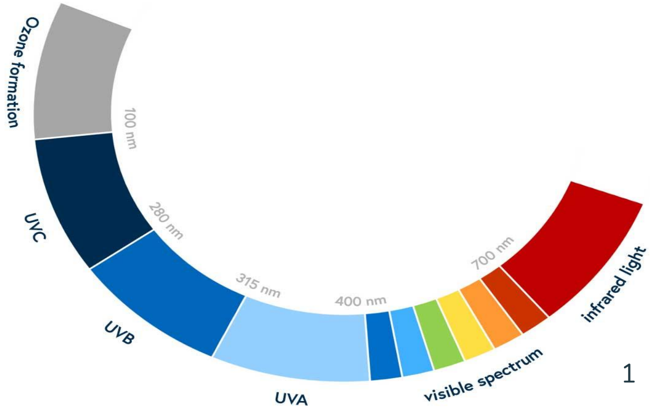
Project - Effect of UVC light on Viruses

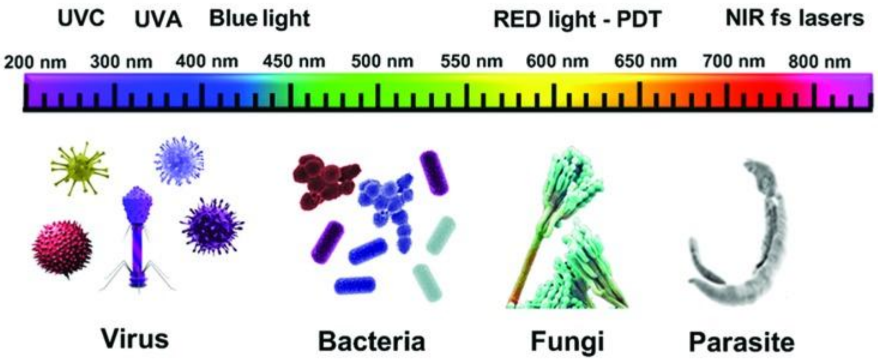
Mohit Pavan kumar -2018102016
Gowthami Gongati - 2018102048



SUN light and UV

Sunlight contains three types of UV light

1. *UVA(315-400 nm)*
2. *UVB (280-315 nm)*
3. *UVC (100-280 nm)*



1. UVA :

Which makes up the vast majority of the ***ultraviolet radiation reaching the Earth's surface***. It's capable of penetrating deep into the skin and is thought to be responsible for up to 80% of skin ageing, from wrinkles to age spots.

2. UVB :

Which can damage the DNA in our skin, leading to sunburn and eventually skin cancer (recently scientists have discovered that UVA can also do this).

Both are reasonably well known, and can be blocked out by most good sun creams. ***Both UVA and UVB damage the skin, but nothing is as damaging as UVC .***

3. UVC :

1. This is relatively obscure part of the spectrum consists of a shorter wavelength.
2. More energetic wavelength of light.
3. It is particularly good at destroying genetic material both in humans as well as viral particles.

a. Luckily, most of us haven’t encountered any of these. Because it’s ***filtered out by ozone*** in the atmosphere long ***before it reaches our fragile skin***.

b. Scientists discovered that UVC light can kill microorganisms.

c. In 1878, artificially produced UVC has become a staple method of ***sterilisation***.

d. Can be used in hospitals, airplanes, offices, and factories.

e. And also fundamental to the process of sanitising drinking water

f. Some parasites are resistant to chemical disinfectants like chlorine, Can also be disinfected by UVC

Effect of UVC

“UVC is really nasty stuff – you shouldn't be exposed to it,” says Arnold.

“It can take hours to get sunburn from UVB, but with UVC it takes seconds. If our eyes are exposed… we know that gritty feeling we get if we look at the sun? It’s like that 10 times, just after a few seconds.”

Studies have shown UVC 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. In so many countries

1. **Whole buses are being lit up by the blue light each night.**
2. **UVC-emitting robots have been cleaning floors in hospitals.**
3. **Banks have even been using the light to disinfect their money.**

To use UVC safely, we need specialist equipment and training.

The World Health Organization (WHO) has issued a serious warning against people using UV light to sterilise their hands or any other part of their skin.

