Microbial Inactivation with UVC at 254-nm and 222-nm across multiple surfaces

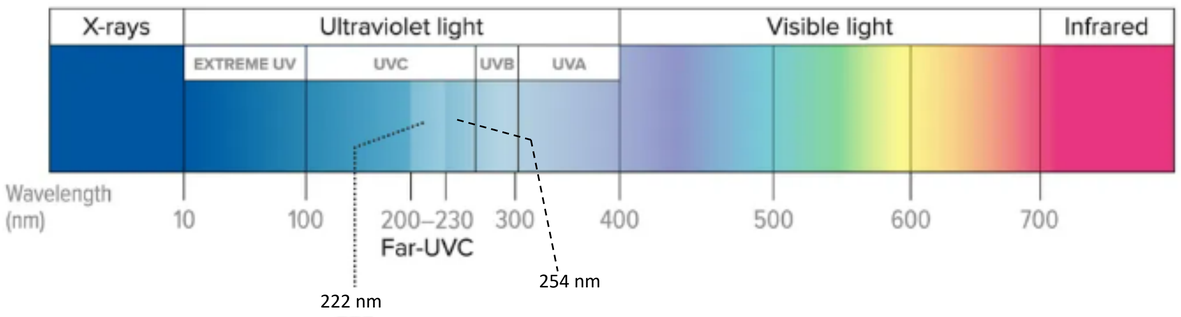
[1]Alberto Garcia, MS; [2]Shelly L. Miller, PhD; [3]Ben Ma, PhD; [2]Karl Linden, PhD; [1]Kenneth Mead, PhD, [1]Stephen Martin, PhD

[1]National Institute for Occupational Safety and Health, [2]University of Colorado Boulder, [3]University of Nevada Reno

Background

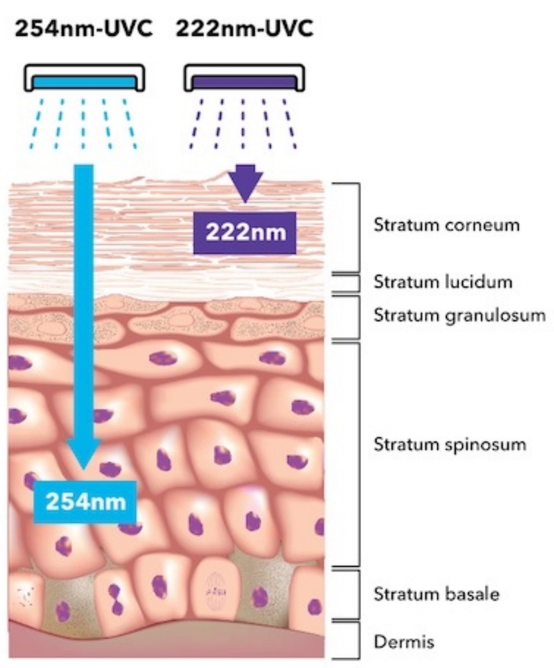
Ultraviolet (UVC) disinfection at 254 nanometers (nm) has been a validated technology for the control and reduction of pathogens – on surfaces, as well as in air and water – for many decades. UVC disinfection at 222 nm, far-UVC is new technology under investigation. This collaboration project with NIOSH and the University of Colorado Boulder evaluates and compares the inactivation efficiency of conventional UVC at 254 nm versus far-UVC at 222 nm on coliphage MS2 for three different surfaces (glass, stainless steel (SS), and PVC plastic).

