International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 4, June 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Research on Effect of UV-C Light on Bacteria & Viruses

Manish Ranjan, Sumit Kumar Singh

Student, Electronics and Communication Engineering,
GL Bajaj Group of Institutions, Mathura, Uttar Pradesh, India

ABSTRACT
In this time, many diseases spread from Bacteria and Viruses. The real example of Virus disease is covid-19. Bacteria and Viruses are very small things that can only see with special equipment (a microscope). Bacteria are microscopic living organisms, usually one-celled, that can be found everywhere. A virus is a submicroscopic infectious agent that replicates only inside the living cells of an organisms. Viruses are the most common biological entities on earth. Once a person is infected with virus, their body become a reservoir of virus particles which can be released in bodily fluids such as by coughing and sneezing or by shedding skin or in some cases even touching surfaces, contact with contaminated food and water. Many diseases like Influenza, Chickenpox, Typhoid are spread from Bacteria and viruses. So, in this paper we discuss how to control the infection of Bacteria and viruses using UV-C (Ultraviolet-C) and also discuss the Effect of UV-C Light on Bacteria & disease.

KEYWORDS: *Ultraviolet, UV-C light, Effect of UV-C light, Benefits, Germicidal UV-C, Applications of Germicidal UV-C*

***How to cite this paper**:* Manish Ranjan | Sumit Kumar Singh "Research on Effect of UV-C Light on Bacteria & Viruses" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-4, June 2020, pp.899-903, URL: www.ijtsrd.com/papers/ijtsrd31251.pdf

IJTSRD31251

1. INTRODUCTION
UVC radiation is known to be highly germicidal. However, exposure to 254-nm-UVC light causes DNA lesions such as cyclobutene pyrimidine dimers (CPD) in human cells, and can induce skin cancer after long-term repeated exposures. It has been reported that short wavelength UVC is absorbed by proteins in the membrane and cytosol, and fails to reach the nucleus of human cells. Hence, irradiation with 222-nm UVC might be an optimum combination of effective disinfection and biological safety to human cells. In this study, the biological effectiveness of 222-nm UVC was investigated using a mouse model of a skin wound infected with methicillin-resistant *Staphylococcus aureus* (MRSA). Irradiation with 222-nm UVC significantly reduced bacterial numbers on the skin surface compared with non-irradiated skin. Bacterial counts in wounds evaluated on days 3, 5, 8 and 12 after irradiation demonstrated that the bactericidal effect of 222-nm UVC was equal to or more effective than 254-nm UVC. [1]

2. Ultraviolet Light
Ultraviolet is the part of the electromagnetic spectrum shown on the left side of the picture below as black—because humans cannot see light of such short wavelength (or high frequency). Many animals such as some insects, some reptiles, crocodiles, salamanders, and small birds can see things that reflect this light. **UV** is a common abbreviation of ultraviolet, mainly used in technical contexts. [2]

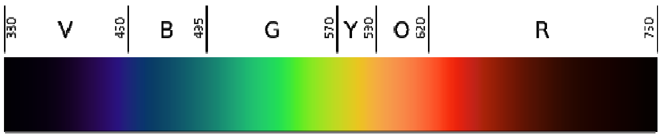

Fig1. Visible Light region

UV (Ultraviolet) Light refers to the region of the electromagnetic spectrum between visible light and X-rays, with a wavelength falling between 400 and 10 nanometers. This electromagnetic radiation is not visible to the human eye, because it has a shorter wavelength and higher frequency than the light our brain perceives as images. An easy way to remember UV light's placement on the electromagnetic spectrum is to examine the ends of the visible light spectrum: Red is the light with the longest wavelength, and Violet is the light with the shortest wavelength. Therefore, light with a wavelength longer than any light in the visible spectrum is called Infrared Light, and light with a wavelength immediately shorter than any light in the visible spectrum is called Ultraviolet Light. [2]