A bus is disinfected using UVC in Shanghai, China

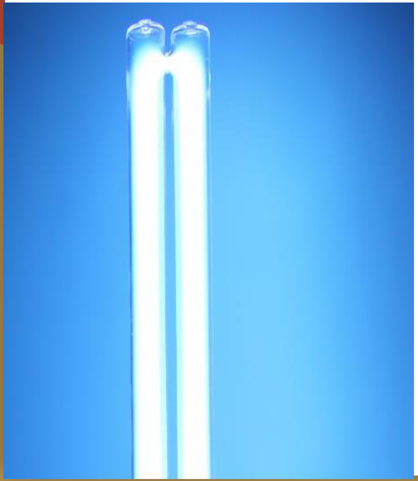
(Image credit: Getty Images)

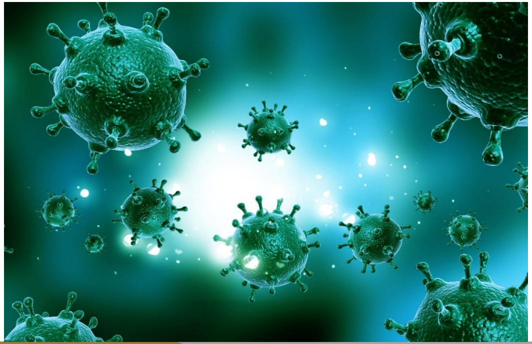
Far-UVC

Recently, scientists have discovered a promising new type of UVC which is less dangerous to handle, and still lethal to viruses and bacteria. ***Far-UVC*** has a shorter range of wavelength than regular UVC, and so far, experiments with human skin cells in the lab have shown that it doesn't damage their DNA (more research is needed to be sure).

However, the vast majority of the UVC lamps on the market don't use far-UVC yet – and again, it hasn't been tested in actual humans, just on our cells in petri dishes and other animals. So this type of radiation probably won't help us during the current pandemic either.

- UV-C (200-280 nm) is most traditionally referred to as germicidal UV with ability to kill bacteria, viruses, mold, and fungi.
- While UV-C is most traditionally referred to as germicidal UV, UV-B wavelengths have also demonstrated effectiveness against certain bacteria.
- UV-A (320-400 nm) and UV-B (280-320 nm) light causes oxidation of proteins and lipids causing cell death.
- Broad band UV lamps have also been shown to inhibit photo-reactivation, the process that can result in self-repair of damaged microbes.





Would UVA or UVB work instead? And if so, does this mean you can disinfect things by leaving them out in the sun?

In the developing world, sunlight is already a popular means of sterilising water – it's even recommended by the World Health Organisation (WHO). The technique involves pouring the water into a clear glass or plastic bottle, and leaving it out in the sun for six hours. It's thought to work because the UVA in sunlight reacts with dissolved oxygen to produce unstable molecules such as hydrogen peroxide, the active ingredient in many household disinfectants, which can damage pathogens.

Without water, sunlight will still help to disinfect surfaces – but it may take longer than you'd think.

Research on Sars which is close relative of Covid-19, found that exposing the virus to UVA for 15 minutes had no impact on how infectious it was. However, the study didn't look at longer exposures, or UVB, which is known to be more damaging to genetic material.

Instead, other viruses might provide some clues. Take the flu. When scientists analysed hospital admission records in Brazil, they found that the number of flu cases tended to go up during the burning season, when there is more smoke in the atmosphere from forest fires and the UV in sunlight is diluted.

Another study found that the longer flu particles were exposed to sunlight– and the more concentrated it was – the less likely they were to remain infectious.

All this means that using sunlight to disinfect surfaces is extremely problematic.

First of all, no one knows how long it takes to deactivate Covid-19 with sunlight, or what strength is needed. And even if they did, the amount of UV in sunlight varies depending on the time of day, the weather, the season, and where in the world we live – especially which latitude – so this wouldn’t be a reliable way to kill the virus.

Finally, it goes without saying that disinfecting our skin with any kind of UV will lead to damage, and increase our risk of skin cancer.

And once the virus is inside our body, no amount of UV is going to have any impact on whether we are infected.

