BPU11 CONGRESS
11th International Conference of the Balkan Physical Union
28 August – 1 September 2022, Belgrade, Serbia

THE EFFECTIVNESS OF GERMICIDAL UV-C LED ON DIFFERENT MICROORGANISAM

A. SOFTIC, D. HUSEJNAGIC
University of Tuzla, Tuzla, Bosnia and Herzegovina, amela.softic@unitz.ba

ABSTRACT

Recent occurrence of the pandemic revived the interest for germicidal ultraviolet (UV) lamps for disinfection. The use of the UV-C Light Emitting Diodes (LED) can deactivate microbes in air and water, but to achieve safe and successful disinfection of surfaces, careful and precisely defined usage is required that needs additional research. Commercially available UV-C LED lamp with the wavelength of 253,7 nm is used on two types of bacteria (one of them drug resistant) and one fungus.

The presented research results show that, in addition to the dependence of the efficacy on the time of exposure and surface distance from the lamp, the relative effectiveness of disinfection for the same conditions varies for the type of microbe. For E-coli it was between 72% and 90%, for Pseudomonas aeruginosa between 81% and 97%, while for the Candida albicans it went from 93% to 98%.

Keywords: Germicidal UV lamp, UV-C LED, microorganism disinfection, surface sterilization, relative efficacy

INTRODUCTION

Even though UV lamps have been used for disinfection of water and surfaces for the last 40 years, the recent pandemic sparked the interest in preventing and weakening any potential spreading of diseases using the novel UV-C LED lamps.

Energy of the UV radiation damages the DNA and RNA, causing the mutations which stop replication and leads to the inactivation and death of microorganisms. Bacteria and viruses vary in susceptibility to the UV radiation.[1]

Studies show that UV-C wave lengths between 200 and 280 nm can disinfect surfaces along the line of radiation and at the right dosage.[2] However, there are wide disparities between UV-C measurement and actual microbe reductions[3,4]. These differences may be due to measurement and experimental variables. The lack of correlation between UV-C metrology and actual pathogen reduction can lead to infection control professionals falsely believing a UV-C lamp is achieving the desired effect.

In addition to the question of the relative efficacy, UV-C can also be a hazard for humans[2] and must be applied carefully with research backing the application with well-defined conditions.

Commercially available UV-C devices emit at a variety of UV-C light intensity. The weaker the intensity, the greater time required to reach the desired cumulative dose[5]. Based on the “inverse square law”, increasing the distance between the UV-C source and the target surface reduces the intensity and the time required to achieve the same flow rate.

This study was undertaken to determine how the altering of the distance between the UV-C source and the target, as well as the exposure time affect the actual bacterial and fungus reduction.

Available strains of *Escherichia coli (E. coli)*, *P. aeruginosa*, and *Candida albicans* were used to test the microbicidal effect of UV radiation.

EXPERIMENTAL SET –UP

Bacteria *E. coli* and fungus *Candida albicans* were selected for this study due the fact that they grow readily, while bacteria *Pseudomonas aeruginosa*, was chosen for the study due to its increased resistance to the antibiotics.

200 μl of each referent strains stock solution was inoculated in BHI broth and incubated for 24 hours at 37°C. After incubation, a ten-fold series of decimal dilutions in sterile 0.9 % saline was made from the broth. From the last dilution, 1ml was taken and pipetted into sterile petri dishes, after which it was exposed to UV light under different conditions.

After irradiation, a sterile and cooled nutrient medium – Plate Count agar, was poured into each petri dish, whereupon was incubated for 24 hours at 37°C. After incubation, the number of grown colonies on plates that were exposed to radiation was counted and compared with the number of colonies on plates that were not exposed to UV light.

A factory-calibrated, commercially available, UV-C LED with 253,7 nm wave length is used as a source of UV radiation, as shown in the experimental set-up in Figure 1. In order to test if the manufacturer declared values match the factual values, the selected times of exposure were 10 s, 20 s and 30 s, at the distance of 5 cm from the plates, and 30 s for the distances of 3 cm, 5 cm and 6 cm.