2.1. Types of Ultraviolet Light
UV light has three wavelength categories:
- UV-A Light
- UV-B Light
- UV-C Light

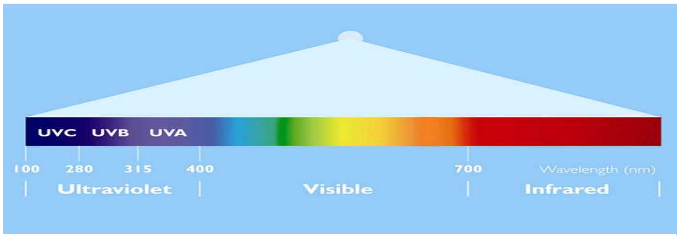

Fig2. Division of UV Light

2.1.1. UV-A Light
UV-A light (320-400nm) is UV light with the longest wavelength, and the least harmful. It is more commonly known as "black light", and many use its ability to cause objects to emit fluorescence (a coloured glowing effect) in artistic and celebratory designs. Many insects and birds can perceive this type of UV radiation visually, along with some humans in rare cases such as Aphakia (missing optic lens). [2]

2.1.2. UV-B Light
UV-B light (290-320nm) causes sunburns with prolonged exposure along with increasing the risk of skin cancer and other cellular damage. About 95% of all UV-B light is absorbed by the ozone in Earth's atmosphere. [2]

2.1.3. UV-C Light
UV-C light (100-290nm) is extremely harmful and is almost completely absorbed by Earth's atmosphere. It is commonly used as a disinfectant in food, air, and water to kill microorganisms by destroying their cells' nucleic acids. With UV-C technology it is possible to destroy more than 99.99% of all pathogens within seconds, without addition of chemicals, without harmful side effects, inexpensively, highly efficiently and absolutely reliably. [2]

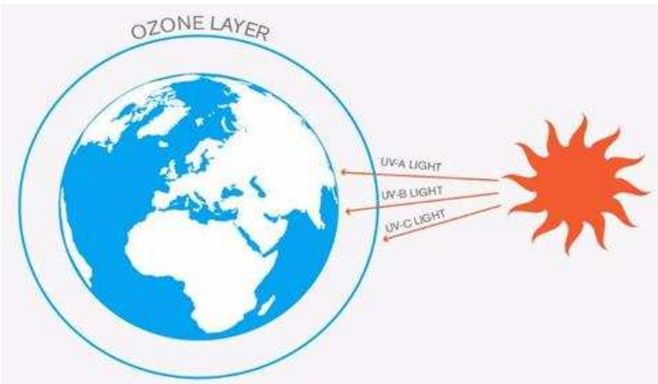

Fig3 (a). Absorption of UV Light through Ozone layer

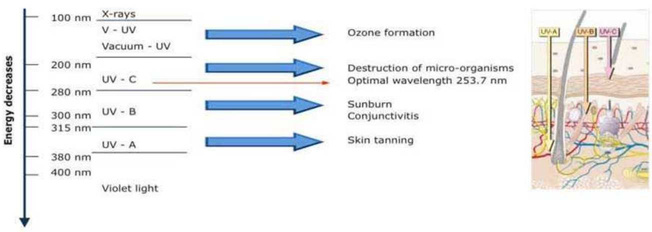

Fig3 (b). Absorption of UV Light through our body

3. Benefits of UV-C technology
- **Defeat micro-organisms** Proven effective against viruses, bacteria, melds and spores.
- **Protect against microorganism growth -** Keeps the surface of water reservoir clean from biofilm. Keeps air treatment systems clean.
- **Reliable disinfection** Disinfection effects is directly related to UV dose (intensity and exposure time of micro-organisms). It's simple to measure effectiveness once system design is validated.
- **Easy and cost-effective** UV-C installation have low capital and operation costs and are easy to operate and maintain.

