White Paper:
UV_M 222® Far-UVC Disinfection* s in the Workplace: Testing Effectiveness of Long-Range Surface Disinfection

It is widely known that harmful bacteria and viruses exist in public places, but a means to safely control the pathogen level throughout the day has not existed. UV Medico aims to solve this with its UVM 222 EXC UV disinfection lamp. The UVM 222 EXC is a wall or ceiling-mounted UV that uses excimer lamps to produce 222nm of light capable of inactivating viruses and bacteria, effectively eliminating their ability to replicate, leaving them harmless. The experiment discussed here aims to investigate the effectiveness of the UVM 222 EXC lamp on long-range surface disinfection.

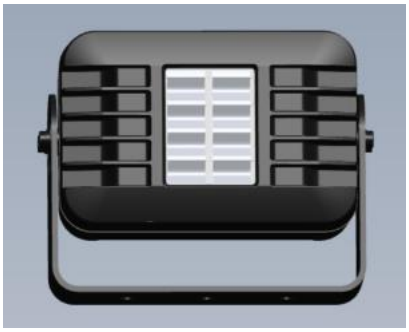


Figure 1: UVM 222 EXC UV Lamp

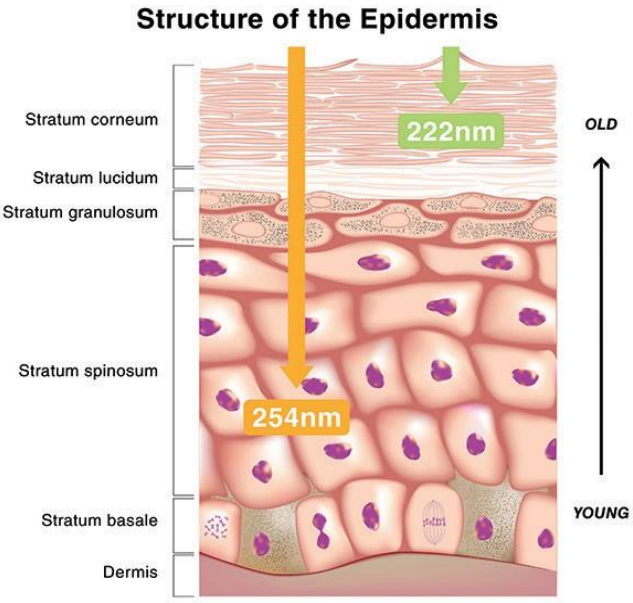


Figure 2: Penetration of epidermis of 254nm vs. 222nm

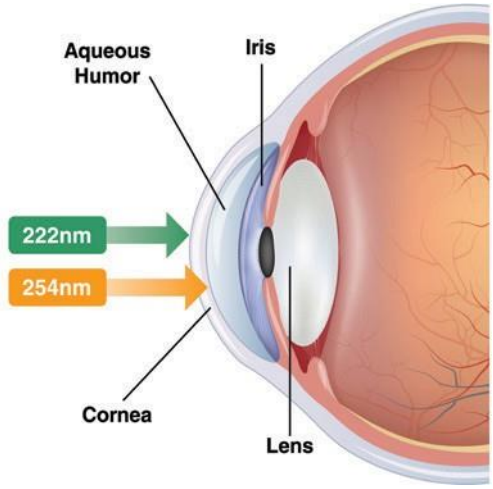


Figure 3: Ocular penetration of 222nm vs. 254nm

Background

A wavelength of 222nm is a very unique wavelength of light that has similar microbial reduction ability to 254nm, the wavelength more generally used today in disinfection applications. A wavelength of 254nm is hazardous to human beings and can be harmful when skin is exposed directly. Prolonged exposure to 254nm is known to cause skin and eye damage, which can potentially lead to photokeratitis, cataracts, skin aging, or skin cancer. New studies have suggested that 222nm has very different interactions when it comes into contact with human skin and eyes. When 222nm hits human skin, all of the light is absorbed by proteins in the outer layers of the skin, thus not allowing enough penetration to have the same negative side effects as 254nm (see Figure 2). Similarly, when 222nm comes into contact with eyes, the light is absorbed almost entirely by the cornea, leaving the areas behind
the eye virtually undamaged (see Figure 3). These attributes are pivotal for the future of microbial reduction because high-traffic areas can be disinfected safely.

Germicidal lamps that emit 254nm normally contain mercury, a substance known to cause harmful side effects when inhaled or ingested in large amounts.

