White Paper

# Using UV 222nm light to significantly reduce pathogens like SARS-CoV-2(COVID-19) in indoor spaces

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VENDIglobe

*Disease-causing bacteria and viruses threaten the lives of millions of people each year. Since the start of the pandemic, millions have become infected and more than 1 million people worldwide have died. And these numbers continue to increase as many countries move into second and even third waves of infection.*
*History shows us that it's only a matter of time before the next novel pathogen threatens our lives and livelihoods.*
*We need ongoing solutions to defend ourselves from pathogens to reduce their impact on our families, businesses, schools, and communities. We need safe and effective technology for indoor public spaces where people gather—from airports, schools, and public transportation to all forms of entertainment venues—that can effectively reduce pathogens.*

## Could ultraviolet light be an effective solution?

Recent studies point to ultraviolet (UV) light technology as an important potential solution for reducing pathogens in indoor spaces. We know UVC light can reduce pathogens, but traditional germicidal lamps have a peak emission of 254nm which can penetrate our skin and eyes, so it cannot be used where unprotected people are present. These shortcomings constrain how these devices must be operated and limit their widespread use in occupied indoor spaces.

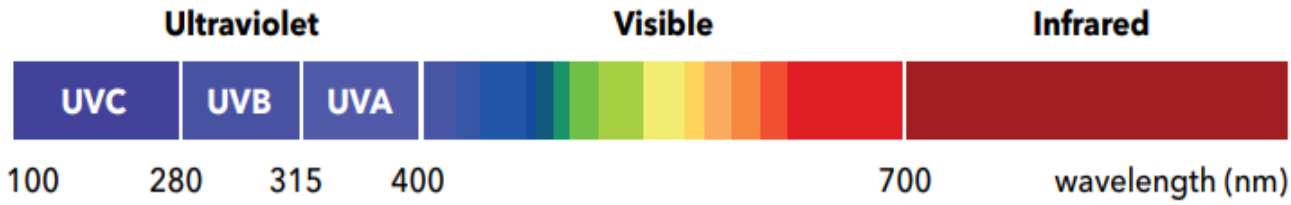
## Is UV 222nm light the answer?

Promising new studies show that shorter UVC wavelengths— with the sweet spot being 222nm—have the unique ability to significantly reduce pathogens and may also be used around people. This white paper examines how shorter wave, UV 222nm light—paired with a short pass filter that prevents longer wavelengths from being emitted—can effectively reduce pathogens like the SARS-CoV-2 coronavirus that causes COVID-19 as well as harmful bacteria, influenza, and even antibiotic-resistant superbugs like MRSA, and may also be used around people. Let's start with a quick look at UV light.

## UVA, UVB, and UVC: what's the difference?

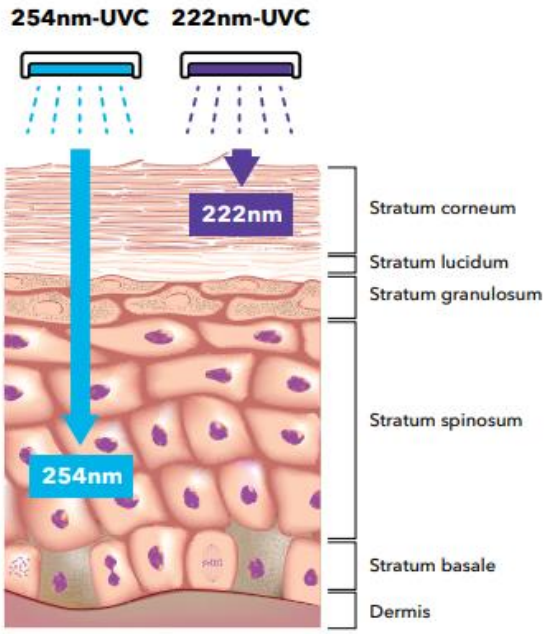
UV light is made up of 3 bands: UVA, UVB and UVC. Around 95% of the sun's rays that reach the ground are UVA rays. They have the longest wavelengths (315nm-400nm) and can damage our skin, causing premature ageing such as wrinkles and are thought to play a role in some skin cancers. UVB rays (280nm-315nm) makeup around 5% of the sun's rays and, while they don't penetrate our skin as deeply as UVA, they can cause significant damage to our skin, including redness, sunburn, and skin cancer. We use sunscreen and wear sunglasses to protect our eyes and skin from both UVA and UVB rays. Most UVC rays (100nm-280nm) don't reach the earth's surface because they're absorbed by the ozone layer. UVC has the shortest wavelengths that, at ranges below 230nm, can't penetrate beyond the top layer of our skin or eyes.

