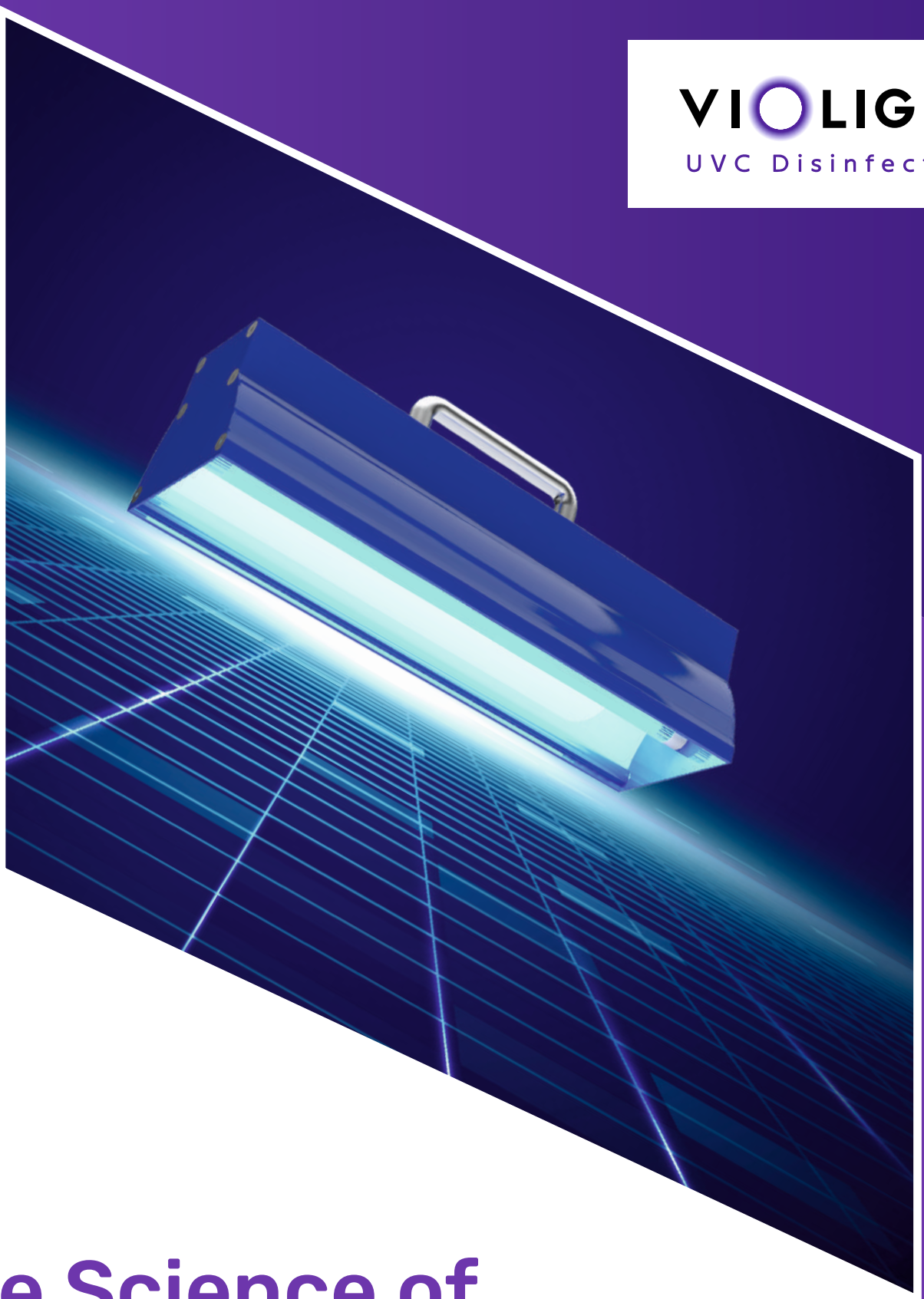
VIOLIGHT
UVC Disinfection



# The Science of
# UV Disinfection

## Pathogen Control in Pandemic Times

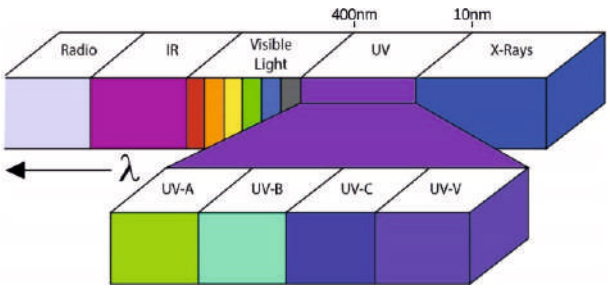
# Introduction

UV or Ultraviolet is a form of electromagnetic radiation with a wavelength that is shorter than that of visible light (10 nanometre (nm) to 400nm) and invisible to the naked human eye. Electromagnetic radiation comes from the sun and is transmitted in waves or particles at different wavelengths and frequencies. This wide range of wavelengths is known as the electromagnetic (EM) spectrum and is generally divided into seven regions in order of decreasing wavelength and increasing energy and frequency such as radio waves, microwaves, infrared (IR), visible light, ultraviolet (UV), X-rays, and gamma-rays. UV radiation present in sunlight constitutes about 10% of the total electromagnetic radiation output from the Sun.

## UV is generally divided into sub-bands as below (Refer Chart)

- UVA or near UV(315~400 nm)
- UVB or middle UV(280~315 nm)
- UVC or far UV(180~280 nm)

The UVC range between 180nm ~280nm is what is of great interest for it's germicidal properties and is the focus of renewed interest these days.




# A Brief History of UV

Ultraviolet light was discovered by Johann Wilhelm Ritter in 1801 after his observation on invisible light that beyond the optical region of the electromagnetic spectrum, it darkened silver chloride. Ritter split sunlight with a prism and measured the relative darkening of the chemical as a function of wavelength. The region just beyond the optical violet region produced the most darkening and hence was eventually called 'ultra' violet.

