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

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/aheh.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

* 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 ofdisease.

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

* 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 ofdisease.

** 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.

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(3): 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

1.27 Pilot study on the decontamination efficacy of an installed 222-nm ultraviolet disinfection device (Care222®), with a motion sensor, in a shared bathroom

Hiroki Kitagawa, Yuki Kaiki, Kayoko Tadera, Toshihito Nomura, Keitaro Omori, Norifumi Shigemoto, Shinya Takahashi, Hiroki Ohge. (2021). Pilot study on the decontamination efficacy of an installed 222-nm ultravioletdisinfection device (Care222™), with a motion sensor, in a shared bathroom, *Photodiagnosis and Photodynamic Therapy*, 34: 102334. https://doi.org/10.1016/j.pdpdt.2021.102334

1.28 Disinfection capabilities of a 222 nm wavelength ultraviolet lighting device: a pilot study

Jun Chance Goh, Dale Fisher, Eileen Chor Hoong Hing, Lee Hanjing, Yap Yan Lin, Jane Lim, Ong Wei Chen, and Lim Thiam Chye. (2021). Disinfection capabilities of a 222 nm wavelength ultraviolet lighting device: a pilotstudy. *Journal of Wound Care*, 30(2): 96-104. https://doi.org/10.12968/jowc.2021.30.2.96

1.29 Far-UVC efficiently inactivates an airborne pathogen in a room-sized chamber

Ewan Eadie, Waseem Hiwar, Louise Fletcher, Emma Tidswell, Paul O'Mahoney, Manuela Buonanno, DavidWelch, Catherine S. Adamson, David J. Brenner, Catherine Noakes, Kenneth Wood. (2021). Far-UVC efficiently inactivates an airborne pathogen in a room-sized chamber. *scientific reports*, In Review. https://doi.org/10.21203/rs.3.rs-908156/v1

1.30 Anti-microbial effect of filtered 222nm excimer lamps in a hospital waiting area

Jacob Thyrsted, Søren Helbo Skaarup, Andreas Fløe Hvass, Sara Moeslund Joensen, Stine Y. Nielsen, Elisabeth Bendstrup, Pernille Hauschildt, Christian K. Holm. (2021). Anti-microbial effect of filtered222nm excimer lamps in a hospital waiting area. *medRxi*, Preprint. https://doi.org/10.1101/2021.09.03.21263096

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

1.31 UV Inactivation of SARS-CoV-2 across the UVC spectrum: KrCL excimer, mercury-vapor, and LED sources

Ben Ma, Patricia M. Gundy, Charles P. Gerba, Mark D. Sobsey and Karl G. Linden. (2021). UV Inactivationof SARS-CoV-2 across the UVC spectrum: KrCl excimer, mercury-vapor, and LED sources. *Applied and Environmental Microbiology*, 87(22): e01532-21. https://doi.org/10.1128/AEM.01532-21

1.32 Computer Modeling Indicates Dramatically Less DNA Damage from Far-UVC Krypton Chloride Lamps (222nm) than from Sunlight Exposure

Eadie E, O'Mahoney P, Finlayson L, Barnard IRM, Ibbotson SH, Wood K. (2021). Computer Modeling Indicates Dramatically Less DNA Damage from Far-UVC Krypton Chloride Lamps (222 nm) than from Sunlight Exposure. *Photochem Photobiol*. 97(5): 1150-1154. https://doi.org/10.1111/php.13477

1.33 Minimal, Superficial DNA Damage in Human Skin from Filtered Far-Ultraviolet C

R.P. Hickerson, M.J. Conneely, S.K. Hirata Tsutsumi, K. Wood, D.N. Jackson, S.H. Ibbotson, E. Eadie (2021). Minimal, Superficial DNA Damage in Human Skin from Filtered Far-Ultraviolet C. *British Journal of Dermatology*, 184(6): 1197-1199. https://doi.org/10.1111/bjd.19816

1.34 UV and violet light can Neutralize SARS-CoV-2 Infectivity

Mara Biasin, Sergio Strizzi, Andrea Bianco, Alberto Macchi, Olga Utyro, Giovanni Pareschi, Alessia Loffreda, Adalberto Cavalleri, Manuela Lualdi, Daria Trabattoni, Carlo Tacchetti, Davide Mazza, Mario Clerici. (2022). UV and violet light can Neutralize SARS-CoV-2 Infectivity. *Journal of Photochemistry and Photobiology*, Vol. 10: e100107. https://doi.org/10.1016/j.jpap.2021.100107

1.35 Effect of ultraviolet C emitted from KrCl excimer lamp with or without bandpass filter to mouse epidermis

Narita K, Asano K, Yamane K, Ohashi H, Igarashi T, et al. (2022). Effect of ultraviolet C emitted from KrCl excimer lamp with or without bandpass filter to mouse epidermis. PLOS ONE 17(5): e0267957. https://doi.org/10.1371/journal.pone.026795

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 thecure, 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

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 onairborne and surface bacteria? *Canadian Journal of Infection Control*, 32(2): 108-111. https://ipac-canada.org/photos/custom/CJIC/IPAC_Summer2017_Linda%20Lee.pdf

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

3.8 Evaluation of multiple ICU fixed in-room air cleaners with ultraviolet germicidal irradiation, in high-occupancy areas of selected commercial indoor environments

Linda Lee, George Delclos, Matthew Lee Berkheiser, Monique Barakat & Paul Jensen. (2021). Evaluation of multiple fixed in-room air cleaners with ultraviolet germicidal irradiation, in high-occupancy areas of selected commercial indoor environments, *Journal of Occupational and Environmental Hygiene*, Epub ahead of print. https://doi.org/10.1080/15459624.2021.1991581.

* 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.