Health & Safety

UV-C Sanitizers: Panacea or Pandemic Theater?

The emergence of the novel coronavirus has created a boom in certain industries, especially those involved with cleaning and sanitation. Social media feeds are filled with the next amazing ultraviolet-C (UV-C) light sanitizing device that will "clean" your cell phone, newspaper, and even library books. Manufacturers of UV light sanitizers make the claim that their equipment deactivates 99% of harmful molecules. But how effective are these devices? Are these machines simply putting on a show to reduce people's anxiety, or are they truly decontaminating objects? What damage to the collections might result? This article discusses how UV-C disinfection works, its limitations, and why that UV sterilizer may not be worth purchasing to "kill" COVID-19.

UV-C (or UVC) light refers to a portion of the ultraviolet spectrum, specifically 200–280 nm. It is known for its germicidal properties and has been used for more than 40 years as a method of decontamination in many industries such as water management, healthcare, and pharmaceuticals. Another decontamination term that is used is ultraviolet germicidal irradiation (UVGI) where only one specific wavelength of the UV-C spectrum is used for sanitizing: 253.7 nm to be exact. However, some articles and companies use "UV-C" and "UVGI" interchangeably. UV-C is often used as a terminal method of disinfection after initial cleaning and disinfection methods to ensure that all pathogens are inactivated, especially in healthcare settings. Many sources find that chemical cleaning and disinfection processes, coupled with UV sanitation as a last step, is the most effective method of disinfection. UV-C works by breaking down the chemical bonds and scrambles the DNA or RNA molecules. Once it is in this new jumble, the pathogen can no longer replicate, even with a viable host. Coronaviruses, like SARS-CoV-2, are very long, single-strand RNA molecules, so they also should be susceptible to UV-C light.

While UV-C is effective against pathogens, there are factors that are necessary when using UV-C light for it to be effective against infectious elements. The effectiveness of UV-C light can depend upon UV irradiance (or intensity), exposure time, ambient relative humidity (RH), distance of the organism from the UV light source, incident angle of the surface to the UV light source, air flow, and overall surface exposure of the affected area. In fact, the abundance of variables makes calculating the UV dose necessary to denature an organism extremely challenging.

The UV dose or fluence rate needed to denature a pathogen is calculated by multiplying UV irradiance by exposure time in seconds. Knowing the UV irradiance is critical for calculating the UV dose needed to eradicate a pathogen. For example, American Air and Water, a company that specializes in UV-C decontamination equipment and services, had two companies verify their UV lamps to determine UV irradiance so that the fluence rate using their equipment could be calculated. This kind of documentation is what is necessary to be able to determine whether a UV light disinfection device will decontaminate a surface.

How else can one determine the effectiveness of a UV-C light sanitizing device? According to the International Ultraviolet Association (IUVA), there are few accepted standards when it comes to selecting equipment for UV disinfection of surfaces. If one is interested in purchasing such equipment, ask the manufacturer these questions before acquiring:

- Do they have copies of scientific papers demonstrating that their unit will work as advertised? The papers should show that the pathogens are deactivated to the level claimed by the company. Third-party lab testing is also recommended as it reduces bias. It also helps to look up the tested pathogens to determine if they are similar in structure to the targeted germs.
- Is the company registered with the Environmental Protection Agency (EPA) as a pesticide device-producing agency? Ultraviolet light units are considered pesticide devices as they are designed to kill, inactivate, or suppress the growth of infectious organisms.

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- Is there an automatic safety shut-off to protect the operator from accidental exposure? UV-C/UVGI light levels can cause burns and retina damage and should be used with extreme caution.
- Does the device emit or generate ozone? Generally, any device that produces ozone should be avoided due to its deleterious effects on humans, organic materials, and the environment.
- Does the equipment meet NIOSH, UL, IEEE, and other related safety standards?
- If it is to be used for sanitization of healthcare equipment, does it have approval from the Food and Drug Administration (FDA)?

As mentioned, even for a device that passes muster, there are additional variables that can interfere with the UV light's ability to decontaminate. Let us look at one of those variables: Surface texture. The ideal surface for disinfection with UV-C light is a perfectly flat surface. Otherwise, any small crevice can be missed by the UV light, harboring bacteria that sits untouched by the UV rays. This is known as a shadow effect. Essentially, if any texture on a surface obscures the UV light, the energy irradiated in the "shadowed" areas will be greatly reduced, or the area may not be exposed at all. So, for a heavily textured surface, the UV fluence rate will need to be much higher either through increasing the UV intensity and/or exposure time or by placing the surface closer to the light source. As conservators know, stronger and/or increased exposure to light energy will result in more damage to an object.

As conservators, we understand the effects ultraviolet light can have on materials. UV light is what we recommend be eliminated from light sources in exhibition and storage. We make strong efforts to ensure that sunlight is filtered of its high-energy UV rays, since it is not needed for the human eye to perceive color and it is the most damaging part of the light spectrum. In addition, because UV-C light is indiscriminate, it will just as readily break up cellulose chains as it will the RNA of the novel coronavirus.

UV-C should be effective against COVID-19 virus, as it is effective against similar coronaviruses such as SARS-CoV-1 and MERS-CoV. Several studies have indicated that it can eradicate SARS-CoV-2 on surfaces, including flat-fold N-95 respirators. Again, other variables, such as incident angles, play a role on how well the entire surface is decontaminated. In some cases, this means that the UV fluence rate will need to be higher to make up for the areas that are not irradiated sufficiently. And if the space is humid, the UV light fluence rate needs to be even higher. That stronger fluence rate could come from increased exposure time or higher UV irradiance. In most cases, it would have to be an increase in exposure time since most devices have a fixed irradiance due to lamp output.

Is UV-C a viable option for collecting institutions amid a pandemic? With the number of variables to be considered in using UV-C effectively combined with the risks associated with UV light exposure for organic materials, it is probably not feasible for best practice. In most cases, a simple 24-hour quarantine is sufficient, cost-effective, and simple, as virus molecules start to degrade almost immediately when outside of a human or animal host.

UV-C light is a useful tool for the healthcare industry where decontamination is essential. Reducing the possibility of infection is paramount, especially during a pandemic. However, it is not a cure-all and should be used with discretion. As discussed, there are multiple factors that need to be examined when using UV-C light for sanitizing purposes. UV-C germicidal equipment may seem like a panacea, but when you dig deeper into the functionality of UV-C light, the variables that need to be considered for effectiveness, and the potential damage to collections and personnel, one finds that it is not a "one-size-fits-all" solution when compared to something as easy as quarantining.

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