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REVIEW ARTICLE

COVID-19 AND ITS DERIVATIVES: A RELATION WITH LIGHT FOR HEALTH

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ABSTRACT

Light now has many applications in life and plays a vital role in therapeutic and protective fields. In the recent era, many light sources are considered for prevention, sterilization, and curing, especially with artificial lamps. Since the coronavirus pandemic appeared in 2019, the world has been interested in sterilization by light rays from a physical and applied point of view. In this work, the authors focus on definite spectral bands and their direct effects on the current COVID-19 pandemic for a prevention spreading purpose.

According to the light use results, until now, the most useful method for decontamination against COVID-19 is ultraviolet C. The other spectral bands like UVA, UVB, and violet-blue show that they have a more negligible effect on the deactivation of the COVID-19 virus. The UVA and UVB help increase vitamin D in the human body, reflecting positively on the immunity system and increasing the recovery rate. The violet-blue band is helpful in decontamination against bacteria microorganisms. As for the IR band, the studies are still recent, and until now, there is no recommendation to use this band in sterilization against this pandemic. Studies continued on UV utilization because the world urgently needs industrial and domestic disinfection systems and sterilization. The other bands have another substantial practical effect on health improvement so any people can survive and overcome different diseases.

KEYWORDS

UVC disinfection, blue light, disinfection devices, environmental UV bands, prevention from COVID-19

INTRODUCTION

COVID-19, the pandemic that started in 2019, told us dramatically how our health is so important and the many benefits of the use of light. As for knowledge, and according to the World Health Organization (WHO), Coronavirus disease is an infectious disease caused by the SARS-CoV-2 virus. The recent pandemic (COVID-19) was first reported in Wuhan, China, in 2019 and subsequently spread globally to become the fifth documented pandemic since the 1918 influenza pandemic [1] [2] [3]. By 2022, about two and half years from the day COVID-19 was first detected, over 4.6 million people worldwide have lost their lives because of the disease spread. The best way to prevent and slow down transmission is to be well informed about the disease and how the virus spreads.

The more the pandemic increases, the more interest is in how to protect and disinfect. This article focuses on the multiple uses of light in many fields during the last two years and significantly, the relationship benefits for health (cure and disinfection). These studies show us how much some spectral light bands have, their benefits and how they can be used.

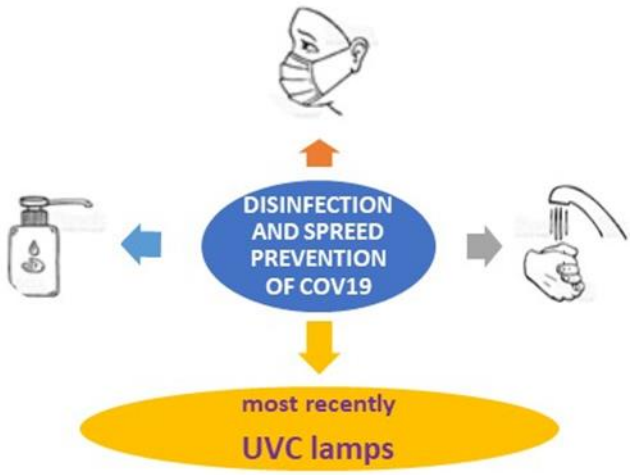
UVC BAND AND DECONTAMINATION

Researchers have discovered that viruses have been sensitive to heat radiation and UV light from the early nineteenth century until now. COVID-19 is considered to belong to the SARS Coronavirus family; moreover, researchers have indicated that ultraviolet light (UVC) has the capability to destroy viruses and can be effective for sterilizing device surfaces or human clothes (Figure 1) that may contaminate with the SARS-CoV-2 virus [4]. UVC radiation inactivates microbes by damaging their DNA. Unfortunately, severe eye and skin injuries can result if UVC lamps are misused or if the skin is irradiated accidentally. Besides, some materials may indicate degradation after prolonged exposure to UV light. Researchers and recommendations of healthcare committees prove that over 90% of bacteria, and viruses on the body surface, and clothes were utterly removed after examining the body disinfection chamber [5] [6].

