USHIO

White Paper: Testing Long-Range UV Disinfection* with Care 222® Far-UVC Disinfection Modules

For Further Information - Please Contact
Ushio America, Inc.
800.838.7446
Care222@ushio.com
ushio.com

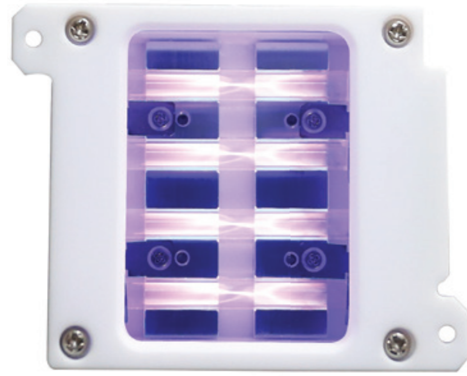

Figure 1: Care222 UV Lamp Module

Even with existing technology, millions of people today are infected every year by airborne pathogens and contaminated surfaces. Public places and high traffic areas such as airports, subways, and hospitals are all prime suspects for cross-contamination and disease-causing volatile organic compounds. Hospital acquired infections amount to almost two million infections and nearly 100,000 deaths per year in the United States. In recent years there have been many developments in the fields of microbial reduction and UV technology, but they also bring with them their fair share of problems. Products created with popular germicidal wavelengths such as 278nm or 254nm are very effective at inactivating viruses and bacteria but pose serious risks such as skin cancer and cataracts when exposed to human skin. Ushio created the Care222 far-UVC disinfection module to meet today's disinfection expectations while potentially allowing for safe implementation in occupied and highly contaminated areas.

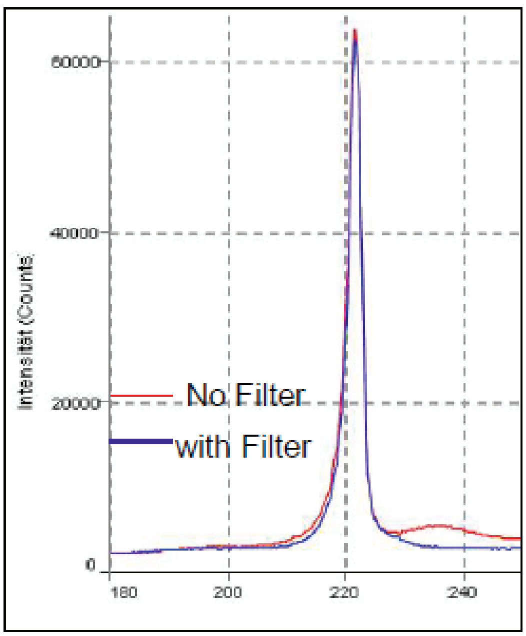

Figure 2: Spectral graph of Excimer lamp with and without short pass filter

Background

The Care222 module is a wall or ceiling-mounted UV light source developed by Ushio containing multiple excimer lamps capable of producing 222nm light. An excimer lamp is a special chamber filled with noble gas that does not use inner electrodes and is completely Mercury-free. When high voltage is applied across the outside of the glass, the gas inside excites and emits UV light. This construction means that these lamps can be turned on or off instantly without warm-up time or decreased lifetime similar to other lamps.

The Care222 module is safer than conventional excimer lamps because it is made with a specially designed short pass filter that filters out the longer, harmful wavelengths from the lamp. The result is a safe, single-peak, narrow-band wavelength of disinfecting light (see Figure 2).

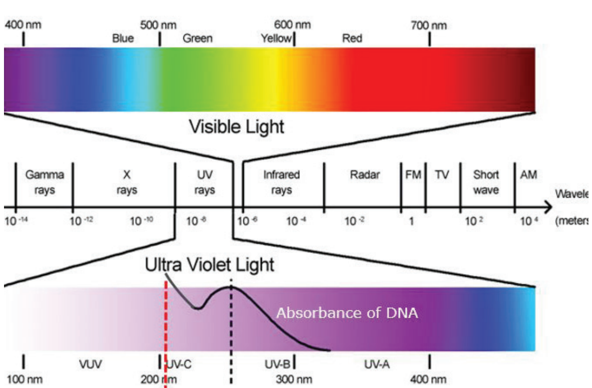

Figure 3: DNA absorbance relative to wavelength

The emitted wavelength of 222nm has similar DNA absorption and is equally effective at disinfection as 254nm (see Figure 3), but it is largely absorbed by proteins and human tissue. Thus, this wavelength of UV light can be potentially used to inactivate viruses and bacteria without the negative side effects on skin and eyes. Studies have shown that wavelengths below 230nm are absorbed by the top layer of the skin, not penetrating deeper into epidermis, causing sunburn or skin cancer. These wavelengths are also potentially safe for eyes with the light being completely absorbed by the cornea, leaving the rest of the eye undamaged (see Figure 4). This is a breakthrough for germicidal applications because it provides us the ability to reduce pathogens while maintaining a safe environment.

