https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1280232/

https://www.consumerlab.com/answers/does-uv-light-kill-coronavirus/uv-light-covid/

ConsumerLab.com Answers

Ultraviolet Light Sanitizers and Coronavirus (COVID-19)

Question:
Do UV light sanitizing wands and boxes kill coronavirus (COVID-19)?

Answer:
Yes, ultraviolet light in the "C" range, also known as UVC, has been shown to kill SARS-CoV-2, the virus that causes COVID-19. The big challenge with using UV-C light is being sure your UV lamp provides a large enough dose of UVC light to all the surfaces you need to disinfect, such as a mask, phone, or an entire room, and that you are not exposed to the UVC light, as it is dangerous. UVC works fastest and most reliably on non-porous surfaces, but it may be easier and faster, as well as safer, to clean such surfaces with liquid disinfectants.

https://www.researchsquare.com/article/rs-25728/v1

Far-UVC light efficiently and safely inactivates airborne human coronaviruses

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Abstract

A direct approach to limit airborne transmission of pathogens is to inactivate them within a short time of their production. Germicidal ultraviolet light (UV), typically at 254 nm, is effective in this context, but it is a health hazard to the skin and eyes. By contrast, far-UVC light (207-222 nm) efficiently kills pathogens without harm to exposed human cells or tissues. We previously demonstrated that 222-nm UV light efficiently kills airborne influenza virus (H1N1); here we extend the far-UVC studies to explore efficacy against human coronaviruses from subgroups alpha (HCoV-229E) and beta (HCoV-OC43). We found that low doses of, respectively 1.7 and 1.2 mJ/cm^2 inactivated 99.9% of aerosolized alpha coronavirus 229E and beta coronavirus OC43. Based on these results for the beta HCoV-OC43 coronavirus, continuous far-UVC

exposure in public locations at the currently recommended exposure limit (3 mJ/cm^2/hour) would result in 99.9% viral inactivation in ~ 25 minutes. Increasing the far- UVC intensity by, say, a factor of 2 would halve these disinfection times, while still maintaining safety. As all human coronaviruses have similar genomic size, a key determinant of radiation sensitivity, it is realistic to expect that far-UVC light will show comparable inactivation efficiency against other human coronaviruses, including SARS-CoV-2.

https://www.bbc.com/future/article/20200327-can-you-kill-coronavirus-with-uv-light

There is also a third type: UVC. This relatively obscure part of the spectrum consists of a shorter, more energetic wavelength of light. It is particularly good at destroying genetic material – whether in humans or viral particles. Luckily, most of us are unlikely to have ever encountered any. That's because it's filtered out by ozone in the atmosphere long before it reaches our fragile skin.

Or that was the case, at least, until scientists discovered that they could harness UVC to kill microorganisms. Since the finding in 1878, artificially produced UVC has become a staple method of sterilisation – one used in hospitals, airplanes, offices, and factories every day. Crucially, it's also fundamental to the process of sanitising drinking water; some parasites are resistant to chemical disinfectants such as chlorine, so it provides a failsafe.

Though there hasn't been any research looking at how UVC affects Covid-19 specifically, studies have shown that it can be used against other coronaviruses, **such as Sars**. The radiation warps the structure of their genetic material and prevents the viral particles from making more copies of themselves.

However, it's not quite as good as we might have hoped. In a recent study – which looked at whether UVC could be used to disinfect PPE – the authors found that, while it is possible to kill the virus this way, in one experiment it needed **the highest exposure out of hundreds of viruses that have been looked at so far**. The amount of ultraviolet required varied widely, depending on factors such as the shape and type of material the virus was on.

Nevertheless, a concentrated form of UVC is now on the front line in the fight against Covid-19. In China, whole buses are being **lit up by the ghostly blue light each night**, while squat, UVC-emitting robots have been **cleaning floors** in hospitals. Banks have even been using the light to **disinfect their money**.

https://spectrum.ieee.org/tech-talk/semiconductors/optoelectronics/ultravioletled-maker-demonstrates-30second-coronavirus-kill

