EFFICACY OF CEILING MOUNTED UV-C SYSTEMS

UVANGEL® PATHOGEN CONTROL TECHNOLOGY

The CDC states that ultraviolet irradiation of air is an effective means of "reducing the transmission of airborne bacterial and viral infections in hospitals."[1] Ultraviolet germicidal irradiation (UVGI) occurs when UV light at an effective wavelength of 254 nanometers, disrupts the nucleic acid in the DNA of a microorganism, preventing it from replicating.

The development of active UVGI air treatment systems that assume the footprint of a standard 2' x 4' ceiling panel or light fixture was developed in recent years. Similar to upper room air treatment and active air duct treatment, these systems can be safely used in occupied spaces 24/7/365 where the pathogens are generated and freely circulated. Below are a few studies that show the effectiveness of this UV-C technology in healthcare.

PEER-REVIEW HOSPITAL

After installing UV-C ceiling mounted systems, airborne bacteria in patient rooms were reduced an average of 42% in a hospital in Kentucky.[2] Common HAIs and catheter-associated urinary tract infections were reduced significantly as were overall infections by 60%. There were no reported changes to the amount or type of cleaning done, infection control protocols, or reporting procedures. Other infections traditionally considered contact transmissible (central line–associated bloodstream infection and methicillin-resistant Staphylococcus aureus), also declined noticeably.

C. Diff reduced 88%	CAUTIs reduced 55%
MRSA reduced 54%	CLABSIs reduced 44%
VREs reduced 14%	**Overall infections reduced 60%**

Conclusions: Continuous shielded UV-C reduced airborne bacteria and may also lower the number of HAIs, including those caused by contact pathogens. Reduced infections result in lessened morbidity and lower costs.

PEER-REVIEW LTCF

Over the course of six months, data was collected and analyzed in a study that was conducted at a long-term care hospital in TN.[3] The overall infection rate was significantly lower in rooms with UV-C units than in those without. The bacteria air sampling in the patient rooms were reduced by 51% and the total reduction in infections dropped by 28%. An anecdotal note to this study, staff reported that allergy symptoms were reduced, and absenteeism was lowest in the wing where the UV-C systems were installed.

Airborne bacteria reduced 51%	Infection rate reduced 28%

Conclusion: Findings suggest that continuous exposure to UV-C treated air reduces HAIs. Shielded UV-C units in patient rooms may be an effective non-staff intervention dependent method for reducing HAIs.

PEER-REVIEW PHARMACY STUDY

Viable air particles pose a risk in areas where sterile preparations are compounded.[4] Mean airborne fungal and bacterial colony forming units were obtained pre-installation and again in 6 months. A statistically significant decrease of 78% and 62% was observed for fungal and bacterial particles, respectively.

After installing the UV-C systems in the anteroom, dispensing/ receiving and processing areas, bacteria and fungi was decreased in the anteroom by 86% and 90% respectively. The UV-C systems reduced the contaminated air flow, so the levels of bacteria and fungi were decreased by 92% and 100% in the compounding IV room where no units were installed.

Anteroom Results	Pre-CFUs	Post-CFUs	% Decrease
Fungi Air Sampling	1.8	0.18	90%
Bacteria Air Sampling	35.3	4.85	86%
Compounding Results			
Fungi Air Sampling	3.25	0.0	100%
Bacteria Air Sampling	1.5	0.125	92%

Conclusions: This study demonstrates how using shielded UV-C technology can decrease the spread of airborne pathogens throughout a compounding pharmacy.

PEER REVIEW AIR AND SURFACE

Field trials were set up at three hospitals (Texas, Nevada, and Massachusetts) where we tested air and surface for bacteria, installed continuous UV-C products at the room level, and then tested air and surface again.[5] In all cases, airborne bacteria was reduced between 79% and 91% over pre-installation values. Most surfaces also showed reductions in bacteria from 48% to 69%, although we report one incident of an increase of 288%.