In the last two years, many researchers worked hard to measure and determine an approximate effective disinfection dose for the Coronavirus. These measurements were performed at various distances from sources with different intensities. The results concluded that the approximate disinfection dose using an ultraviolet source (UVC) was around 60 mJ/cm2 considering the distance between the source and the irradiated area [7] [8] [9] [10]. On the other hand, according to the International Ultraviolet Association, it is generally accepted that a dose of 40 mJ/cm^2 of 254 nm light kills at least 99.99% of "any pathogenic microorganism". Therefore, UVC light is just novel to SARS-CoV2 [11].

Concerning the disinfection process, one of the famous tools used is the UV chambers. The uniformity of the irradiation must be considered to ensure that all samples along the irradiated area will be uniformly exposed to the disinfection dose. Therefore, several types of research focused on this matter by using different techniques; some are simple while others are complicated to achieve the best uniformity [12] [13] [14]. Faramawy and Reda [15] illustrated how to enhance the uniformity by applying a simple and applicable technique to their designed and manufactured UV exposure cabinet stabilized at the radiometry lab, National Institute of Standards (NIS), Egypt. In the presence of the COVID-19 pandemic and the need for sterilization of devices or even workers to avoid the spread of diseases and to ensure safety and protection, the authors depended on the enhancement uniformity results and hence irradiance levels increment for the next step, how such UV exposing cabinets help in the COVID-19 epidemic. This method was applied to COVID-19 samples extracted from patients as an experimental study to chase the effect of an enhanced dose and uniformity on inhibition of the virus in the samples. The results were promising, and the inhibition of the virus increased uniformly along with the sample's irradiated area with lower exposure time.

FIGURE 1. DIFFERENT TOOLS USED FOR THE DISINFECTION PROCESS.



Another vital research project was about masks that became a mandatory tool for humans to avoid Infectious diseases as one of the most effective COVID-19 prevention measures [16]. Although this article may not relate to the role of the light band in the COVID 19 disinfection, it is directly related to the spread prevention of the diseases. Juri Taborri et al. [16] are interested in measuring and evaluating the breathability of each mask for each manufacturer. The authors tested about 300 commercially available masks from different companies to evaluate the reproducibility and uncertainty in the breathability measurement. The results indicated that most commercial companies' mask samples did not meet the acceptability threshold and did not satisfy standard requirements for breathability per each mask. In their conclusion the authors recommended that the measurement reproducibility parameter should be introduced into standards to reduce misclassifications related to the breathability compliance of surgical masks.

VARIETY IN THE RECENT DISINFECTION DEVICES

Since the spread of the COVID-19 pandemic, the world has been fascinated to produce devices and tools used for air sterilization to limit the spread of this disease, and of course, the sources used in such devices are UVC (Figure 2). This article highlights some devices that achieve the disinfection purpose. Xenex company, U.S., produced a Light Strike Robot for this purpose, to deactivate the COVID-19 virus in the air within 2 Minutes [17]. The Xenex Robot helps decontaminate many surfaces in hospitals, medical office buildings, hotels, offices, gyms, airplanes, and other spaces to save many people's healthcare. This device's disinfection dose of UVC radiation is about 40 mJ/cm^2 at 1 m.

Hamzavi et al [18], on the other hand, produced their research on a prototype model using Ultraviolet germicidal irradiation (UVGI) as a method for disinfection to facilitate the reuse of dwindling supplies. The irradiation area is approximately 38 cm × 114 cm, allowing for the treatment of around 18 to 27 masks (2 minutes per side). The distance between the lamp and the table surface is approximately 14 cm, with an incident dose of about 400 mJ/cm^2. It is important to note that delivering a sufficient dose depends on the irradiance level; hence, it can be longer or shorter depending on its capabilities.

