Ultraviolet Disinfection Using Light-Emitting Diodes for Municipal Water Treatment Facilities

- Ultraviolet water treatment can destroy pathogens that are chlorine resistant (e.g., giardia and cryptosporidium).
- Traditional and LED-based UV-C sources do not add any chemicals to the water, which can alter the taste and/or composition of the water; they destroy the microorganisms and pathogens using light energy or photons.
- UV-C LED is an efficient electrification method to disinfect water that also offers environmental, health, and safety benefits to workers.
- No disinfection byproducts are generated using UV-C LED water treatment.
- UV-C LED can increase the plant productivity since the hold time in the chemical treatment processing can be reduced.
- LEDs eliminate the use of mercury in the traditional UV lamps.

Background, Objectives, and New Learnings

There are three types of ultraviolet radiation (UV); UV-A rays have a wavelength of 320–420 nanometers (nm); UV-B rays have a wavelength of 280–320 nm; and UV-C rays have a wavelength of less than 280 nm. UV-C light has been used for several decades for disinfection applications, and is well-established as a means of controlling pathogens in water. UV-C is also referred to as ultraviolet germicidal irradiation (UVGI) because of its capability of rendering microorganisms inactive by damaging their DNA and thus preventing the microorganisms' replication. Today, UV-C light is usually generated by low- and medium-pressure mercury lamps. And for larger-scale applications—such as municipal water treatment—UV light systems employ mercury lamps as the current standard practice for mitigation of pathogens. Small UV-C systems for treating water for household point-of-use are available with light-emitting diode (LED) emitters, but larger. UV-C LED systems for municipal and industrial water disinfection applications are still under development.

LEDs are taking an increasing share of the overall UV light source market. The cost of LEDs has decreased over the last five years, and now LEDs are viewed as the "next generation" in UV disinfection where UV-C light sources are needed. While visible-spectrum LEDs have penetrated the markets for general lighting, signage, TV, and mobile backlighting, and other consumer goods, UV LEDs are just beginning to replace incumbent technology sources, e.g., mercury lamps, in other applications. Today, UV-A and UV-B LEDs are used in the industrial process for curing powder coatings, adhesives, inks, and related applications, whereas UV-C LEDs still require R&D to make them market competitive.

The objective of this project is to accomplish the pilot-scale testing of a new device that will apply UV-C light to the disinfection of water, specifically UV-C light that is generated from multiple LED emitters housed in a pilot unit that can be scaled to capacities found in municipal drinking water treatment plants.

Benefits

LED emitters have numerous advantages over chemical- and mercury-vapor-based systems that are currently used for treating water at municipal and industrial facilities. The advantages of LED-based systems include lower cost to operate, longer life, and absence of mercury. Other advantages include tunable wavelengths and much more flexibility in the design of the integrated housings, e.g., fixtures, for the LEDs themselves. On the other hand, it is expected that the integration of UV-C LEDs into a full-size reactor will be a complex optimization exercise, and there is no existing pilot data on UV-C LED disinfection system performance and costs—hence the critical need for this pilot-scale project.

This research offers significant, multifold benefits to the public. Some of the direct public benefits are improved water safety from reduced or elimination of mercury lamps and potential chemical toxicity, overall cost reduction for water treatment for residential, commercial, and industrial customers, improved water quality, improved water sustainability by facilitating recycling, and reuse of water.

While the public benefits are substantial, the benefits for the participating utility are also significant, including:

- Research results are directly applicable to water treatment facilities in the utility service territory
- Research leverages the expertise and resources of the U.S. Environmental Protection Agency (EPA) water laboratory and Washington University in St. Louis (a research center that was used by the past EPRI Municipal Water and Wastewater Program)
- Shared learnings through collaborative research

Project Approach and Summary

The project aims to collaborate with Washington University in St. Louis and the EPA water laboratory (one of the largest federal R&D water laboratories in the country), along with a UV-C LED manufacturer in this effort to work with each participating utility.

The key steps involved in this research project are:

1. Design and supply a pilot-scale UV-C LED device with a maximum capacity of six gallons-per-minute (GPM) that will accommodate a continuous flow of water at varying flow rates to simulate full-scale operation,
2. Perform pilot testing of this UV-C LED device in the EPA Water R&D Laboratory at Cincinnati, OH, under continuous operation of feed water flow simulating various contaminated water types,
3. Provide control, sampling, data collection/analysis, and results reporting in support of the pilot testing, and
4. Develop customer engagement tools to provide a path for utilities to initiate follow-on customer field demonstration projects.

Deliverables

- Technical Report that includes project summary, key findings, and overall effectiveness of UV-C LED light compared to the traditional methods
- Executive Summary that provides a high-level overview of the project
- Final summary presentation

The non-proprietary results of this work will be incorporated into EPRI Program 199: Electrification for Customer Productivity, and made available to funding members of that program and to the public, for purchase or otherwise.

Price of Project

The price per participating utility member is $79,000. The project needs at least three funders to get started.

Project Status and Schedule

The targeted timeline is up to fifteen (15) months from the project start date.

Who Should Join

Electric and water utilities interested in helping the municipal water and wastewater treatment facilities with new technologies that offer environmental, health, and safety benefits to their customers.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Technical Contacts

Allen Dennis at 865.218.8192 (adennis@epri.com)
Baskar Vairamohan at 865.218.8189 (bvairamohan@epri.com)

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com