Conclusions: The data indicate that using active, shielded UV-C air technology at the room level reduces the bioburden in the air and on surfaces, including in occupied spaces.

UV vs. CORONAVIRUSES

There is currently great interest in emerging pathogens like coronaviruses. Approximately 100 sequences of the SARS-CoV-2 genome have been published and these suggest there are two types, Type I and Type II, of which the latter came from the Huanan market in China while the Type I strain came from an unknown location (Zhang 2020).

The effectiveness of UV on Coronaviruses was started by Hirano back in 1978. The table below summarizes the results of studies that have been performed on Coronaviruses under ultraviolet light exposure, with the specific species indicated in each case. The D90 value indicates the ultraviolet dose for 90% inactivation. Although there is a wide range of variation in the D90 values, this is typical of laboratory studies on ultraviolet susceptibility. The range of D90 values for coronaviruses is 7-241 J/m 2, the average which is 67 J/m 2, should adequately represent the ultraviolet susceptibility of the SARS-CoV-2 (COVID-19) virus.

Table 1: Summary of Ultraviolet Studies on Coronaviruses

Microbe	D_{90} Dose J/m^2	UV k m^2/J	Base Pairs kb	Source
Coronavirus	7	0.35120	30741	Walker 2007[a]
Berne virus (Coronaviridae)	7	0.32100	28480	Weiss 1986
Murine Coronavirus (MHV)	15	0.15351	31335	Hirano 1978
Canine Coronavirus (CCV)	29	0.08079	29278	Saknimit 1988[b]
Murine Coronavirus (MHV)	29	0.08079	31335	Saknimit 1988[b]
SARS Coronavirus CoV-P9	40	0.05750	29829	Duan 2003[c]
Murine Coronavirus (MHV)	103	0.02240	31335	Liu 2003
SARS Coronavirus (Hanoi)	134	0.01720	29751	Kariwa 2004[d]
SARS Coronavirus (Urbani)	241	0.00955	29751	Darnell 2004
Average	**67**	**0.03433**		

[a] (Jingwen 2020) [b] (estimated) [c] (mean estimate) [d] (at 3 logs)

UV ANGEL PERFORMANCE/VALIDATION STUDIES

UV Angel has conducted two separate laboratory tests by an independent third party against surrogate pathogens including Escherichia coli (gram negative), Staphylococcus aureus (gram positive), Cladosporium cladosporioides (fungus spore formers) and MS2 Bacteriophage (MS2) (virus surrogate).[6] The UV Angel Air showed elimination rates from 90%. Laboratory tests and mathematical modeling show elimination rates approaching 100% against more than 80 serious disease-causing pathogens.

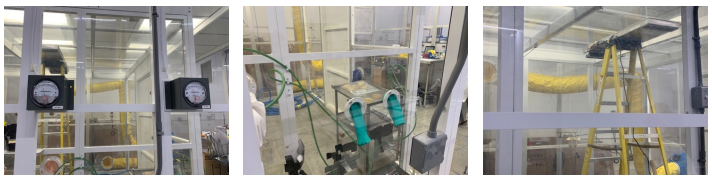
UV mathematical modeling and D90 rates have been established for 80 pathogens, known or suspected airborne component in their transmission cycle, including bacteria, viruses, and fungi. Many pathogens, if they are drawn into the UVGI chamber, are neutralized in a single pass. Perhaps more significantly, for some of the most virulent pathogens, including MRSA, VRE, and C. difficile, the removal rate (reflecting both filtration and UV disinfection) was 100 percent modeled for those pathogens that pass through the chamber.