### The spectrum of visible and invisible light




This graphic illustrates the 3 types of ultraviolet light the sun produces: UVA, UVB, and UVC.

## Structure of the epidermis



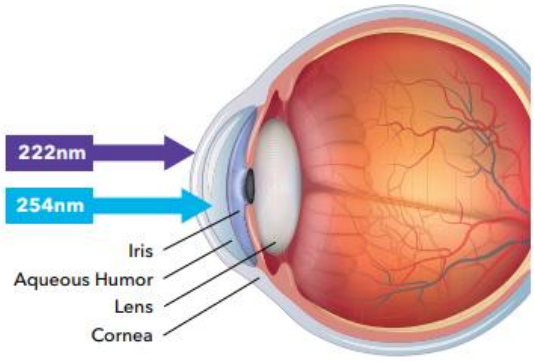

Penetration of epidermis of 254nm vs 222nm

**This graphic illustrates** the significant difference between 254nm and 222nm light: the shorter wavelengths of UV 222nm light have a limited ability to penetrate past the outer layer of our skin. This layer, the stratum corneum, consists of dead skin cells and serves as the primary barrier between our bodies and the environment. Conversely, longer wavelengths like 254nm can deeply penetrate the layers of our skin and can damage the DNA in our skin cells, causing burns and skin cancers.

## Anatomy of the eye

DNA absorbance relative to the wavelength

This graphic illustrates how 254nm (and longer) wavelengths can damage our eyes—including incurable diseases like macular degeneration—because wavelengths of 230nm




and above can penetrate our eyes. Shorter wavelength 222nm light has a limited range that prevents it from penetrating past our corneas, the outermost layer of our eyes.

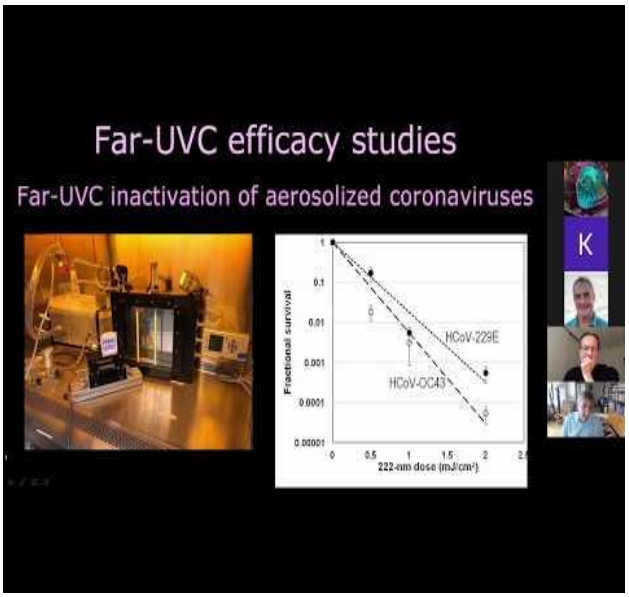
## Shorter UVC wavelengths yield effective results

David Brenner directs the Center for Radiological Research at Columbia University Irving Medical Center in New York City and has numerous distinctions within his field, such as the Oxford University Weldon Prize and the Radiation Research Society Failla Gold Medal Award. Founded by a student of Marie Curie more than a century ago, the Columbia Center for Radiological Research is committed to exploiting all forms of radiation to improve human health and medical care.

