Using of UV lamps and UV robots for disinfection in the medical practice and in the hospital during the coronavirus epidemic

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Abstract: In this article are presented different types of bactericidal / viricidal UV lamps and UV Robots and their effectiveness in the inactivation of bacteria, viruses, fungi, protozoa and mites. In particular it describes vacuum UV-V lamps and robots that can generate ozone. Ozon has the possibility to reach all objects inaccessible to direct radiation and it also destroys these microorganisms. The next type of bactericidal ozone-free UV-C lamps and UV-C robots, which shorten the disinfection time. All topics presented in the article combined with the use of UV lamps and UV robots are based on the results of laboratory tests in various countries (Germany, USA, China, South Korea, Denmark) that were applied to destroy SARS-CoV-2 corona viruses.
Keywords: UV robots, lamps, radiation, UV, UV-V, UV-C, UV-B, UV-A, virus, bacteria, DNA, RNA, coronavirus, H1N1, aerosol, disinfection, decontamination, ultraviolet, epidemic.

INTRODUCTION

Ultraviolet light has been known for its bactericidal properties for many years. Recently it has also proven effectiveness in fighting influenza viruses and antibiotic-resistant bacteria.
Nowadays, fighting against the coronavirus epidemic, we are looking for effective alternatives to using a large amount of sprayed disinfectant solutions that are constantly used to spray surfaces. We are looking for solutions that enable effective disinfection of all areas that are not accessible for manual cleaning, as well as the decontamination of protective clothing and protective masks (Fig.1). One of such solutions is the use of modern **bactericidal** and **viricidal** lamps and robots that emit ultraviolet UV-C / UV-V radiation.
Various aspects of ultraviolet radiation are presented in the course of this article, as an important method to decontaminate the aerosol that is generated in the medical practice and in the office as well.
There are offered effective portable lamps and UV robots by the company **uv.alfapolmed.com**.
Ultraviolet ray sterilization is one of the most effective and easiest ways to ensure effective decontamination of surgical aprons, helmets and masks.
UV lamps and UV robots are big value method used in daily work in the medical practice and in the hospital during the SARS-CoV-2 epidemic, they were also proven in the elimination of all types of microorganisms, influenza viruses, SARS, MERS, bacteria (Escherichia coli, Staphylococcus aureus, Salmonella, Shigella and others that cause sepsis), fungi (Candida albicans), mites (Fig.2) (Fig.3).

Fig. 1. The Protective mask

Fig. 2. The UV lamps are universal

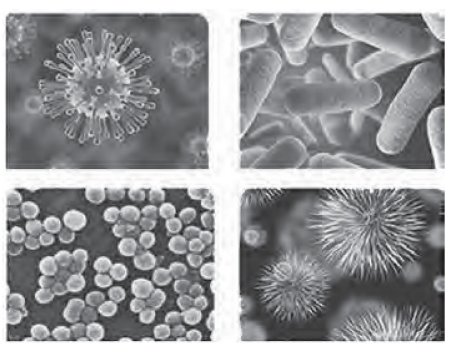

Fig. 3. The UV radiation inactivates various microorganisms

The conclusions listed in references below the article are based on the results of tests performed in laboratories in different countries, including China, Germany, Denmark, USA, South Korea.
ARIS-K2 UV disinfection mobile robot is equipped with 6pcs UV tubes and thermal camera, which enables to measure body temperature in the day time and disinfect the desired room automatically at night. It is designed to disinfect object surface and air autonomously, which avoid human contact that contaminates the environment. This UV disinfection mobile robot is applicable to indoor public place like hospital, office, shopping mall or high-risk environment. It is able to move autonomously and disinfect the desired area requiring no work, which reduces insecurity of manual disinfection. It is also capable of recording disinfection data to track the disinfection situation (Fig.4).

Fig. 4. Using of UV robot

HOW DOES UV RADIATION WORK?