Ultraviolet-LED Maker Demonstrates 30-Second Coronavirus Kill

Seoul Viosys shows UV-C LEDs are deadly, lays out path to better efficiency

By Samuel K. Moore

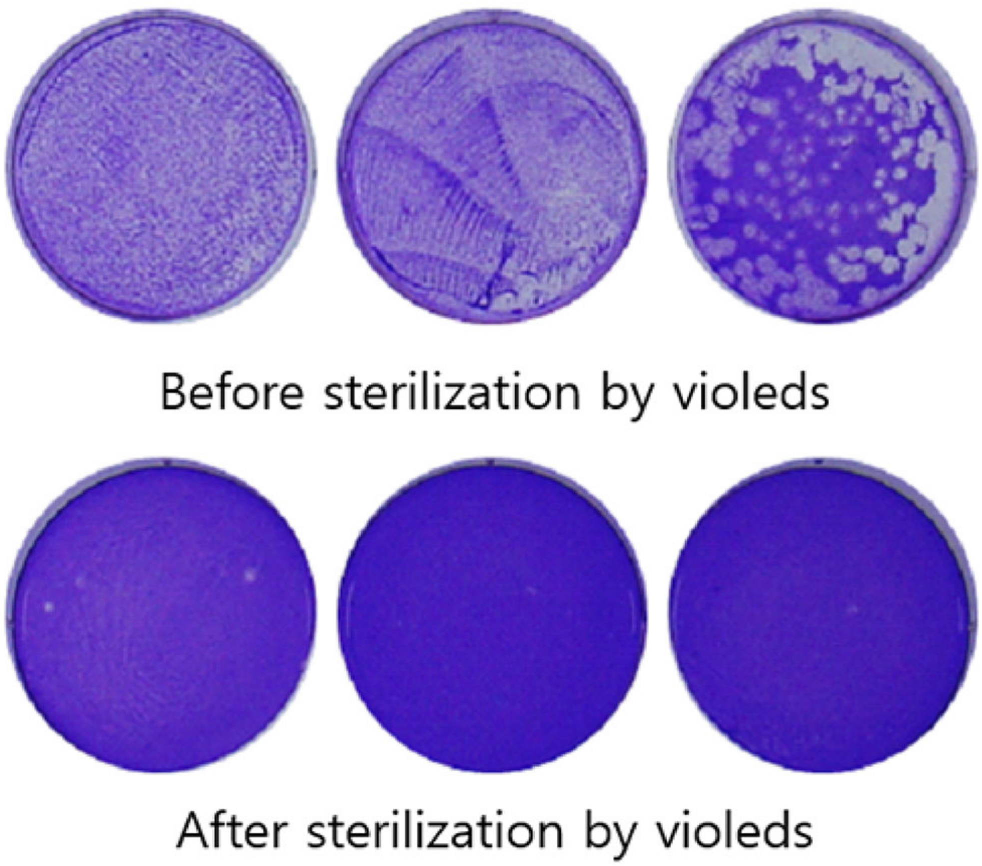
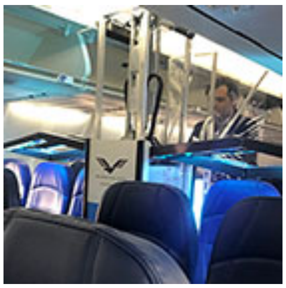
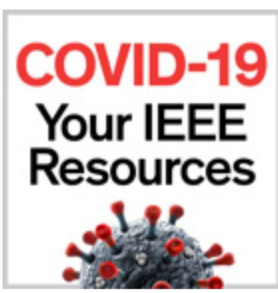


Image: Seoul Viosys/Sensor Electronic Technology/Business Wire

Autonomous Robots Are Helping Kill Coronavirus in Hospitals



Flight of the GermFalcon: How a Potential Coronavirus-Killing Airplane Sterilizer Was Born



COVID-19: Your IEEE Resources

Robots and stranger machines have been using a particular band of ultraviolet light to sterilize surfaces that might be contaminated with coronavirus. Those that must decontaminate large spaces, such as hospital rooms or aircraft cabins, use large, power-hungry mercury lamps to produce ultraviolet-C light. Companies around the world are working to improve the abilities of UV-C producing LEDs, to offer a more compact and efficient alternative. Earlier this month, Seoul Viosys showed what it says is the first 99.9 percent sterilization of SARS-COV-2, the coronavirus that causes COVID-19, using ultraviolet LEDs.

