns as a chemical is being added to the actual drinking water treatment process. A more cost-effective solution is the use of a surrogate compound that is less harmful and does not influence the quality of the drinking water. Caffeine has been described as a superior surrogate due to its similar kinetic rate constants compared to 2-MIB and its easy availability (Wang et al., 2015).

If possible, a CB test should be conducted in parallel to the performance test to assess if the specified UV dose is delivered by the full-scale system. This will assure the customer that the system meets all specified requirements and up-scaling has been completed properly by the manufacturer.

Following the performance tests, the customer will understand how to set the system to ensure 100% compliance and first optimization potentials should have been identified. The biggest challenge, however, is to develop control strategies that allow for operational cost savings by applying only the UV and hydrogen peroxide doses necessary to reduce T&O below the notification level.

As online monitors to directly measure the scavenging potential are not currently available, surrogate measurements must be taken and the results fed back to the UV AOP system. Then either the chemical feed and power input can be reduced, or increased, as necessary. The following parameters typically affect the scavenging potential most frequently:

- TOC/DOC
- Alkalinity
- pH

For all these parameters, online instruments are available and their signal can be used to adjust the AOP system in real time. This does not mean that the scavenging potential can be exactly predicted as the TOC/DOC value does not consider the type of organic, but it will be relatively accurate as most of the natural organic matter in reservoirs and rivers does not totally change its composition. Considering this, the control of the UV AOP system still should contain some conservatism, bearing in mind that the true scavenging potential cannot be reflected by the above-mentioned surrogate measurements.

By incorporating online instruments, the selection of the right UV and hydrogen peroxide doses can be fully automated assuring proper level of treatment through the entire T&O period.

**Conclusions**

UV AOPs have demonstrated their feasibility and reliability as an easy to operate treatment barrier against algae bloom related T&O issues. The challenge is the proper design of the system to avoid unnecessarily high operational costs or insufficient treatment. Following the guidelines and the recommended steps outlined here will ensure the selection of the most appropriate and efficient design based on the established UV and hydrogen peroxide dose for the specific project site.

---

**References**


UV Treatment of RO Permeate for Potable Reuse at the Scottsdale Water Factory

Keith Bircher
Calgon Carbon Corp., 38 Kappele Ave., Toronto, ON, M4N 2Z1, Canada
Contact: 416.358.0986 or kbircher@calgoncarbon.com

Keywords: Ultraviolet, UV, Potable Reuse, NDMA, AOP

The city of Scottsdale water campus
The Scottsdale Water Campus, near Phoenix, Arizona, was built in the 1990s as a 20 MGD water reclamation plant and 10 MGD advanced water treatment (AWT) plant utilizing microfiltration (MF) and reverse osmosis (RO). In 2011 and 2012, the AWT plant was upgraded to 24 MGD, including a 20 MGD Sentinel™ Chevron UV reactor to treat NDMA and other potential contaminants. The primary purpose was to increase the capacity for aquifer replenishment for potable reuse. A flow schematic of the upgraded facility is shown in Figure 1, while Figure 2 shows the filtration and RO units.

UV system design
Selection of the UV supplier and equipment was based on a rigorous specification and evaluation of both capital costs and the net present value of operating costs over the life of the system. Calgon Carbon was awarded the contract with its Sentinel™ Chevron 48 AOP UV. This system offered the lowest total cost of ownership and operation by using medium-pressure UV technology combined with highly efficient turndown capability.

The UV system is designed to destroy 1-log of NDMA at 20 MGD and a minimum UV transmittance of 95%. The Sentinel™ Chevron 48 AOP reactor has 18 x 20 kW medium pressure UV lamps arranged in a compact vessel four feet (1.2 m) in diameter and six feet (1.8 m) long.

The Sentinel™ 48 AOP system uses the highest power medium pressure UV lamps in the industry resulting in fewer lamps, less maintenance and a smaller footprint. The ability to turn off banks of lamps and to turn down lamps to 40% enables the system to efficiently tailor the UV power to the plant needs, thereby reducing operating costs.

Modeling to predict full-scale performance
Full-scale performance is dependent on the flow rate, the UV lamp output, the UV transmittance of the water, the path length in the UV reactor, the UV dose response of the contaminant and the reactor hydraulics (UV dose distribution).

Computational Fluid Dynamic modeling (CFD) coupled with UV Intensity Field modeling is used to predict full-scale performance.

UV sensitivity ($D_L$)
In UV Disinfection the UV sensitivity (Dose per log or $D_L$) (Bircher, 2007) of an organism is needed in CFD modeling to predict performance. It is also needed if multiple organisms
are used in bioassay testing to arrive at a single dose equation that combines all organisms. Figure 4 shows a typical UV dose response for MS2 Phage where the $D_L$ at any point in this curve is defined as the UV dose at that point divided by the log inactivation.

**Figure 4.** Typical dose response of MS2 Phage used in bioassay

**NDMA UV dose per log ($D_L$)**

NDMA is unique in AOP treatment as its destruction by UV AOP is predominantly by direct photolysis and not via the hydroxyl radical. Therefore, hydrogen peroxide is not necessary and is sometimes not used if NDMA is the only target compound. In this manner NDMA behaves much like a microbial organism in that the $D_L$ is independent of water quality. Figure 5 shows the UV dose response of water from the Scottsdale facility with a $D_L$ of 714 that is typical of NDMA.

