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UVC based Sterilization for Hospitals during COVID-19 Pandemic for the Control of Pathogenicity

Ashwini Valluri and Sharda Dhadse*

CSIR-National Environmental Engineering Research Institute Nagpur, MS, India

*Corresponding author: sn_dhadse@neeri.res.in

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Abstract: **As it is well known that hospitals became the hotspots for the spread of COVID-19, it is preferable to control the transmission of infection by UVC. As UVC became much safer to use than any other UV lights, the transmission of airborne pathogens is the fastest means of spread of infection in human during outbreak of current pandemic COVID-19 caused by COV-2.**

UVC light is a historic and prudent philosophy for contravention and reduction of airborne viral infections without the human hazards with normal germicidal UVC lights. The use of outstandingly low level UVC light in open territories may address a secured and fitting strategy for limiting the transmission and spread of airborne-interceded microbial contamination. Public places like medical clinics, offices and public division may have higher risk of infection spread. UV-C lights are highly recommended and favored techniques to treat and maintain a strategic distance from contamination. The scope of this review paper is to study advantages and disadvantages of UVC and its effects on human body.

Keywords**: Sterilization, disinfectant, ultraviolet-c light, Air-borne microbial disorders, corona virus, COVID-19**

I. Introduction

Bright radiations are undetectable beams which are essential for the energy that originates from the sun. UV radiation arrives at the world's surface which is comprised of two sorts of beams, called UVA and UVB. There is UVC sort of radiation which is having more limited frequency with harming kind of radiation. Notwithstanding, it is totally separated by the air and doesn't arrive at the world's surface (Figure 1).

Medium frequency UVB is naturally dynamic, yet can't enter past the shallow skin layers. Bright radiation additionally originates from sun lights and tanning beds. It can cause skin harm, ultimately maturing, melanoma and different sort of skin malignancy. It additionally causes issue with the eyes and insusceptible framework. Skin experts prescribe that individual to utilize sunscreens that shield the skin from the two sorts of bright radiation. Till date, the transmission of airborne microns is the quickest methods for transmission in human flare-up, for example, measles, SARS, MERS, pig flu, corona virus. This flare up shows direct effects on human wellbeing (Figure 2).

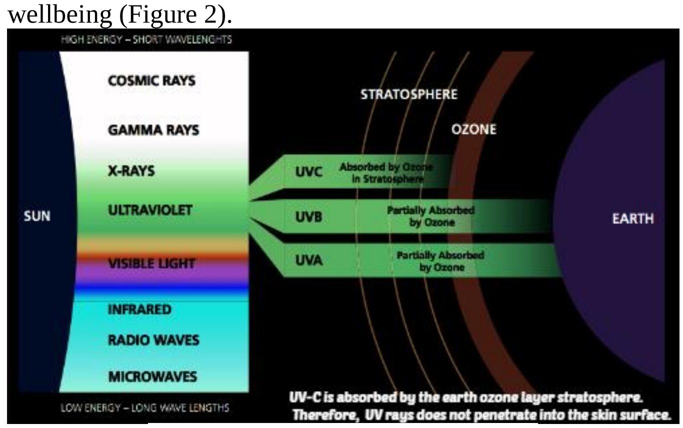

Figure 1: Spectrum of light with UV

Even though for maintaining the inner environment of the indoor area had become very crucial because at present people spend their majority of time in indoor environment. (Hopp and Martinac et al., 1998, Ashmore, Dimitroulopoulou, 2009). Till date, various methodologies have been in use to control the indoor environment and one of them is active filtration as well as the basic measures such as proper hand hygiene, different decontamination tools and one of them is UVC radiation. A direct approach can be far UVC light to kill the pathogens and airborne viruses. But use of UVC light is avoided in public settings as it is harmful to human skin (Ahmad, 2017). However, it is proved that far UVC does not harm to the mammalian skin because far UVC cannot even penetrate into the outer layer, but it kills the pathogens as the bacteria and viruses with micrometer and with miniature dimension. This approach is based on minimum penetration of UV light wavelength range upto 222 nm to 207 nm into the mammalian skin. Though far UVC light have shorter wavelength and is capable of killing microbes much smaller than the human cell (Lorian et al., 1985; Metzler et al., 2001) and other reactive organs like cornea lens has (<5000 nm) wavelength. Hence, the penetration of far UVC with (<200 nm) through the cornea has assumed to be zero (Kolozsvari et al., 2002) according to the preclinical studies.