UV LEDs are deadly to viruses and bacteria, because the 100-280 nanometer wavelength C-band shreds genetic material. Unfortunately, it's also strongly absorbed by nitrogen in the air, so sources have to be powerful to have an effect at a distance. (Air is such a strong barrier, that the sun's UV-C doesn't reach the Earth's surface.) Working with researchers at Korea University, in Seoul, the company showed that its Violed LED modules could eliminate 99.9 percent of the SARS-COV-2 virus using a 30-second dose from a distance of three centimeters.

Unfortunately, the company did not disclose how many of its LEDs were used to achieve that. Assuming that it and the university researchers used a single Violed CMD-FSC-CO1A integrated LED module, a 30-second dose would have delivered at most 600 millijoules of energy. This is somewhat in-line with expectations. A study of UVC's ability to kill influenza A viruses on N95 respirator masks indicated that about 1 joule per square centimeter would do the job.

While the 3-centimeter distance may work in tight spaces such as an air filter or water purifier—products that UV LEDs already serve—it won't do for hospital-room-sterilizing robots. The GermFalcon airplane cabin sterilizer, for example, needs to bathe an aircraft cabin in light strong enough to kill the virus in seconds from a distance of about 30 centimeters, its inventor Dr. Arthur Kreitenberg told *IEEE Spectrum* last month. Today's UV-C LEDs can't produce enough light for the job, he said. But with the GermFalcon's mercury lamps, which measure output in watts, that power comes at a large cost in energy and bulk. The system's iron-phosphate battery pack has to deliver 100 amperes to produce the needed UV power.

The potential advantages of UV-C LEDs over mercury lamps include a lack of toxic mercury, better robustness, longer lifetimes, faster startup, and emission at a diversity of wavelengths, which may aid in their germicidal role. But it's their potential for efficiency that could be most important.

At the moment, mercury lamps have a better wall-plug efficiency—electrical power in versus optical power out—than the UV-C LEDs on the market now. The wall plug efficiency of today's UV-C LEDs is just 2.8 percent, with 3.3 percent-efficient systems in the R&D phase, according to Jae-hak Jeong, technical research fellow and vice president at Seoul Semiconductor, Seoul Viosys' parent company. Mercury lamps boast 15-35 percent.

The mercury lamp's advantage is not expected to last, because researchers expect UV-C LEDs to follow a similar efficiency improvement path to solid-state lighting's blue LEDs. However, UV-C devices have a long way to go. Blue LEDs typically have an internal quantum efficiency, the fraction of electrons injected into a specific part of the LED that result in the generation of photons—of about 90 percent. For UV-C it's 30-40 percent, says Jeong. For external quantum efficiency—the ratio of photons emitted to electrons passing through the LED—the comparison is even worse. About 70 percent for blue LEDs versus 10-16 percent for UV-C devices.

According to Jeong, boosting these figures will take improvements both to fabrication process and to epitaxy, the growth of the semiconductor crystal that the LEDs are made upon. These LEDs are usually built by using epitaxy to grow a layer of crystalline aluminum nitride atop a sapphire wafer. Defects in the crystal are a main limiter to LED performance, so improving the epitaxy process is one path toward brighter LEDs.

http://www.iuva.org/IUVA-Fact-Sheet-on-UV-Disinfection-for-COVID-19

IUVA Fact Sheet on UV Disinfection for COVID-19

The International Ultraviolet Association (IUVA) believes that UV disinfection technologies can play a role in a multiple barrier approach to reducing the transmission of the virus causing COVID-19, SARS-CoV-2, based on current disinfection data and empirical evidence. UV is a known disinfectant for air, water and surfaces that can help to mitigate the risk of acquiring an infection in contact with the COVID-19 virus when applied correctly. "The IUVA has assembled leading experts from around the world to develop guidance on the effective use of UV technology, as a disinfection measure, to help reduce the transmission of COVID-19 virus. Established in 1999, the IUVA is a nonprofit dedicated to the advancement of ultraviolet technologies to help address public health and environmental concerns," says Dr. Ron Hofmann, Professor at the University of Toronto, and President of the IUVA.

It must be noted that “UVC”, “UV disinfection” and “UV” as used here and in the scientific, medical and technical literature, specifically and importantly refers to UVC light energy (200-280nm light) in the germicidal range which is not the same as the UVA and UVB used in tanning beds or sunlight exposure.

Facts on UV and COVID-19

Can UVC help prevent COVID-19 transmission by reducing contamination?