**Figure 5.** Fluence (UV dose) response of NDMA

NDMA absorbs at the low UV wavelengths with a peak around 228 nm as shown in Figure 6.

**Figure 6.** NDMA spectral molar absorption coefficient

**Full-scale fluence rate calculations**

The UV fluence rate at every point in the reactor is calculated as follows:
The spectral lamp output between 200 and 300 nm is divided into 5 nm bands, and the lamp fluence rate, $E_0(\lambda)$, at each wavelength is determined using the UVCalc fluence rate model (Bolton Photosciences Inc.). The fluence rate is multiplied by the NDMA molar absorption coefficient for that wavelength band divided by the absorption coefficient at 254 nm to give a NDMA-weighted fluence rate at each wavelength normalized to 254 nm. Since the number of photons per unit energy is proportional to the wavelength this is multiplied by the wavelength ratio to determine the equivalent photons absorbed at 254 nm. Summing this from 200 to 300 nm gives the total NDMA-weighted fluence rate at each point in the reactor (see equation 1).

$$E_0(254) = \sum_{\lambda=200 \text{ nm}}^{300 \text{ nm}} E_0(\lambda) \frac{\varepsilon_c(\lambda)}{\varepsilon_c(254)} \frac{\lambda}{254}$$  (1)

where

- $E_0(254)$ is the NDMA-weighted 254 nm equivalent fluence rate (mW/cm$^2$)
- $E_0(\lambda)$ is the fluence rate (mW/cm$^2$) at wavelength band $\lambda$
- $\varepsilon_c(\lambda)$ is the molar absorption coefficient (M$^{-1}$ cm$^{-1}$) of NDMA at wavelength $\lambda$ and
- $\varepsilon_c(254)$ is the molar absorption coefficient (M$^{-1}$ cm$^{-1}$) of NDMA at 254 nm

The ratio $\lambda/254$ converts the number of photons per unit energy at wavelength $\lambda$ to that at 254 nm.

This is the same as the accepted technique used to calculate the germicidal fluence rate for the destruction of microorganisms using broad spectrum UV, except that if the action spectrum is measured in energy (Joules) multiplying by the wavelength ratio is not necessary.

This process is illustrated in Figure 7 where the NDMA-weighted fluence rate is the integral or sum under the NDMA-weighted fluence rate curve.

**CFD program**
The CFD analysis was performed using CFX software (ANSYS Inc., Canonsburg, PA). The reactor geometry was divided into a mesh of approximately 3 million volume elements and the fluid-dynamics and photo-statics are calculated in each cell with the CFD program reading the fluence rate at the mesh points.

The program calculates the destruction of the target compound in each mesh cell as the water flows through the reactor using:

$$\frac{DC}{Dt} = \frac{-E_0(254) \times C}{D_L \times \log e}$$  (2)

where:

- $C$ is the concentration of NDMA in the volume element
- $E_0(254)$ is the NDMA weighted fluence rate (Equation 1) in that volume element (mW/cm$^2$)
- $D_L$ is the dose required for 1-log reduction (mJ/cm$^2$/log) for NDMA.

or for finite volume elements in CFD where the water passing through it in time $t$ with change in concentration $\Delta C$:

$$\Delta C = \frac{-E_0C}{D_L \times \log e} t$$  (3)

**Illustration of CFD results**
Figure 8 is a plot of the NDMA-weighted fluence rate in the reactor, while figure 9 shows the NDMA destruction through the reactor.

**Operational control equation**
The Sentinel reactor can operate with 18, nine or five lamps, and each lamp can be turned from 100% power (20 kW) to 40% power (8 kW). It has very efficient turn down from 18 x 20 kW or 360 kW to 5 x 8 kW or 40 kW to tailor the power consumption to the operating conditions (flow, UV transmittance and target NDMA log reduction). The CFD modeling is used to determine the log reduction of NDMA under a variety of operating conditions of UV absorbance, relative lamp output and flow.
Regression analysis then can be used to find the best fit of the log reduction to these parameters using Equation 4:

$$\log t = 10^4 \times UVA \times \left( \frac{S}{S_0} \right)^{\frac{C+D UVA}{Q \times D_L}}$$

where:
- UVA is the UV absorbance = – log10 (UVT/100)
- $S/S_0$ is the relative lamp output
- $Q$ is the flow rate, MGD
- $D_L$ is the UV sensitivity = 714 mJ/cm²/log

A, B, C, D and E are constants derived from fitting this equation to the results of CFD modeling for each lamp condition.

This equation is programmed into the PLC controls of the reactor enabling the NDMA log reduction to be calculated and the lamp power and number of operating lamps to be adjusted to meet the target log reduction set at the operator interface.

### Operational experience

In a 10-day performance trial in February 2012, the system consistently achieved the target 1-log (90%) NDMA removal while continuously adjusting the number of operating lamps and lamp power to match varying plant operating conditions. This is illustrated in Figure 10.