Figure 5 shows the properties of electromagnetic waves and wavelengths:
- UV-A and UV-B rays are part of sunrays that reach the earth and can be noticed after a long day at the beach.
- UV-A radiation between 315nm and 400nm damages collagen fibres and increases the risk of cataracts.
- UV-B radiation between 280 and 315nm has a therapeutic significance and is necessary for the proper development of the human body. It is involved in the synthesis of vitamin D. It can also cause of sunburn, erythema, skin allergies and skin cancer, including skin melanoma.
- UV-C radiation between 200 and 280nm has a strong bactericidal effect and inactivates bacteria, viruses, mites, fungi and moulds. It can cause skin burns and conjunctivitis. Moreover, it can damage nucleic acids, **DNA** and **RNA** and is the most important property that we use against germs.
- UV-V radiation (vacuum) is generated in the vacuum environment and has a wavelength of 100-200nm and generates ozone. It has the property that these short waves falling directly on the exposed surface cause disinfection process and ozone generated by these waves carries photons to **inaccessible places that are not directly exposed**.

In the following we will concentrate on UV-C/UV-V radiation, which is important because of disinfection purposes in practice and in laboratories during the SARS CoV-2 epidemic. In the English literature it is called UVGI (ultraviolet germicidal irradiation). The killing effect of the UV-C/UV-V radiation occurs as result of the absorption of electromagnetic wave energy by the exposed object. This leads to excitation of atoms and ionization of their molecules. Absorbed energy destroys chemical bonds within DNA and RNA nucleic acids. UV-C/UV-V rays act on both the cell nucleus and the cell wall. Nucleic acids are breaking these bonds into single aminoacids and proteins are irreversibly damaged, thus inactivating viruses, bacteria, fungi and mites.

EFFECT OF UV-C/UV-V RADIATION

UV-C/UV-V radiation is used in medicine and in everyday life to disinfect gases (air) by inactivating the aerosol created during the work in medical practice or in a dental and prosthetic laboratory. Food, air conditioning ducts, heating and ventilation systems can also be disinfected with this radiation as well.
The UV lamps and UV robots can be used for the following facilities:
- medical and dental practices, prosthetic laboratories,
- hospitals (Fig. x of UV robots), pharmacies
- beauty salons and physiotherapy

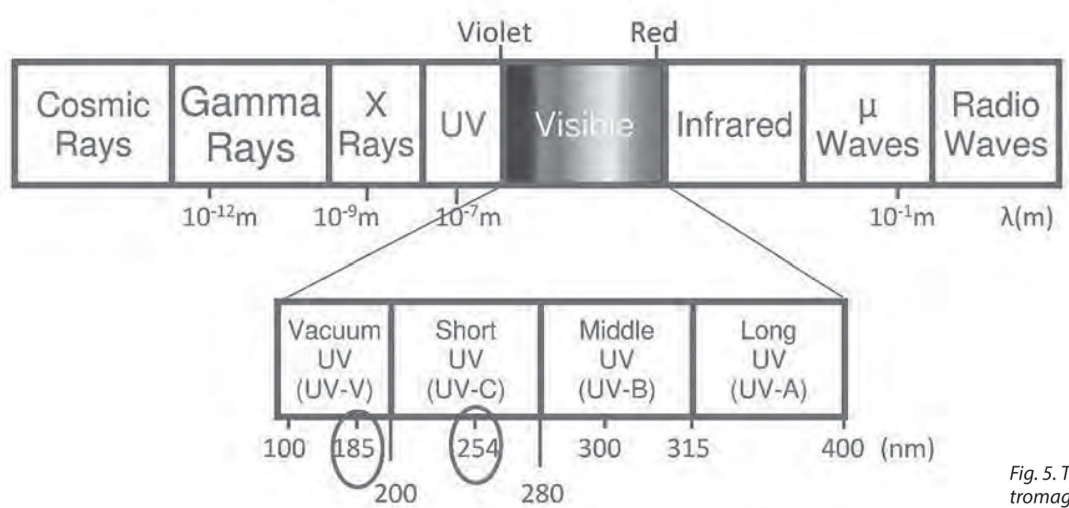

Fig. 5. The types of electromagnetic radiation

Fig. 6. Disinfection of the toilet with a portable lamp

Fig. 7. Disinfection of personal items

Fig. 8. Use of a lamp for disinfecting various domestic premises

Fig. 9. Use of a lamp for disinfecting carpets and bed linen

Fig.10. Neutralisation of odour from the kitchen

- schools and kindergartens
- fitness, changing rooms, waiting rooms
- swimming pools
- toilets, bathrooms (Fig. 6)
- surfaces – dental chairs, laboratory tables, desks, cabinets, furniture
- objects at home and in the office
- soft toys, underwear, bags (Fig. 8)
- tools and protective clothing
- apartments, carpets, bed linen (fig. 8 and 9)
- aircrafts, trains, subways, buses, trams
- airport, factories (Fig. 12).