In contrast, the UVM 222 EXC uses excimer lamp technology made by filling a glass chamber with noble gas, which is excited by applying a high voltage through external electrodes instead of internal ones.

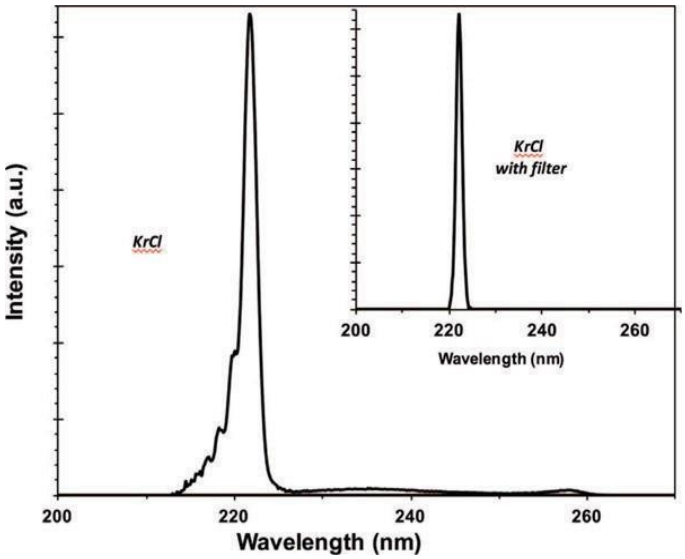


Figure 4: Spectral graph of Excimer lamp with and without short pass filter

This configuration allows for lower temperature operation and fast on/ instead of internal ones off times with no warm-up required, effectively increasing the lamp's lifetime. Excimer lamps naturally produce a spectrum of light that includes traces of higher and lower wavelengths, some of which are potentially harmful, but UV Medico's UVM 222 EXC uses a special short pass filter to block unwanted wavelengths, resulting in a single, narrow band of disinfecting light (see Figure 4).

Test Setup

In order to validate the microbial reduction ability of the UVM 222 EXC , UV Medico's research facility performed an experiment in office meeting rooms. Two similar sized meeting rooms were compared with one of them being treated by the UVM 222 EXC (Room 1), whereas the second room (Room 2) was not. The target surface for this disinfection test was a conference table at the center of the room. In the treated room, Room 1, two UVM 222 EXC were installed on opposite walls positioned diagonally from each other with each disinfecting a separate side of the conference table (see Figure 5). A simulation was taken of the light projecting from the lamps onto the table and can be seen in Figure 6. The simulation shows the intensity of the light at different parts of the table and which parts of the table were receiving more radiation.

The test was run for two weeks with bacteria collection taking place in the morning and evening of every weekday over the course of the experiment. Both conference rooms were holding meetings and appointments throughout the day. The dates and times of all meetings were recorded to better understand the amount of traffic going through both of these rooms over the course of the experiment (see Figure 8). Todetermine the amount of bacterial growth, cotton swab samples were taken twice a day—in the morning around 8AM and again in the evening at 5PM.

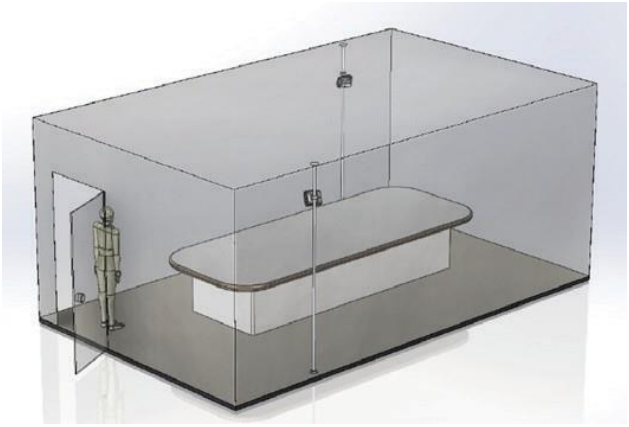


Figure 5: Position of UVM 222 EXC in Room 1

To avoid anomalies, samples were taken from the conference table at two different places. These samples were collected and cultivated in agar. The combined colony counts from both of these samples were considered the total colony count for that room.