Light in general and UV light in particular has been used for destroying microorganisms for over 140 years. A brief history of the use of light for is presented below:

| | |
|---|---|
| 1855 | Arloing & Daclaux demonstrate the power of sunlight - Killing Bacillus anthracis |
| 1877 | Downes & Blunt discover that bacteria are inactivated by sunlight<br>- violet blue spectrum most effective. |
| 1892 | Geisler uses a prism & heliostat to demonstrate that sunlight and electric arc lamps lethally affect Bacillus Typhosus |
| 1903 | Barnard & Morgan discover biocidal properties of UV spectrum 226~328nm |
| 1932 | Ehris & Noethling isolates biocidal spectrum to 254nm |
| 1957 | Riley uses UV light for effective TB control |
| 1999 | WHO recommends UVC to combat the spread of TB |
| 2000 | US Army recommends the use of UVC for isolation of disease |
| 2003 | CDC endorses the use of UVC light in hospitals |

In spite of its effectiveness being known for the most part of the 20th century its adoption has not been as wide as would have been expected, largely in part due to the discovery and use of antibiotics. With growing concerns of antibiotic resistant "Superbugs", UVC light has tremendous potential as microbes cannot resist the germ-killing power of UVC.

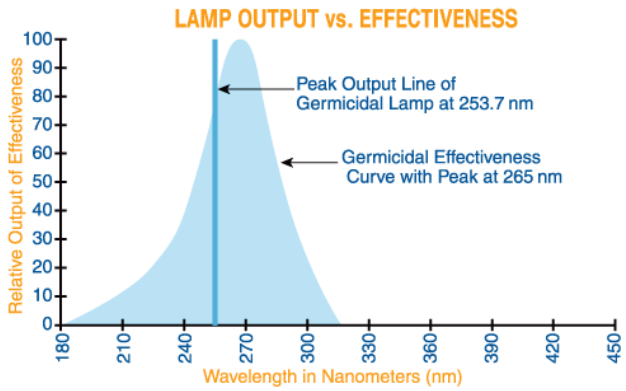
It's significant to note that in the last couple of decades, applications have been developed around the use of UVC light for effective germ control. It's been used for drinking and wastewater treatment, air disinfection, the treatment of fruits & vegetables as well as in office environments for disinfecting computers & other equipment. Within laboratories, research facilities & hospitals UVC has been used for medical sanitation, room disinfection and sterile work facilities.