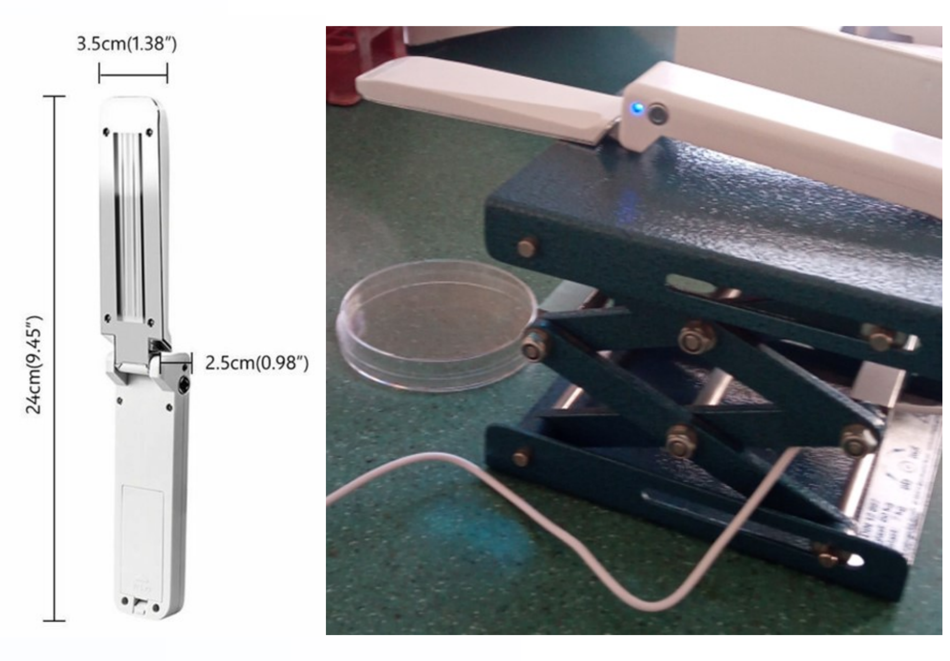

Figure 1. Exposure setup with the horizontally placed lamp

RESULTS AND DISCUSSION

After the plates were removed from the incubator and were left to replicate for 24 hours, photographs were obtained. The three-part Figure 2. shows the appearance of the control and the exposed plates. In all three microorganisms, the effect of the UV-C exposure is visible with the naked eye.