Far-UVC in the electromagnetic spectrum

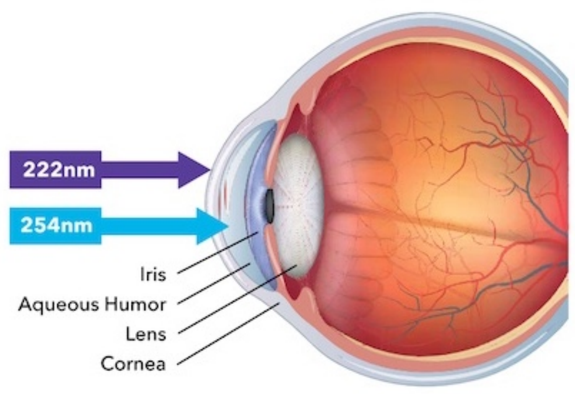


SOURCE: NASA.GOV KNOWABLE MAGAZINE

Dermal Penetration of UVC



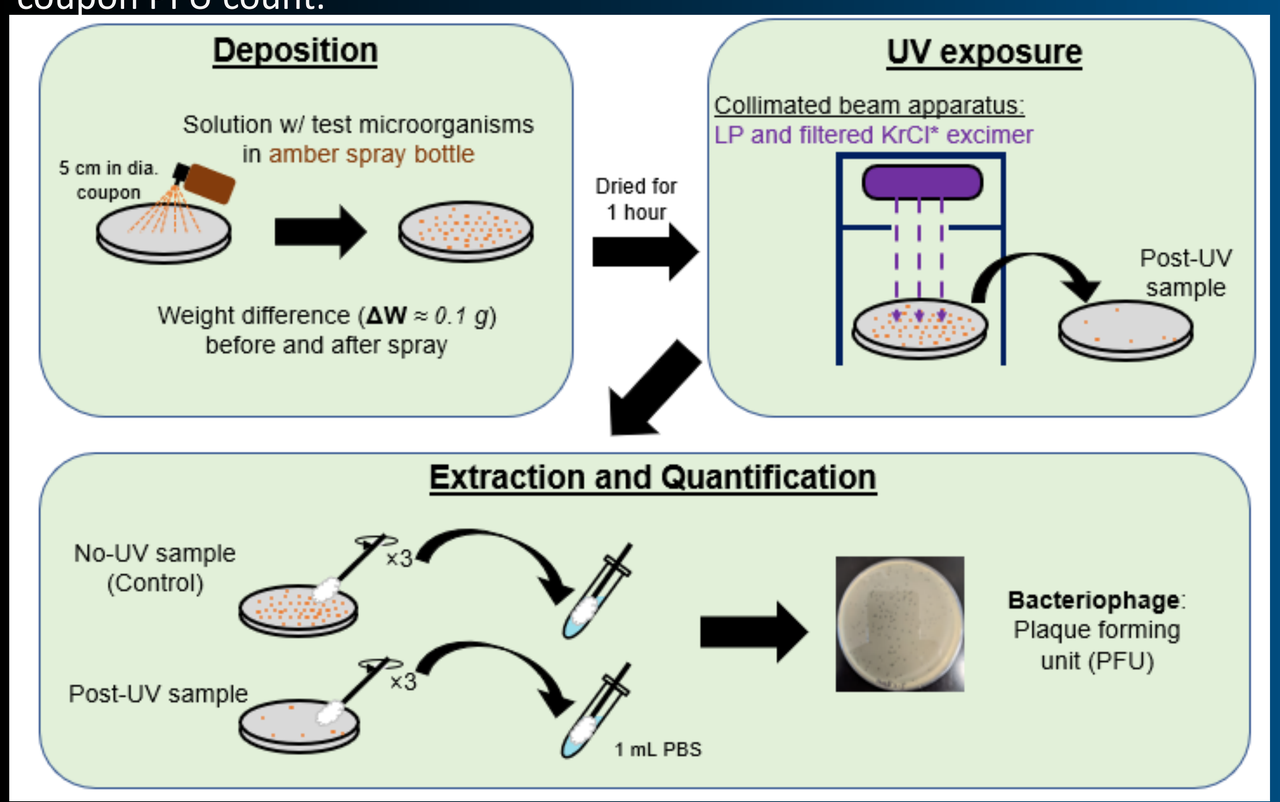
Tear Layer Penetration of UVC



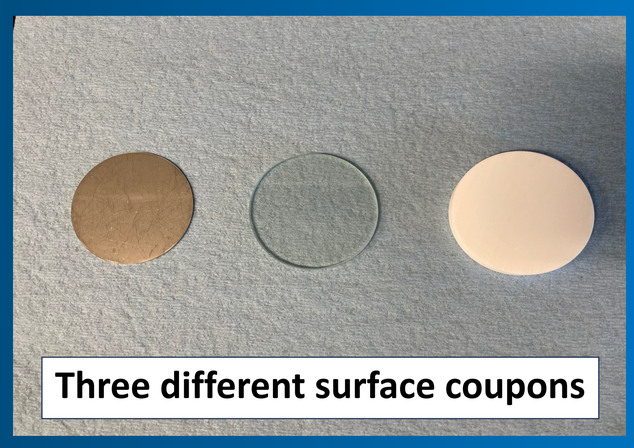
Source: https://blooloop.com/technology/in-depth/far-uvc-technology-attractions