FIGURE 2. DIFFERENT EXAMPLES OF UVC AIR DISINFECTION APPLICATIONS

Sterilization gates and devices recently appeared in conjunction with the COVID-19 pandemic and attracted the author's attention. This rectangular equipment also uses UVC lamps and disinfection spray on both sides with maximum ozone to disinfect the air and humans. This cabinet is manufactured according to safety standards such as BS EN 60598 (EN 62471:2008), EN 60598-1:2015/A1:2018, and EN 14255-1:2005. UVC gates are suggested to be used in many places because they are designed to ensure safe air decontamination and free of potential viral hazards keeping people safe from the infection as much as possible. They produce doses of around 1.2 to 1.7 mJ/cm^2 of far UVC light (222 nm) within less than 30 seconds, which is efficient enough to kill 99.9% of airborne coronaviruses carried by aerosols.

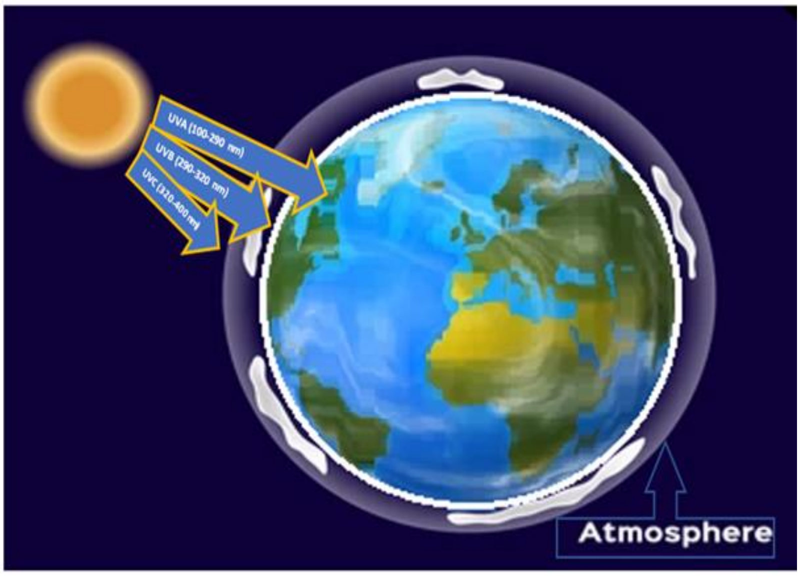
Is it safe to use a UVC lamp for disinfection purposes at home? An essential question that has lately shown up around the world as a reason of interesting in sterilization of inner houses air. UVC lamps used for disinfection purposes may pose potential health and safety risks depending on the UVC wavelength, dose, and duration of radiation exposure. The risk may increase if untrained individuals use these units. Several manufacturing companies have worked hard to avoid direct exposure hazards to the UVC by producing a unique household tool provided with a timing controller side by side with a possible sensor to sense any body movement. The disinfection coverage area is up to 2-3 m depending on the room area or the office; on the other hand, the movement sensors enable the device to stop operating if any moving body passes through.

Biological safety cabinets are used for Polymerase Chain Reaction (PCR) purposes, general tools decontamination and irradiated areas, or even samples disinfection for research. These devices need a mandatory performance test to ensure the disinfection doses occur all the time. The NSF/ANSI 49-2020 and related test standards focus more on how High-Efficiency Particulate Air (HEPA)-filtered effectiveness is than the performance of UVC lamps inside the cabinet. While some other research still is concerning the dose mechanism measurements and ensuring the proper disinfection dose and verifying the effective parameters on irradiation from the UVC sources. Therefore, it is recommended that these test standards are more interested in mentioning how to perform a practical dose test for these cabinets.

UVA, UVB, VITAMIN D, AND CORONAVIRUS INACTIVATION

It is well known that sunlight contains a spectrum of UVA, UVB, and UVC, with wavelengths ranging from 320–400 nm, 260–320 nm, and 200–260 nm, respectively (Figure 3). Sunlight that reaches the earth's surface contains only UVA and a small amount of UVB since UVC is absorbed by atmospheric ozone. The UVC can inactivate COVID19, while vitamin D synthesis is closely associated with UVB radiation exposure.