Over the past eight years, Brenner and his team have been developing the use of a unique type of ultraviolet light, called UVC light, designed to safely kill viruses such as the SARS-CoV-2 virus that causes COVID-19, as well as drug-resistant bacteria.

As we begin to look forward to a post-COVID era, Brenner envisages the use of overhead UVC light in hospitals, nursing homes, buses, planes, trains, train stations, schools, restaurants, offices, theatres, gyms, food preparation areas -- anywhere where people move closer together.

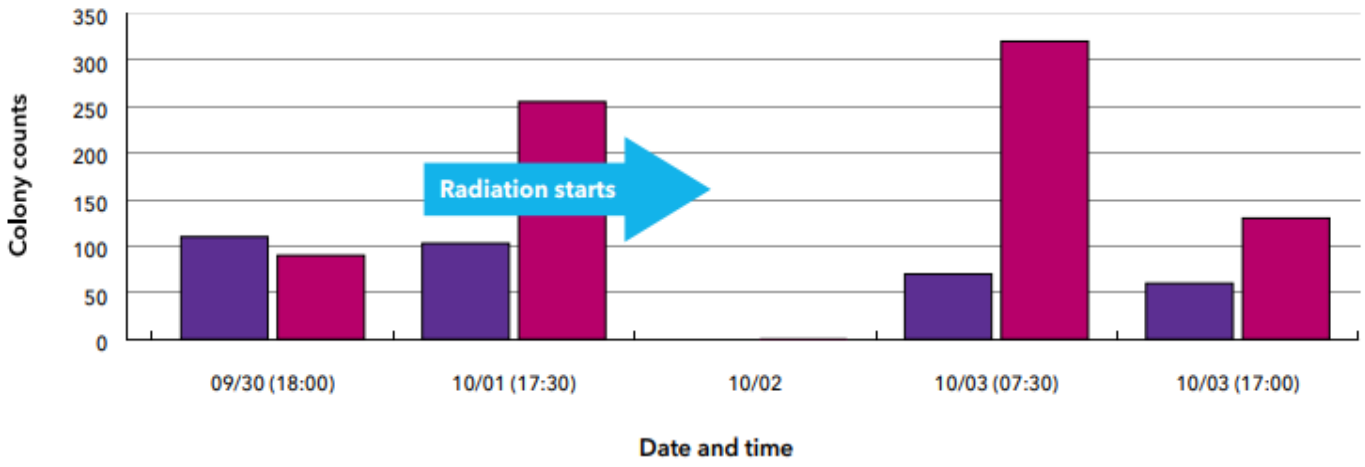
April 2017 TED Talk, Dr. Brenner shares his research on how UVC could potentially kill superbugs and be used around people.




The physics of UVC 222nm light: Studies, safety, and efficacy Dr. David J. Brenner, Ph.D., D.Sc. Theoretical physicist Higgins Professor of Radiation Biophysics College of Physicians & Surgeons Columbia University COVID-19 Virtual Symposium: April 8, 2020 (Video length – 11:23)

**Watch the video >>**

**Air quality comparison** 222nm




This graph compares the number of bacteria found in air sample collections in the treated and untreated bathroom stalls at regular intervals during the test, showing the efficacy of the UV 222nm light that our lamps emit in combating airborne pathogens.

## Japan studies on UVC 222nm light

Inspired by Dr. Brenner's research, Ushio® Inc., a lighting manufacturer in Japan, performed two studies to test the effectiveness of far-UVC 222nm wavelengths using filtered UVC excimer lamps. The first examines the efficacy of using 222nm light to kill bacteria in a public bathroom.

Over 3 days, researchers took surface samples from the floor, toilet seat, doorknob, and switch panel before, during, and after testing, and then analyzed the swabs for bacterial growth. Researchers also collected air samples in each stall throughout the study to test air quality and the presence of airborne contaminants.