4. Effect of UV-C Light
Continuous low doses of far-ultraviolet C (far-UVC) light can kill airborne flu viruses without harming human tissues, according to a new study at the Centre for Radiological Research at Columbia University Irving Medical Centre (New York, NY).1 The findings suggest that use of overhead far-UVC light in hospitals, doctors' offices, schools, airports, airplanes, and other public spaces could provide a powerful check on seasonal influenza epidemics, as well as influenza pandemics.

Scientists have known for decades that broad-spectrum UVC light, which has a wavelength between 200 and 400 nm, is highly effective at killing bacteria and viruses by destroying the molecular bonds that hold their DNA together. This conventional UV light is routinely used to decontaminate surgical equipment. "Unfortunately, conventional germicidal UV light is also a human health hazard and can lead to skin cancer and cataracts, which prevents its use in public spaces," says study leader David Brenner. [3]

Several years ago, Brenner and his colleagues hypothesized that far-UVC could kill microbes without damaging healthy tissue. "Far-UVC light has a very limited range and cannot penetrate through the outer dead-cell layer of human skin or the tear layer in the eye, so it's not a human health hazard. But because viruses and bacteria are much smaller than human cells, far-UVC light can reach their DNA and kill them," Brenner said. [3]

4.1. UV-C Effect on Screen
Acute (short-term) effects include redness or ulceration of the skin. At high levels of exposure, these burns can be serious. For chronic (long-term) exposures, there is also a cumulative risk, which depends on the amount of exposure during your lifetime. The long-term risk for large cumulative exposure includes premature aging of the skin and skin cancer. [4]

5. Application of Germicidal UVC Light
5.1. water Application
UV water purification offers a secure, effective and cost-efficient alternative to chemical treatment. With no harmful by-products, the worldwide use of germicidal UVC technology is critical for eco-systems and reducing pollutants in rivers, oceans and other bodies of water. UV water purification applications still grow within the industries of water reclamation, ship ballast water, waste water, beverage, industrial and commercial process water, pool and spa, aquaculture and life sciences. [5]

5.2. Air Application
Maintaining clean, fresh air is essential to life, and many industrial processes cause pollutants, contaminants, and nuisance odors in the atmosphere and in the immediate environment. Our proprietary germicidal UVC technology

offers OEMs affordable and effective solutions for both air sterilization and odor control. [6]

5.2.1. Air Sterilization

UV technology provides air sterilization from transmissible agents, fungi, bacteria, viruses, and spores. A UV germicidal lamp integrated in a hospital air conditioning system will sterilize pathogens that cause illness and contaminants that aggravate asthma and other respiratory ailments. In general, air conditioners are breeding grounds for harmful organisms that cannot be treated with filters alone, risking health in locations such as burn centres, and methadone and TB clinics. [7]

In industries that require a sterile and clean environment, UVC is utilized to reduce the number of 'live' organisms in the air, such as in scientific laboratories. Here it may also sterilize equipment and surfaces when employees are not in the room. Printing, plastics and rubber, or wood and surface treatment industries produce harmful and toxic chemicals and sterilization of air offers many benefits. Germicidal lamps in sterilization units are used to protect the health of workers by reducing or eliminating VOCs and industrial exhausts containing solvents. [6]

5.2.2. Odor Control

There are many areas of application for germicidal UVC odor control, including wastewater plants, farms, commercial kitchens (HVAC), kennels, food processing plants, or in any circumstance where odor is a by-product of operations.
For many industries, odor control can help to reduce the extra time and money spent on nuisance complaints. At wastewater plants, for example, hydrogen sulphide-based odors are a concern for operator safety and an annoyance to nearby residences or public facilities. [6]

5.3. Surface Application

Germicidal UVC lamps offer *surface sterilization* without chemicals, which is critical in many industries. In food processing, for example, UVC can kill viruses, bacteria, yeast, and fungi in seconds, eliminating the need to use harmful chemicals on surfaces that come in contact with food.
UVC technology is indispensable in locations where human health is contingent on a sterile environment, such as hospitals and surgical centres. During prolonged surgical procedures, for example, UVC is used to minimize infection.