During the first week, the lamps were on at all times (including overnight) except when the room was occupied. During the second week, the lamps were on between the hours of 8AM and 10PM, but again, only when the room was unoccupied. The UVM 222 EXC s were installed with a motion sensor to turn off when motion was detected. The untreated room, Room 2, had no radiation throughout the test but had a very similar amount of traffic in the form of meetings and appointments. The amount of bacteria colonies found in both rooms throughout the experiment can be found in Figure 7

Results

Figure 7 shows the colony counts of Room and Room 2. The bottom graph of Figure 7 shows varying levels of contamination on the table throughout the test, with low levels on some days and higher levels on other days. The level of contamination can vary due to factors such as the number of people in a meeting, the purpose of the meeting, or the extent of the regular cleaning done in these rooms.

Another observation is the increased, sometimes drastic, levels of contamination measured on the conference room table in the evenings relative to the mornings.

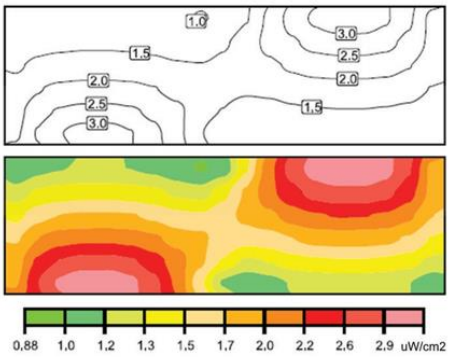
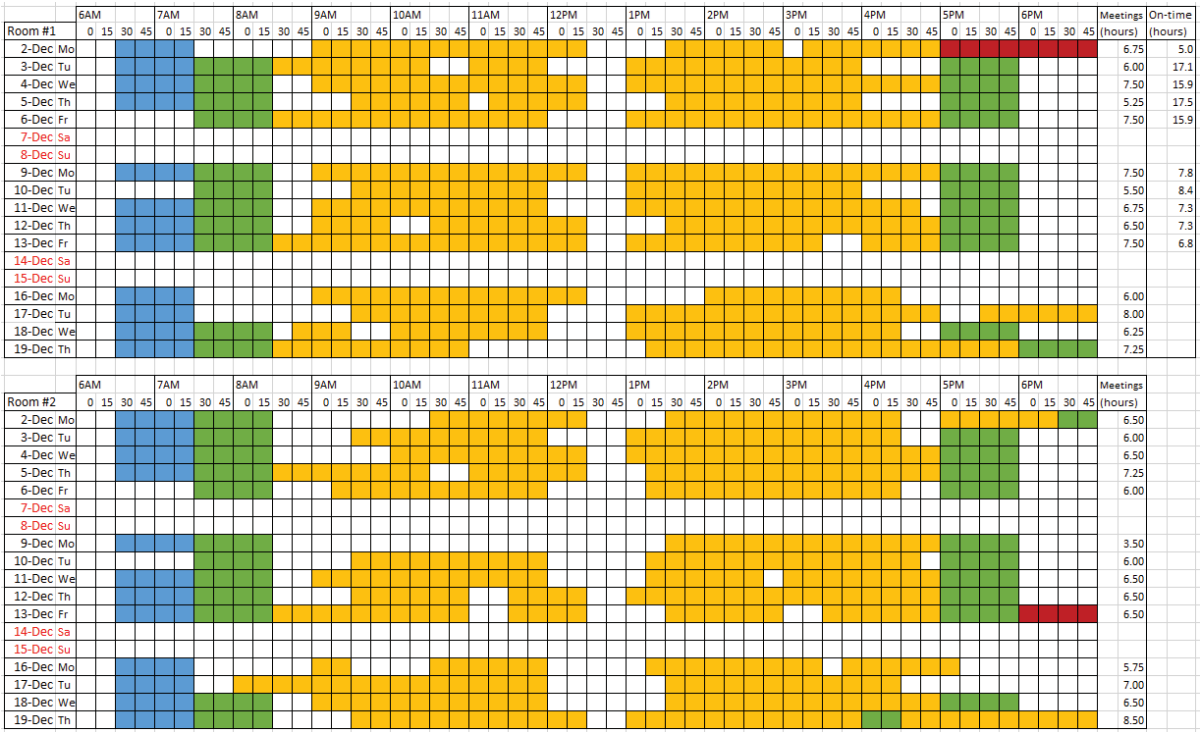


Figure 6: Contour and heat map from light simulation of UVM 222 EXC onto conference table

The reasons for this may vary as well, but this is likely due to regular cleanings that each room receives every day before the workday begins. A quick wipe down of the tables can reduce pathogen count early in the day, but only temporarily. As the day goes on, people come in and out of the rooms, so bacteria levels in the evening are likely related to the number of people who come into contact with the table that day. Over the course of the day there are many opportunities for germs and bacteria to get into the air and onto surfaces resulting in higher contaminated areas. This implies that it is much more effective to treat the room periodically throughout the day than to perform overnight treatment only.