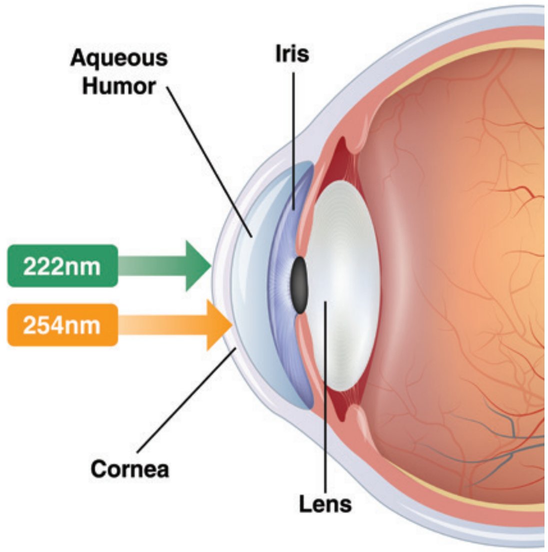

Figure 4: Ocular penetration of 222nm vs. 254nm

Test Setup

In one experiment, the floor, toilet seat, doorknob, and switch panel were all examined for bacteria (see Figure 5) because they are likely to be the most contaminated areas. It should be noted that the bathroom stalls were cleaned about 4 times a day, so this may have affected the amount of bacteria.

The Care222 module used in this experiment was equipped with a motion sensor to turn off the lamp when motion was detected. An on/off switch for the lamps was placed near the toilet seat, accessible to the user. The test was run for three days. A logger recorded data from the lamp to determine when the lamp was on and for how long. Having this information allowed the researchers to determine the dosage delivered to the specific areas in the stall. To measure the rate of bacterial reduction, cotton swab samples were taken from the floor, toilet seat, doorknob, and switch panel before, during, and after the experiment and then analyzed for bacterial growth (see Figure 6). Samples from the air were also gathered a few times throughout the experiment in each stall to test the air quality and the presence of any airborne contaminants. Figure 7 outlines the amount of bacteria colonies found in the treated and untreated bathroom stalls at several times during the experiment. The results of the air sample collections can be found in Figure 8.

Results

The graphs in Figure 7 show that after treatment, bacteria growth in the stall equipped with a Care222 module was noticeably lower than the bacterial growth in the untreated stall in almost all areas. The bottom graph in Figure 7 shows that much of the bacteria growth is on the floor and the toilet seat in the untreated stall, with little bacteria growth on the doorknob and switch panel. In this stall, you will notice decreasing colony counts, which may be due to the regular cleaning it receives. Nevertheless, compared to the amount of bacteria in the treated stall, the bacteria levels in the untreated stall are still decreased significantly after the first day. As time goes on, bacteria levels are either reduced further or maintained at a relatively lower level. In contrast, bacteria levels in the treated stall remained relatively constant and much lower than the bacteria levels in the untreated stall. This shows that the Care222 module helped reduce the amount of bacteria at these high-interaction spots.

Location	Intensity µW/cm2
1 - Floor	1.1
2 - Toilet Seat	1.4
3 - Switch Panel (on wall)	2.7
4 - Door Knob (behind door)	1.8

Figure 5: Experimental points of interest and measured UV intensities

The findings from the air samples show that the Care222 module is effective not only for surface-level pathogen reduction but also for pathogen reduction in the air. The two stalls are completely separate and isolated from each other and do not have a direct air exchange between them. Because the main ventilation through these stalls is through the building's vents and air conditioning, the air in both stalls is not shared. Figure 8 shows a comparison of the bacterial growth of the air samples taken from the treated and untreated bathroom stalls. At the beginning of the experiment, the bacteria levels in both stalls are relatively similar. The bacteria level in the air in the untreated stall increases as time progresses, whereas in the treated stall, the bacteria level in the air is reduced.