The questions

1. Lambda vs viruses vs RNA
2. Generic study of all viruses
3. Intensity effect on viruses (Watt/m^2)
4. How much area to do sanitization
5. Intensity effect of light (for a 6 feet exposure time)
6. 18 watts LED, 1 milli watts for these things effecting and how far can i do sanitization
7. If i want to do for a 6 feet area what should be the exposure time
8. How RNA getting destroyed using lambda (DNA) also
9. Why others lambda not destroyed theirs RNA then
10. Cadtool , open source tool (model DNA, RNA)-not done.

Effect of Lambda on viruses: (Generic study)

The effect ie. the survival of the viruses will be mostly depending on time of exposure and the intensity of light but not the Lambda of the light . It means certain wavelengths can the viruses in which 254nm, 260nm, 305 nm, 310 nm are very effective on most of the viruses, where the most commonly used one is 254 nm. But increasing or decreasing the wavelength will not increase or decrease the effect on it, but only the intensity and time of exposure matters, if that certain wavelength can kill the viruses.

Even if 222 nm does prove relatively safe, there are still **exposure limits**. Furthermore, it may not work against as broad a spectrum of bacteria and viruses as 254 nm.

The lamps mix krypton and chlorine gases to produce single-wavelength photons—as opposed to a broad spectrum—that can range from 207 nm to 222 nm.

Here all the wavelengths are not safe so we must add filters which remove all except the desired wavelengths, to use the lamps safely.

Why the other Lambdas can't kill the viruses:

The **lytic cycle**: The phage infects a bacterium, hijacks the bacterium to make lots of phages, and then kills the cell by making it explode (*lyse*).

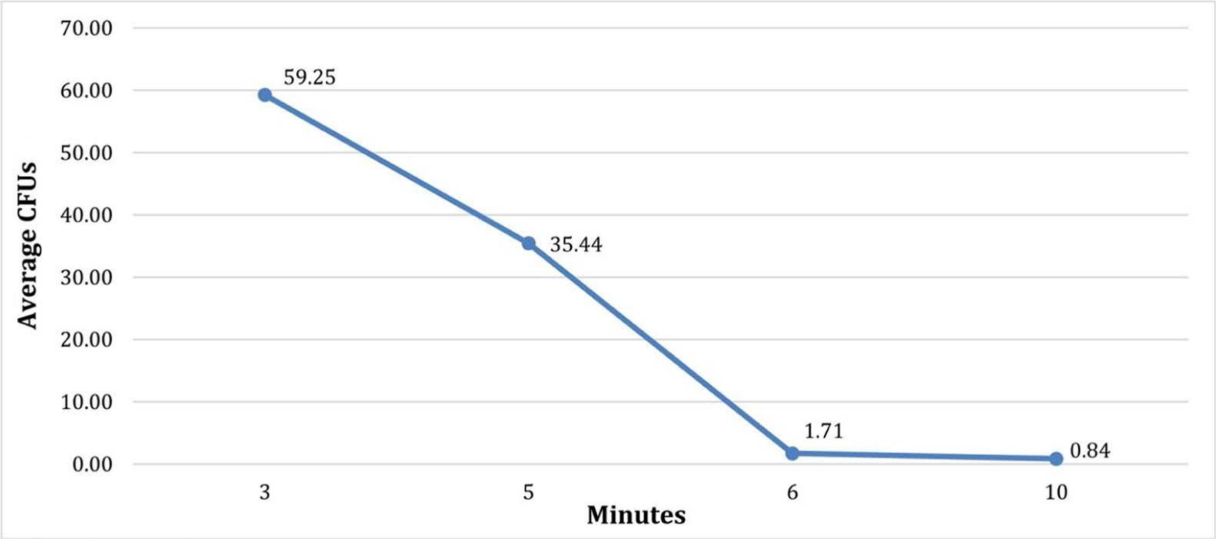
The **lysogenic cycle**: The phage infects a bacterium and inserts its DNA into the bacterial chromosome, allowing the phage DNA (now called a **prophage**) to be copied and passed on along with the cell's own DNA.

Bacteriophages, just like other viruses, must infect a host cell in order to reproduce. The steps that make up the infection process are collectively called the **lifecycle** of the phage.

Some phages can only reproduce via a lytic lifecycle, in which they burst and kill their host cells. Other phages can alternate between a lytic lifecycle and a lysogenic lifecycle, in which they don't kill the host cell (and are instead copied along with the host DNA each time the cell divides).