## Measuring the effectiveness of 222nm light on surfaces

The study found that after treatment, bacteria growth in the stall treated with 222nm light was noticeably lower than in the untreated stall in almost all areas. Over time, bacteria levels were either further reduced or maintained at a relatively lower level in the treated room.

### Study results:

Researchers were able to use UV 222nm light to reduce the number of bacteria in high-interaction spots**.**

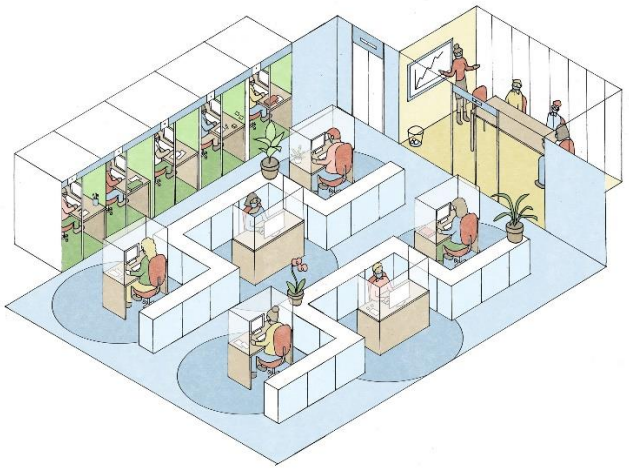
## Testing the efficacy of 222nm light on airborne pathogens

The air quality results are also promising for pathogen reduction because airborne-transmitted diseases can be harder to control than surface-transmitted diseases. In shared spaces, invisible contaminants, such as bacteria, viruses, pollution, and volatile organic compounds can quickly spread. Airborne particles can also lead to increased surface contamination.

### What we can learn from this study:

UV 222nm technology has the potential to reduce pathogens in the air and surfaces of indoor spaces

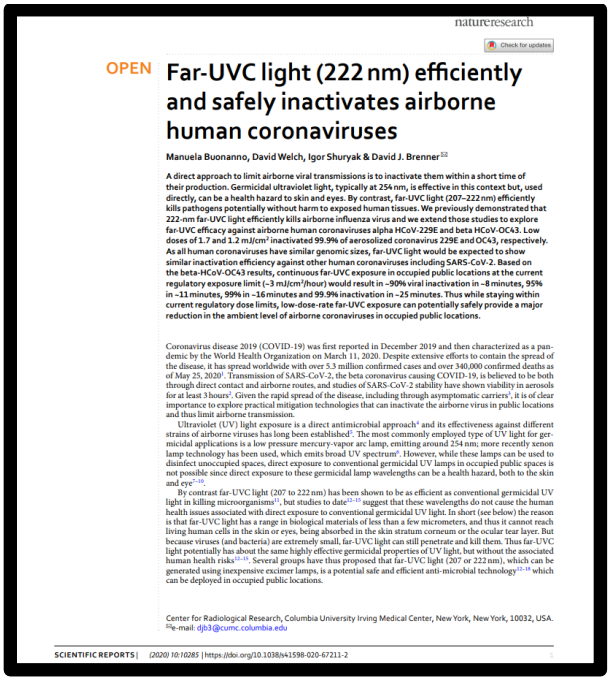
Keeping the contamination levels of surrounding air and surfaces low and controlled is pivotal for maintaining the health and quality of our environment



Office or cubicle can have its own UV 222nm Lamp

## Is UV 222nm light effective against airborne coronaviruses?

In a peer-reviewed study entitled Far-UVC light (222nm) efficiently and safely inactivates airborne human coronaviruses published in June 2020 in the journal Nature, researchers at Columbia University Irving Medical Center reported that **99.9%** of aerosolized seasonal coronaviruses (that cause the common cold) were inactivated when exposed to far-UVC 222nm light for 25 minutes.



nature research

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**Far-UVC light (222 nm) efficiently and safely inactivates airborne human coronaviruses**