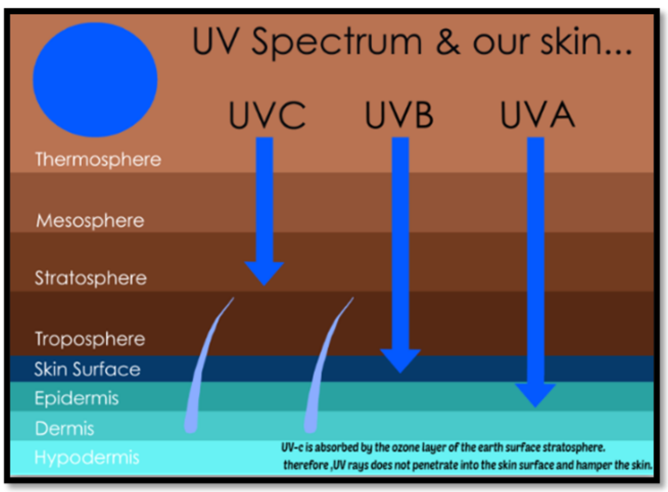

Figure 2: Absorption of UV rays into the skin

An amazing absorbance of UV-B and UV-A shows up as a result of the high measure of absorbance into the skin. The past investigations on microorganisms the viability of far UVC light (Buonanno et al., 2013, 2017) to biophysical reason rather than the human wellbeing security issues with ordinary germicidal 254 nm wide range. Far UVC isn't unsafe on skin or tissues. Because of its solid absorbance in external (layer corneum) on the outside of human skin, nor the external tear layer on the external surface of the eye, neither of which contain living cells; notwithstanding, on the grounds that microbes and infections are regularly of micron or more modest measurements, far-UVC light can in any case productively navigate and inactivate them (Buonanno et al., 2013, 2017).

Airborne microbe

An essential extraordinary circumstance of the UVC based way of thinking in clear differentiation to immunization moves close, that UVC light has probably going to be earth shattering against each airborne animal. For instance, while there will be varieties in UVC inactivation productivity as various flu strains show up, they became apparently not going to be gigantic (Kowalshi et.al., 2009). In addition, as multi-drug-safe assortments of moment living creatures make, their UVC inactivation efficiencies became ridiculous to change unfathomably (conner-kerr, et.al., 1998). Far-UVC light has a staggering and unobtrusive framework for avoidance and decreasing of airborne viral ailments without the human success risks inherent with ordinary germicidal UVC lights. In the event that these outcomes were admitted in different conditions, it follows that the use of particularly low level UVC light in open domains may address a guaranteed and reasonable strategy for restricting the transmission and spread of airborne-mediated microbial ailments. Public districts, for example, clinical focuses, experts' workplaces, schools, air terminals and planes may be considered. This method may help limit coincidental flu scourges, transmission of tuberculosis, likewise as pandemics (Kirkland et al., 1999; Chang, 1985).

The yearly number of passing in the US ascribed to SSI (Surgical Site Infection) has been assessed as 8200 (Klevens et al. 2007). A main point of contention adding to the degree and seriousness of the SSI issue is the cash of medication safe microorganisms, for example, MRSA (Methicillin-resistant *Staphylococcus aureus*) (Fry et.al 2011). The issue of medication opposition is the utilization of germicidal UV lights (Ritter et al., 2007; Taylor et.al, 1995). Investigations on this light with traditional germicidal UV lights have indicated incredible guarantee, with UV fluences relating to 4 to 5 logs of MRSA cell slaughter bringing about huge abatements in SSI rates. (Ritter et al., 2007). UV radiations in the frequency range transmitted by a germicidal light are a human wellbeing, causing generally equivalent degrees of natural harm in human cells just as microorganisms (Koch-Paiz et al., 2004). Present investigations have expressed that the improved ecological sterilization can bring down the pace of diseases identified with medical care (Rutala et.al 2010; Sweeney et.al, 2009; Miller, 2015).

