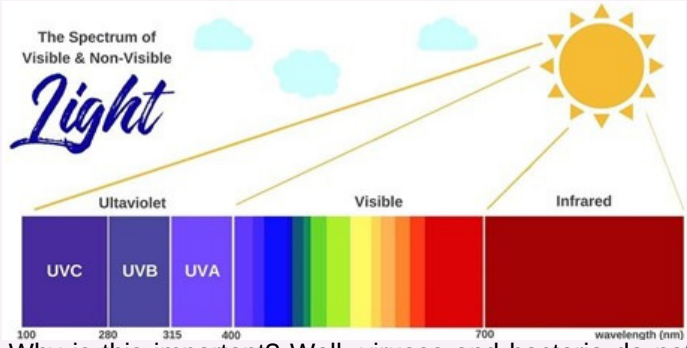
Is UVC lighting the way to a COVID-19 free future?

What if I told you that a part of the UV light spectrum could be used to kill Covid-19? What if I also told you that these particular wavelengths are so far thought to be completely safe to humans? What should we do with it?

"Use it!". That's what I exclaimed when Dr Kenny Wood asked our 4th year *Stars and Nebula* class those exact questions during a tutorial last semester. The UK's vaccination program is now well under way, but virologists have not been the only scientists fighting the pandemic fight. More and more research is emerging from the world of medical physics on the use of far-UVC light to destroy the SARS-CoV-2 virus responsible for Covid-19. This includes work from Kenny and a team here in St Andrews, along with a group at Ninewells Hospital in Dundee, that has caught the attention of both the UK and Scottish government.

What is UV-C?

On earth, as all of you sun cream wearers will hopefully know, we receive UV-A and UV-B light from the sun that may damage our skin and eyes, potentially leading to more serious issues such as skin cancer and cataracts. However, the sun also emits a third type of UV radiation: UV-C. These wavelengths, lying on the shorter end of the spectrum between 100-280 nm, are absorbed by ozone in the atmosphere before they can reach us here on the ground [1].



Why is this important? Well, viruses and bacteria do not cope very well under the UV-C spotlight. In fact, UV-C has been known for a long time to inactivate not only the SARS-CoV-2 virus responsible for Covid-19 [2], but thousands of different viruses, and even the bacteria behind drug resistant 'Superbugs' [3]. Now, given our well established fear of its longer wavelength family, you might have already guessed at a potential problem here; surely at this higher energy, UV-C must be the lethal Godfather of all ultraviolet light?

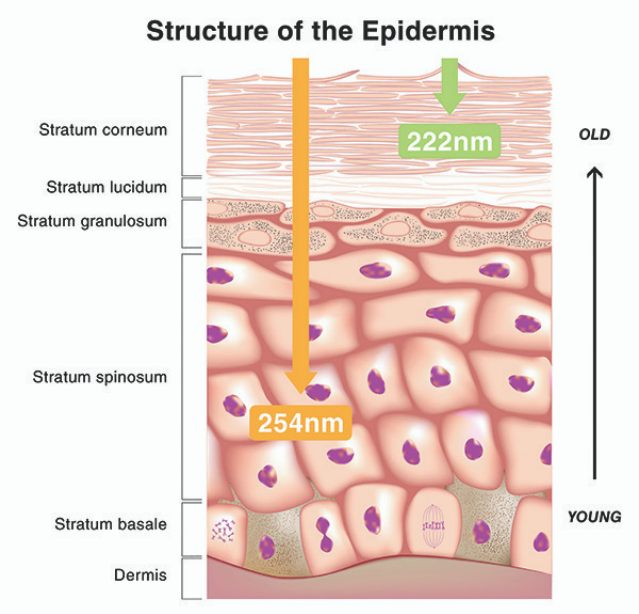
Whilst there is practically no evidence of UV-C causing skin cancer, exposure can result in significant skin and eye damage. The good news is that we have known about the killing capabilities of ultraviolet for decades! In other words, scientists have already worked out how they can exploit the UV's bug busting abilities, whilst simultaneously protecting us from these harmful rays. From slowing the spread of infection during the 1957 influenza pandemic, to cleaning the New York subway [4], and even in Russian prisons [5], this is a tried and tested disinfection method that has been around since the 1930s. The technology in question is known as '254 nm upper-room Ultraviolet Germicidal Irradiation (UGVI)' [6], and operates by enclosing the UV lighting within beams above head height, allowing the radiation to disinfect the circulating air in the 'upper room' without affecting us down below. If properly installed this can equate to 24 air changes per hour!