Manuela Buonanno, David Welch, Igor Shuryak & David J. Brenner

**A direct approach to limit airborne viral transmissions is to inactivate them within a short time of their production. Germicidal ultraviolet light, typically at 254 nm, is effective in this context but, used directly, can be a health hazard to skin and eyes. By contrast, far-UVC light (207–222 nm) efficiently kills pathogens potentially without harm to exposed human tissues. We previously demonstrated that 222-nm far-UVC light efficiently kills airborne influenza virus and we extend those studies to explore far-UVC efficacy against airborne human coronaviruses alpha HCoV-229E and beta HCoV-OC43. Low doses of 1.7 and 1.2 mJ/cm² inactivated 99.9% of aerosolized coronavirus 229E and OC43, respectively. As all human coronaviruses have similar genomic sizes, far-UVC light would be expected to show similar inactivation efficiency against other human coronaviruses including SARS-CoV-2. Based on the beta-HCoV-OC43 results, continuous far-UVC exposure in occupied public locations at the current regulatory exposure limit (~3 mJ/cm²/hour) would result in ~90% viral inactivation in ~8 minutes, 95% in ~11 minutes, 99% in ~16 minutes and 99.9% inactivation in ~25 minutes. Thus while staying within current regulatory dose limits, low-dose-rate far-UVC exposure can potentially safely provide a major reduction in the ambient level of airborne coronaviruses in occupied public locations.**

Coronavirus disease 2019 (COVID-19) was first reported in December 2019 and then characterized as a pandemic by the World Health Organization on March 11, 2020. Despite extensive efforts to contain the spread of the disease, it has spread worldwide with over 5.3 million confirmed cases and over 340,000 confirmed deaths as of May 25, 2020[1]. Transmission of SARS-CoV-2, the beta coronavirus causing COVID-19, is believed to be both through direct contact and airborne routes, and studies of SARS-CoV-2 stability have shown viability in aerosols for at least 3 hours[2]. Given the rapid spread of the disease, including through asymptomatic carriers[3], it is of clear importance to explore practical mitigation technologies that can inactivate the airborne virus in public locations and thus limit airborne transmission.

Ultraviolet (UV) light exposure is a direct antimicrobial approach[4] and its effectiveness against different strains of airborne viruses has long been established[5]. The most commonly employed type of UV light for germicidal applications is a low pressure mercury-vapor arc lamp, emitting around 254 nm; more recently xenon lamp technology has been used, which emits broad UV spectrum[6]. However, while these lamps can be used to disinfect unoccupied spaces, direct exposure to conventional germicidal UV lamps in occupied public spaces is not possible since direct exposure to these germicidal lamp wavelengths can be a health hazard, both to the skin and eye[7–10].

By contrast far-UVC light (207 to 222 nm) has been shown to be as efficient as conventional germicidal UV light in killing microorganisms[11], but studies to date[12–15] suggest that these wavelengths do not cause the human health issues associated with direct exposure to conventional germicidal UV light. In short (see below) the reason is that far-UVC light has a range in biological materials of less than a few micrometers, and thus it cannot reach living human cells in the skin or eyes, being absorbed in the skin stratum corneum or the ocular tear layer. But because viruses (and bacteria) are extremely small, far-UVC light can still penetrate and kill them. Thus far-UVC light potentially has about the same highly effective germicidal properties of UV light, but without the associated human health risks[12–15]. Several groups have thus proposed that far-UVC light (207 or 222 nm), which can be generated using inexpensive excimer lamps, is a potential safe and efficient anti-microbial technology[12–14] which can be deployed in occupied public locations.

