Whitepaper

UVC LED Upper-Air Disinfection: A Cornerstone in the Fight against Coronavirus

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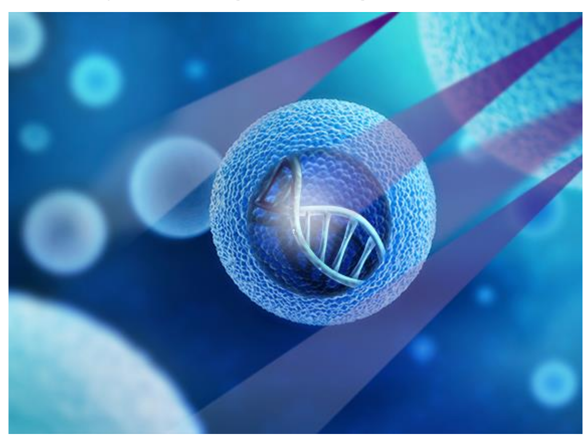
Background

For well over a century, the disinfection power of UVC irradiation has been established, accepted, and very well understood. There have been hundreds of scientific studies published on the effectiveness of UVC to achieve inactivation of viruses and pathogenic microbes on surfaces (Downes & Blunt, 1877), in water (The River Durance Treatment Plant, Marseille France, 1910) and in air (William F. Wells 1933-1935).

The mechanism for pathogenic microbe and virus inactivation thru UVC irradiation is relatively straightforward: UVC irradiation induces damage to the genomes of bacteria and viruses by breaking bonds and forming photodimeric lesions in nucleic acids, DNA and RNA. These lesions, in turn, prevent both transcription and replication, and ultimately lead to inactivation… preventing microorganisms and viruses from infecting and reproducing.

Coronaviruses (including SARS-CoV-1, MERS-CoV, and SARS-CoV-2) belong to a widely diverse family of single-stranded RNA viruses, comprised of an integral membrane protein and protected by a lipid bilayer. These viruses have been shown to be vulnerable to UVC irradiation, and both the CDC and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have endorsed UVC as a suggested mitigation step to reduce the spread of COVID-19.



Rendering of UV energy damaging a microorganism's DNA.

A Cornerstone in the Fight against Coronavirus:

Over the past twenty years, the world's population has faced enormous impacts to health and the global economy from highly infectious zoonotic viruses such as SARS-C0V (2002-2003, *Severe acute respiratory syndrome-related coronavirus*), MERS-CoV (2012-2013, *Middle East respiratory syndrome-related coronavirus*) and more recently, SARS-CoV-2 (2019-Present, *Severe acute respiratory syndrome-related coronavirus 2).*

In the latest strategic battle against SARS-CoV-2, and the disease it causes, COVID-19, one of the most crucial decisions businesses, healthcare providers, and safety managers face is how to design and manage an effective contagion control program. Moreover, it is becoming increasingly clear that relying upon one single modality alone (e.g., autonomous robots delivering pulsed xenon UV-C for surface decontamination during unoccupied-hours, or air filtration/decontamination of air as it passes through HVAC systems, or manual sanitizing wipes and topical chemical washing for surface disinfection), is insufficient and at best, only partly effective.

Accordingly, the U.S. Centers for Disease Control and Prevention (CDC) now recommends a *layered* approach to managing the risk of COVID-19.[1] A structured, multifaceted strategy combines numerous prevention measures including manual cleaning and disinfection, physical distancing, and especially ventilation interventions such as adding high-efficiency particulate air (HEPA) filtration systems, and upper-room ultraviolet germicidal irradiation (UVGI) systems.

Creating this type of continuous, determined decontamination program whenever people are present is essential. Stated simply, you can achieve temporary, near-total surface decontamination using a pulsed xenon robot in areas which are unoccupied by wiping down surfaces at the start of the business / work / school day. However, the first infected individual to enter the room in the morning introduces the contamination process all over again.

In order to achieve a successful decontamination program, it is crucial to select the best, most relevant tool for the job at hand: In the case of COVID-19, the primary transmission vector is airborne aerosol spread, not surface contamination. The CDC now estimates that the risk of COVID-19 infection by fomite (surface) transmission route is quite low, and generally, less than 1 in 10,000.[2] This means that each contact with a contaminated surface has less than a 1 in 10,000 chance of resulting in an infection.

Therefore, while surface decontamination is still a big part of a layered approach to contamination control, it is likely not the key to providing a safe environment as it pertains to COVID-19. Surface decontamination alone may not be the best starting point for your overall program.

Rather, a combined ventilation and upper-air approach utilizing photobiology and UV-C decontamination is essential for containing an airborne aerosol spread. Without question, lingering aerosol risk and direct droplet transmission are the primary culprits in the spread of COVID-19. Since UV-C irradiation has been confirmed as highly effective in the deactivation of airborne and aerosolized coronavirus, including COVID-19, [ibid] a combination of enhanced ventilation and air treatment equipment are the most effective implements in the fight. These tools should be included at the start of your program.

Furthermore, as the cornerstone for any successful germicidal control program, one of the most powerful, effective and sustainable weapons to deliver UV-C in this battle is continuous **upper-air disinfection**.