Not everyone knows that UV-C/UV-V lamps and UV-C robots can remove unwanted odours quickly and effectively (Fig.10). New furniture or renovation materials generate intense smells including formaldehyde. It is easy to remove these types of odours with UV-V/UV-C lamps (Fig. 11).

The same applies to the elimination of humidity and smell of fire in the buildings and cellars.

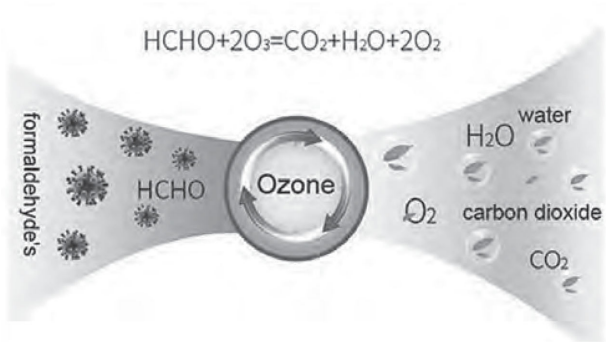

Fig. 11. Formaldehyde is neutralized by ozone

Fig. 12. UV robots in work in airport [or factory

TYPES OF UV-C/UV-V LAMPS

Classification of lamps according to function:

- flow-through lamps - sterilize the air that passes through the filter into the chamber and is exposed to UV rays. The peoples may stay in the room while the lamps are operating but these lamps cannot sterilize surfaces and objects. Unfortunately, the improved ozone disinfection (as with UV-V lamps) does not exist. Flow-through lamps are more expensive. They are often used in operating rooms and intensive medical stations.
- direct-acting lamps are the most commonly used

Classification of lamps according to the wavelength of the generated light:

- 185nm lamps generating ozone
- 254nm lamps not generating ozone

Classification of lamps according to the way the direct-acting lamp is mounted:

- mounted on the wall
- ceiling mounted
- standing, portable are practical, as they can be set up in different places in the practice, so that the radiation reaches wherever it is needed (Fig. 13).

UV-C ROBOTS

Mobile robots are equipped with UV mercury-vapor lamp and they don't produce ozone.

Modern lamps are equipped with **motion sensors** (Fig. 14). The lamp goes out automatically if a person or animal approaches within 5 metres and an acoustic signal is automatically activated. There must be no person or animal in the room where the UV-C/UV-V lamp is switched on (Fig.15).

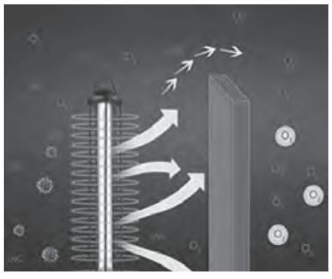

Fig.13. The ozone from UV-V lamp reaches inaccessible places

There are also lamps that can be switched ON and OFF by remote control (Fig. 16) and the exposure time can be set to 15, 30 and 60 minutes.

Currently the most bactericidal lamps on the market are made of doped quartz glass (Fig. 17).

This type of glass blocks the transmission of light wavelength of 185nm and transmits wavelength of 254nm. l amps that generate 185nm wavelengths are made of a different type of quartz glass

WHAT IS OZONE?

Ozone is a gas molecule with 3 oxygen atoms and the symbol O_3. Ozone has the ability to release single oxygen atoms from the air. Ozone is generated by the UV-V vacuum lamps with a wavelength of 185 nm produce ozone by breaking down O_2 oxygen molecules into individual O atoms, which then attach themselves to other O_2 oxygen molecules to form O_3 ozone molecules. The advantage of ozone is that it inactivates bacteria and damages their cell walls, membranes, enzymes and nucleic acids by reactive oxygen species. The inactivation of viruses in UV-V radiation is caused by damage to the viral proteins and their genome.