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SCIENTIFIC REPORTS | (2020) 10:10285 | https://doi.org/10.1038/s41598-020-67211-2

## This study found:

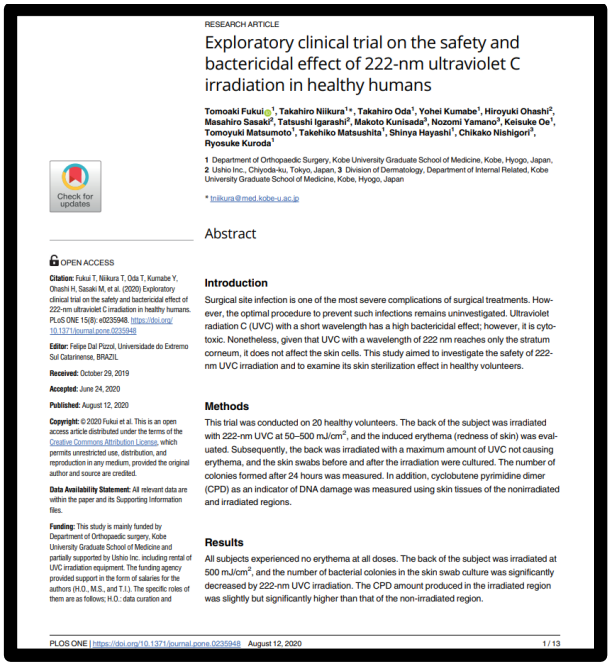
1. Even with very low exposure (1.7 and 1.2 mJ/cm2) to far-UVC light, more than 99.9% of coronaviruses present in airborne droplets were neutralized, meaning they could no longer reproduce or cause infection

2. Continuous exposure to far-UVC 222nm light at the current regulatory limit(~3 mJ/cm2/hour) eradicated airborne viruses in minutes:

- 8 minutes – 90%
- 16 minutes – 99%
- 25 minutes – 99.9%

## Is UV 222nm light safe for humans?

A study conducted by Kobe University researchers called Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans published in August 2020 in PLOS ONE suggests that the filtered far-UVC light emitted by 222nm modules can be used to reduce pathogens while people are present.



RESEARCH ARTICLE

Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans

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**Citation:** Fukui T, Niikura T, Oda T, Kumabe Y, Ohashi H, Sasaki M, et al. (2020) Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans. PLoS ONE 15(8): e0235948. https://doi.org/10.1371/journal.pone.0235948

**Editor:** Felipe Dal Pizzol, Universidade do Extremo Sul Catarinense, BRAZIL

**Received:** October 29, 2019

**Accepted:** June 24, 2020

**Published:** August 12, 2020



**Data Availability Statement:** All relevant data are within the paper and its Supporting Information files.

**Funding:** This study is mainly funded by Department of Orthopaedic surgery, Kobe University Graduate School of Medicine and partially supported by Ushio Inc. including rental of UVC irradiation equipment. The funding agency provided support in the form of salaries for the authors (H.O., M.S., and T.I.). The specific roles of them are as follows; H.O.: data curation and

Abstract

**Introduction**

Surgical site infection is one of the most severe complications of surgical treatments. However, the optimal procedure to prevent such infections remains uninvestigated. Ultraviolet radiation C (UVC) with a short wavelength has a high bactericidal effect; however, it is cytotoxic. Nonetheless, given that UVC with a wavelength of 222 nm reaches only the stratum corneum, it does not affect the skin cells. This study aimed to investigate the safety of 222-nm UVC irradiation and to examine its skin sterilization effect in healthy volunteers.

**Methods**

This trial was conducted on 20 healthy volunteers. The back of the subject was irradiated with 222-nm UVC at 50–500 mJ/cm², and the induced erythema (redness of skin) was evaluated. Subsequently, the back was irradiated with a maximum amount of UVC not causing erythema, and the skin swabs before and after the irradiation were cultured. The number of colonies formed after 24 hours was measured. In addition, cyclobutene pyrimidine dimer (CPD) as an indicator of DNA damage was measured using skin tissues of the nonirradiated and irradiated regions.

**Results**

All subjects experienced no erythema at all doses. The back of the subject was irradiated at 500 mJ/cm², and the number of bacterial colonies in the skin swab culture was significantly decreased by 222-nm UVC irradiation. The CPD amount produced in the irradiated region was slightly but significantly higher than that of the non-irradiated region.