5.3.1. Food Processing

Surface sterilization using UV technology improves the shelf life of food stuffs, including breads and meats. In addition, UV hormesis can reduce post-harvest losses due to the delayed ripening of fruits and vegetables. With 550 million dollars of fresh fruits and vegetables exported from the US year to date, UV hormesis offers great potential.

UV germicidal is increasingly being used for the surface sterilization of filling equipment, conveyor belts, transport containers, working surfaces of foodstuffs, counter tops, and on liquid-sugar tanks to kill mold and bacteria. [7]

5.3.2. Low Pressure UV Curing

Low pressure UV technology can cure inks, resins, and adhesives with no hazardous waste and fewer maintenance costs. Currently, there is a growing trend in many industries to change from heat-cured inks to UV-cured inks. Our proprietary low-pressure pellet amalgam lamp technology produces the only lamp that allows for vertical orientation.

5.3.3. Medium Pressure UV Curing

Medium pressure UV technology is used in many curing applications, including adhesive bonds, coatings, engraving and plating resist, inks, varnishes, lacquers and decorative glazes. Curing with UV saves on maintenance costs and produces no hazardous by-products. More manufacturers are converting to UV curing systems. [6]

6. Ultraviolet germicidal irradiation technology

Ultraviolet germicidal irradiation (UVGI) is a disinfection method that uses short-wavelength ultraviolet (ultraviolet C or UV-C) light to kill or inactivate microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions.[8] UVGI is used in a variety of applications, such as food, air, and water purification.

UV-C light is weak at the Earth's surface since the ozone layer of the atmosphere blocks it.[9] UVGI devices can produce strong enough UV-C light in circulating air or water systems to make them inhospitable environments to microorganisms such as bacteria, viruses, molds, and other pathogens. UVGI can be coupled with a filtration system to sanitize air and water.

6.1. Germicidal Lamp

Germicidal UV for disinfection is most typically generated by a mercury-vapor lamp. Low-pressure mercury vapor has a strong emission line at 254 nm, which is within the range of wavelengths that demonstrate strong disinfection effect. The optimal wavelengths for disinfection are close to 270 nm.[10]:2–6

Mercury vapor lamps may be categorized as either low-pressure (including amalgam) or medium-pressure lamps. Low-pressure UV lamps offer high efficiencies (approx. 35% UV-C) but lower power, typically 1 W/cm power density (power per unit of arc length). Amalgam UV lamps utilize an amalgam to control mercury pressure to allow operation at a somewhat higher temperature and power density. They operate at higher temperatures and have a lifetime of up to 16,000 hours. Their efficiency is slightly lower than that of traditional low-pressure lamps (approx. 33% UV-C output), and power density is approximately 2–3 W/cm. Medium-pressure UV lamps operate at much higher temperatures, up to about 800 degrees Celsius, and have a polychromatic output spectrum and a high radiation output but lower UV-C efficiency of 10% or less. Typical power density is 30 W/cm^3 or greater.

Depending on the quartz glass used for the lamp body, low-pressure and amalgam UV emit radiation at 254 nm and also at 185 nm, which has chemical effects. UV radiation at 185 nm is used to generate ozone.

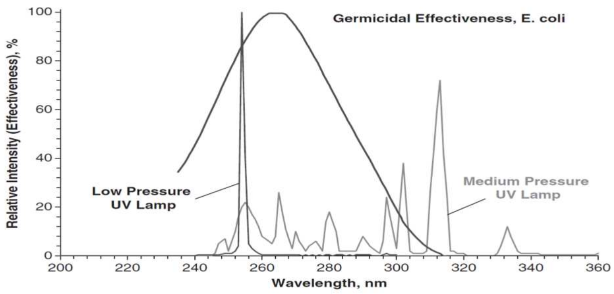

Fig4 (a). Low pressure and Medium pressure UV Lamp

The UV lamps for water treatment consist of specialized low-pressure mercury-vapor lamps that produce ultraviolet radiation at 254 nm, or medium-pressure UV lamps that produce a polychromatic output from 200 nm to visible and infrared energy. The UV lamp never contacts the water; it is either housed in a quartz glass sleeve inside the water chamber or mounted externally to the water, which flows through the transparent UV tube. Water passing through the flow chamber is exposed to UV rays, which are absorbed by suspended solids, such as microorganisms and dirt, in the stream.[11]