![Figure 10. NDMA log reduction measured during the 10-day performance trial](image)

### Conclusion

The Sentinel AOP system is treating NDMA for the city of Scottsdale. The compact size and efficient turndown make this medium-pressure UV system ideal for potable reuse. NDMA-weighted UV dose per log ($D_L$) can be used in CFD modeling to accurately predict the performance of the full-scale UV AOP reactor allowing UV dose pacing to continuously optimize power consumption.

This same technique can be used for UV/hydrogen peroxide or UV/chlorine AOP where the hydrogen peroxide or chlorine weighted UV dose is used instead of NDMA. However, in this instance the UV dose per log ($D_L$) is dependent on the scavenging of background water and the oxidant. It is possible, however, to determine the effect of water quality parameters such as UV absorbance (as a proxy for TOC), pH, nitrate and alkalinity and thereby calculate the $D_L$ of any contaminant. In this way the destruction of any contaminant can be determined and tracked.

### References

Bircher, K.; Wright, H. 2007, Who needs RED? An Empirical Method for Validating the Log-Inactivation of a UV Reactor thereby eliminating the need for RED and RED Bias, Water Quality Technology Conference, Columbus, SC.


Bircher, K.; Vuong, M.; Crawford, B.; Heath, M.; Bandy, J. 2011, Scale Up of UV AOP Reactors from Bench Tests using CFD Modeling, WateReuse Conference, Phoenix, AZ.
UV Disinfection and Advanced Oxidation: A New Way of Tackling Old Problems

Patrick Bollman, P.E., UV Product Specialist, and Jon McClean, VP of Research, Design & Engineering
Evoqua Water Technologies, 238 Commercial Drive, Beaver Dam, WI 53916
Contact: 920.885.4628, patrick.bollman@evoqua.com or jon.mcclean@evoqua.com

Introduction
Modern wastewater and drinking water facilities face an array of complex and sometimes contradictory problems. On one hand, they need to treat microorganisms that are becoming increasingly chlorine-tolerant while driving down the disinfection byproducts caused by high doses of chlorine. While on the other, treat the new contaminants that are emerging, such as pesticides caused by intensive land use, pharmaceutical products consumed in increasing quantities by an aging population, or synthetic organics washing into the aquifer. These emerging contaminants are referred to as Compounds of Emerging Concern (CEC).

Water scarcity will lead to relying more on the reuse of water and has accelerated the urgency to develop and add process barriers to remove these contaminants from the water supply without exacerbating this issue. Few conventional drinking water treatment processes can address these emerging issues and almost no conventional municipal wastewater processes are capable of targeting these problematic compounds.

Metabolized and un-metabolized Pharmaceutical and Personal Care Products (PPCPs) are not new; however, their potential to cause effects on living tissue is now subject to scrutiny. A study (USGS, 2002) by the US Geological Survey published in 2002 brought attention to PPCPs in water. Following sampling of 139 susceptible streams in 30 states, detectable quantities of PPCPs were found in 80 percent of the streams.

PPCPs include:
- Sunscreen products
- Prescription, over-the-counter and veterinary drugs
- Diagnostic agents
- Fragrances and cosmetics
- Nutraceuticals (e.g., vitamins)
- Illicit drugs
- Veterinary drug use, especially antibiotics and steroids

The USEPA maintains an active program called the Contaminant Candidate List (CCL) to identify contaminants in public drinking water that warrant detailed study and may require regulation under the Safe Drinking Water Act (SDWA). The most recent Contaminant Candidate List, CCL4 was finalized on Nov. 17, 2016, and contained 97 chemicals or chemical groups, 12 microbiological contaminants, and 10 pharmaceutical compounds.

The list includes antibiotic pharmaceuticals such as erythromycin, and nine hormones: 17 alpha-estradiol, 17 beta-estradiol, equilin, equilin, estriol, estrone, ethinyl estradiol, mestranol, and norethindrone.

Ultraviolet (UV) alone or in combination with selected chemical oxidants has the ability to produce large amounts of the hydroxyl radical (·OH) or chlorine (Cl·) radical from hypochlorite (ClO\(^{-}\)). These species aggressively attack organic compounds, either by the abstraction of hydrogen atoms from water, (alkanes and alcohols), or it can add itself to the compound (olefins and aromatic compounds).

<table>
<thead>
<tr>
<th>Species</th>
<th>Relative Oxidation Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>1.00</td>
</tr>
<tr>
<td>Hypochlorous acid</td>
<td>1.10</td>
</tr>
<tr>
<td>Permanganate</td>
<td>1.24</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>1.31</td>
</tr>
<tr>
<td>Ozone</td>
<td>1.52</td>
</tr>
<tr>
<td>Atomic oxygen</td>
<td>1.78</td>
</tr>
<tr>
<td>Hydroxyl radical</td>
<td>2.05</td>
</tr>
<tr>
<td>Positively charged hole on Titanium dioxide (TiO(_{2}^{2+}))</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Table 1. Relative oxidation power of principal oxidizing species
Table 1 illustrates how powerful the hydroxyl radical is. It is non-selective and initiates a complex cascade of oxidation reactions leading to mineralization of the organic compound.