With its effectiveness against a host of viruses UVC has found renewed interest as an effective tool in combating the spread of Covid-19 and other virus borne illnesses. It will continue to grow as new ways to deploy this powerful light are discovered.

## How UV Works

Unlike other disinfection methods, UVC light disinfection offers an eco-friendly and effective solution to inactivate microorganisms in a hassle-free approach. The bacterias, protozoa, and viruses, when exposed to the UV light weaken and are incapacitated to further reproduction and spread of infections.

The germicidal range of UV shown in the attached graph peaks at 265nm. VIOlight UVC devices use low-pressure mercury-arc continuous UVC lamps that generate over 90% of its energy at 254nm. This radiation is very close to the peak of the germicidal effectiveness curve of 265nm, the most lethal wavelength to microorganisms.




UVC light has demonstrated efficacy against pathogenic organisms, including viruses responsible for typhoid, cholera, hepatitis, and other viral diseases. The high energy associated with the UVC light due to its short wavelength (254nm), when absorbed by the RNA and DNA of the microorganisms damages their nucleic acids and inactivates them. These changes caused in the RNA and DNA structures render the microorganism incapable of performing vital cellular functions including replication. Even the "Superbugs" that have developed a strong resistance to antibiotics have no defence against UVC light. These microorganisms that can't reproduce are considered dead; since they are unable to multiply to infectious numbers within a host. This is why UVC disinfection is also referred to as Ultraviolet Germicidal Irradiation (UVGI).

## Effectiveness of UV

UVC light has proven to be highly effective against a broad spectrum of microorganisms. Bacteria, fungi, viruses contain RNA or DNA and are susceptible to UVC irradiation. Given the longstanding use of UVC for disinfection, there is a plethora of information regarding dosages necessary to inactivate different microorganisms.

The effectiveness of UVC in an environment or device depends on a number of factors. The length of time the microorganism is exposed to UVC light, the intensity of the UVC light & the microorganism's ability to withstand UVC irradiation. In general bacteria and viruses take less dosage of UVC than fungi & spores to inactivate. For inactivation of specific pathogens please refer to the detailed Dosage Chart* that can be downloaded from our website.

Another very important factor in this form of sterilization is the LINE OF SIGHT exposure of the microorganisms to the UVC light. Systems where the design blocks the UVC light are not as effective. Sterilization is most optimum in the line of sight so the design and placement of the UVC light source is critical to the efficacy of the device. Also important is the cleanliness of the glass envelope of the UVC light source. Any dust or film coating on the lamp will lower the output thus impacting effectiveness

## UV & COVID-19

UVC can help prevent COVID-19 transmission by reducing contamination. UVC light has proven to be very effective in inactivation of at least two other coronaviruses that are near relatives of the COVID-19 virus: SARS-CoV-1 and MERS-CoV. The International Ultraviolet Association (IUVA) has published its findings on COVID-19 based on the existing research. Please download this on our website or directly at https://www.iuva.org/IUVA-Fact-Sheet-on-UV-Disinfection-for-COVID-19.

Research conducted by Cornell University has confirmed the effectiveness of UVC light on COVID19 coronavirus and its findingscan be downloaded at https://www.researchgate.net/publication/339887436_2020_COVID19_Coronavirus_Ultraviolet_Susceptibility

## Safety & Environment

UV forms 10% of the electromagnetic radiation from the Sun. Within this the germicidal UVC which forms a small portion is blocked by the earth's atmosphere and prevented from reaching us. But it is an unequivocal fact that UV (more so UVC) is harmful to humans and other forms of life. UVC is classified as "reasonably anticipated to be a human carcinogen" by medical research. It presents a hazard to skin and eyes so direct exposure to UVC is ALWAYS to be avoided. Exposure of eyes to UVC can produce extremely painful inflammation and can cause damage to the retina of the eye.