Figure 7: Bacteria colony counts of Room 1 and 2 throughout the experiment

The top graph in Figure 7 shows the amount of contamination on the table in Room 1, the UV-treated room during the experiment. As mentioned above, the experiment was split into two phases, each lasting a week. The first week had the lamp on 24 hours a day except when the room was occupied. The second week had the lamp on between the hours of 8AM and 10PM except when the room was occupied. Performing the test in two different phases shows the variation in surface contamination. Comparing the two graphs, one can see the dramatically lower levels of contamination every day of the test. In Room 1, contamination levels on all days stay below 50cfu with most days having less or virtually no contamination. Room 2, the non-treated room, had higher contamination levels than Room 1 almost every day of the test. By the end of each day, bacteria levels were generally much higher in Room 2 than in Room 1.



Room #1	Meetings (hours)	On-time (hours)
2-Dec Mo	6.75	5.0
3-Dec Tu	6.00	17.1
4-Dec We	7.50	15.9
5-Dec Th	5.25	17.5
6-Dec Fr	7.50	15.9
7-Dec Sa		
8-Dec Su		
9-Dec Mo	7.50	7.8
10-Dec Tu	5.50	8.4
11-Dec We	6.75	7.3
12-Dec Th	6.50	7.3
13-Dec Fr	7.50	6.8
14-Dec Sa		
15-Dec Su		
16-Dec Mo	6.00	
17-Dec Tu	8.00	
18-Dec We	6.25	
19-Dec Th	7.25	

Room #2	Meetings (hours)
2-Dec Mo	6.50
3-Dec Tu	6.00
4-Dec We	6.50
5-Dec Th	7.25
6-Dec Fr	6.00
7-Dec Sa	
8-Dec Su	
9-Dec Mo	3.50
10-Dec Tu	6.00
11-Dec We	6.50
12-Dec Th	6.50
13-Dec Fr	6.50
14-Dec Sa	
15-Dec Su	
16-Dec Mo	5.75
17-Dec Tu	7.00
18-Dec We	6.50
19-Dec Th	8.50

Figure 8: Schedule of both meeting rooms for duration of experiment

The next important observation is the very similar levels of contamination between phase 1 and phase 2 of the study. Comparison between the amounts of contamination during the two phases shows the extra radiation during night hours (10PM-8AM) makes almost no difference in the cleanliness of the conference room table. With this knowledge, the user can choose to only irradiate the room during the prime hours of the day, which would save money, energy, and the life expectancy of the lamps without having to sacrifice cleanliness. After completion of phase 2, bacteria samples were collected for two more days from the treated room without the UVM 222 EXC on to see how bacteria behave and spread after treatment. One will notice that as soon as the room was no longer being treated, bacteria levels reverted back to higher levels, more similar to the levels in Room 2. This shows how consistent the growth of bacteria is and that regular irradiation is necessary to keep contamination levels low and controlled.

Conclusion

This study demonstrates the effectiveness of the UVM 222 EXC on surface contamination. The study helps users determine optimal treatment times and shows to what extent the UVM 222 EXC s are able to reduce pathogens, especially at a distance. The researchers who conducted the study were able to determine that even if the room was fully occupied, irradiation for 10 minutes or more during the lunch hour and between meetings when the room was unoccupied could result in significant bacterial reduction.

This demonstrates that constant irradiation is not necessary for maintaining safe contamination levels, but consistent, periodic treatment is more important. The findings of this study provide useful information for germicidal applications using UV light and shed light on the future of pathogen reduction with UV Medico's UVM 222 EXC s. The importance of sanitary surroundings and environments are often neglected until we fall ill. With the UVM 222 EXC s, the hope is that we'll all be able to walk into public places with a peace of mind.

Note: Disinfection effectiveness by 222nm radiation is application dependent. The UVM 222 EXC may be used in occupied and unoccupied spaces and meet national and international safety standards.

*All references to "disinfection" are referring generally to the reduction of pathogenic bioburden and are not intended to refer to any specific definition of the term as may be used for other purposes by the U.S. Food and Drug Administration or the U.S. Environmental Protection Agency.