FIGURE 3. THE ULTRAVIOLET SPECTRUM FROM THE SUN AND THE ALLOWED SPECTRUM TO PENETRATE THE EARTH



Until now, it is well known that the recently emerged SARS-CoV-2 are inherently sensitive to UVC, while UVA and UVB lack virucidal deactivation. However, very recent research; [19] [20] [21] discusses the probable effect of UVA and UVB on disinfection purposes. Successful decontamination using other wavebands requires higher dosages and longer administration times.

Many reports have also identified an association between COVID-19 fatalities and latitude. One of these articles has analyzed the impact of sunlight on reducing SARS-CoV-2 transmissibility, morbidity, and mortality [19]. The intensity of sunlight is highest in areas close to the equator, and consequently, the populations in these regions with an increase of regular exposure to sunlight, are less at risk of vitamin D deficiency, based on the data obtained from the USA [19]. Studies in Jakarta, Indonesia, showed that a higher duration of sunlight exposure was associated with a rise in the recovery rate among patients [20]. That is because the direct exposure of the skin to the sunlight promotes producing an essential vitamin D component that directly regulates the immune system, and hence the Vitamin D can lower the potential risk of respiratory tract infections, including COVID-19.

Another relationship was foundforthe link between COVID-19 and local environmental conditions [21]. The findings indicate that the lower temperature regions were associated with a rapid increase in the COVID-19 cases compared to the countries in warmer regions. Similar studies were held on the relation between the winter and summer to how much the COVID-19 can spread [22]. Temperature may play a significant role in viral transmissibility. Therefore, we can find an interesting link between sunlight exposure, latitude, and vitamin D status with COVID-19 incidence, fatality, and recovery rates from these interesting research studies.

Focusing on the UVB (290–315 nm) in sunlight, fascinating papers discussed the use of this band in the deactivation of COVID 19 on surfaces and air, resulting in reducing infected people's death [20] [21]. Recent direct measurements of UVB sunlight showed shorter inactivation times, less than approximately 10 minutes, depending on latitude, season, and hour [21]. The calculation estimations were held near noon, with clear-sky direct sunlight for mid-latitude sites between March and September. The inactivation times in these months give values of the time for 90% inactivation (T90) < 90 min and less than 60 minutes for many equatorial sites for 12 months of the year. In conclusion, UVB sunlight's direct measurements inactivation effect on the COVID-19 shows a shorter T90 time depending on latitude, season, and hour. Another research study was interested in finding evidence of UVB radiation's protective role in reducing COVID-19 deaths [21]. These authors discussed an increment in a permanent unit in Ultraviolet Index (UVI), which is associated with around a 1% point decline in daily growth rates of COVID-19 deaths. By the end of the research, they concluded they found a significant negative association between UVI and COVID-19 deaths, showing evidence of the protective role of UVB in mitigating COVID-19 deaths. In addition, if it is confirmed via clinical studies, then the possibility of mitigating COVID-19 deaths via sensible sunlight exposure or vitamin D intervention would be attractive.

Faramawy and Reda [15] focused their research to study using UVB and UVA lamps on COVID-19 samples to study the inactivation effect. The results indicated that they have the disinfection effects, but the exposure dose and exposure time results were much higher, approximately three to four times than UVC's results. Thus, for the primary sterilization of devices, tools, and even humans, a much shorter time is needed for exposure, so the UVC lamps still have the priority.

VIOLET-BLUE LIGHT AND CORONAVIRUS, DISINFECTION SUPPOSES

Blue band phototherapy is a well-known method for neonate jaundice, but it can be used for disinfection purposes; and it is one of the exciting experiments that have been taken into account in recent times. Processes such as disinfection, photocatalytic cleaning, plant growth, and wound healing can be triggered with the help of blue light LED systems. Consequently, violet-blue light with a 405 nm wavelength is the most useful antimicrobial disinfection tool, so it can be recommended to continuously decontaminate surfaces and the environment [23] [24]. LEDs with an emission maximum in this range and a narrow spectral width of about 10 nm represent an attractive light source for disinfection applications.

Disinfection processes using blue LEDs are currently attracting increasing attention. This is due to the excellent tolerability of the light and its antimicrobial effect without the addition of exogenous photosensitizers [25]. However, even though LEDs have become more powerful in the past decade, LEDs in the UVC range are not a perfect disinfection technique compared to UVC radiation. They still have low energy efficiencies of 10 % or less [26].