Advantages of far UVC

Far- UVC light with wavelength of (207 to 222nm) has been shown efficient to regular germicidal UV light in killing the microorganisms. (Narita et.al., 2018, 2018) studies till now have suggest that the wavelength of far UVC light doesn't cause any harm to the human health the main reason behind is far-UVC light has a reach in natural materials of not exactly a couple of micrometers and furthermore can't arrive at living human cells (skin or eye), being caught up in the skin layer corneum or the visual tear layer. Far UVC shorter wavelength doesn't allow it to pass through the barrier of non cell of the skin simultaneously its wavelength makes it superior in penetrating and inactivating viruses and bacteria. Far UVC light became 1000 times safer to use then the regular UVC light (Todaro, 2016). Even when people moving around it can used it as a disinfectant. Considering the biophysical properties, the germicidal 245 nm board spectrum UV-C light, the far UVC lights has not cytotoxic nature when exposed in the human tissues and cell (in vivo or in vitro conditions). The special properties of far UVC provide great potential to the field of disinfectant to enhance and explore the disinfectant (Kowalski, et.al 2009) (Table 1). Similarly, H_2O is also used as a disinfecting agent and the comparison of UVC and the H_2O_2 is given in Table 2.

Far UVC light superior to regular disinfectant methods

When far UVC is combined with indoor air filtration it effectively eliminates the airborne bacteria, viruses and gives better version of disinfectant to keep sanitized healthcare and clean room environment. Incorporation of far UVC light as a cleaning tool can help healthcare stuff to work in highly sterilized area without any harm and also avoid HAI (Healthcare Associated Infections). Few recently tested methods are as follows.

Table 1
Comparing the merits and demerits of UVC for surface disinfection

Advantages	**Disadvantages**
Doesn't require the manipulation of room furniture and other items in the room before decontamination.	Time consuming: requires about 2.5 to 5 hours.
Has a sporicidal activity	It cannot be used, but only as part of the terminal cleaning after the patient has vacated the room.
Can be used for disinfecting both medical devices and environmental surface	It requires shutting of the (warming, ventilation, and cooling HVAC (Heating Ventilation, and Air conditioning) framework and fixing the ways to forestall its break.
Broad spectrum activity against pathogens involved in health care infections.	Can't be used in an occupied room.
Disposal or safety concern (residue: oxygen and water)	The effectiveness depends on use of specific parameters (eg. concentration, contact, time etc.)
This can be used for decontaminating complex rooms and devices.	It is expensive
No irritation or odor issues	UVC requires right amount of energy to be efficient.
Doesn't coagulate blood or fix tissue to surface	UVC light is only effective for viruses not the chemicals.
There is proof that it can reduce the rate of hospital acquired *Clostridium difficile* infection	UVC is effective within the surface on the field.
The product distributes uniformly in the room.	Distance also influences the adequacy of the UVC

Method 1

Two cell line were developed in MEM with 10% FBS (Fetal cow-like serum) at that point the infection strains comprising of MEM was warmed inactivated were proliferated for FBS HCoV-229E and HCoV-OC43. These strains were immunized in cup for 24 hours which contain old host cells for spread and this old host cells were 80 to 90% intersecting, following one-hour hatching, the cell monolayer was washed and agonized in new defilement media for 4 to 3 days, 33 degrees Celsius HCoV-229E and 35 degree Celsius HCoV-OC43. The supernatant with working stock was accumulated (300g for 15mins). The contamination titer was directed significantly tissue culture with infective bit TCID 50 by assessing cytopathic impacts. Which was scored with the assistance of splendid magnifying lens (10x) cytoplasm and cell adjusting. Benchtop vaporized light chamber was utilized to do relative investigation by coaching dampness, temperature and airborne molecule size and afterward the vaporized were uncovered the far UVC and tests were gathered utilizing Bio-Samplers (Welch, et. al., 2018). The far UVC light was situated around 22cm and guided at 254 nm. UV-communicating to plastic window every airborne was uncovered roughly 20 seconds as cross over window. The radiation chamber contained biosafety level 2 bureau and all yield and info furnished with HEPA channel to keep undesirable pollution from the whole framework. Through the light chamber, the aerosolized infection was productively sent through the framework indicated from the control and clear infection mix (Buonanno et al., 2020).