Not content to stop there, scientists took a closer look and found that some wavelengths of UV-C might actually be much safer than we first thought...

Far-UV-C technology - in Room 230 of the Physics building!

Far-UV-C' refers to wavelengths below 230 nm, and research undertaken in the last few years suggests that within this range, the radiation poses no risk of skin or eye damage whatsoever [7]. Why? As it turns out, our bodies actually have a natural armour that these wavelengths cannot penetrate. Both the outermost layer of our skin, composed of dead skin cells, and the tear layer of our eyes, contain proteins that readily absorb all far-UV-C, preventing the light from really getting anywhere.

This has motivated the production of new far-UV-C technology that, at 222nm, can be given the freedom to shine down on an entire room of people at no risk, whilst continually disinfecting the air that we breathe and the surfaces we touch.



As a relatively new technology, further evidence for both the efficacy and safety of 222 nm UV is continually being sought, including some new results sent to us by Dr Wood last week. In collaboration with Fluid Gravity Engineering, a local St Andrews company, they modelled how UV could reduce viral concentrations of COVID-19 in a classroom setting. To explain what the computer simulations found, let me first set the scene...

You're in Room 230 in the Physics building. There are four air grates and three open windows. 7000 viral particles are released simultaneously from random locations. A number of simulations are then run based upon two different configurations of the 222nm UV lights: the 'USHIO' illumination pattern, and an isotropic illumination pattern.

The results show that the simulation with an isotropic illumination of the entire room by eighteen 222 nm lamps at the current regulatory limits, the viral concentration would reduce to 0.1% in just over 25 minutes. If the wattages were increased by a factor of a hundred above those limits, however, the virus could be inactivated in less than a minute! A hundred times the current safety levels may sound like a lot, but ongoing safety studies suggest that this could definitely be a feasible reality.

New variant? No problem.

As you will be tired of hearing about from recent news stories, the virus behind Covid-19 is a rapidly mutating one, which leads to new variants. With the emergence of these new strains, there is growing concern over the efficacy of the COVID-19 vaccinations. So, is it the same with UV light? Could the virus evolve to become UV-resistant?

During a TED talk in July of last year, Dr David Brenner, one of Kenny's colleagues at Columbia University and a leading spokesperson for the largescale use of UV-C light, was asked a similar question [8].

In the answer lies perhaps the most distinguishing characteristic of UV-C light compared to other infection control methods. Brenner explained that, unlike vaccinations or drugs that act on a particular feature of viral RNA, UV light hits the virus "like a sledgehammer", causing "unpredictable damage" to the genome. In other words, COVID doesn't know what's coming! The virus could not possibly evolve to be prepared for ANY type of attack on EVERY part of its genetic material. Not only this, but as I said earlier, ultraviolet light has been used for decades with no evidence of viruses or bacteria ever having become resistant.

So, is UV-C the light at the end of the tunnel?

With the potential this work has, not only for the current pandemic but for the prevention of other infectious viruses in the future, as well as a solution for untreatable 'superbugs', it is no wonder that the government has taken interest in the work done by Dr Wood and his colleagues. In a report written for the UK and Scottish governments in October of last year, Kenny, together with Dr Ewan Eadie of the Ninewells' photobiology department, outlined the ways in which both the old and new UV technology could be put to use right now [9].

They advocate for the immediate installation of 254 nm upper-room UVGI in high risk areas with low levels of ventilation, such as care homes, dentists and particular hospital clinics. They also suggest that this technology could be rolled out to businesses such as those in hospitality, or indoor sports.

As far as the implementation of the 222 nm UV is concerned, further studies into the long term safety and efficacy of far-UV-C are needed, and are indeed already planned. However, given the positive results of recent human and animal safety studies, the two physicists believe 'the benefits of installing filtered far-UV-C lighting outweigh the risks'. As to the practicalities, ramping up manufacturing will be the primary battle. The 222 nm lamps are currently more expensive than the conventional ones, with production almost exclusively in Japan and America. Perhaps you know someone in optics looking for a new project – 222 nm LEDs, anyone?

by Rachel Black

Want to find out more?

Dr David Brenner of Columbia University, mentioned earlier in this article, will be giving the colloquium next Friday (the 12th of February) on everything far-UV-C. Kenny informs me that this will also be recorded and sent to some very interested government advisors...