**History**

Advanced oxidation processes (AOP) can be usefully defined as: Near ambient temperature and pressure water treatment processes which involve the generation of hydroxyl radicals in sufficient quantities to effect water purification (Glaze et al., 1987).

The earliest evidence of this phenomenon was recorded by Bach (1889), who observed who observed the photolysis of carbonic acid. The decomposition of H$_2$O$_2$ by UV was later observed by Thiele (1907). Kornfeld (1922) developed the reaction products from the photolysis of H$_2$O$_2$. Therefore, the basic concepts of the modern AOP technologies are over 100 years old.

Today these processes are an essential tool in the removal of a number of microconstituent compounds such as N-nitrosodimethylamine (NDMA). NDMA is a known carcinogen and is effectively removed using only UV light. UV light at or close to 228 nm is used to photolyze this compound – effectively breaking the bonds within the molecule. In the United States, California has established a notification level of 10-ng/L for NDMA, which likely will serve as a future regulation in the state.

In the north of Holland, the PWN Water Supply Company successfully replaced breakpoint chlorination at their Andijk drinking water treatment plant by using the UV/H$_2$O$_2$ process. The plant wanted to provide control against emerging organisms that are chlorine tolerant while reducing by-product formation and controlling organic contaminants. The effect of UV and H$_2$O$_2$ on 12 pesticides was studied. For an electric energy of 1 kWh/m$^3$ degradation varied from 18% for trichloroacetic acid to 70% for atrazine. For a combination of ≤1 kWh/m$^3$ and ≤15 g/m$^3$ H$_2$O$_2$ all pesticides could be degraded by more than 80% (Kruithof et al., 2005).

In the UK, operators at the Mid Southern Water drinking water plant at Boxall’s Lane used UV light to effectively remove a wide variety of pesticide species from well water being abstracted from chalk aquifers (McCLean, 2000). Atrazine, simazine and diuron in concentrations 0.1 to 0.5 μg/L were successfully removed using UV light alone and a higher removal rate was achieved when UV was combined with that of H$_2$O$_2$.

A 12-month study undertaken at Greater Cincinnati Water Works examined the ability of a low-pressure and medium-pressure UV system to reduce 7 contaminants of interest (atrazine, metolachlor, MTBE, MIB, ibuprofen, gemfibrozil and 17-α-ethynylestradiol), some of which have been found in the Ohio River (Metz, 2011).

Figure 1. ETS-UV™ systems used as part of an AOP pilot study at the Greater Cincinnati Public Water Works

The study examined the addition of up to 10 mg/L of H$_2$O$_2$ in conjunction with the UV systems, and recorded encouraging degradations under different process conditions (Meyer, 2009). This facility also compared UV-mediated AOP using chlorine (Cl$_2$) rather than the conventional H$_2$O$_2$. The improvement in performance and probable cost-savings they measured were striking at this facility.

Studies carried out by Watts and Linden (2007) and Watts et al. (2012) have shown that UV/Cl$_2$ AOP is significantly more cost-effective than UV/H$_2$O$_2$ as an AOP (Watts et al., 2012). Additional studies undertaken by Rosenfeldt et al. (2013) at Greater Cincinnati Water Works, using the ETS-UV system, showed that UV/Cl$_2$ AOP is capable of reducing MIB by up to 90%, and that this combination out performs UV/H$_2$O$_2$ at low oxidant concentrations with significantly lower costs by avoiding the need for quenching agents. Interestingly, the study showed no evidence of disinfection by-products formation; this is likely due to the highly reactive nature of the oxidizing species within the AOP environment.

**The science of photolysis**

Conventional ozonation or H$_2$O$_2$ oxidation of organic compounds does not completely oxidize many species to CO$_2$ and H$_2$O. In a number of reactions, the intermediate oxidation products can be more toxic than the initial compound. Completion of the oxidation reactions is regularly achieved using UV light. Ozone readily absorbs UV light to form ·OH from a H$_2$O$_2$ intermediate, as shown below:

\[
O_3 + hv \rightarrow O_2 + O(^1D) \\
O(^1D) + H_2O \rightarrow H_2O_2 + hv \rightarrow 2 \cdot OH
\]
The molar absorption coefficient of $\text{H}_2\text{O}_2$ for UV light at 254 nm (the wavelength produced by low-pressure) is very low. The $\text{H}_2\text{O}_2$ absorbance increased when polychromatic lamps (medium-pressure lamps with broader spectral output) are used and further increased when high-quality synthetic quartz is selected with enhanced UV transmittance below 240 nm. The process is still inefficient due to the low absorbance of UV above 220 nm.

The direct photolysis of hydrogen peroxide leads to the formation of hydroxyl radicals

$$\text{H}_2\text{O}_2 + \text{hv} \rightarrow 2 \cdot \text{OH}$$

The $\cdot$OH radicals are unselective and so react quickly. At $\text{H}_2\text{O}_2$ concentrations over 100 mg/L, the species are scavenged by $\text{H}_2\text{O}_2$.

