ULTRA EFFECTIVE

Ultraviolet light has been used in the past to fight coronaviruses such as MERS and SARS. Romain Guillame examines the science and explores the options for using UVC against ongoing waves of the Covid-19 coronavirus

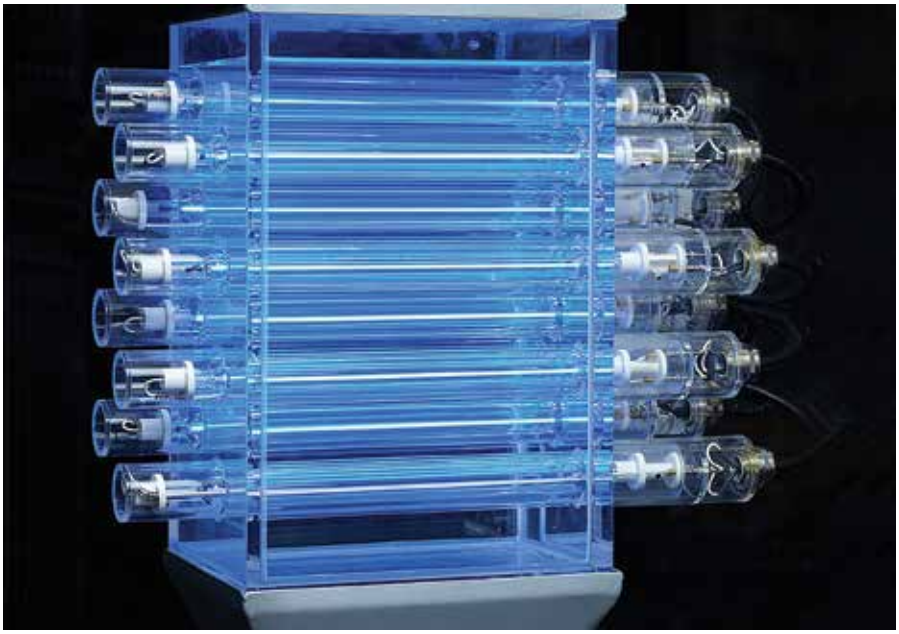
The purpose of this article is to clarify how photonics (the science and technology of light) and more specifically ultraviolet (UV) can help to combat the coronavirus pandemic. A lot of information, articles and products relating to this subject have appeared and it is important to maintain critical thinking towards this flow of data.

The examples we look at will mainly be based on SARS CoV-2 more commonly known as Covid-19, which is currently the centre of attention, but they will also help us to understand the facts for other pathogens such as viruses, bacteria, fungi and algae.

WHAT IS UV?

The wavelength (expressed in nm for nano-meter) characterises the type of light (its colour, for example). The human eye is sensitive to the range 400–700nm, which represents 'visible light'; it goes from purple to red. A rainbow is a perfect example of the colour palette that our eye is able to see. UV light is between 200nm and 400nm, and is normally divided into three categories: UVA (400–315nm), UVB (315–280nm), UVC (280–200nm). The sun produces all three categories of UV. However, the ozone layer in the atmosphere absorbs the vast majority of UVB and UVC rays. At ground level there is almost only UVA left. UVC is harmful. Living beings are not naturally exposed to this wavelength of light, because most of it is absorbed by our atmosphere and its ozone layer, so have never developed systems to protect themselves from it. UV rays are known to be harmful to the skin and eyes, which is why we protect ourselves by putting on sunscreen and wearing sunglasses. In reality UV is harmful to all living things, from micro-organisms (viruses) to humans.

"UV light and in particular UVC is taking an increasingly important role in the fight against the Covid-19"



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SOURCES OF UV

Besides our sun, many sources of artificial UV exist: the three main types are lasers, lamps, and LEDs. In our article we will focus on the last two, lasers typically have a point source and therefore are not suitable for decontaminating surfaces. In general, the main differences between LEDs and lamps in the UVC are summarised in **Figure 1**.

