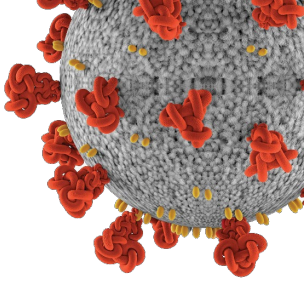
UV Light and its Applications



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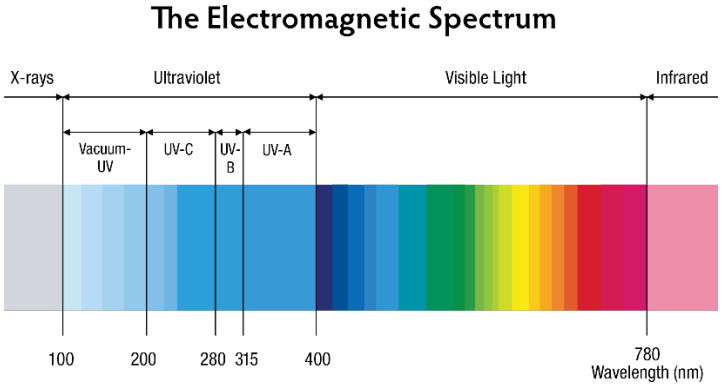
What is ultraviolet light/radiation?

There are three types of ultraviolet radiation in the short-wavelength spectrum that differ in their biological activity and the extent to which they can penetrate the skin:

- **Short-wavelength UVC (200-280nm)** – Has the most energy, can penetrate skin and is the most damaging. Therefore, UVC light is used for disinfection. However, there is evidence that far UVC (207-222 nm) does not cause epithelial or retinal damage.[1,2,3,4] UVC lamps and robots are commonly used to sanitize water, objects (such as laboratory equipment) and spaces (such as buses and airplanes).
- **Medium-wavelength UVB (280-315nm)** – Is responsible for delayed tanning and burning. In addition to these short-term effects, it contributes to skin aging and significantly promotes the development of skin cancer.
- **Long-wavelength UVA (315-400nm)** – Accounts for approximately 95 percent of the UV radiation reaching the earth's surface. It can penetrate into the deeper layers of the skin and is responsible for the immediate tanning effect. Furthermore, it contributes to skin aging and wrinkling.



According to the World Health Organization and the journal *Nature Research*, "Far-UVC light efficiently and safely inactivates airborne human coronaviruses":

- Germicidal ultraviolet light (UV), typically at 254 nm, is effective in this context, but it is a health hazard to the skin and eyes.
- A direct approach to limit airborne transmission of pathogens is to inactivate them within a short time of their production.
- A recent preprint study[5] showed that: "222-nm UV light efficiently kills airborne influenza virus (H1N1)." *The authors further "extended 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/cm2 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/cm2/hour) would result in 99.9% viral inactivation in ~ 25 minutes."*

[1] 207-nm UV light - a promising tool for safe low-cost reduction of surgical site infections. I: in vitro studies. Brenner et al. *PLOS One*. 2013 Oct 16;8(10):e76968. doi: 10.1371/journal.pone.0076968. eCollection 2013.
[2] The protective role of melanin against UV damage in human skin. Brenner et al. *Photochem Photobiol*. 2008 May-Jun;84(3):539-49. doi: 10.1111/j.1751-1097.2007.00226.x.
[3] Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light. Brenner et al. *Radiat Res*. 2017 Apr;187(4):483-491. doi: 10.1667/RR0010CC.1. Epub 2017 Feb 22.
[4] Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases. Welch, D., Buonanno, M., Grilj, V. et al. *Sci Rep* 8, 2752 (2018).
[5] Far-UVC light efficiently and safely inactivates airborne human coronaviruses. *Nature Research*. 10.21203/rs.3.rs-25728/v1 April 27, 2020

- 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.

Germicidal/UVC lamps[6]

A germicidal lamp is a special type of light that produces UVC rays.

How does it work?

- This short-wave UVC light disrupts DNA or RNA base pairing, causing formation of pyrimidine dimers, and leads to the inactivation of bacteria, viruses and protozoa. It also can be used to produce ozone for water disinfection.

What are the dangers?

- For humans, skin exposure to germicidal wavelengths of UVC light can produce rapid sunburn and skin cancer. Exposure of the eyes to this UV radiation can produce extremely painful inflammation of the cornea and temporary or permanent vision impairment, up to and including blindness in some cases. UVC also can damage the retina of the eye. However, there is evidence that far UVC (207-222 nm) does not cause epithelial or retinal damage.[7,8,9,10]

- Another potential danger is the UVC production of ozone, which can be harmful to one's health. The U.S. Environmental Protection Agency designated 0.05 parts per million (ppm) of ozone to be a safe level. Lamps designed to release UVC and higher frequencies are doped so that any UVC light below 254 nm wavelengths will not be released to minimize ozone production. A full-spectrum lamp will release all UV wavelengths and produce ozone when UVC hits oxygen molecules.

Are there are any downsides to using UVC?

- UVC radiation is able to break down chemical bonds. This leads to accelerated aging of plastics, insulation, gaskets and other materials. Note that plastics sold to be "UV-resistant" are tested only for UVB because UVC does not normally reach the surface of the earth. When UVC is used near plastic, rubber or insulation, care should be taken to shield these items. Metal tape or aluminum foil will typically suffice, but it is an added step.

How can the UVC exposure time necessary to effectively sterilize a surface be calculated?[11]

The exposure time necessary to disinfect a surface using UVC dosing is a factor of energy (microwatts) and time over area (seconds/cm^2) of the object. In practical terms, the necessary germicidal dose is based on:

- Time of exposure, light intensity and distance of the UVC light from the object(s) requiring disinfection. Therefore, when the light is within a few inches (distance) of the mask, for example, the bulb wattage (microwatts) is not a major factor; however, the longer the object is exposed (time) to the object, the higher the degree of sterilization.

- Additionally, a secondary form of disinfection is advisable to ensure maximum sterility of the object. Avoid liquid agents as they generally degrade the integrity of the mask material. Time is the most prudent recommendation.

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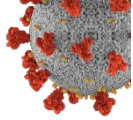
[6] www.clordisys.com
[7] 207-nm UV light - a promising tool for safe low-cost reduction of surgical site infections. I: in vitro studies. Brenner et al. *PLOS One*. 2013 Oct 16;8(10):e76968. doi: 10.1371/journal.pone.0076968. eCollection 2013.
[8] The protective role of melanin against UV damage in human skin. Brenner et al. *Photochem Photobiol*. 2008 May-Jun;84(3):539-49. doi: 10.1111/j.1751-1097.2007.00226.x.
[9] Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases. Welch, D., Buonanno, M., Grilj, V. et al. *Sci Rep* 8, 2752 (2018).
[10] The protective role of melanin against UV damage in human skin. Brenner et al. *Photochem Photobiol*. 2008 May-Jun;84(3):539-49. doi: 10.1111/j.1751-1097.2007.00226.x.
[11] Based on interviews with industry experts at SaniLight.com and ultraviolet.com.



- Consider UVC sanitization of the object (N95 mask) and suspend it on a hook for up to seven days before reuse. The best strategy is to cycle masks on a daily basis before reuse, though this may require a larger quantity of masks, which at this time is often unavailable.

Conclusion

While UV sterilization may not be the ultimate answer to disinfection concerns during the COVID-19 pandemic, it is a currently available and cost-effective option on the market. As more is learned about SARS-CoV-2, AAOMS recommends all OMSs institute intentional redundancies in their office infection control policies until evidence-based recommendations can be made to protect their patients and staff.