Figure 6: Surface and air samples being taken

The results of this experiment also suggest a correlation between airborne bacteria and surface contamination. The exact reasons are presently unknown, but the Care222 module provides the opportunity to treat air and surfaces at the same time. Reducing the pathogen levels of surrounding air and surfaces is pivotal for maintaining a healthy environment.

Conclusion

In summary, the experiment demonstrates that the Care222 module is effective at reducing bacteria both on surfaces and in the air. This is exciting news for the germicidal UV industry because UV treatment traditionally has been an intermittent process because rooms have to be completely vacant before UV germicidal treatment can be made. Ushio's Care222 modules will open up the possibility to irradiate occupied and unoccupied spaces and reduce pathogen levels to consistently low levels. The implementation of Ushio's Care222 modules in public places will be an important step towards our goal of providing a clean and safe environment.

Figure 7: Surface bacteria colony counts in treated and untreated stalls

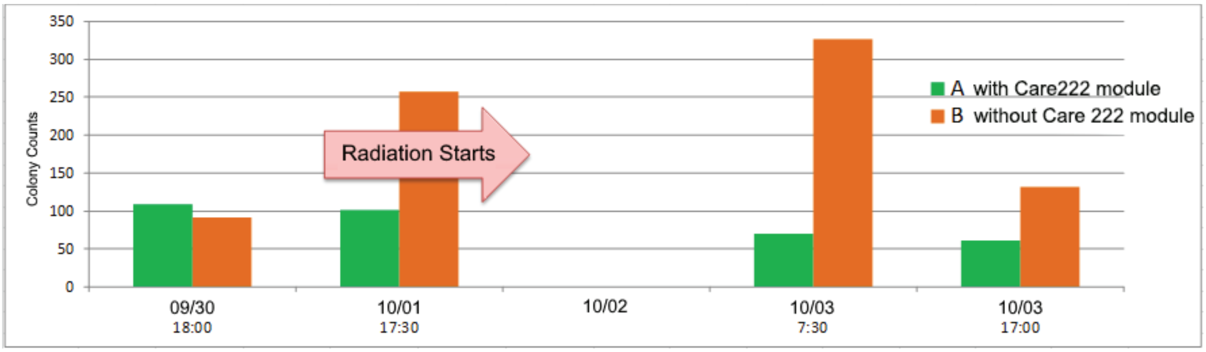

Figure 8: Air quality comparison

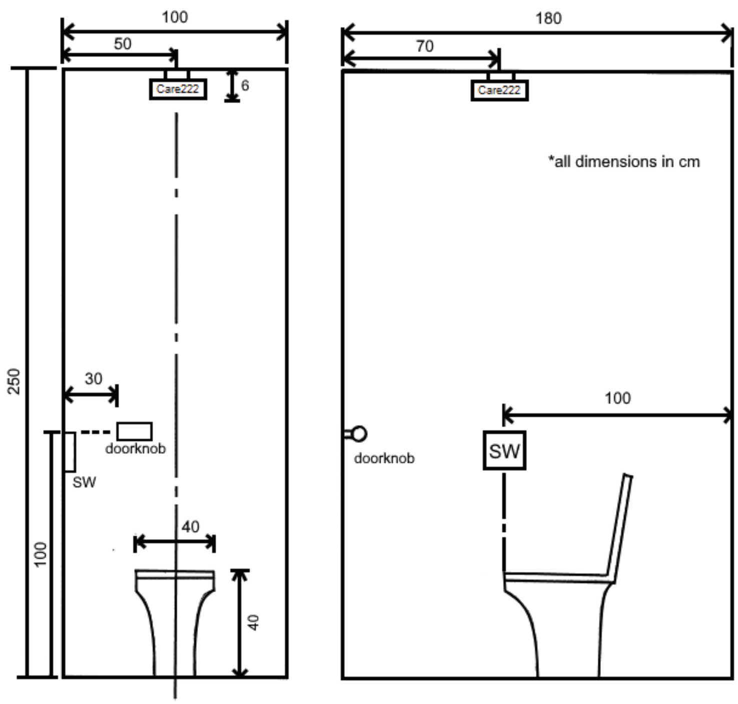

Figure 9: Dimensions of experimental setup in bathroom stall

Note: Disinfection effectiveness by 222nm radiation is application dependent. The Care222 module may be used in occupied or unoccupied spaces and the device meets 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.