In UVC the interest of LEDs will be limited to making small compact systems,

UVC lamps should not be used around exposed skin

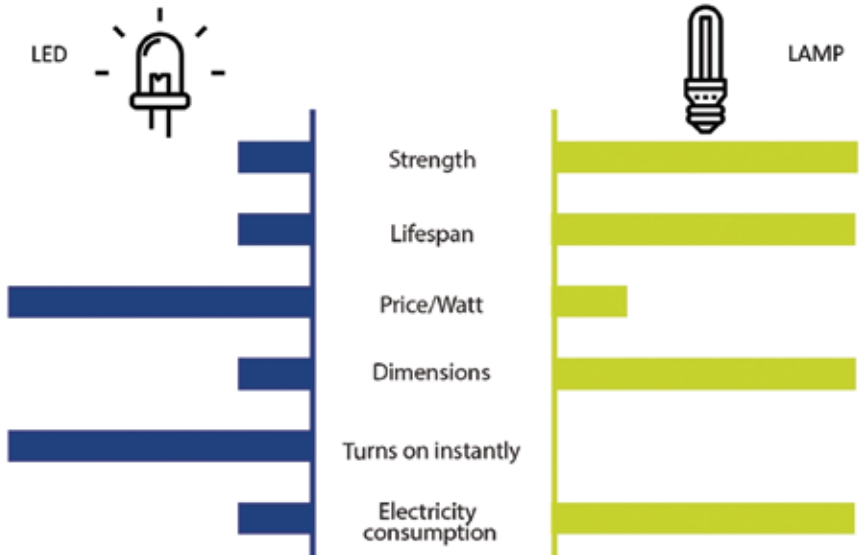
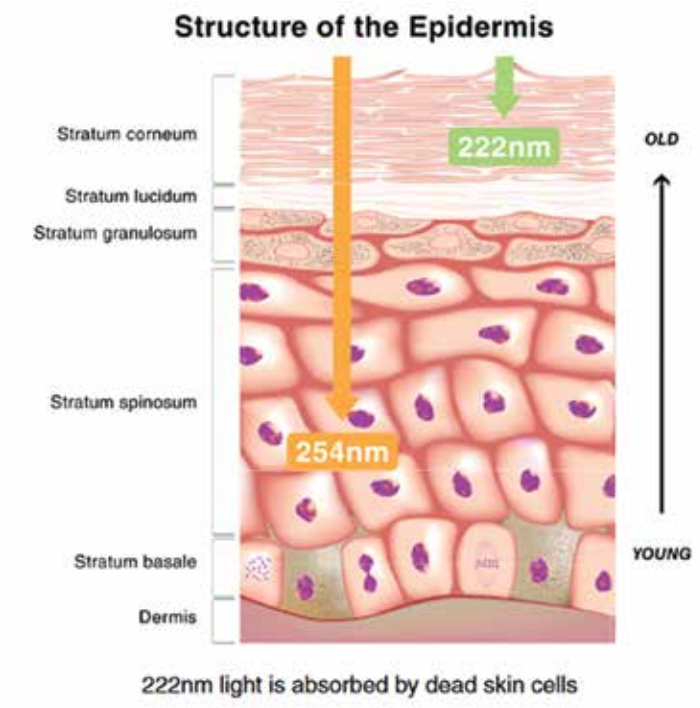


Figure 1: Main differences between LEDs and lamps in the UVC



UV light occurs between 200nm and 400nm, and is normally divided into three categories: UVA (400–315nm), UVB (315–280nm) and UVC (280–200nm)

where the lamps are too bulky. The lamps are more powerful, last longer and are cheaper. This is why for the vast majority of applications where UVC is required, lamps are preferred.

But with equivalent spectrum (UVC for example) all UV lamps are not equal and to determine if a lamp is going to be effective, two important parameters must be taken into consideration.

Power: Often expressed in mW/cm², it quantifies the intensity of light emitted during one second. Or 'how bright the light is'.

Quantity: If an object moves under a lamp, the slower it goes or the higher the power the greater the exposure to UV Light.