These reaction mechanisms are complex and varied. The illustration below highlights some potential breakdown pathways.

Figure 2. Potential reaction pathways

The active chlorine species, and indeed chlorine mediated AOP processes, are gaining traction. Operating cost, ease of chemical handling and safety are essential considerations. The conventional practice of dosing $\text{H}_2\text{O}_2$ to then need to quench it with expensive chemicals looks to be obsolete.

A better way

The Evoqua approach to UV-mediated AOP is to combine an advanced electrode arrangement upstream of the UV lamps into the AOP system.

The electrode consists of anode and cathode plates that are highly efficient in converting TDS and other mineral salts found in most ground or surface water into the active chlorine species and cleaving the water into $\cdot$OH, via the formation of $\text{H}_2\text{O}_2$.

$$2\text{H}_2\text{O} \rightarrow \text{H}_2\text{O}_2 + \text{H}_2$$

The anode and cathode work together to produce trace amounts of $\cdot$OH and ClO$^-$/HOCl (the ratio depends on the pH of the water), which are formed in situ immediately upstream of the UV lamps. The electrodes use a switching power supply to remove any hard water deposits off them. This has the obvious benefit of not requiring the bulk storage of $\text{H}_2\text{O}_2$ on site nor does it require the addition of quenching agents due to the inherent inefficiency of the conventional $\text{H}_2\text{O}_2$ AOP.

Initial testing of the electrode/UV technology has shown great success. The first study occurred at a drinking water facility in New York to show the effectiveness of MIB destruction. The results showed a greater than 75% reduction (testing analysis only showed <9.8 ng/L in the effluent concentration, so reduction could have been much higher).

The second study was performed at a direct potable reuse demonstration facility in California targeting 1,4-dioxane. Once again, the technology showed to be effective providing a $>0.5$-log reduction, which is industry standard for 1,4-dioxane. Results of pilot are shown above in the upper right. Additional pilot/testing is scheduled to begin by the end of 2017 with additional data expected in 2018.

Figure 3. Electrode assembly being inserted into an ETS-UV™ AOP system, directly upstream of the UV lamps

Figure 4. Electrode-based AOP removal of 1,4 dioxane

UV will continue to play an active role as a disinfection barrier against the chlorine tolerant organisms. As the available water supply dwindles, and we are forced to use and eventually reuse water, so the removal of micro-contaminants, CECs and
PPCPs will become more pressing. Conventional wastewater plants were not built as a barrier to these nuisance compounds so cannot be expected to effectively remove them. Oxidation using UV light and a number of oxidants would seem to be a logical next step. Hydrogen peroxide alone probably isn’t the answer to AOP process, and UV-mediated AOP using chlorine and the active chlorine species offers significant operational and safety benefits (Rosenfeldt et al., 2013).

References


Meyer, M. 2009, Greater Cincinnati Water WQTC.


2017 IUVA World Congress

The International Ultraviolet Association honored outstanding contributions and achievements at the 2017 IUVA World Congress in September in Dubrovnik, Croatia. With numerous submissions over several categories, the awards selection committee included Jennifer Osgood, of CDM Smith; Jutta Eggers, with DVGW; and Harold Wright, of Carollo. IUVA President Oliver Lawal presented the awards to the 2017 winners.

Best Research Paper for the period 2015-17


Authors: Sara Beck, University of Colorado; Harold Wright, Carollo; Thomas Hargy, Corona Consulting; Thomas Larason, National Institutes of Standards & Technology; and Karl Linden, University of Colorado

This paper represents the first time that a very accurate tuneable laser from the National Institute of Science and Technology has been used to determine the action spectra for several important pathogens and microorganisms used for biodosimetry tests of UV reactors. This is very important information for the validation of UV reactors using medium pressure (polychromatic) UV lamps.

Best paper in IUVA News for the period 2015-17


Authors: Adel Haji Malayeri and Madjid Mohseni, University of British Columbia; Bill Cairns, Trojan; and Jim Bolton, Bolton Photosciences

The sensitivity of organisms to UV, especially of pathogens, is essential knowledge in applying requirements for UV to disinfect and also in adequately designing UV treatment technology and installations to protect public health. This collection and curated assembly of the scientific state of knowledge around such microbe sensitivities is a substantial undertaking and a significant contribution to easily access the state of the science and to aid in the practical implementation of UV from the regulatory to site installation stages.
**Best Classic UV Paper**


**Authors:** Keith Bircher, Calgon Carbon; and Harold Wright, Carollo

This was the first paper to suggest the calculation of log-inactivation instead of RED (Reduction Equivalent Dose) in the dose calculation for a UV reactor and has enabled the use of a single equation to incorporate multiple surrogate organisms with varying UV sensitivities in the validation dose equation. It also is the first paper to suggest the use of a combined variable. The use of this combined variable forms a substantial part of the proposed “Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems” now under review for issuance by the US EPA as an adjunct to the UVDGM.

