

## UV Published Research References

### 1 222nm Published Research

#### 1.1 Comparison of stratum corneum thickness in children and adults

Fairley J.A, Rasmussen J.E. (1983). Comparison of stratum corneum thickness in children and adults. *Journal of the American Academy of Dermatology*, 8(5): 652–654. [https://doi.org/10.1016/s0190-9622\(83\)70074-5](https://doi.org/10.1016/s0190-9622(83)70074-5)

#### 1.2 Higher effectiveness of photoinactivation of bacterial spores, UV resistant vegetative bacteria and mold spores with 222 nm compared to 254 nm wavelength subtilis Spores in Aqueous Suspensions at 172, 222 and 254 nm

Clauss, Marcus. (2007). Higher effectiveness of photoinactivation of bacterial spores, UV resistant vegetative bacteria and mold spores with 222 nm compared to 254 nm wavelength. *Clean Soil Air Water*, 34: 525-532. <https://doi.org/10.1002/ahch.200600650>

#### 1.3 Comparison of the Disinfection Effects of Vacuum UV (VUV) and UV Light on Bacillus subtilis Spores in Aqueous Suspensions at 172, 222 and 254 nm

Wang, D., Oppenländer, T., El-Din, M.G. and Bolton, J.R. (2010). Comparison of the Disinfection Effects of Vacuum UV (VUV) and UV Light on *Bacillus subtilis* Spores in Aqueous Suspensions at 172, 222 and 254 nm. *Photochemistry and Photobiology*, 86: 176-181. <https://doi.org/10.1111/j.1751-1097.2009.00640.x>

#### 1.4 207-nm UV Light - A Promising Tool for Safe Low-Cost Reduction of Surgical Site Infections. I: In Vitro Studies\*

Buonanno M., Randers-Pehrson G., Bigelow A.W., Trivedi S., Lowy F.D., *et al.* (2013). 207-nm UV Light - A Promising Tool for Safe Low-Cost Reduction of Surgical Site Infections. I: *In Vitro* Studies. *PLOS ONE*, 8(10). <https://doi.org/10.1371/journal.pone.0076968>

#### 1.5 Action spectra for validation of pathogen disinfection in medium-pressure ultraviolet (UV) systems

Sara E. Beck, Harold B. Wright, Thomas M. Hargy, Thomas C. Larason, Karl G. Linden. (2015). Action spectra for validation of pathogen disinfection in medium-pressure ultraviolet (UV) systems. *Water Research*, 70: 27-37. <https://doi.org/10.1016/j.watres.2014.11.028>

#### 1.6 207-nm UV Light—A Promising Tool for Safe Low-Cost Reduction of Surgical Site Infections. II: In-Vivo Safety Studies\*

Buonanno M., Stanislauskas M., Ponnaiya B., Bigelow A.W., Randers-Pehrson G., *et al.* (2016). 207-nm UV Light—A Promising Tool for Safe Low-Cost Reduction of Surgical Site Infections. II: *In-Vivo* Safety Studies. *PLOS ONE*, 11(6): e0138418. <https://doi.org/10.1371/journal.pone.0138418>

### **1.7 Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light**

Buonanno, M., Ponnaiya, B., Welch, D., Stanislauskas, M., Randers-Pehrson, G., Smilenov, L., Lowy, F. D., Owens, D. M., & Brenner, D. J. (2017). Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light. *Radiation Research*, 187(4): 483–491. <https://doi.org/10.1667/RR0010CC.1>

### **1.8 Disinfection and healing effects of 222-nm UVC light on methicillin-resistant *Staphylococcus aureus* infection in mouse wounds\***

Narita, K., Asano, K., Morimoto, Y., Igarashi, T., Hamblin, M. R., Dai, T., & Nakane, A. (2018). Disinfection and healing effects of 222-nm UVC light on methicillin-resistant *Staphylococcus aureus* infection in mouse wounds. *Journal of photochemistry and photobiology B: Biology*, 178: 10–18. <https://doi.org/10.1016/j.jphotobiol.2017.10.030>

### **1.9 Far-UVC light prevents MRSA infection of superficial wounds *in vivo*\***

Ponnaiya B., Buonanno M., Welch D., Shuryak I., Randers-Pehrson G., *et al.* (2018). Far-UVC light prevents MRSA infection of superficial wounds *in vivo*. *PLOS ONE*, 13(2): e0192053. <https://doi.org/10.1371/journal.pone.0192053>