Table 4: Combined UV + Filter Removal Rates

Microbe	Type	Size µm	Filter %	UV Rate %	Total %
Acinetobacter	Bacteria	1.225	21	100	100.00
Adenovirus	Virus	0.079	9	100	100.00
Aeromonas	Bacteria	2.098	35	100	100.00
Aspergillus	Fungi	3.354	45	93	96.30
Bacillus anthracis	Bacteria	1.118	19	61	68.20
Bacteroides fragilis	Bacteria	3.162	44	100	100.00
Blastomyces dermatitidis	Fungi	12.649	50	99	99.65
Bordetella pertussis	Bacteria	0.245	4	100	100.00
Burkholderia cenocepacia	Bacteria	0.707	11	100	100.00
Burkholderia mallei	Bacteria	0.674	10	100	100.00
Burkholderia pseudomallei	Bacteria	0.494	7	100	100.00
Candida albicans	Fungi	4.899	49	79	89.19
Candia auris	Fungi	4.899	49	75	87.31
Chlamydia pneumoniae	Bacteria	0.548	8	100	100.00
Chlamydophila psittaci	Bacteria	0.283	4	100	100.00
Cladosporium	Fungi	8.062	50	98	98.75
Clostridium botulinum	Bacteria	1.975	33	100	100.00
Clostridium difficile	Bacteria	2	34	100	100.00
Clostridium perfringens	Bacteria	5	49	100	100.00
Coronavirus (Wuhan)	Virus	0.11	6	100	100.00
Corynebacterium diphtheriae	Bacteria	0.698	10	100	100.00
Coxsackievirus	Virus	0.027	19	100	100.00
Cryptococcus neoformans	Fungi	4.899	49	99	99.67
Curvularia lunata	Fungi	11.619	50	71	85.57
Ebola virus	Virus	0.09	8	100	100.00
Echovirus	Virus	0.024	20	100	99.89
E. coli	Virus	0.5	7	100	100.00
Enterobacter cloacae	Bacteria	1.414	24	100	100.00
Enterococcus	Bacteria	1.414	24	100	100.00
Enterococcus faecalis	Bacteria	0.707	11	100	100.00
Francisella tularensis	Bacteria	0.2	4	91	91.49
Fusarium	Fungi	11.225	50	92	96.23
Haemophilus influenzae	Bacteria	0.285	4	100	100.00
Haemophilus parainfluenzae	Bacteria	1.732	30	100	99.99
Hantaan virus	Virus	0.096	7	100	100.00
Helicobacter pylori	Bacteria	2.1	35	100	100.00
Histoplasma capsulatum	Fungi	2.236	36	99	99.56
Influenza A virus	Virus	0.098	7	100	100.00
Junin virus	Virus	0.122	6	100	100.00
Klebsiella pneumoniae	Bacteria	0.671	10	100	100.00
Lassa virus	Virus	0.122	6	100	100.00
LCV	Virus	0.087	8	100	100.00
Legionella pneumophila	Bacteria	0.52	7	100	100.00
Listeria monocytogenes	Bacteria	0.707	11	99	98.98

Table 4: Combined UV + Filter Removal Rates

Microbe	Type	Size µm	Filter %	UV Rate %	Total %
Marburg virus	Virus	0.039	15	100	100.00
Measles virus	Virus	0.158	5	100	100.00
MERS virus	Virus	0.11	6	89	90
Mucor	Fungi	7.071	50	95	98
Mumps virus	Virus	0.164	5	100	100
Mycobacterium avium	Bacteria	1.118	19	100	100
Mycobacterium kansasii	Bacteria	1.118	19	100	100
Mycobacterium tuberculosis	Bacteria	0.637	9	100	100
Mycoplasma pneumoniae	Bacteria	0.177	5	100	100
Neisseria meningitidis	Bacteria	0.775	12	100	100
Nocardia asteroides	Bacteria	1.118	19	100	100
Norwalk virus	Virus	0.029	18	97	98
Parainfluenza virus	Virus	0.194	4	100	100
Parvovirus B19	Virus	0.022	21	100	100
Penicillium	Fungi	3.262	44	60	78
Proteus mirabilis	Bacteria	0.494	7	100	100
Pseudomonas aeruginosa	Bacteria	0.494	7	100	100
Reovirus	Virus	0.075	9	99	99
RSV	Virus	0.19	5	100	100
Rhinovirus	Virus	0.023	21	99	99
Rhizopus	Fungi	6.928	50	93	96
Rickettsia prowazeki	Bacteria	0.6	9	100	100
Rotavirus	Virus	0.073	9	100	100
Rubella virus	Virus	0.061	11	67	71
Salmonella typhi	Bacteria	0.806	13	100	100
SARS virus	Virus	0.11	6	100	100
Serratia marcescens	Bacteria	0.632	9	100	100
Stachybotrys chartarum	Fungi	5.623	49	12	55
Staphylococcus aureus	Bacteria	0.866	14	100	100
Staphylococcus epidermis	Bacteria	0.866	14	100	100
Streptococcus pneumoniae	Bacteria	0.707	11	77	80
Streptococcus pyogenes	Bacteria	0.894	14	100	100
Trichophyton	Fungi	4.899	49	71	85
Ustilago	Fungi	5.916	50	46	73
VZV	Virus	0.173	5	100	100
Yersinia pestis	Virus	0.707	11	100	100