Methods

Two UVC-generating light sources were used in this study based on popularity of units in the market, a low-pressure mercury vapor lamp (LPUV) that emits at 254 nm and a Krypton-Chloride (KrCl*) excimer lamp that emits at 222 nm. A calibrated radiometer measured UVC incident irradiance at the center of a sample surface before each UVC exposure experiment. Coliphage MS2 in water with an absorbance similar to human saliva (absorbance at 222 and 254 nm = 10 cm-1) was used for surface deposition. Future steps on this project include the same evaluation in a saliva and mucin solution. All UVC exposures were performed on 5-cm diameter round coupons made of glass, stainless steel, and PVC plastic. The coupons laid flat during inoculation with MS2, drying, and UVC dosing. The coupons dried for approximately 1-hour within a biological safety cabinet prior to UVC dosing. Time-matched controls (no UVC exposure) were used (one per sample) over the course of the exposure tests. The tests were conducted using variable exposure times (based on the dose) at a UVC source distance of 15 cm directly above the coupons. Multiple serial dilutions were plated, and plaque-forming units (PFUs) were counted to calculate the log-reduction values (LRV) comparing control versus exposed coupon PFU count.



Experimental Setup



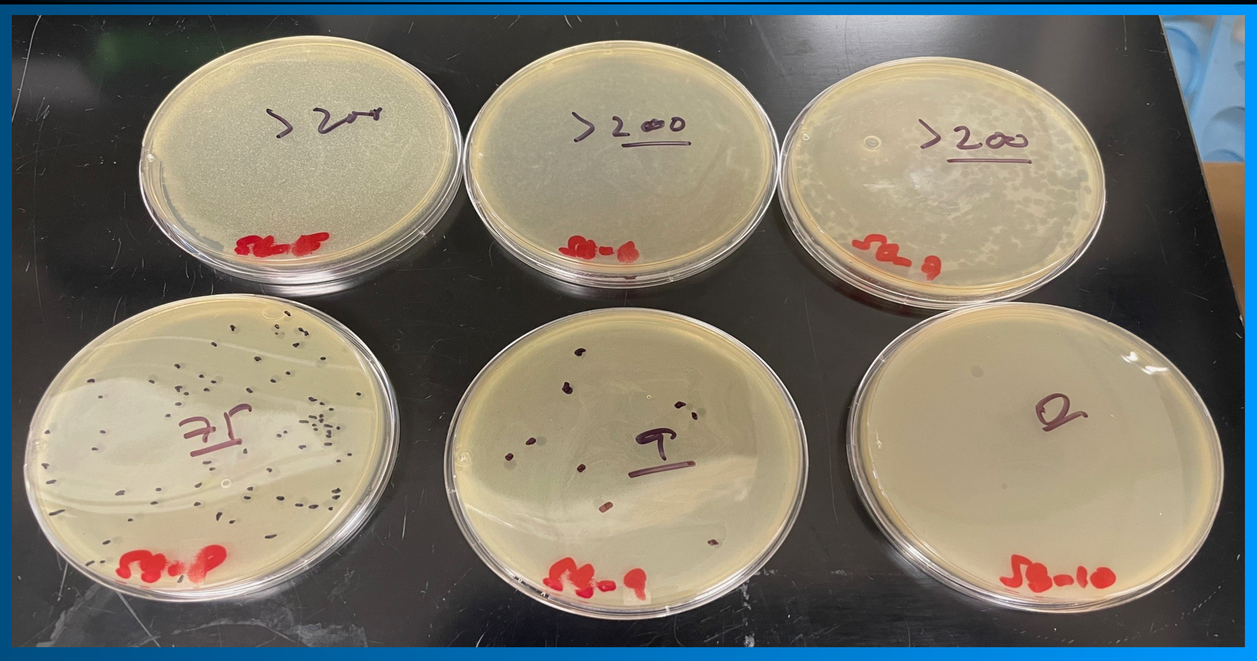
Three different surface coupons

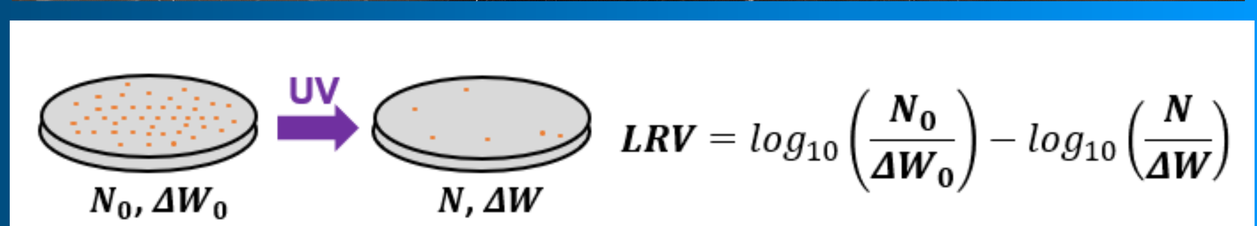
Extraction into PBS vials

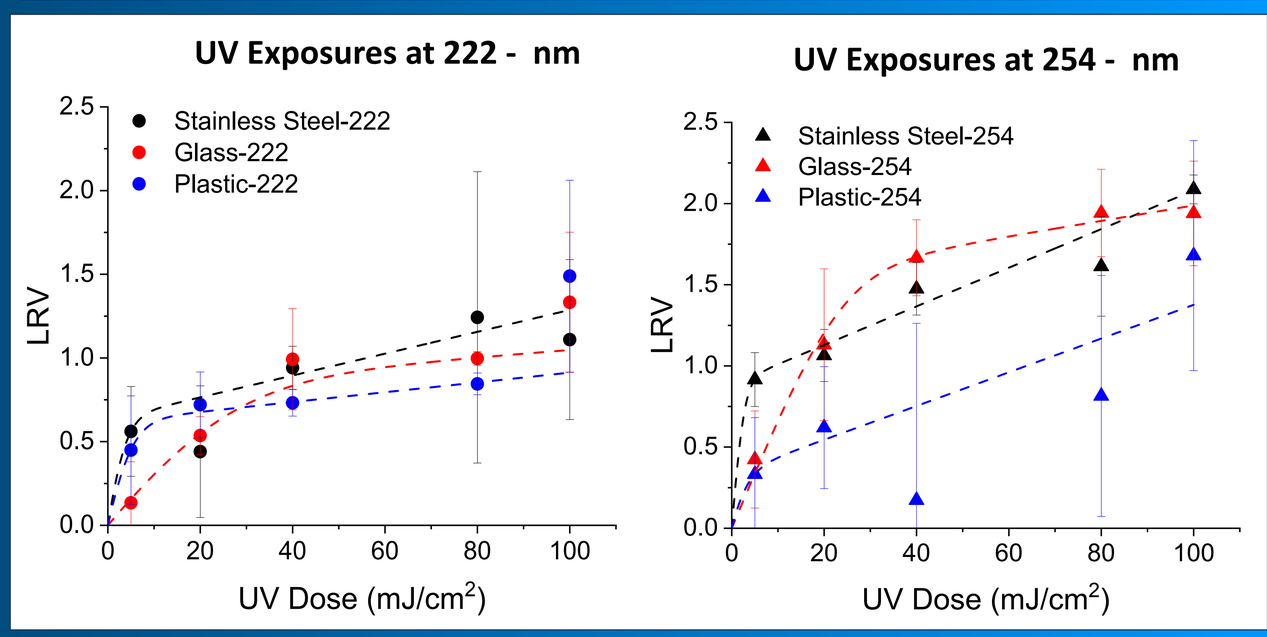
SS and Glass coupons dosed

Plating multiple dilutions/sample

Results







Discussion

Both KrCl* excimer lamp at 222 nm and LPUV at 254 nm are effective for disinfection when using MS2 on the three evaluated surfaces. The LPUV exhibited slightly higher log-reduction values for surface disinfection when compared to the KrCl* excimer lamp at the same dose. UV reflection from surfaces may improve UV disinfection performance, especially for highly reflective materials, like stainless-steel in this case.

Acknowledgments

The authors also thank Dr. Katherine Ratliff from the Environmental Protection Agency for continued advisory support. Finally, the authors wish to thank Dr. Mark Hernandez and his research group at the University of Colorado Boulder for expert assistance during the ongoing experiments.