It is this quantity of light received, called the 'dose' that allows us to compare different solutions. It is expressed in mJ/cm² (J = Joules) and we calculate it as follows:

Dose = Power per unit area (mW/cm²) x Exposure time

UV AGAINST MICRO-ORGANISMS

At the end of the 19th century, it was discovered that UV light deactivated micro-organisms and that the most effective wavelength is in UVC: around 254nm. UVC interferes with and destroys the nucleic acids, DNA or RNA of bacteria, viruses or other micro-organisms. The micro-organisms can no longer reproduce and become inactive.

Over the next century many applications were developed, the main and best known being the decontamination of drinking water. In 2006 the ANSES (National Agency for Health, Environment and Work Safety) reported the effectiveness of this technology[1].

UV VS COVID-19?

UVC has been used in the past to fight other coronaviruses like MERS and SARS and was used in the fight against the recent Ebola outbreak in West Africa. Furthermore it is expected to have the same effect on Covid-19. This is why UV light and in particular UVC is taking an increasingly important role in the fight against the Covid-19 alongside, social distancing, hand sanitiser gel and different PPE. UV appears to be a quick fix to destroy the virus everywhere: on your mobile phone, in the air, in your water bottle, on your hands... without using chemicals that can damage electronics.

"Studies show that viruses with single-stranded RNA are 6 times more sensitive to UV than those with double-stranded RNA"

But there are several points of which to be aware:

UVC is very effective against micro-organisms, but is also dangerous for humans – we are also organisms! UVC lamps should not be used around any exposed skin. On 24 April 2020 The International Association of Ultraviolet (www.iuva.org) issued a press release strongly advising against its use on the human body. The WHO (World Health Organisation) has organised an awareness campaign against the use of UV lamps to sterilise hands or skin.

Numerous offers for UV lamps to sterilise air, objects and surfaces are flourishing on the Internet. The majority of these solutions can be dangerous and do not reach the required UVC dose in the time suggested, so do not even deactivate the virus!

UV DOSE REQUIRED

The dose required to deactivate different viruses and bacteria in water is very well known and is noted in a 2005 review[2]. The dose will deactivate a certain percentage of virus; more dosage (by increasing the dwell time) means a higher percentage of deactivation.

There have been no published studies specifically carried out on the Covid-19 virus [at time of writing], but some elements can be used to estimate the necessary dose:

- Covid-19 contains single-stranded RNA and studies have shown that viruses with single-stranded RNA are 6 times more sensitive to UV than those with double-stranded RNA.
- Covid-19 has a diameter of 0.05–0.2 microns and a virus of 0.1 microns in diameter, it takes 10 millijoules (mJ)/cm² to deactivate it[3].
- A coronavirus requires 6mJ/cm² in air with low humidity to be 90% deactivated[3].

COVID-19 LIFESPAN

A study from April 16, 2020[4] published by the New England Journal of Medicine investigated the viability of Covid-19 in air and on various surfaces, established that the virus would be stable/active up to 72 hours on (certain) surfaces and 3 hours in the air. This study also indicated that aerosol (air) transmission of Covid-19 is possible, as it remains active for several hours in air. UV therefore is a solution for decontaminating both surfaces and air. ■

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Footnotes:

1 *ANSES, November 2010. Évaluation de l'innocuité des réacteurs de lampes à rayonnements ultraviolets et de l'efficacité de ces proceeds pour la désinfection des eaux destinées à la consummation humaine*

2 *Hijen, Wim & Beerendonk, Erwin & Medema, Gertjan. (2006). Inactivation Credit of UV Radiation for Viruses, Bacteria and Protozoan (oo) Cysts in Water: A Review. Water research. 40 3–22. 10.1016/j.watres.2005.10.030*

3 *W. Kowalski, Ultraviolet Germicidal Irradiation Handbook. Springer Berlin Heidelberg, 2009*

4 *N. van Doremalan et al., "Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1," New England Journal of Medicine, March 2020*

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