That being said there are plenty of ways to ensure that this risk is taken care of in the design of the system. UVC is blocked by a number of materials, including glass (Except quartz and soft glass that are used to make the UVC light source) and most clear plastics. Using these materials it's possible to design a system that makes it safe to observe the UVC system from outside.

The biggest advantage of UVC is disability to provide residue free disinfection. It avoids risk of dangerous or undesirable residues that need to be wiped down or neutralized after the disinfection process. The process is environmentally friendly as there are no toxic or dangerous chemicals that require specialized storage and handling. It follows that there are no process byproducts to reckon with. The UV bulbs do not require any special handling and disposal is similar to the fluorescent tubes or compact fluorescent lamps (CFL) making it a green alternative to chemical disinfectants.

## Benefits of UV

While there are limitations of UVC in disinfection use, there are many benefits. Disinfection times are fast, often less than 15 mins. This allows for fast turnaround times for rooms, spaces & objects or being disinfected. Its inherent simplicity makes it easy to deploy and use. All surfaces / objects within a certain distance will be assured disinfection in a certain amount of time as long as light is not blocked from falling on that surface. It's easy to plan and use a UVC disinfection system within the parameters as long as the limitations are established and understood.

For surfaces at close quarters it means even quicker disinfection and no wait time after disinfection. There are no liquids being used as in a fogging system which means that sensitive equipment can be disinfected without any risk of damage. There is no need to isolate rooms from HVAC systems given the lack of chemical mixtures. All this means a quick preparation time to setup and start a UVC disinfection cycle.

In addition the biggest advantage to UVC light disinfection is the low costs. The UVC systems are generally run off a regular wall outlet and draw very little power. The system is simplistic with typically no or very few moving parts requiring little maintenance. UVC lamps typically last thousands of hours at their peak output and even changing these bulbs are as simple as the ones you are used to doing in an office or house.

## Limitations of UV

The biggest limitation of UVC disinfection is its LINE OF SIGHT characteristic. Shadow areas do not receive adequate disinfection so systems have to be designed around this by effective use of reflective material OR by repositioning the UVC light source or the object to be disinfected . Distance also plays a role in the efficacy of UVC light. In general the strength of the UVC light decreases further away from the light source following the inverse square law. This means that at twice the distance the UVC light will have only 1/4th of its power. This relationship limits how far a single source of light can be placed before it becomes too weak to provide effective disinfection. System designs have to take this distance factor into account and compensate it by providing adequate time to assure an adequate level of disinfection.

## Applications

Today, UVC light is experiencing a surge in usage and explosion in applications where quick and effective disinfection is called for. There are systems available to disinfect rooms, & high touch surfaces, inside ambulances & operating theaters, tools & equipment inside disinfection chambers, continuous UVC pass through conveyors and other applications. It's finding increasing application for disinfection in commercial spaces and homes with awareness of disease and concern about pathogen spread being at all time high due to the COVID-19 pandemic.

## About VIOlight

We have known light and worked with it for 40 years. From making critical parts for the global lamp makers to manufacturing specialty lighting products ourselves we have been involved with the lighting industry in one form or another.

VIOlight is the result of our evolution beyond light in a literal and metaphorical sense. VIOlight range of products use UVC radiation which is literally beyond the visible part of the electromagnetic spectrum. And metaphorically, with these products we are now moving beyond mere lighting to disinfection by lighting. VIOlight brings a fresh new take on the decades-old science of UVC disinfection.

We aim to provide our customers products that are aesthetically designed, scientifically validated & affordably priced. VIOlight is committed to being a leader in pathogen control and sanitization space.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