## This study found:

1. UVC 222nm light didn't cause any erythema on study participants at even high doses (up to 500 mJ/cm2)

2. The bacterial colonies in the skin swab cultures were significantly lowered by UV 222nm irradiation

## Can UV 222nm light inactivate SARS-CoV-2?

A study published in September 2020 in the American Journal of Infection Control by researchers at Hiroshima University entitled Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination found that far-UVC 222nm light effectively reduced more **than 99.7%** of surface contamination of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19.

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination

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Key Words:
COVID-19
Environmental contamination
Disinfection
Far-UVC

**Background:** Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has emerged as a serious threat to human health worldwide. Efficient disinfection of surfaces contaminated with SARS-CoV-2 may help prevent its spread. This study aimed to investigate the in vitro efficacy of 222-nm far-ultraviolet light (UVC) on the disinfection of SARS-CoV-2 surface contamination.
**Methods:** We investigated the titer of SARS-CoV-2 after UV irradiation (0.1 mW/cm$^2$) at 222 nm for 10-300 seconds using the 50% tissue culture infectious dose ($TCID_{50}$). In addition, we used quantitative reverse transcription polymerase chain reaction to quantify SARS-CoV-2 RNA under the same conditions.
**Results:** One and 3 mJ/cm$^2$ of 222-nm UVC irradiation (0.1 mW/cm$^2$ for 10 and 30 seconds) resulted in 88.5 and 99.7% reduction of viable SARS-CoV-2 based on the $TCID_{50}$ assay, respectively. In contrast, the copy number of SARS-CoV-2 RNA did not change after UVC irradiation even after a 5-minute irradiation.
**Conclusion:** This study shows the efficacy of 222-nm UVC irradiation against SARS-CoV-2 contamination in an in vitro experiment. Further evaluation of the safety and efficacy of 222-nm UVC irradiation in reducing the contamination of real-world surfaces and the potential transmission of SARS-CoV-2 is needed.
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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has emerged as a serious threat to human health worldwide.[1,2] SARS-CoV-2 is mainly transmitted through infected respiratory droplets and close contact with infected people. Recent studies showed that SARS-CoV-2 can remain viable for days on surfaces under controlled experimental conditions.[3,4] Furthermore, surfaces in hospitals treating patients with COVID-19 were found to be contaminated by SARS-CoV-2, suggesting that the hospital environment could be a potential medium of transmission.[5-7] Therefore, if environmental disinfection is not effective, SARS-CoV-2 may spread widely and cause nosocomial infections.

Recently, ultraviolet (UV) light disinfection systems have been increasingly used in health care settings in an attempt to decrease the transmission of nosocomial pathogens and prevent health care-associated infections.[8] Most UV disinfection systems use germicidal lamps emitting UV radiation C (UVC) around 254 nm. However, it is well known that 254-nm UVC is harmful to the skin and eyes. Previous reports demonstrated that 222-nm UVC light, belonging to far-UVC (207-222 nm), has the same highly effective germicidal properties as 254-nm UVC; however, it is less harmful to the skin and eyes than 254-nm UVC because far-UVC light has a very limited penetration depth in the skin or eye.[9-11] In addition, previous studies have