Fig. 14. The lamp with motion sensor

Fig. 15. People and animals must not remain in the room while ozone is produced

Fig. 16. The lamps with remote control

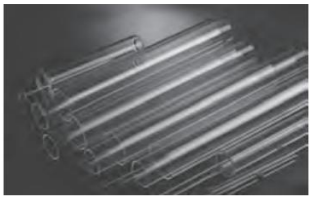

Fig. 17. Special quartz glass for lamps

Fig.18. Disinfection time depending on room size and lamp power

Room area	Power	Recommended disinfection time	Ventilation time without ozone	Ventilation time with ozone
~ 10m²	38 W	15 Min.	20 Min.	30 Min.
~ 10m²	60 W	15 Min.	20 Min.	30 Min.
~ 20m2	38 W	30 Min.	20 Min.	30 Min.
~ 20m²	60 W	15 Min.	20 Min.	30 Min.
~ 40m²	38 W	60 Min.	30 Min.	40 Min.
~ 40m²	60 W	30 Min.	30 Min.	40 Min.
~ 60m²	60 W	60 Min.	30 Min.	40 Min.

DISINFECTION PROCESS

In everyday practice, the disinfecting properties of ozone are associated with the need to ventilate the room where the lamp had been in operation. To shorten the ventilation time, UV-C light with a wavelength of 254nm is helpful.
This wavelength destabilizes ozone, i.e. the three-atom ozone molecule is broken down and thus converted into O_2 i.e. oxygen
Therefore, equipping the office with both types of lamps could be a practical solution, which allows both disinfection of the room, e.g. during a night break with a UV-V ozone lamp, and efficient preparation and decontamination of the practice with a UV-C lamp resulting in a reduction of the ventilation time in the morning before starting work. A similar procedure can be used between patient treatments. First the UV-V lamp is used, and the inaccessible areas are disinfected, then the UV-C lamp is used, which breaks down ozone.

THE CHOICE OF THE l AMp DEpENDING ON THE SIz E OF THE ROOM

The dose of ultraviolet radiation is calculated in a similar way to that of X-rays (Fig. 18).
The energy of UV-C/UV-V lamp = lamp power x exposure time.
The radiation dose determines the effectiveness of the inactivation of microorganisms

ADVANTAGES OF USING UV ROBOTS

1. UV disinfection
2. Check body temperature
3. Audio warning
4. path navigation
5. Obstacle avoidance
6. Wireless transmission
7. Automatic charging

DISINFECTION pROCESS USING UV ROBOTS

This UV robot can be operated via tablet or computer (Fig. 19)
The operator need to create the map and set up mission first.
The robot will move from starting point of the map to execute the mission.

The robot disinfects the entire specified area along the paths preset by the operator (Fig. 20)

- The robot starts to disinfect the desired area once preset time.
- The robot navigates autonomously to a certain area and disinfects the area according to the pre-set mission.
- The robot will navigate to a next specific area as soon as the first specified area is ready.
- Disinfection continues until all disinfection tasks are completed.

Ciąg dalszy ze str. 23

The UV robot will return bąck to docking station getting charged and switch to standby mode.

EFFECTIVENESS OF UV-V / UV-C LAMPS AND UV ROBOTS AGAINST VIRUSES

UV C/UV-V lamps and UV robots are highly effective and inactivate the bioaerosol to 99.9%. It should be noted that the viruses cause most infections of the upper respiratory tract (up to 90%), including the currently most dangerous pathogen, the SARS-CoV-2.

In 2004, the effects of UV-C and UV-V radiation on the infectivity of SARS-CoV-2 corona viruses were investigated at the University of Marburg (Fig.23). The test results confirmed that the effect of UV-C/UV-V radiation is significant and fast. After only one minute of exposure, laboratory virus samples showed no reproductive capacity. The volume of SARS-CoV-2 particles in the samples used in this research experiment was significantly higher than statistically found in rooms where virus-infected patients stayed.