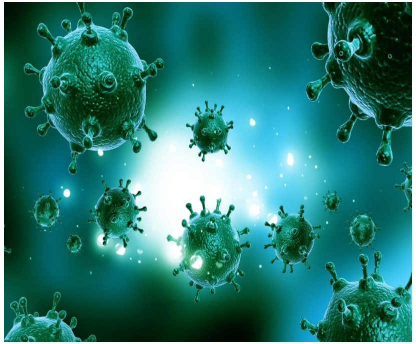
Let's take closer look at these two cycles. As an example, we'll use a phage called lambda, which infects *E. coli* bacteria and can switch between the lytic and lysogenic cycles. For this reason the other lambda can’t kill the viruses.

And the other reason that they can’t be killed by other wavelengths is that the energy required to break the molecular bond. The energy should be sufficient no not more energy should be given, because the more energy than required is always useless and becomes ineffective, giving less energy can’t break the bond and more energy is also same it doesn’t effect that bonds.



*Culture data not shown

Average number of CFUs post ultraviolet disinfection by cycle length. *CFU*, colony forming unit.



The study took place at an academic hospital in Chicago, Illinois. Baseline cultures were obtained from keyboards in intensive care units. Automated UV-C lamps were installed over keyboards and mice of those computers. After the experiment, Incremental increases in cycle length resulted in progressive improvements in bactericidal activity until a ceiling effect was reached at a 6-minute cycle. Moving beyond a 6-minute cycle (99.2% reduction) to a 10-minute cycle (99.6%) resulted in an absolute improvement of 0.47%

UV light is electromagnetic radiation with wavelengths shorter than visible light but longer than X-rays. UV is categorised into several wavelength ranges, with short-wavelength UV (UVC) considered "germicidal UV". Wavelengths between about 200 nm and 300 nm are strongly absorbed by nucleic acids. The absorbed energy can result in defects including pyrimidine dimers. These dimers can prevent replication or can prevent the expression of necessary proteins, resulting in the death or inactivation of the organism.

- Mercury-based lamps operating at low vapor pressure emit UV light at the 253.7 nm line.
- Ultraviolet light-emitting diode (UVC LED) lamps emit UV light at selectable wavelengths between 255 and 280 nm.
- Pulsed-xenon lamps emit UV light across the entire UV spectrum with a peak emission near 230 nm.

How it affects RNA :

A novel UV-C-light-induced ribozyme activity was discovered within the highly structured 5′-genomic regions of both Hepatitis C Virus (HCV) and the related Classic Swine Fever Virus (CSFV). Cleavage is mediated by exposure to UV-C light but not by exogenous oxygen radicals. It is also very selective, occurring at base positions HCV C79 and CSFV A45 in some molecules and at the immediately adjacent 5′-positions HCV U78 and CSFV U44 in others. Among other reaction products, the majority of biochemically active products detected contained 3′-phosphate and 5′-phosphate-end groups at the newly generated termini, along with a much lower amount of 3′-hydroxyl end group.

It is known that both DNA and RNA chains are affected by direct exposure to ultraviolet (UV) light , which in the case of DNA can result in the formation of pyrimidine dimers or random breaks . The effects of UV light on RNA are relatively unknown, although UV-C irradiation has been shown to induce mainly pyrimidine dimers and uridine hydrates and, less frequently, unspecific chain breaks.

Intensity effect on viruses (watt/m^2)

“We show for the first time that far-UVC efficiently inactivates airborne aerosolized viruses, with a very low dose of 2 mJ/cm^2 of 222-nm light inactivating >95% of aerosolized H1N1 influenza virus,” the authors wrote. “Continuous very low dose-rate far-UVC light in indoor public locations is a promising, safe and inexpensive tool to reduce the spread of airborne-mediated microbial diseases.”

Ultraviolet germicidal irradiation (**UVGI**) is a disinfection method that uses short-wavelength ultraviolet (ultraviolet C or UVC) light to kill or inactivate microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions. UVGI is used in a variety of applications, such as food, air, and water purification UVGI uses UV-C within 200-300 nm..