**Best Conference Paper for the period 2015-17**


**Author:** Gabriele Messina, University of Siena

Microbial keratitis, or MK, is a condition caused by various infectious agents. Use of contact lenses is the major risk factor for MK. The aim of the study was to test a novel UV C (UVC) emitted by Light Emitting Diode (LED) for disinfecting contact lenses. The conclusion of the study shows the effectiveness in reducing contact lens microbial contamination and, given the lack of effectiveness on certain pathogens of commercialized solutions, the fact that new methods, such as UVC, should be developed to facilitate contact lens hygiene.

**UV Young Professional Award**

Dr. Li Si, of Peking University

This award recognizes a young professional (defined as being younger than 35 through Dec. 31, 2017) who has made an exceptional contribution to UV research, design, innovation or applications in the period 2016-17. Dr. Li Si’s research involves the application of UV, including UV LEDs in effective decomposition of emerging contaminants (antibiotics and endocrine disrupting compounds) in drinking water and wastewater. She has published three peer-reviewed papers and presented in six conferences in the areas of photolysis and photocatalysis.

Dr. Si won the President’s Graduate Fellowship at National University of Singapore in 2016, and she was the leader of a team that were finalists in the Singapore Challenge 2016 competition, with a project to use a bioretention garden and a UVA/LED photocatalytic system to recycle greywater for toilet flushing.
Innovative Application of UV

Professor Kumiko Oguma, of the University of Tokyo, for her exemplary innovative work involving UV applications

Dr. Oguma’s research aims to develop and apply new UV technologies to provide safe, stable and sustainable water to people not only living in urban areas with large-scale municipal water supplies but also living in remote areas with decentralized small-scale water supplies. In particular, she has made genuine achievements in point-of-use (POU) water treatment devices that fit developing countries and mobile systems that cope with emergency circumstances.

Dr. Oguma has been leading the research and application of UV light emitting diodes (UV LEDs) to water disinfection and has proposed several innovative reactor designs.

UV Light Award for Volunteer Recognition

Ron Hofmann, professor of civil engineering at the University of Toronto

The UV Light Award for Volunteer Recognition honors a dedicated volunteer working to support the mission of the IUVA.

Since joining the IUVA at its inception in 1999, Professor Hofmann has served as an active IUVA participant and leader and is currently secretary of the Executive Operating Committee. He joined the IUVA Board of Directors in 2004, with a particular interest in educational outreach. He has chaired or co-chaired the technical program of many of the IUVA’s regional and World Congresses. In addition, he currently serves as chair of the Education Committee.
Lifetime Achievement Award
Regina Sommer, professor at the Medical University of Vienna

This award recognizes professional dedication and lifetime achievement in promoting UV and the mission of the IUVA.

Professor Sommer has made a number of significant contributions to the UV industry, including as a major contributor to the Austrian Standards, a key to general UV disinfection in Europe predating many other national standards such as the UVDGM, as well as other standards efforts.

She runs the Water Test Centre Wientalas practically applying the ÖNORM disinfection standards for both LP and MP UV technologies. In addition to this, she serves on the Austrian drinking water commission and is also the water quality representative for the Austrian Standards Institute. Professor Sommer is an associate professor at the Medical University of Vienna, Austria. She is not only an author of numerous high-impact publications but also specifically key publications to the fundamental aspects of UV disinfection.

Best Student Presentations
Oliver Lawal and Ron Hofmann presented the awards.

First place
David Miklos, Technical University of Munich

UV/H₂O₂ Pilot-Scale Process Validation and Process Reliability Evaluation for Trace Organic Chemical Removal from WWTP Effluents

Authors: David B. Miklos, Rebecca Hartl, Karl G. Linden, Jörg E. Drewes and Uwe Hübner
Second place (tie)
Natalie Hull, University of Colorado-Boulder

Longitudinal Disinfection Performance of a UV-LED Reactor Piloted at a Drinking Water Plant

Authors: Natalie Hull and Karl Linden

Second place (tie)
Wen-Long Wang, School of Environment, Tsinghua University

Degradation of Trace Organic Chemicals by LED-UV/Chlorine for Water Reclamation: Synergistic Effects

Authors: Wen-Long Wang, Uwe Hübner, David Miklos, Karl G. Linden, Hong-Ying Hu, Jörg E. Drewes

American Air & Water®

UVC SYSTEMS FOR A HEALTHIER INDOOR ENVIRONMENT

American Air & Water®, Inc.
Your Solution Provider for all Air, Surface & Water Disinfection Needs

www.americanairandwater.com
Toll Free: 888-378-4892 * Fax: 843-785-2064

Boston Electronics

UV Photodiodes and UV-LEDs

High reliability, high performance, and affordable UV SiC sensors, from sglux; and Deep UV-LEDs from Nikkiso. Boston Electronics is your single source for these superior UV devices.

www.boselec.com    uv17@boselec.com
IUVA and Other Related Events

2018 International Symposium on Potable Reuse
Jan. 22-23, 2018 / Austin, Texas
www.awwa.org/conferences-education/conferences/potable-reuse.aspx

IUVA Americas Conference
Feb. 26-28, 2018 / Redondo Beach, California
www.iuva.org/Americas-Conference

UV LED Technologies & Applications
April 22-25, 2018 / Berlin, Germany
www.iuva.org/BerlinConference

IUVA and Other Related Events

One-Stop UV-Supplier
for Ballast Water Treatment Systems
Special Components for Special NEEDS:
- MEDIUM Pressure Lamps
- LOW Pressure Lamps
- Electronic POWER Supplies
- UV-Sensors
- Quartz sleeves

hönle group

The heart and soul
for your UV equipment – made in Germany

The heart: Our medium pressure UV lamps
We develop and manufacture most powerful UV lamps at highest quality standards.