Images during lab testing

PROOF OF EFFECTIVENESS

Tests conclusively support that UV Angel Air treats bacteria, fungus and viruses in the air including: Gram negative and gram-positive bacteria, fungal pathogens and viral surrogates.

The UV Angel Air results showed laboratory elimination rates up to 99.99%.

Sources: Centers for Disease Control and Prevention. 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings. Available from: http://www.cdc.gov/hicpac/2007IP/2007isolationPrecautions.html. Accessed 26 August 2016 2. Tina Ethington, MSN, RN, CEN, NE-BC, Sherry Newsome, BSN, RN, MBA/MNA, Jerri Waugh, BSN, RN, MBA/MHA, Linda D. Lee, DrPH, MBA, Cleaning the air with ultraviolet germicidal irradiation lessened contact infections in a long-term acute care hospital, American Journal of Infection Control, December 2017 3. Douglas W. Kane, MD; Cynthia Finley RRT; Diane Brown RRT, Linda Lee PhD, UV-C Light and Infection Rate in a Long Term Care Ventilator Unit, May 23, 2016 4. Don Guimera, MSN, RN, CIC, CCRP, FAPIC, Jean Trzil, PharmD, Joy Joyner, RN, CIC, Nicholas D. Hysmith, MD, FAAP, Effectiveness of a shielded UV-C air disinfection system in an inpatient pharmacy of a tertiary care children's hospital, American Journal of Infection Control, August 2017 5. Linda D. Lee., DrPH, MBA, Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria? Canadian Journal of Infection Control, Summer 2017 6. Lee. Report on the Performance of the UV Angel Air [a]Walker CM, Ko G Effect of ultraviolet germicidal irradiation on viral aerosols. *Environ. Sci. Technol.* 2007, 41, 15, 5460-5465 Weiss M, Horzinek MC. Resistance of Berne virus to physical and chemical treatment. *Vet Microbiol.* 1986;11(1-2):41-49. doi:10.1016/0378-1135(86)90005-2 Hirano N, Hino S, Fujiwara K,Physico-chemical properties of mouse hepatitis virus (MHV-2) grown on DBT cell culture. Microbiol Immunol. 1978;22(7):377-90. [b]Saknimit M1, Inatsuki I, Sugiyama Y, Yagami K. Virucidal efficacy of physico-chemical treatments against coronaviruses and parvoviruses of laboratory animals. Jikken Dobutsu. 1988 Jul;37(3):341-5. [c]Duan SM, et. al, Stability of SARS coronavirus in human specimens and environment and its sensitivity to heating and UV irradiation. Biomed Environ Sci. 2003 Sep;16(3):246-55. Darnell ME, et. al, Inactivation of the coronavirus that induces severe acute respiratory syndrome, SARS-CoV. J Virol Methods. 2004 Oct;121(1):85-91. [d]Kariwa H[1], Fujii N, Takashima I,Inactivation of SARS coronavirus by means of povidone-iodine, physical conditions, and chemical reagents. Jpn J Vet Res. 2004 Nov;52(3):105-12.