On the other hand, although blue light is far less harmful to humans and materials, it can pass through the cornea and lens to the retina and may cause diseases such as dry eye, cataracts, and macular degeneration. It even stimulates the brain, inhibits melatonin secretion, and enhances hormone production, affecting sleep quality in the long run. Therefore, blue LEDs require a precise analysis of their emissions and a classification according to the risk groups defined in the international standard IEC 62471 to ensure safe operation. Single blue high-power LEDs without diffusers typically belong to risk group one or two [27]. They do not represent a photobiological danger as long as people do not stare into the light. Eye-protectors are necessary when high-energy blue LEDs are used. Unfortunately, another disadvantage of blue light technology is that viruses cannot be deactivated [27] [28]. Even though the blue light may not be used as a disinfection tool for COVID-19, it helps prevent a surface from bacteria infection. Therefore, the author mentions the importance of this band for disinfection purposes.

INFRARED BANDS AND DRY HEAT, TRIALS FOR COVID-19 DISINFECTION

Few researchers in recent years have studied how much Infrared radiation can affect or deactivate viruses, especially during the current pandemic. Infrared (IR) heating has many benefits over traditional heating. Thermal processing is an essential method of inactivating foodborne viruses [29]. This study shows that the heating or treating with IR radiation wavelengths technique effectively decontaminates some human viruses with temperatures from 600C - 900C with suitable exposure time for each suggested temperature. One of the other vital studies was the first case treated with near-infrared light [30]. The study used NIR light therapy to use a device containing light-emitting diodes (LEDs) at a wavelength, which can penetrate the skull to stimulate and heal underlying tissue. The results were auspicious for treating cortical hypos-perfusion brought on by COVID-19 infection, which means this technique cures the pandemic symptoms but does not yet affect the COVID-19 virus itself. Studies also discuss the possibility of red and infrared phototherapy to reduce the impact of the respiratory complications of coronavirus diseases [31]. The studies and results show that infrared light can reduce some of the critical complications of coronavirus infections, i.e., pulmonary inflammation and lung fibrosis.

The direct effect of infrared on COVID-19 decontamination is still being studied. One of these recent surveys concluded that IR radiation might have a virucidal effect on healthcare, in decontaminating sensitive instruments, and high-efficiency particulate air (HEPA) filters to reduce transmission and save lives [32]. The advantages of IR decontamination include uniform heating, low energy consumption, and short cycle times, but there are currently no approved IR decontamination systems for all events.

CONCLUSION

The electromagnetic radiation delivered to the earth from the sun is divided into definite spectra; UVB, UVA, visible light, and IR. Since the COVID-19 pandemic started, the urgent necessity for continuous sterilization and the possibility of light therapy appears as important. The recent studies focused on sterilization by using artificial UV sources, especially the UVC lamps, set in different devices. Ultraviolet radiation is most effective and probably saves radiation under many decontaminated surfaces precautions. This is available using devices such as biological safety cabinets or any other UV chambers and a proper disinfection dose and distance. Air decontamination requirements appeared as important as well, and hence, other devices like sterilization gates, UV robots, and household UV lights have presented as possible options. These devices have unique designs with proper disinfection doses that sterilize the air without harming untrained people in houses, offices, and airplanes. Warnings and precautionary instructions are considered as the UVC sources are used to reach the desired prevention and decontamination disposal goals. Other research has been directed to study the effect of environmental UVB and UVA on reducing the spread of COVID-19. Many exciting links are found between sunlight exposures, latitude, the autumn and summer seasons, and vitamin D status with COVID-19 incidence, fatality, and recovery rates. On the other hand, blue light is known for jaundice therapy but a trend to use it in the sterilization field has recently appeared. The findings concluded that this spectrum band might not be used as a disinfection tool for COVID-19, but the blue light helps more in disinfection for bacteria on the surface.

Therefore, as long as we live with periodical seasonal pandemics, we cannot give up using light sources to support good health, earning a superior ability to survive and overcome different diseases.

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DECLARATIONS

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