The UV sensitivity of a virus is determined via a survival curve, with the log viral surviving fraction as a function of UV exposure (D is measured as fluence in J/m2). The simplest and most common survival curve for viruses follows single-hit kinetics, i.e., $n/no = e^{-kD}$, where n/no is the virus surviving fraction and k is the slope of the survival curve when $\ln(n/no)$ is plotted versus D. The UV exposure that produces an average of one lethal hit per virion occurs when $D = 1/k$ and is called the $D37$ ($n/no = 0.37$)

UV dose cannot be measured directly but can be inferred based on the known or estimated inputs to the process:

- Flow rate (contact time)
- Transmittance (light reaching the target)
- Turbidity (cloudiness)
- Lamp age or fouling or outages (reduction in UV intensity)

In air and surface disinfection applications the UV effectiveness is estimated by calculating the UV dose which will be delivered to the microbial population. The UV dose is calculated as follows:

UV dose $\mu Ws/cm^2$ = UV intensity $\mu W/cm^2$ × exposure time (seconds)

Dosages for a 90% kill of most bacteria and viruses range from 2,000 to 8,000 $\mu W{\cdot}s/cm^2$.

a minimum dose of 2,500 $\mu W{\cdot}s/cm^2$

Lamps designed to release UVC and higher frequencies are doped so that any UV 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 (O_2) molecules.

For 254 nm UV, this TLV(threshold limit value)is 6 mJ/cm^2 over an eight-hour period. The TLV function differs by wavelengths because of variable energy and potential for cell damage,0.2 $\mu W/cm^2$ was widely interpreted as the upper permissible limit of irradiance at eye height.

How RNA and DNA being destroyed by UV

A. DNA & RNA is the genetic material that makes up all living organisms, controlling their growth, development, functioning and reproduction.

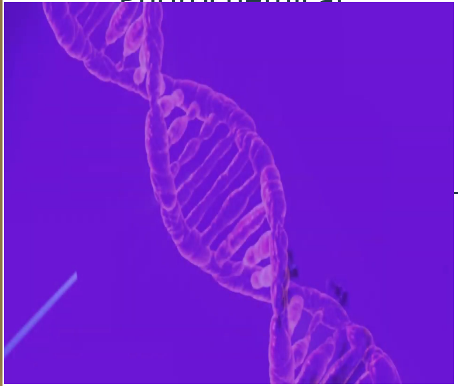
B. UV light produces electromagnetic energy that can destroy the ability of microorganisms to reproduce and cause inactivation of microbes by causing mutations and/or cell death.

C. This is caused by the photochemical reactions in nucleic acids (DNA & RNA).

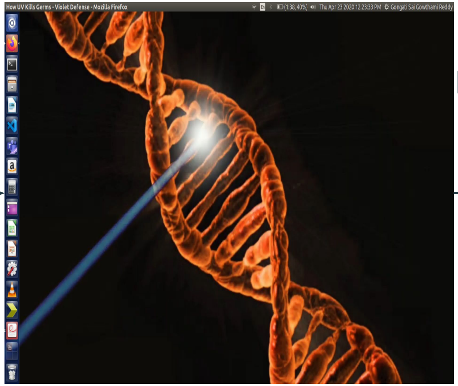
D. The ultraviolet energy triggers the formation of specific thymine or cytosine dimers in DNA