Increasing concerns about the epidemic of airborne viruses such as the **H1N1** influenza virus and coronavirus, which cause acute respiratory syndrome (**SARS-CoV-2**), focused global attention on indoor air disinfection and promoted the development of air purification techniques to eliminate airborne viruses and bacteria (Figs. 21 and 22).

Scientific studies confirm that 254nm **reactive oxidants** are formed by the ozone dissociation reaction under the influence of UV-C. Therefore, the simultaneous use of lamps with higher energy intensity of photons in UV-V and UV-C lamps can be used for air purification, thus reducing the decontamination time.

Fig. 22. Wardrobe disinfection

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Datum 01. November 2004

Gutachten

Zur Beurteilung der inhibierenden Wirkung von UVC-Strahlen auf die Infektiosität von SARS-Coronavirus

erstellt von
PD Dr. rer.nat. Stephan Becker
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1. Untersuchungsgegenstand:
Untersucht wurde der Einfluss von UVC-Strahlen auf die Infektiosität des SARS-Coronavirus (SARS-CoV).

Fig. 23. Assessment

Nowadays there are robots generating UV radiation, which have become more important in the fight against the epidemic in Wuhan. (Fig. 24)

UV lamps and UV robots are an alternative for office crew who need to avoid exposure to the virus. As well, the amount of disinfectants is reduced because their effect is replaced by electromagnetic waves.

Fig. 19. UV robot

Fig. 20. Preset of UV robot for the mision

Fig. 21. Air disinfection in an apartment

CONCLUSION

The UV-C and UV-V lamps and UV robots are extremely useful and helpful when decontamination and microbiological purity are required, and consequently improve the quality of our work. We can perform our activities in a biologically clean room, effectively prevent infections, and ensure safety for patients and staff.

Fig. 24. UV robot in the hospital of Hubei Province

The radiation from UV-V lamps reaches inaccessible places that cannot be directly exposed to the radiation. The lamps are equipped with control devices such as a remote control, a motion sensor and a timer.
Please follow the instructions and recommendations in the operating instructions of the UV lamp and UV robots supplier and aftersales service company (**uv.alfapolmed.com**).

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Further references are available by the author

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Ciąg dalszy ze str. 19

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He graduated from the Faculty of Automatic Control, Electronics and Computer Science of the Silesian University of Technology in Gliwice in 1975, where he obtained the degree of M.Sc. Automatic Control, Electronics and Computer Science. Until 1981, he was a scientific staff member at the University of Silesia and a PhD student at AGH in Kraków (thesis title "Linearization of digital systems using the orthogonal functions of the Haar and Walsh bases").
In 1988, he joined the R&D department at KROHNE Messtechnik GmbH as head of the Research and Development Centre (Corporate Research K-CPR). He worked in this position until 2019. In 2020, he founded PrIMac UG and focused on using the physical properties of UV radiation to fight the viruses DNA/RNA, and microorganisms during the COVID-19 epidemic. Currently, he is working with a team of doctors on the implementation of innovative methods to help patients suffering from sleep apnea. The innovative solutions aim to eliminate apnea masks. The problem of sleep apnea is huge, as it affects about 4-6% of the world's population.

Henrik Krisch's research interests include magneto-resistive, ultrasonic and fiber-optic sensors, analog and digital electronics, measurement and control techniques, and digital algorithmic techniques. In these specialties, he has numerous scientific and research achievements and numerous patents in the form of industrial measuring instruments, starting from the development - from 1988/91 of a vortex flowmeter (VORTEX FM100, FM200) and implementation into production in Krohne Messtechnik GmbH / Germany, Krohne Marshall / India and in 1995 in Krohne Chengde CRK in China. He developed numerous innovative sensors for flow meters and subsequent versions of flow meters with magneto-resistive sensors with their implementation in production. In 2011-2019, he worked on the use of innovative Photonic Techniques for industrial purposes, including the construction of high-temperature flow meters (up to ~ 1000 ° C) with a large measuring range. He has published numerous scientific and research works of international scope, speeches and papers at international conferences. He promoted over 40 graduates of technical sciences.

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