### **1.10 Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases\*\***

Welch, D., Buonanno, M., Grilj, V., *et al.* (2018). Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases. *Sci Rep*, 8: e2752. <https://doi.org/10.1038/s41598-018-21058-w>

### **1.11 Chronic irradiation with 222-nm UVC light induces neither DNA damage nor epidermal lesions in mouse skin, even at high doses**

Narita, K., Asano, K., Morimoto, Y., Igarashi, T., Nakane, A. (2018). Chronic irradiation with 222-nm UVC light induces neither DNA damage nor epidermal lesions in mouse skin, even at high doses. *PLOS ONE*, 13(7): e0201259. <https://doi.org/10.1371/journal.pone.0201259>

### **1.12 Effect of far ultraviolet light emitted from an optical diffuser on methicillin-resistant *Staphylococcus aureus* *in vitro***

Welch, D., Buonanno, M., Shuryak, I., Randers-Pehrson, G., Spotnitz, H.M., *et al.* (2018). Effect of far ultraviolet light emitted from an optical diffuser on methicillin-resistant *Staphylococcus aureus* *in vitro*. *PLOS ONE*, 13(8): e0202275. <https://doi.org/10.1371/journal.pone.0202275>

### **1.13 Evaluation of acute corneal damage induced by 222-nm and 254-nm ultraviolet light in Sprague–Dawley rats**

Sachiko Kaidzu, Kazunobu Sugihara, Masahiro Sasaki, Aiko Nishiaki, Tatsushi Igarashi & Masaki Tanito (2019). Evaluation of acute corneal damage induced by 222-nm and 254-nm ultraviolet light in Sprague–Dawley rats. *Free Radical Research*, 53(6): 611-617. <https://doi.org/10.1080/10715762.2019.1603378>

### **1.14 DNA Damage Kills Bacterial Spores and Cells Exposed to 222-Nanometer UV Radiation**

Willie Taylor, Emily Camilleri, D. Levi Craft, George Korza, Maria Rocha Granados, Jaliyah Peterson, Renata Szczpaniak, Sandra K. Weller, Ralf Moeller, Thierry Douki, Wendy W. K. Mok, Peter Setlow. (2020). DNA Damage Kills Bacterial Spores and Cells Exposed to 222-Nanometer UV Radiation. *Applied and Environmental Microbiology*, 86(8): e03039-19. <https://doi.org/10.1128/AEM.03039-19>

**1.15 [Long-term effects of 222 nm ultraviolet radiation C sterilizing lamps on mice susceptible to ultraviolet radiation](#)**

Yamano, N., Kunisada, M., Kaidzu, S., Sugihara, K., Nishiaki-Sawada, A., Ohashi, H., Yoshioka, A., Igarashi, T., Ohira, A., Tanito, M. and Nishigori, C. (2020). Long-term effects of 222 nm ultraviolet radiation C sterilizing lamps on mice susceptible to ultraviolet radiation. *Photochem Photobiol*, 96: 853-862. <https://doi.org/10.1111/php.13269>

**1.16 [222-nm UVC inactivates a wide spectrum of microbial pathogens](#)**

K. Narita, K. Asano, K. Naito, H. Ohashi, M. Sasaki, Y. Morimoto, T. Igarashi, A. Nakane. (2020). 222-nm UVC inactivates a wide spectrum of microbial pathogens. *Journal of Hospital Infection*, 105(3): 459-467. <https://doi.org/10.1016/j.jhin.2020.03.030>

**1.17 [Far-UVC light \(222 nm\) efficiently and safely inactivates airborne human coronaviruses](#)**

Buonanno, M., Welch, D., Shuryak, I., *et al.* (2020). Far-UVC light (222 nm) efficiently and safely inactivates airborne human coronaviruses. *Sci Rep*, 10: e10285. <https://doi.org/10.1038/s41598-020-67211-2>

**1.18 [Predicting airborne coronavirus inactivation by far-UVC in populated rooms using a high-fidelity coupled radiation-CFD model](#)**

Buchan, A.G., Yang, L. & Atkinson, K.D. (2020). Predicting airborne coronavirus inactivation by far-UVC in populated rooms using a high-fidelity coupled radiation-CFD model. *Sci Rep*, 10: e19659. <https://doi.org/10.1038/s41598-020-76597-y>