The soul: Our electronic lamp controls for UV lamps up to 32 KW
They combine excellent lamp control performance with highest reliability, also for marine applications like BWTS.

uvtechnik.com
www.eta-uv.de

eta plus electronic gmbh
Lauterstrasse 29, 72072 Nuertingen, Germany
phone +49 7022 6002 813, info@eta-uv.de

The heart: Our medium pressure UV lamps
We develop and manufacture most powerful UV lamps at highest quality standards.

The soul: Our electronic lamp controls for UV lamps up to 32 KW
They combine excellent lamp control performance with highest reliability, also for marine applications like BWTS.

www.eta-uv.de
Consulting M&A Announces Consulting Company

Consulting M&A Business Development LLC announces the formation of a new high-level UV Consulting company specializing in UV systems, UV lamps, UV ballasts, new UV technology advice traditional UVC vs. future UVC with LEDs, marketing and how to go to market. The group is comprised of industry experts from multiple UV market segments.

A high level of expert knowledge can be crucial when new products are being designed, planned, pre-tested and validated. R&D, marketing and technical staffing invest time, money and resources during new product development cycles so efficiency of these resources and added value is crucial.

Many managers in the UV industry (i.e., R&D, engineering, operations, etc.) often wonder if they have the right internal expertise. They may ask such questions as: What is the current market demand in terms of UV systems? What state of the art technology should be offered to avoid obsolescence in the next 5+ years? Our group will provide the necessary support in this and many other areas of the product realization cycle.

For further information, see [http://uvlampconsulting.com](http://uvlampconsulting.com) or contact Karl Platzer (platzer@uvlampconsulting.com).

AquiSense Technologies and Distform S.L. Collaborate to Offer Award-Winning Food Protection

AquiSense Technologies announced a commercial collaboration with Distform S.L. on its product line, mychef™ combi ovens. AquiSense’s PearlAqua Micro™ has been integrated into the mychef™ oven for disinfection of the steam vapor.

The addition of the PearlAqua Micro provides an enhanced level of protection against pathogens that affect food quality and safety. The PearlAqua Micro utilizes advanced UV-C LED technology and is the world’s smallest UV disinfection system.

International Water Association Launches Book


Atlantic Ultraviolet Unveils NSF Certification

Atlantic Ultraviolet Corporation® (AUV) announced receipt of NSF® International certification for its line of SANITRON® ultraviolet water purifiers, models S37C to S25,000C, for compliance with NSF®/ANSI 61 and 372 — Drinking Water System Component — Health Effects and Lead Content. SANITRON® Models S37C through S25,000C are capable of handling 12 gallons per minute (GPM) to 416 GPM while providing bactericidal treatment of water.

Atlantic Ultraviolet’s SANITRON® line of water purifiers, 12 gallons per minute (GPM) and higher, also have been tested and certified to NSF®/ANSI 61 and NSF®/ANSI 372 (low lead requirements). Engineered and manufactured in the US of type 316 stainless steel and the highest quality materials, all NSF® Ultraviolet Water Purifier SANITRON® models come with five standard features and numerous optional accessories that provide safe, rapid and economical water treatment for a variety of applications.

Boston Electronics Debuts Radiometer

UV sensors are used in industrial, research and development, and workplace safety applications. Frequently, the measurement signal generated by the sensor is sent directly to an instrument for display. For these applications, Boston Electronics specifies sglux GmbH’s UV radiometers with sensors tailored to the customer’s requirements. These UV radiometers detect, measure, and store the UV sensor’s signal and provide a wide range of operational features.

The sglux UV*PLOT is a Radiometer/Datalogger for use with sglux USB UV sensors. UV*PLOT software can be used on computers and/or tablets. If you need to display more than just the current radiation intensity, UV*PLOT has additional...
features such as a dosimeter function, datalogging, or seeing the intensity history on the screen.

The UVPL0T is an all-round instrument for professional display and processing of radiometric data. It can be connected via USB or local network via LAN or Wi-Fi. A four-channel version is available as the UVMULTIPL0T. For more information, visit www.boselec.com or uv@boselec.com or call 617.566.3821.

Nedap Introduces Lamp Driver
Nedap UV introduced its new 4kW electronic Lamp Driver at the Aquatech Amsterdam exhibition. The new Lamp Driver is a compact electronic Lamp Driver featuring active Power Factor Correction, low distortion THD and high-efficiency.

The rack mount option allows compact assemblies of multiple lamp systems in cabinets with small footprint. The 4kW Lamp Drivers can be paralleled or connected in series for operation at higher lamp power levels at ambient temperatures up to 55°C (131°F) and will be UL and cUL approved. For more information, contact Tonnie Telgenhof at tonnie.telgenhof@nedap.com, or visit www.nedap-uv.com.

