Efficacy of Ultraviolet Radiation on Microbial Eliminations from Conditioning Airflow †

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Abstract: Disinfection of air conditioning rooms are related to reduce the risk of pathogenic epidemics. Various chemical and physical disinfection approaches are applied to the rooms for healthcare. In this study, efficacy of ultraviolet radiation on microbial elimination of air conditioning room was analysis. Ultraviolet chamber is constructed and assembled over the air conditioner in 25 cubic meter room. Ultraviolet-C (UVC) is radiated to airflow out of air conditioner. Five places of enrich media were placed on different position of room floor at different time interval for fifteen minutes. Plates were closed and reversed incubation at room temperature. Different types of microbial colonies on plates were counted. Average number of colonies from radiation on airflow room were analyzed and compared to those from non-radiation on airflow room (control). The result showed that ultraviolet radiation on conditioning airflow have efficiency on microbial reduction depending on the expose time. Furthermore, ultraviolet radiation may be effect on microbial cell injury because injured colonies were slowly growing and appearing in enrich media. Therefore, UVC radiation chamber assembled over the air conditioner have benefit on eliminating microorganisms in air conditioning room and will be used in enhancing efficacy on room disinfection for various healthcare purposes.

Keywords: Microorganism, UVC, Ultraviolet, Eliminate, Air-Conditioner

1. Introduction

Peoples are always working and living in internal air circulation space which is controlled by air conditioning system. Air conditioning system is also used to cool and dehumidify an interior room. This system provides clean and comfort atmosphere in common living room and hospital safety room. Nowadays, pandemic crisis of air infectious diseases is aware because it cases the acute respiratory syndrome, especially coronavirus.

The air conditioning system is composed of filtration and disinfection parts which are important in reducing air microorganism contamination. Un-ventilated space with the air conditioning system may bring about pathogenic dispersion. Various methods are applied to eliminate particle matter

including germs. The chemical disinfectant methods are useful but have detrimental effects of human health.

Therefore, it is better to choose another disinfection method that has no or less side effects. Ultraviolet (UV) irradiation is one type of electromagnetic energy with a wavelength (100–400 nm) in between wavelength of visible light and x-ray. Ultraviolet-C (UVC) radiated a short wavelength in between 200–280 nanometer (nm). UVC lamp is more effective because it leaves no residue. Low-pressure mercury discharge lamps emitting UVC radiation are generally used in microbial disinfectant [1 Reed 2010]. UVC lamps are implemented in disinfection technologies for reducing microbial contamination in air and material surfaces in specific and public spaces [2]. UVC radiation can destroy pathogens such as bacteria, viruses, mold, and yeast, thus it has also known as Ultraviolet Germicidal Irradiation. [1, 3]

UVC radiation inactivate pathogenic microorganisms by modifying chemical structure of DNA [4]. This radiation at wavelengths 260-265 nm destroys the pathogen's DNA and RNA, since DNA absorbs the best radiation. However, the elimination of microorganisms depends on the radiation concentration and the time of use. These UV lamps may directly cooperate into air conditioning system to kill microorganisms inside the system. The UV disinfection system should be designed and fabricated for using especially in epidemic situation. The key parameters and protocols the UV sterilization process should be managed for the effective and safe disinfection system. Limitation of UV disinfection in various aspects should be analysis.

In this work, an external unit of UVC lamps was designed and installed over the airflow out of the air-conditioners. The reduction efficiency of microorganism from UVC cooperated air conditioning room were analyzed at different time intervals in compared to that of normal air conditioning room.

2. Experimental Procedure

Experimental room and condition.

The experimental room dimension is 2.76x3.12x2.90 m (WxLxH). Room was installed 9000 BTU air conditioner at wall center with 2.6-meter height. Filter efficiency of conditioning system are filtrated 3-10 micron in size of particle matters. An experimental temperature of air conditioning room was setting at 25±2 °C thirty minutes before starting an experiment. Enhancing aeration of room was performed by using electrical fan.

UVC system. Two blubs of 18 watts UVC lamp (265 nm) were cooperated in the opaque box owing to human safety form UVC radiation. This box is opened on the top and bottom for air flowing in and flowing out of box. This UVC system, 0.0196 m^3 in size were installed over the air conditioner. UVC system was started the operation when air conditioning room was stable.

Media preparation. Luria-Bertani medium compose of 10 gL^{-1}tryptone, 5 gL^{-1} yeast extract and 10 gL^{-1} NaCl were prepared and adjusted pH to 0.7. Fifteen gL^{-1} agars are added into the medium bottle and sterilized by autoclaving at 15 psi, from 121°C for 15 minutes. Warming medium was poured approximately15 mL into each petri dish plate and allow to cool down before using in the experiments.

Microbial collection and analysis.

After UVC operation, five-sterilized plates were setting on different positions of room floor. The cover of petri dish plates was opened for 15 minutes at 0, 3, 6, 12 and 24 hours. These plates were closed the cover and reversely incubating plate at room temperature Microbial colonies appeared on each plate were separately counted and identified for five days. Data of normal air conditioning room and UVC treatment room were collected and analyzed.

