Efficacy of Inactivation of Legionella pneumophila by Multiple-Wavelength UV LEDs

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Citation:

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Impact/Purpose:

Ultraviolet (UV) light has been successfully used for treating a broad suite of pathogens without the concomitant formation of carcinogenic disinfection byproducts. The emerging light-emitting-diodes (LED) device generating germicidal UV wavelengths has enormous potential for the point-of-use (POU) devices in water disinfection. In this study, we investigated the efficacy of multiple-wavelength UVC LEDs for inactivating Legionella pneumophila which are frequently detected in the plumbing systems of large buildings. Also, we examined the applicability of a low power UVC-LED POU device for use in hospital, senior care facilities, and other buildings where immunosuppressed individuals are at risk from infections of L pneumophila.

Description:

Background: Ultraviolet (UV) light has been successfully used for treating a broad suite of pathogens without the concomitant formation of carcinogenic disinfection by-products (DBPs). However, conventional mercury UV lamps have some practical limitations in water treatment applications, such as inefficient energy consumption and more importantly potential mercury contamination upon disposal of the lamps. Comparatively, the emerging light-emitting-diodes (LED) device generating germicidal UV wavelengths is smaller, lighter, less fragile, and mercury-free. Moreover, it has enormous potential for the point-of-use (POU) devices in water disinfection. In this study, we investigated the efficacy of multiple-wavelength UV LEDs for inactivating Legionella pneumophila which are frequently detected in the plumbing systems of large buildings. Methods: Log phase L. pneumophila cells were used in all experiments and were generated by incubation at 35C for 48 hours in buffered yeast extract broth. Bench-scale performance evaluations were conducted using a collimated beam (CB) apparatus with LEDs emitting at 255 nm, 265 nm, and 285 nm as well as a monochromatic low-pressure (LP) UV lamp at 254 nm for comparison. The incidence irradiance of UV intensity was measured with a calibrated radiometer at before and after each CB exposure. At each wavelength, six CB exposures were conducted in duplicate generating a UV dose-response curve demonstrating up to 4-log inactivation for L. pneumophila. The CB exposure tests were performed using washed cultures of L. pneumonia at 105 CFU/mL. Samples were plated onto buffered charcoal yeast extract (BCYE) agar and then incubated for 5-7 days at 35C. The number of colony forming units(CFU) present were counted. Results: The 265 nm and 285 nm LEDs were most effective for inactivation of L. pneumophila, followed by the 255 nm LED and lastly the LP UV. For a 2-log inactivation (i.e., 99% reduction) credit by all the wavelengths LED, UV doses averaged approximately 2 mJ/cm2, whereas the UV doses were increased by 50% (i.e., about 3 mJ/cm2) for the least effective LP UV. The UV doses for L. pneumophila yielded much greater inactivation rate constants than E. coli, enteric viruses and other opportunistic premise plumbing pathogens (OPPPs) such as nontuberculous mycobacteria. Conclusions: Overall, UV LEDs demonstrated the capability to effectively inactivate L. pneumophila. Superior performance of all the LEDs tested to conventional LP UV encourages further studies on its applicability for sustainable water treatment and the development of a low power UV-LED POU device. The latter would be applicable for use in hospital, senior care facilities, and other buildings where immunosuppressed individuals are at risk from infections of OPPPs including L pneumophila.

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