Enaqua Non-Contact UV Reactors Approved by California Water Resources Control Board
In December 2017, Enaqua announced that its non-contact UV reactor has received conditional acceptance from the California Water Resources Control Board’s (CWRCB), Division of Drinking Water (DDW)-Recycled Water Committee (RWC). This means the system is validated for use for the disinfection of recycled water. Enaqua is the first company to successfully validate non-contact UV reactors per National Water Research Institute (NWRI 2012) guidelines following a rigorous validation process, which started with a revision to the NWRI 2012 protocol to suit a non-contact UV reactor. This is important, as it opens the possibility for customers in California and across the United States to upgrade their disinfection systems using Enaqua’s unique non-contact UV systems.

Join IUVA now...
...to help advance the sciences, engineering and applications of ultraviolet technologies to enhance the quality of life and protect the environment.

Benefits of membership include:

**Magazine**
Each quarterly issue of *IUVA News* contains:
- Technical articles
- Industry news
- Calendar of events

**Websites**

To learn more about IUVA, visit www.iuva.org
January 2018
2018 International Symposium on Potable Reuse, Jan. 22-23
Austin, Texas
www.awwa.org/conferences-education/conferences/potable-reuse.aspx

February 2018
IUVA Americas Conference, Feb. 26-28
Redondo Beach, California
www.iuva.org/Americas-Conference

IUVA Corporate Members

Large organization
Calgon Carbon UV Technologies
Carollo Engineers, Inc.
CDM Smith Inc.
CH2M Hill Engineers, Inc.
Crystal IS
Evoqua Water Technologies
Hazen & Sawyer
Heraeus Noblelight GmbH
Light Sources, Inc.
LIT Ultraviolet Technology
MWH Global
Newland Hi-Tech Group Co. Ltd.
NYC Dept. of Environmental Protection
Philips Lighting BV
Phoseon Technology
SUEZ Treatment Solutions
Trojan Technologies
Xylem Inc.

Small organization
ABIOTEC Technologie UV
Advanced UV Inc.
Allanson Lighting Technologies, Inc.
American Air & Water, Inc.
AquihSense Technologies
Best UV
Boston Electronics
Dowa International Corporation
E. Vila Projects & Supplies, SL
Excellitas Technologies Corporation
Foshan Comwin Light & Electricity Co., Ltd.
Funatech Co., Ltd.
GAP EnviroMicrobial Services Ltd.
Gigahertz-Optik Inc.
Glasco UV LLC
Grundfos Water Treatment GmbH
HaiNing YaGuang Lighting
Electrical Co. Ltd.
JenAct Ltd.
Light Progress

Medium organization
American Ultraviolet Company
Aquionics Incorporated
atg UV Technology
Atlantic Ultraviolet Corporation
Atlantium Technologies Ltd.
Berson UV-techniek
Bio-UV SA
et plus electronic GmbH
Hanovia Ltd.
HDR, Inc.
Nikkiso
Real Tech Inc.
Ushio America, Inc.
UV-technik Speziallampen GmbH
Water Technologies de Mexico
ZED Ziegler electronic Devices GmbH

Small organization
ABIOTEC Technologie UV
Advanced UV Inc.
Allanson Lighting Technologies, Inc.
American Air & Water, Inc.
AquihSense Technologies
Best UV
Boston Electronics
Dowa International Corporation
E. Vila Projects & Supplies, SL
Excellitas Technologies Corporation
Foshan Comwin Light & Electricity Co., Ltd.
Funatech Co., Ltd.
GAP EnviroMicrobial Services Ltd.
Gigahertz-Optik Inc.
Glasco UV LLC
Grundfos Water Treatment GmbH
HaiNing YaGuang Lighting
Electrical Co. Ltd.
JenAct Ltd.
Light Progress

Very small organization
Bolton Photosciences Inc.
Fresh Appeal USA, Inc.
Genicom
OMNI Solutions LLC
Peschl Ultraviolet
Silver Bullet Water Treatment
UV Care
UV Lamp Consulting
UV Resources

IUVA News November 2017
Deep UV LEDs for Disinfectant Applications

- High Performance and High Reliability 3535 SMD package.
- Bare Chip is Available

D series
If=100mA
280nm Po=11mW Vf=5.2V
275nm Po=25mW Vf=5.4V
265nm Po=45mW Vf=6.0V

M series
If=350mA

L series
If=600mA

Z series
If=800mA
Po=75mW Vf=6.9V

NEW

http://www.ultraviolet-led.com
http://www.dowa-electronics.co.jp

For more information, please contact "electronics@dowa.co.jp"

DOWA ELECTRONICS MATERIALS CO., LTD.
Water purification isn’t purely about satisfying the demand for clean water. Customers also have a thirst for ways to reduce energy and maintenance costs with solutions from a partner they trust. Like Philips. Our state-of-the-art UV lamps, drivers and modules are optimized for performance in a wide range of applications. They also come with exceptional development support, including microbiological performance testing. And we’re pioneering the development of UVC LED modules, so together we can be sure it’s pure, today and tomorrow.