3. Result

The result of microbial numbers on plates of normal conditioning room (control) and additional UVC room are presented on Table 1 and Table 2. After incubating plate at room temperature, microbial cells grew and presented in colonies on plates within two days. When these cultured plates were further incubations, microbial colonies were increasing. The results are presented the data of colony number within 2-4 days before combining of different colonies are occurred. Glabrous texture

of define margin colonies with different colors are defined as bacterial and yeast colonies. Colony with filamentous multicellular hyphae are defined as fungi colony.

Under the control treatment, the average numbers of bacteria and yeast grown on the beginning time plates (0 hour) were 11.25, 14.75 and 17.25 colonies when plates were culturing at 2, 3 and 4 days, respectively. The average numbers of the same microorganisms grown on plates of the other collecting times (3, 6, 12, 24 hours) are not statistically different among of them and between that of the zero hour plates.

At two-day incubation, fifteen minutes of UVC radiation can effect on reducing bacterial and yeast colonies which appeared on medium plate at o hours, approximately 30% compared to number of the control plate. When UVC radiation time on the flowing out air was increased (3-24 hours), average numbers of bacterial and yeast colonies on plate were reduced, approximately 50% compared to number of the control plate.

When incubation times is increased (at 3, 4 days), average number of bacteria and yeast colonies are enhanced 30-50% in the control treatment, while those in UVC radiation treatment are enhance 50-100% in compared to those of two days of the same condition.

Average number of fungi colony on plate of each treatment are similar direction to those of bacteria and yeast colonies. UVC radiation can reduce average number of fungi colony. However, fungi colony are found in small number in compared to average number of bacteria and yeast colonies

Table 1. Average number of bacteria and yeast colonies grown on plate collecting from control room and UVC room at different time. Culturing plates are counted the colony at 2, 3 and 4 days.

Treatments	Days	Number of Bacteria and Yeast				
		Hours				
		0	3	6	12	24
Control	2	11.25±1.26	12.50±1.29	11.00±1.29	12.50±1.52	14.50±3.11
	3	14.75±1.26	16.25±1.71	16.25±0.96	18.50±0.58	19.00±2.16
	4	17.25±1.26	18.50±1.29	18.50±1.73	20.00±1.41	20.00±2.16
UVC	2	08.00±4.08	06.00±0.00	06.40±3.44	07.60±3.05	04.40±2.61
	3	12.50±7.78	10.00±3.32	08.40±3.36	10.00±2.83	11.40±6.41
	4	15.75±7.04	11.80±3.11	09.20±3.96	10.80±3.35	11.00±4.71

Table 2. Average number of fungus colony grown on plate collecting from control room and UVC room at different time. Culturing plates are counted the colony at 2, 3 and 4 days.

Treatments	Days	Number of Fungi				
		Hours				
		0	3	6	12	24
Control	2	1.25±0.50	0.25±0.50	0.25±0.50	0.25±0.50	0.25±0.50
	3	1.25±0.50	0.50±0.58	0.50±0.58	0.75±0.50	0.75±0.50
	4	1.25±0.50	0.50±0.58	0.50±0.58	0.75±0.50	0.75±0.50
UVC	2	0.25±0.50	0.20±0.45	0.60±0.89	0.00±0.00	0.20±0.45
	3	0.25±0.45	0.20±0.45	0.20±0.45	0.00±0.00	0.20±0.45
	4	0.50±0.58	0.20±0.45	0.00±0.00	0.00±0.00	0.20±0.45

4. Discussion

Microorganisms are normally distributed in room area. Our results show that normal air conditioning room has no potentiality to reduce microbial contamination, although long time operation (24 hours) is performed. UVC radiation in the air flowing out box over the air conditioner have an efficiency in reducing microorganisms in the air conditioning room, approximately 30-50% in compared to normal condition. Moreover, UVC radiation condition seem to enhance the injury of microbial cell higher than normal condition. Since, the recovery rate of cell on medium plate under UVC treated condition at 3 and 4 days were 1.5-2.0 times, while those of cell on medium plate under normal condition were 1.3-1.5 times compared to cell number at 2 days under the same condition. High injury cells may die but less injury cells may recover under rich medium condition. Therefore, cells are slowly divided and developed into colony.

The efficacy of UVC rays on the microbial disinfection depends on the duration of exposure, intensity, wavelength of radiation and microbial morphology [5]. This experiment used UV lamps emitting light at 265 nm are capable to destroy microorganisms similar to previous report [6]. Biomolecules in cellular microorganisms have potent to absorb different wavelength of electromagnetic radiation at different level depending on their chemical structures. This high energy wavelength is induced oxidative stress in cellular mechanisms. The strong UV absorption of DNA and RNA molecules induce molecular excitation and transition especially in nitrogenous base. [7] These bases become stable dimers which disturb DNA functions in cell. [8] Therefore, UVC radiation have potent to kills cell by directly damaging DNA. DNA repair system, such as excising and replacing bases, may occur owing to their adaptation. Therefore, the recovery rate of cell on medium plate derived from UVC treated condition are higher than that from normal condition.

5. Conclusion

External UVC unit cooperated to air conditioning system reduced microbial numbers in air conditioning room in compared to non UVC unit condition. The strong UVC energy arose DNA damaging of air contaminant microorganisms. UVC radiation has potent to induce microbial cell injury and die. Therefore, UVC should be suitable for developing as physical treatment in reducing contamination of air microorganism.

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