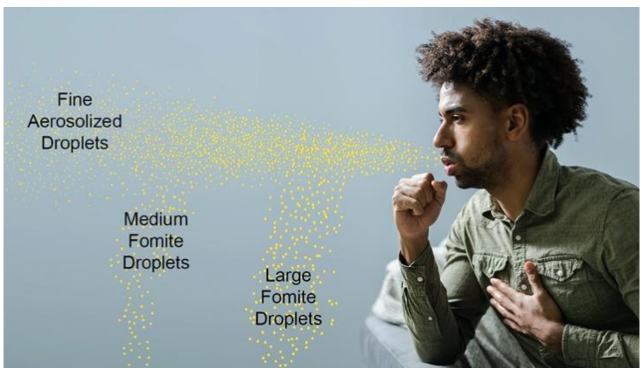
Start your Germicidal Program with Upper-Air UVC Disinfection

For over 70 years, upper-air germicidal ultraviolet irradiation (UVGI) systems have been accepted as a potent, effective foundation for disinfection and airborne contamination control. [1] The landmark TUSS project (TB/UV Shelter Study) was a double-blind, placebo-controlled field trial of upper-room ultraviolet germicidal treatment involving six cities and 14 shelters from 1997 – 2004. [5] Coordinated between St. Vincent's Hospital and Harvard School of Public Health, TUSS deployed 1200 UVGI luminaires to disinfect the air in nearly 200,000 sq. feet within a diverse set of buildings which helped establish the safety guidelines and categorize the efficacy of upper-air GUV in combatting airborne tuberculosis. [ibid]

Reinforced by a more recent 2015 study in an actual clinical setting, upper-air germicidal UV disinfection was confirmed to be an extremely powerful tool in reducing airborne tuberculosis transmission under real hospital conditions.[6,7]

Although the diseases are different, the primary vectors of transmission for TB, new strain influenza viruses like H1N1, and the various coronaviruses (including SARS-CoV, MERS-CoV, and SARS-CoV-2) are all very much the same: Primarily transmitted by inhalation of contagious droplets produced by infected persons while simply talking, coughing, laughing, shouting, singing or sneezing.[8]

Moreover, the dangers posed by inhalation of contagion have been highlighted by recent compelling evidence that respiratory droplets remain airborne a lot longer, and can travel a lot farther, than previously thought. Respiratory droplets have been shown able to travel up to 8 meters under some circumstances. [9]



Mechanisms of droplet, aerosol, and fomite transmission of SARS-CoV-2.

These findings are consistent with other studies, which have reported on the robustness and tenacity of SARS-CoV-2 compared to the previous coronaviruses. In one study, SARS-CoV-2 was widely detected in the air approximately 4 meters from infected patients in a hospital ward. [11] In other *in vitro* studies, which have determined the persistence of SARS-CoV-2, the virus was shown to maintain its infectivity in aerosols for up to 16 hours.[12, 13, 14]

Implementation: A Heightened Sense of Urgency for an Integrated Approach

Highlighting the need for an integrated, layered plan of attack was the recent 2020 finding from the Korean Academy of Medical Sciences.[15] Early in the pandemic, the primary transmission mode of SARS-CoV-2 had been thought to be principally *close-range* droplet transmission. However, much like the earlier TB studies, a fresh 2020 - 2021 argument has emerged about the possibility of longer-distance, smaller droplet airborne transmission.

On June 17, 2020, there was a COVID-19 outbreak in a restaurant in South Korea associated with long distance virus transmission as a result of standard indoor airflow patterns (infection occurred with 6.5 meters of distance; and after only five minutes of exposure). A total of three infected cases were identified in this outbreak, with maximum air flow velocity of 1.2 m/s, measured between the infector and infected in a restaurant equipped with ceiling-type air conditioners. Again, the index cases were infected at 6.5 meters away from the infector after only 5 five minutes exposure without any other direct or indirect contact. [16]

This particular outbreak underscores the need for protection and active germicidal control utilizing upper-air disinfection (UVGI) as your program's foundation. Even the most commonly used type of conventional UV-C control within air ducts may be inadequate: When UV-C irradiation is used in ductwork, although it may be practical for purifying the air that ultimately reaches the recirculator, it may not be as effective in limiting viable pathogens, and preventing person-to-person transmission from air outside the ductwork where both an infectious source and vulnerable persons share a confined space and the same air. [17] The CDC guidance suggests that this is especially important in high-risk indoor settings with inadequate ventilation, crowded spaces where distancing is difficult, or areas with a higher density of sick people (Hospital waiting rooms). The primary objective for any successful program must be to keep the breathing zone clean and free of viral load in real-time.

The Continuing Evolution of UV-C Upper-air Disinfection: Advances in LED Technology

Upper-air disinfection has historically used replaceable mercury lamp technologies, with a lamp replacement-required every two years. Today, LED-based, UV-C upper-air germicidal units represent the next generation of disinfection technology. They offer both the program designer, as well as the end user, enormous advantages over conventional mercury lamp systems.

LED UV-C upper-air units are smaller, lighter, less fragile and more environmentally appropriate than traditional systems. Because they do not require the large electronic drivers characteristic of conventional lamp-based systems, they have a smaller form factor. Unlike gas discharge lamps, they provide instant on-and-off capability for added safety, and require no warm-up times at point of switch on; leading to longer replacement intervals and decreased energy demand. Finally, one of the most intriguing aspects of LED UVC upper-air may be the eventual ability to tailor the output wavelength to the target microbe's absorption spectra. [18,19,20]

Conclusions

Creating your successful disinfection control program depends upon layering germicidal technologies and equipment in order to achieve your overall goal. However, it is critical that you select the right tools from the start: Since SARS-CoV-2 is overwhelmingly transmitted via airborne aerosols, choosing UVGI treatment equipment as the foundation is crucial. Surface treatment equipment like pulsed xenon may be a part of an overall program, but neglecting upper-air treatment will leave your targeted treatment space vulnerable.

Furthermore, advances in UVC LED upper-air technology provide a safe, proven and effective means to ensure that workspaces, treatment centers, business settings and schoolrooms can once again gain control, and help mitigate person-to-person transmission against this deadly pathogen and its rapidly emerging variants.

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