P

Photochemical

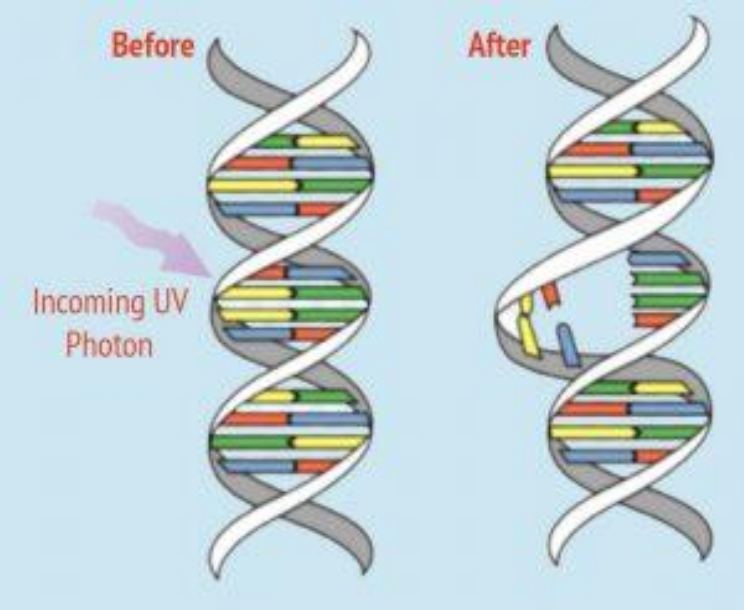


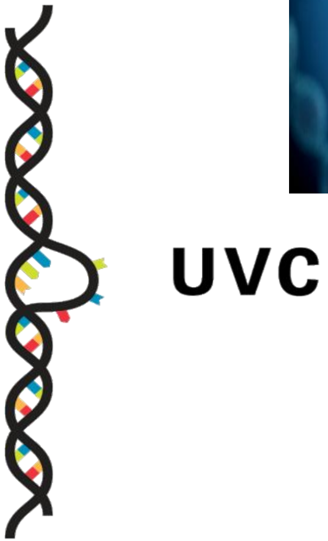
Reaction



Bond Destroyed

E. And destroys the uracil dimers in RNA, which causes inactivation of microbes by causing mutations and/or cell death and failure to reproduce.





Calculations

A G15T8 (15 W germicidal fluorescent bulb) emits **4.9 W of UV-C** with a central peak at **253.7 nm**

UV dose = UV_Energy/Area

UV_Energy = UV_bulb_power * Exposure_time

Area = 4* pi * (UV_bulb distance)^2 (considering spherical divergence)

This leads to :

UV_Energy = UV_bulb_power * Exposure_time / (4 * pi * UV_bulb_distance^2)

So the desired direct exposure time in seconds is:

Exposure_time = (Desired_UV_Energy * 4 * pi * (UV_bulb_distance)^2)/ UV_bulb_power

Units: UV_Energy: Joules; UV_bulb_power: Watts; Area: m^2; UV_bulb_distance: m; Exposure_time: s; pi: 3.141592

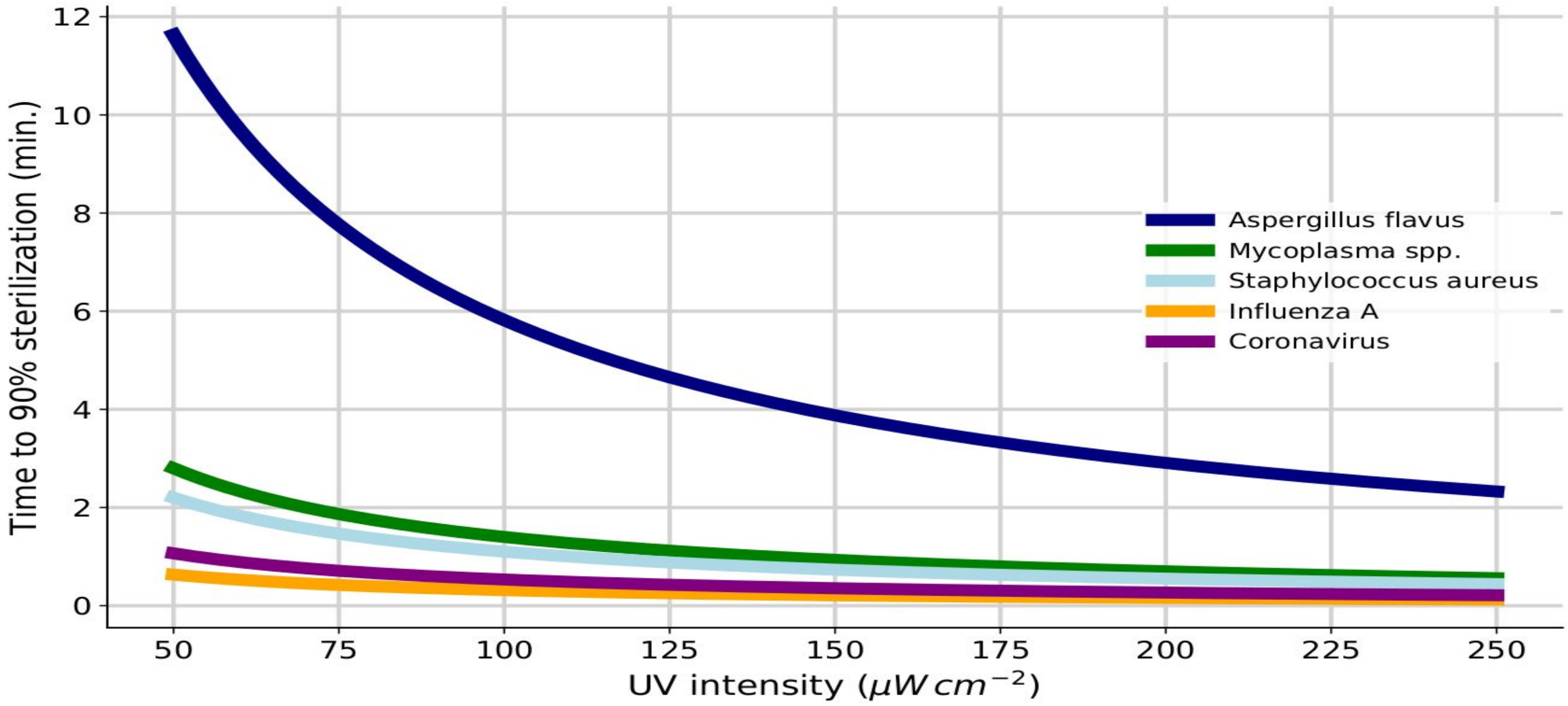
So for the desired 5 J/m^2 Energy we got 12.8 seconds of direct exposure for a 1 m distance