**1.19 [Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination](#)**

Hiroki Kitagawa, Toshihito Nomura, Tanuza Nazmul, Keitaro Omori, Norifumi Shigemoto, Takemasa Sakaguchi, Hiroki Ohge. (2020). Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination. *American Journal of Infection Controls*, 49(3): 299-301. <https://doi.org/10.1016/j.ajic.2020.08.022>

**1.20 [Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans](#)**

Fukui, T., Niikura, T., Oda, T., Kumabe, Y., Ohashi, H., *et al.* (2020). Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans. *PLOS ONE*, 15(8): e0235948. <https://doi.org/10.1371/journal.pone.0235948>

**1.21 [Effect of intermittent irradiation and fluence-response of 222nm ultraviolet light on SARS-CoV-2 contamination](#)**

Kitagawa, H., Nomura, T., Nazmul, T., Kawano, R., Omori, K., Shigemoto, N., Sakaguchi, T., & Ohge, H. (2021). Effect of intermittent irradiation and fluence-response of 222 nm ultraviolet light on SARS-CoV-2 contamination. *Photodiagnosis and Photodynamic Therapy*, 33: e102184. <https://doi.org/10.1016/j.pdpdt.2021.102184>

**1.22 [Exposure of Human Skin Models to KrCl Excimer Lamps: The Impact of Optical Filtering\\*\\*\\*](#)**

Buonanno, M., Welch, D. and Brenner, D.J. (2021). Exposure of Human Skin Models to KrCl Excimer Lamps: The Impact of Optical Filtering. *Photochem Photobiol*, 97: 517-523. <https://doi.org/10.1111/php.13383>

### **1.23 Ozone Generation by Ultraviolet Lamps**

Claus, H. (2021). Ozone Generation by Ultraviolet Lamps. *Photochem Photobiol*, 97: 471-476. <https://doi.org/10.1111/php.13391>

### **1.24 A Need to Revise Human Exposure Limits for Ultraviolet UV-C Radiation**

Sliney, D.H. and Stuck, B.E. (2021). A Need to Revise Human Exposure Limits for Ultraviolet UV-C Radiation. *Photochem Photobiol*, 97: 485-492. <https://doi.org/10.1111/php.13402>

### **1.25 Re-Evaluation of Rat Corneal Damage by Short-Wavelength UV Revealed Extremely Less Hazardous Property of Far-UV-C**

Kaidzu, S., Sugihara, K., Sasaki, M., Nishiaki, A., Ohashi, H., Igarashi, T. and Tanito, M. (2021). Re-Evaluation of Rat Corneal Damage by Short-Wavelength UV Revealed Extremely Less Hazardous Property of Far-UV-C. *Photochem Photobiol*, 97: 505-516. <https://doi.org/10.1111/php.13419>

### **1.26 Extreme Exposure to Filtered Far-UVC: A Case Study**

Eadie, E., Barnard, I.M.R., Ibbotson, S.H. and Wood, K. (2021). Extreme Exposure to Filtered Far-UVC: A Case Study. *Photochem Photobiol*, 97: 527-531. <https://doi.org/10.1111/php.13385>

\* Study is referenced because it includes a discussion of biological safety of far UVC light on mammalian cells and tissues. Inclusion of the study is not intended to make any medical claim regarding the cure, mitigation, treatment, or prevention of disease.

\*\* Study is referenced because it includes a discussion of the characteristics of far-UVC light and its ability to inactivate aerosolized viruses. Inclusion of the study is not intended to make any medical claim regarding the cure, mitigation, treatment, or prevention of disease.

\*\*\*Study is referenced because it explores KrCl lamp health hazards by comparing filtered and unfiltered KrCl lamps using effective spectral irradiance calculations and experimental skin exposures; the study does not address any intended impact on the structure or function of the body.