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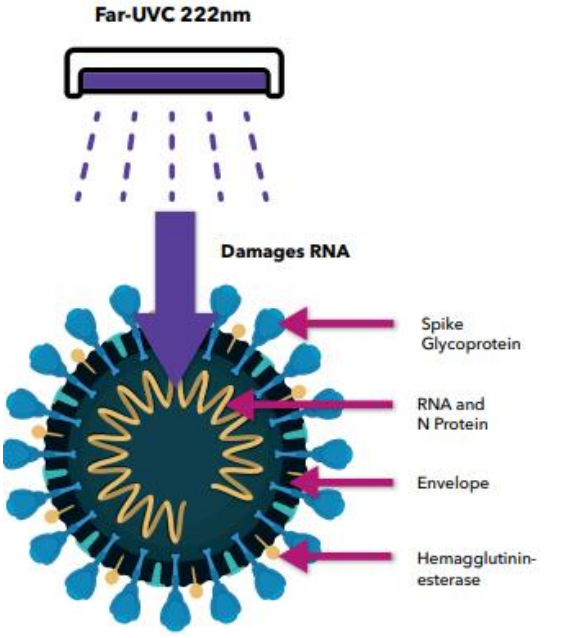
## How does UV 222nm light inactivate viruses?

UV 222nm light inactivates pathogens like coronaviruses by damaging their RNA, which effectively neutralizes them since they are unable to reproduce in our bodies or spread to cause new infections.




SARS-CoV-2 coronavirus. This graphic illustrates how far-UVC 222nm light penetrates and inactivates coronaviruses like SARS-CoV-2

## Technology backed by research

In February 2017, researchers at Columbia University Irving Medical Center published a paper in the National Center for Biotechnology Information (NCBI), U.S. National Library of Medicine called Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light that shows far-UVC 222nm light is as effective at killing (antibiotic-resistant) bacteria as conventional germicidal UV lamps that use 254nm light, but without associated skin damage risks

A paper published in May 2020 in the National Center for Biotechnology Information (NCBI), U.S. National Library of Medicine entitled Long-term Effects of 222-nm ultraviolet radiation C Sterilizing Lamps on Mice Susceptible to Ultraviolet Radiation by researchers at Kobe University investigated the long-term effects of UV 222nm light on the skin using highly photocarcinogenic phenotype mice. The results suggest that UV 222nm lamps can be used as an

alternative to 254nm since 222nm exerts a comparable disinfection ability but can be safely used for sterilizing human skin.

UV 222nm Lamps emit filtered far-UVC 222nm light that's been shown in the lab to inactivate more than 99% of surface pathogens—including SARS-CoV-2 (COVID-19), influenza, bacteria, and antibiotic-resistant superbugs. Far-UVC 222nm light is the only UVC technology shown to be effective in reducing pathogens that may also be used around people. Top 3 reasons to choose products we offer for sale:

1. UV 222nm products may be used when people are present. These modules emit far-UVC 222nm light that cannot penetrate healthy human skin when used per operational specifications

2. It's effective. Study show that far-UVC light technology can reduce surface pathogens—including coronaviruses like the common cold and SARS-CoV-2, influenza, and bacteria

3. It's an added layer of defence. Far-UVC products emit UV 222nm light that damages the RNA of pathogens like coronaviruses and provides an added layer of defence.


15/20/40/60W UV 222nm lamps

## UV 222nm Lamps

We sell products that are:

- Easy-to-use – As easy to install as traditional commercial lighting fixtures.
- Instant on/off at full output power
- Frequent on/off cycles don't affect lamp life
- Able to operate over a wide range of ambient temperatures
- Remotely monitorable for easy programming and troubleshooting
- Easy-to-service for straightforward lamp changes

## Now there's a way to reduce pathogens like coronaviruses

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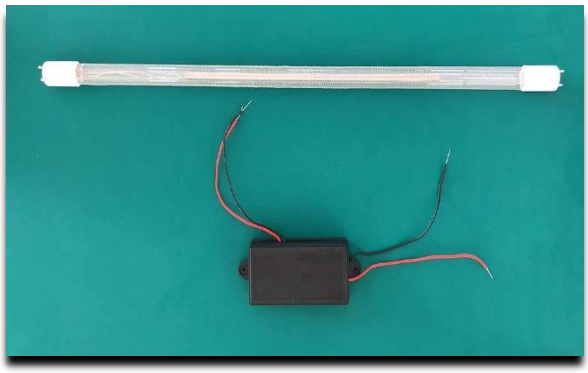

222nm 60W Tube

For the most current specification information,

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