Calculations

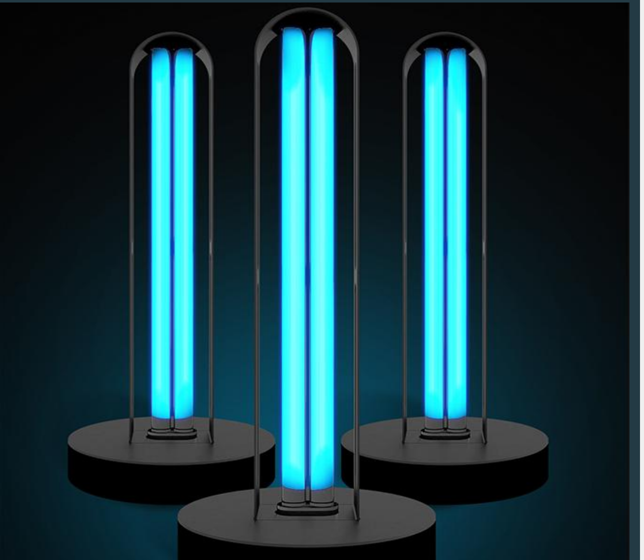
Desired UV_energy (J/m^2)	UV_Power (Watts)	Area (feet)	Exposure time (Seconds)
5	4.5	3.28 (1m)	13.955
5	4.5	1 (0.3048m)	1.2971
5	4.5	6 (1.8288m)	46.6981
5	18	1 (0.3048m)	0.3242
5	18	6 (1.8288m)	11.6797
5	1 milli	1 (0.3048m)	5837.2701
5	1 milli	6 (1.8288m)	210141.725

Here we are calculating the exposure time by varying the bulb power(UV-C light emits from the bulb) , energy and distance. **UV-C** emission from the bulb with a central peak at **253.7 nm**

Sterilization of viruses at different intensities



Key benefits by the UV-C light



1. Environmentally-friendly
2. No chemicals
3. Affordable
4. Kills rapidly - starting within seconds
5. Microbial cells cannot develop resistance to this technology
6. Proven ability to be able to deploy it safely to kill bacteria, mold, fungi, and even viruses

IMPORTANT: ALSO SOME UV-C BULBS CAN PRODUCE OZONE AND WE MUST AVOID BE EXPOSED TO THAT TOO

`

References

- https://www.bbc.com/future/article/20200327-can-you-kill-coronavirus-with-uv-light
- https://www.khanacademy.org/science/biology/biology-of-viruses/virus-biology/a/bacteriophages
- https://www.sciencedirect.com/science/article/pii/S019665531630579X#f0015
- https://www.researchgate.net/post/The_basic_way_to_calculate_UV_dose_from_a_UVC_15Watt_bulb
- https://en.wikipedia.org/wiki/Pyrimidine_dimer
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1280232/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3287179/
- https://www.nature.com/articles/s41598-018-21058-w
- https://viralzone.expasy.org/512

Thank You