## **2 Pulsed Xenon Published Research**

### **2.1 [Inactivation of \*Escherichia coli\* O157:H7 and \*Listeria monocytogenes\* in biofilms by pulsed ultraviolet light](#)**

Montgomery, N. L., Banerjee, P. (2015). Inactivation of *Escherichia coli* O157:H7 and *Listeria monocytogenes* in biofilms by pulsed ultraviolet light. *BMC Research Notes*, 8: 235. <https://doi.org/10.1186/s13104-015-1206-9>

### **2.2 [Evaluation of an ultraviolet room disinfection protocol to decrease nursing home microbial burden, infection and hospitalization rates\\*](#)**

Kovach, C. R., Taneli, Y., Neiman, T., *et.al.* (2017). Evaluation of an ultraviolet room disinfection protocol to decrease nursing home microbial burden, infection and hospitalization rates. *BMC Infect Dis*, 17: 186. <https://doi.org/10.1186/s12879-017-2275-2>

### **2.3 [Pulsed Broad-Spectrum UV Light Effectively Inactivates SARS-CoV-2 on Multiple Surfaces and N95 Material](#)**

Jureka, A.S., Williams, C.G., Basler, C.F. (2021). Pulsed Broad-Spectrum UV Light Effectively Inactivates SARS-CoV-2 on Multiple Surfaces and N95 Material. *Viruses*, 13(3): 460. <https://doi.org/10.3390/v13030460>

\* Study is referenced because it includes a discussion of the effect of pulsed xenon ultraviolet technology on decreasing microorganisms on environmental surfaces. Inclusion of the study is not intended to make any medical claim regarding the cure, mitigation, treatment, or prevention of disease.

### **3 Onboard Air Published Research**

#### **3.1 Effect of Ultraviolet Germicidal Irradiation on Viral Aerosols**

Walker, Christopher M., Ko, GwangPyo. (2007). Effect of Ultraviolet Germicidal Irradiation on Viral Aerosols. *Environ. Sci. Technol.*, 41(15): 5460–5465. <https://doi.org/10.1021/es070056u>

#### **3.2 Ultraviolet Germicidal Irradiation: Current Best Practices**

Martin, Jr., Stephen B., Dunn, Chuck, Freihaut, Jim, Bahnfleth, William, Lau, Josephine, & Nedeljkovic-Davidovic, Ana. (2008). Ultraviolet germicidal irradiation: Current best practices. *ASHRAE Journal*, 50: 28-30+32. [https://www.ashrae.org/file\\_library/technical\\_resources/covid-19/martin.pdf](https://www.ashrae.org/file_library/technical_resources/covid-19/martin.pdf)

#### **3.3 Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria?**

Linda D. Lee, DrPH, MS, MBA. (2017). Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria? *Canadian Journal of Infection Control*, 32(2): 108-111.

#### **3.4 Effectiveness of a shielded ultraviolet C air disinfection system in an inpatient pharmacy of a tertiary care children's hospital**

Guimera, D., Trzil, J., Joyner, J., & Hysmith, N. D. (2017). Effectiveness of a shielded ultraviolet C air disinfection system in an inpatient pharmacy of a tertiary care children's hospital. *American Journal of Infection Control*, 46(2): 223–225. <https://doi.org/10.1016/j.ajic.2017.07.026>

#### **3.5 Cleaning the air with ultraviolet germicidal irradiation lessened contact infections in a long-term acute care hospital\***

Tina Ethington, Sherry Newsome, Jerri Waugh, Linda D. Lee. (2018). Cleaning the air with ultraviolet germicidal irradiation lessened contact infections in a long-term acute care hospital. *American Journal of Infection Control*, 46(5): 482-486. <https://doi.org/10.1016/j.ajic.2017.11.008>

#### **3.6 Rapid and complete inactivation of SARS-CoV-2 by ultraviolet-C irradiation**

Storm, N., McKay, L.G.A., Downs, S.N., *et al.* (2020). Rapid and complete inactivation of SARS-CoV-2 by ultraviolet-C irradiation. *Sci Rep*, 10: e22421 <https://doi.org/10.1038/s41598-020-79600-8>

#### **3.7 Evaluating the Utility of UV Lamps to Mitigate the Spread of Pathogens in the ICU**

Gostine A., Gostine D., Short J., Rustagi A., Cadnum J., Donskey C., Angelotti T. (2020). Evaluating the Utility of UV Lamps to Mitigate the Spread of Pathogens in the ICU. *Applied Sciences*, 10(18): 6326. <https://doi.org/10.3390/app10186326>

\* Study is referenced because it includes a discussion of the effect of operating continuous shielded UV-C at the room level on airborne bacteria. Inclusion of the study is not intended to make any medical claim regarding the cure, mitigation, treatment, or prevention of disease.