Fig4(b). Germicidal Lamp

6.2. LEDs (Light Emitting Diodes)

Recent developments in LED technology have led to commercially available UV-C LEDs. UV-C LEDs use semiconductors to emit light between 255 nm and 280 nm.[12] The wavelength emission is tuneable by adjusting the material of the semiconductor. As of 2019, the electrical-to-UV-C conversion efficiency of LEDs was lower than that of mercury lamps. The reduced size of LEDs opens up options for small reactor systems allowing for point-of-use applications and integration into medical devices.[13] Low power consumption of semiconductors introduce UV disinfection systems that utilized small solar cells in remote or Third World applications.[13]

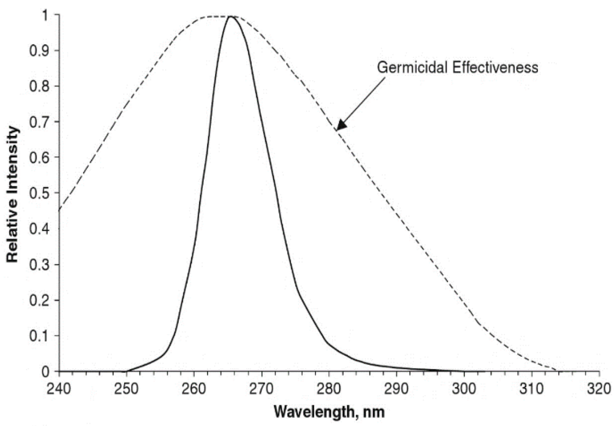

Fig5 (a). UVC Led Emitting 265nm compared to Germicidal Effectiveness Graph

UV-C LEDs don't necessarily last longer than traditional germicidal lamps in terms of hours used, instead having more-variable engineering characteristics and better tolerance for short-term operation. A UV-C LED can achieve a longer installed time than a traditional germicidal lamp in intermittent use. Likewise, LED degradation increases with heat, while filament and HID lamp output wavelength is dependent on temperature, so engineers can design LEDs of a particular size and cost to have a higher output and faster degradation or a lower output and slower decline over time.

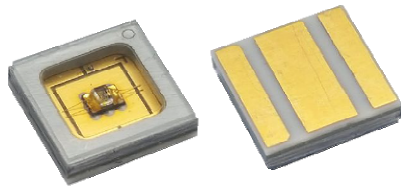

Fig5(b). UV-C LED

7. Conclusions

The UVC treatment of sterile, commercial whole milk inoculated with bacteria caused a significant reduction for all bacterial species tested except *M. smegmatis*. The UVC treatment of colostrum samples inoculated with bacterial contaminants resulted in a significant reduction in the bacterial count at T3 for *Listeria* spp., *Salmonella* spp., and *Acinetobacter* spp., but not of *E. coli*, *Strep. agalactiae*, and *Staph. aureus*. Moreover, UVC treatment of colostrum lowered the concentration of IgG in colostrum in relation to the length of treatment duration. Processes that aim to reduce the bacterial count in colostrum must take into consideration the incidental effects on colostrum IgG. [14]

This study demonstrates that far-UVC light emitted from a laser and delivered using an optical diffuser is an effective tool to kill MRSA *in vitro*. The dose required to kill bacteria on a surface with far-UVC is slightly higher than with conventional UVC at 254 nm; however, given the lack of harmful biological effects with far-UVC, it is an attractive option for disinfection within wounds. The ability to diffuse the laser output over a large area makes this a viable solution for disinfection of infection prone tissues, such as around a catheter or other skin penetrating medical device. [15] We have demonstrated that the Pulsed-UVC device, associated with SOP, significantly reduced microorganisms from common high-touch surfaces.