Based on existing evidence, we believe so. Here’s why:

UVC light has been used extensively for more than 40 years in disinfecting drinking water, waste water, air, pharmaceutical products, and surfaces against a whole suite of human pathogens (***Fluence UV Dose Required review IUVA***). All bacteria and viruses tested to date (many hundreds over the years, including other coronaviruses) respond to UV disinfection. Some organisms are more susceptible to UVC disinfection than others, but all tested so far do respond at the appropriate doses.

- UVC disinfection is often used with other technologies in a multibarrier approach to ensure that whatever pathogen is not "killed" by one method (say filtering or cleaning) is inactivated by another (UVC). In this way UVC could be installed now in clinical or other settings to augment existing processes or to shore up existing protocols where these are exhausted by excessive demands due to the pandemic.
- COVID-19 infections can be caused by contact with contaminated surfaces and then touching facial areas (less common than person-to-person, but still an issue)[vi]. Minimizing this risk is key because COVID-19 virus can live on plastic and steel surfaces for up to 3 days[vii]. Normal cleaning and disinfection may leave behind some residual contamination, which UVC can treat suggesting that a multiple disinfectant approach is prudent. UVC has been shown to achieve a high level of inactivation of a near-relative of COVID-19's virus (i.e., SARS-CoV-1, tested with adequate dose of 254nm UV while suspended in liquid)[viii]. IUVA believes similar results can be expected when treating COVID-19's virus, SARS-CoV-2. However, the key is applying UVC in such a way that it can effectively reach any remaining viruses on those surfaces.
- IUVA also concurs with CDC guidance to hospitals that the germicidal effectiveness of UVC is influenced by the UVC absorbing properties of the suspension, the surface or aerosol that the organism is in; by the type or action spectra of the microorganism; and by a variety of design and operating factors that impact the delivered UV dose to the microorganism (*https://www.cdc.gov/infectioncontrol/guidelines/disinfection*).

- IUVA recognizes that in the cases where the UVC light cannot reach a particular pathogen, that pathogen will not be disinfected. However in general, reducing the total number of pathogens reduces the risk of transmission. The total pathogenic load can be reduced substantially by applying UV to the many surfaces that are readily exposed, as a secondary barrier to cleaning, especially in hurried conditions. This would be a relatively straight-forward matter of illuminating the relevant surfaces with UVC light, for example the air and surfaces around/in rooms and personal protective equipment.
- UV light, specifically between 200-280nm[i] (UVC or the germicidal range), inactivates (aka, 'kills') at least two other coronaviruses that are near-relatives of the COVID-19 virus: 1) SARS-CoV-1[ii] and 2) MERS-CoV[iii] [iv] [v]. An important caveat is this inactivation has been demonstrated under controlled conditions in the laboratory. The effectiveness of UV light in practice depends on factors such the exposure time and the ability of the UV light to reach the viruses in water, air, and in the folds and crevices of materials and surfaces.

Are UVC disinfection devices safe?

Like any disinfection system, UVC devices must be used properly to be safe.) They all produce varying amounts of UVC light in wavelengths of 200nm-280nm. This UVC light is much "stronger" than normal sunlight, and can cause a severe sunburn-like reaction to your skin, and similarly, could damage the retina of your eye, if exposed. Some devices also produce ozone as part of their cycle, others produce light and heat like an arc welder, others move during their cycles. Hence, general machine-human safety needs to be considered with all disinfection devices, and these considerations should be addressed in the operations manual, in the user training, and appropriate safety compliance.

Are there performance standards and UVC validation protocols for UV disinfection devices?

Given the wide array of UVC devices marketed for disinfection of air, water and solid surfaces, the lack of uniform performance standards and the highly variable degree of research, development and validation testing that is performed on different devices, the IUVA urges consumers to exercise caution when selecting equipment and look for evidence of third party testing as well as certification of device materials and electrical components by well-known organizations such as NSF, UL, CSA, DVGW-OVGW or other international requirements as applicable.

For UVC devices designed to inactivate air and solid surfaces in the healthcare industry, members of IUVA are working diligently with other national standards organizations in the lighting and healthcare industry to develop disinfection testing standards[x]. The goal is to develop guidance that will help healthcare providers world-wide choose the best possible technologies for their institutions to use in the fight against multiple drug resistant organisms and other pathogens[xi], like the COVID-19 virus.

IUVA will soon post a website dedicated to UV and COVID-19, please email us at info@iuva.org, if you would like for us to send you alerts on website postings and other IUVA activities.