Table 2
Studies on the effectiveness of UVC in comparison to H_2O_2

Study	Method	Findings
Weber et al, (2013).	Comparison of hydrogen peroxide sprays and the UV technology for surface after cleaning.	UVC, H_2O_2 has shown different ability to decrease the healthcare related *Clostridium difficile* infections.
Holmdahl, et al, 2011	Comparison was made between sodium hypochlorite and hydrogen peroxide based on biological indicators.	Analysis declared that hydrogen peroxide vapour was faster in action and more effective as compared to sodium hypochlorite on stearothermophilus biological indicators.
Mosci et al, 2017	Comparison of manual decontamination with sodium hypochlorite solution 0.5% and automated spray system <8% H_2O_2 + silver ion.	Hydrogen peroxide and silver particles has more suitable to utilize as it has faster effect and is operator independent as compared to hypochlorite.
Fu et al, (2012)	Safety and effectiveness of H_2O_2 spray on stearothermophilus biological indicators with discs containing MRSA, *C. difficile* and *Acinetobacter baumannii*	H_2O_2 vapour system has shown better safety profile, fast action and added effectiveness in bacterial inactivation.
Haas et al, (2014)	The effectiveness of UV light disinfection is adjunct to an improved cleaning of rooms. Which were occupied by isolated patient, by comparing the rate of hospital MDROs before and during UVD use.	Though the quarter missing opportunities to decontaminate the room, remarkable reduction in the rate of hospital MDRO rates noticed during the period of UVD as compared to previous period, UV technology studies have beneficial effect.
Havill, Moore & B. Oyce, 2012	Observational study was done to compare between hydrogen peroxide vapors and UVC to decrease microbial infection in patient care rooms.	HPV is more viable than the UV innovations
Weber et al., 2016	To decrease the microbial contamination of environmental surface in patient care surface the capabilities of UV light technology was tested.	Areas are unaffected by the UV disinfection.

Table 3
Experimental Trials at Hospitals

Author	Duration of follow-up	UV device manufacture	Timing of disinfection	Target room
Pegues et.al, 2017	12-15 months (uncontrolled)	Mercury UVC, optimum UV Clorox healthcare	Before and after discharge	Room of patient contact precaution for c. difficile and MRSA
Health Quality Ontario. (2018).	Before:5 months After:6 months (uncontrolled)	Mercury UVC, IR is 3200 nm with steritrak	Acute care unit	All ICU room Non-ICU room with contact precaution
Anderson et al, 2018	Over 2 year each hospital used the strategy for 7 months (uncontrolled)	Mercury UVC, true-D	After discharge or transfer	Single patient rooms from which patient with contact precaution is discharged
Catalanotli et al, 2016	Community >200 (uncontrolled)	PXUV, Xenen	Night disinfection	All rooms
Miler et al, 2015	Before-after 1 year (uncontrolled)	PXUV, Xenen	Dialysis unit weekly	Primarily contact precaution room all burn unit discharge

Method 2

Using a raising estimations study system, four skin phototype I and II strong volunteers had their unimportant erythema partition (Drug) chose. A disinfectant source (222 nm) generally used to clean equipment and work surfaces were studied for conventionality in human skin. Punch biopsies of enlightened regions were recolored for cyclobutane pyrimidine dimers (CPD). The degree of CPD was differentiated and that in biopsies from unexposed skin and from zones introduced to UVB (280-315 nm) radiation. Consequently, at low does moreover the source was prepared for inducing both erythema and CPD game plan in human skin and the supernatural release was at recurrence of 222 nm and 97% surge was lesser than 250nm. Various researchers have conducted experiments for trial of UVC light at hospitals as given in Table 3.

Few previous studies from various groups have proposed far UVC light (207nm to 222nm) as it is efficient and potential microbiology technology. Far UVC light has shown comparably effective to other airborne diseases (Catalanotti, 2016).

Few important things about UV to be followed

1. UV light system should not be routine cleaning.
2. Risk analysis should be properly done for possible exposure of stuff or patient to UV light.
3. The functionality of the UV light system should be monitored using the samples before and after cleaning.
4. UV light should be maintained in a good working order.
5. Programmed maintenance record should be documented with evidence
6. Before making use of UV light should be sealed and the light mode should be on.
7. UV light should be used as an additional measure and for terminal decontamination.

Manufacturers' instructions for use must be followed to reduce the risk of sub-optimal UV light dosage on micro-organisms. This could result in mutation on the remaining microbes.

II. Conclusion

UVC has broad spectrum which acts as antimicrobial agents which can be used has room decontamination equipment to show effect against air borne pathogens, including *Clostridium difficile*, in some cases room should be vacated prior to decontamination. However, the advanced technology with far-UV light is anytime relatively better choice for the following reasons.

1. Far UV cannot penetrate human skin or eyes.
2. Far UV is safer as compare to any other UV as the light is 10 to 1000 time safer to use around humans and can be used to disinfecting the room.
3. These have shorter wavelength which doesn't allow to pass through the barrier of non-living cells on the skin.
4. Far UV has speed and efficiency as well as safety for use and makes it ideal to make us in hospital as disinfectant.
5. Far UV has demonstrated that it kills *C. difficile* in seconds whereas UV-C take around 45 minutes and chemical cleaning take hours

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