8. References

[1] Kouji Narita, Krisana Asano, Yukihiro Morimoto, Tatsushi Igarashi, Michael R. Hamblin, Tianhong Dai, Akio Nakane Corrigendum to “Disinfection and healing effects of 222-nm UVC light on methicillin-resistant *Staphylococcus aureus* infection in mouse wounds” [J. Photochem. Photobiol. B Biol. 178 (January 2018) 10–18] Journal of Photochemistry and Photobiology B: Biology, Volume 182, May 2018, Pages 146.

[2] Stanford Solar center- http://solar-center.stanford.edu/about/uvlight.html.

[3] Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases.” The other contributors are David Welch, Manuela Buonanno, Veljko Grilj, Igor Shuryak, Connor Crickmore, Alan Bigelow, Gerhard Randers-Pehrson, and Gary Johnson (all at CUIMC).The study was supported by grants from the Shostack Foundation and the National Institutes of Health (1R41AI125006-01).

[4] Kalran University article of Dr. Kevin kahn (Market development Manager, EMEA): https://www.klaran.com/is-uvc-safe.

[5] Harm, W., 1980, *Biological Effects of Ultraviolet Radiation, International Union of Pure and Applied Biophysics*, Biophysics series, Cambridge University Press.[page needed]

[6] LightTech Light source blog Article https://www.light-sources.com/solutions/germicidal-uvc-lamps/uv-light-applications/

[7] hang, Kenneth (2020-05-07). "Scientists Consider Indoor Ultraviolet Light to Zap Coronavirus in the Air". *The New York Times*. ISSN 0362-4331. Retrieved 2020-05-11.

[8] *"Word of the Month: Ultraviolet Germicidal Irradiation (UVGI)"(PDF). NIOSH eNews. National Institute for Occupational Safety and Health. April 2008. Retrieved 4 May 2015.*

[9] "SOLVE II Science Implementation". NASA. 2003. Archived from the original on February 16, 2013. Retrieved 4 May 2015.

[10] *"Ultraviolet disinfection guidance manual for the final long term 2 enhanced surface water treatment rule" (PDF). Washington, DC: United States Environmental Protection Agency. November 2006. Retrieved 30 January 2011.*

[11] Wolfe, R. L. (1990). "Ultraviolet disinfection of potable water". *Environmental Science & Technology*. 24 (6): 768–773. Bibcode: 1990EnST...24...768W. Doi: 10.1021/es00076a001.

[12] Messina, Gabriele (October 2015). "A new UV-LED device for automatic disinfection of stethoscope membranes". *American Journal of Infection Control*. Elsevier. Retrieved 2016-08-15.

[13] *Hessling, Martin; Gross, Andrej; Hoenes, Katharina; Rath, Monika; Stangl, Felix; Tritschler, Hanna; Sift, Michael (2016-01-27). "Efficient Disinfection of Tap and Surface Water with Single High Power 285 nm LED and Square Quartz Tube". Photonics. 3 (1): 7. doi:10.3390/photonics3010007.*

[14] "Evaluation of the effects of ultraviolet light on bacterial contaminants inoculated into whole milk and colostrum, and on colostrum immunoglobulin G" R. V. Pereira, M. L. Bicalho, V. S. Machado, S. Lima, A. G. Teixeira, L. D. Warnick, and R. C. Bicalho. 26feb 2014.

[15] *Research article Manuela Buonanno, Igor Shuryak, Gerhard randers-pehrson, David j brenner, Henry M. Spotnitz. "Effect of far ultraviolet light emited from an optical Diffuser on Methicillin-resistance staphylococcus aureus in vitro" 10 August 2018.*