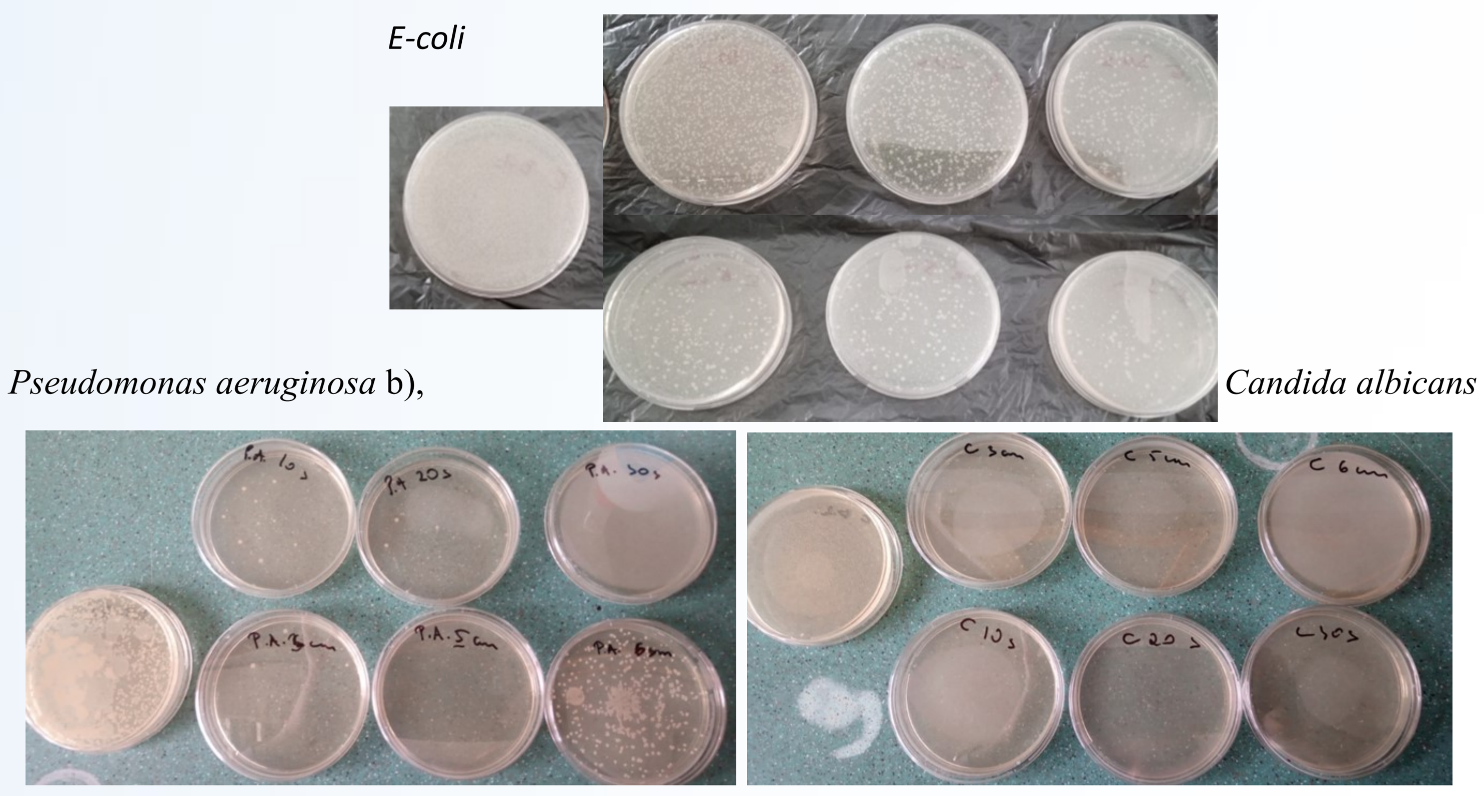

Figure 2. The appearance of control and exposed plates for the selected exposure times and distances

The table 1. gives the count of colony forming units (CFU) for each of the treated microbe plates under the defined conditions. For untreated *E. coli* it was over 2000, for *Pseudomonas aeruginosa* over 1120, and for *Candida albicans* over 3200 per plate.

Table 1. The count of the CFU per plate for the UV-C treated

E-coli

3 cm (30 s)	**200**	**90%**
5 cm	360	82%
6 cm	400	80 %
10 s (5 cm)	560	72 %
20 s	520	74 %
30 s	480	76 %

Pseudomonas aeruginosa

3 cm (30 s)	**30**	**97%**
5 cm	40	96%
6 cm	240	81 %
10 s (5 cm)	150	86 %
20 s	80	92 %
30 s	40	96 %

Candida albicans

3 cm (30 s)	**50**	**98%**
5 cm	80	97%
6 cm	100	96 %
10 s (5 cm)	200	94 %
20 s	50	96 %
30 s	40	97 %

The presented results show that the relative effectiveness of disinfection for the same conditions varies for the type of microbe. For *E-coli* it was between 72% and 90%. For *Pseudomonas aeruginosa* it was between 81% and 97%, while for the *Candida albicans* it went from 93% to 98%. Furthermore, the dependence of the relative effectiveness of disinfection on the time of exposure, was the highest for 30 s (between 72% and 94 %), and for the lamp distance of 3 cm (between 90% and 98 %), which was expected considering the inverse square law.

It is necessary to point out that the bacteria *Pseudomonas aeruginosa* showed good susceptibility to the UV radiation, which is important since this pneumonia causing bacteria is showing increasing signs of resistance to the antibiotics[6] and the use of UV-C radiation can be a way of its elimination in unoccupied spaces and on surfaces.

Although there is a public skepticism about how effective disinfection can be realized with compact GUV lamps[1], the study performed showed that, if the manufactures instructions are followed, the declared disinfection can be achieved.

CONCLUSION

Due to the coronavirus pandemic, GUV is likely to continue to develop in technology and application, UV-C emerging technologies should be studied to better understand these relationships. Since the time required for disinfection can be critical, it is important to understand the germicidal efficacy of high-dose, high-intensity, short-duration UV-C application.

The presented research results show that, in addition to the dependence of the efficacy on the time of exposure and surface distance from the lamp, the relative effectiveness of disinfection for the same conditions varies for the type of microbe. Also, a limitation of the study is that the researchers tested only at a small range of intensities depended on the distance between the lamps and the target surface and exposure times, and future research studies need to confirm these conclusions over a wider range of intensities tested.

REFERENCES

1. IES Committee Report: Germicidal Ultraviolet (GUV) – Frequently Asked Questions, USA, 2020

2. Craig DiLouie, Risks and Rewards of Germicidal UV, Electric,contractor, Lightinng technology, June 2020

3. Masse V, Hartley MJ, Edmond MB, Diekema DJ (2018). Comparing and optimizing ultraviolet germicidal irradiation systems used for patient room terminal disinfection: An exploratory study using radiometry and commercial test cards. Antimicrobial Resistance & Infection Control

REFERENCES

4.Anderson DJ, et al., Effectiveness of targeted enhanced terminal room disinfection on hospital-wide acquisition and infection with multidrug-resistant organisms and Clostridiodes difficile: The Lancet Infectious Diseases18(8):845–853., 2018

5. Arnav Kumar, et al,, UV-C Intensity, Time and Total Dose Germicidal Efficacy, UV Solutions Magazine, Quarter 4, 2021.

6. Yayan J, Ghebremedhin B, Rasche K (2015) Antibiotic Resistance of Pseudomonas aeruginosa in Pneumonia at a Single University Hospital Center in Germany over a 10-Year Period. PLoS ONE 10(10): e0139836.