airocide®

NASA funded TiO2 /PCO technology

Text


“this technology was chosen for one simple reason...”

Because in Space
You don't get a second chance

From the National Aeronautics and Space Administration

NASA had a problem. Plants were being grown on the Space Station and a technology was needed that would eliminate the ethylene gas they produced. The University of Wisconsin solved the problem with a unique air purification technology.

NASA License Granted

NASA licenses patented technologies developed for the space program to companies for use in commercial applications. Such was the case in September 1997 when a manufacturer, KesAir Science & Technology, Inc. was awarded the license to commercialize NASA's Air Purification Technology. The following year the company began marketing the system under the brand names PCR biocide and AiroCide PPT to produce packers and grocery chains. Ethylene is the gas produced by plants that accelerates ripening. By destroying the gas, the shelf life of fruits and vegetables was significantly extended. Employing the NASA technology, florists reported they were able to extend the marketable life of cut flowers by at least ten days.

VOCs Destroyed

Further testing demonstrated the technology was virtually 100% effective in destroying VOCs (Volatile Organic Compounds). VOCs are emitted by a wide array of products numbering in the thousands. Examples of products in the home include: paints, lacquers, paint strippers, cleaning supplies, pesticides, building materials, furnishings, other solvents, wood preservatives, aerosol sprays, cleansers, disinfectants, air fresheners, stored fuels, automotive products, hobby supplies even dry-cleaned clothing.

Anthrax, Virus, Bacteria, Mold Spores, Allergens

The anthrax attacks in December of 2001, prompted the company to test to see if the technology would kill *Bacillus anthracis* as well as it destroys other microscopic organism. Using *B. thuringiensis,* a non-virulent cousin of the anthrax spore, lab tests confirmed the technology would be successful in eliminating even this lethal pathogen. Testing was subsequently expanded to encompass viral and bacterial matter along with pollen, dust mites and other biological pollutants with the same results.

Healthcare Applies the Technology

In 2003 this NASA technology was introduced to hospital operating rooms, clinics, dental offices and other medical facilities in the Americas and Europe, as well as in childcare and prison facilities: locations where infectious diseases, viral, bacterial, and airborne allergens are problems. Follow-up studies demonstrated dramatic reductions in disease and allergen transmission wherever it was deployed. This NASA-developed technology has been shown to eliminate airborne pathogenic and non-pathogenic microorganisms in vegetative and spore states in a variety of commercial, government, and residential market applications including the medical healthcare industry.

Airocide®

AiroCide® is the NASA-developed technology that eliminates airborne pathogenic and non-pathogenic bacteria, mold and fungi, viruses and dust mites, allergens, odors and harmful volatile organic compounds in medical facilities, residential whole-house installations as well as in the space-program.

The Only Technology of its Kind that is Space Certified

Results from 12 years of scientific testing in the United States, field use on the Space Station, lab studies, case studies and customer testimonials are contained in this PROOF book. **AiroCide®** eliminates any biological material that comes in contact with its proprietary photocatalytic matrix, oxidizing the organic matter and releasing only molecules of water vapor and carbon dioxide. The proof is here. There is nothing comparable anywhere. **AiroCide® works!**

AIROCIDE® Product Claims

- It is a totally unique product, unlike anything else in the marketplace
- Exclusive NASA–designed technology and the most difficult field test ever devised – in earth orbit. The only technology of its kind that is actually "space qualified" as certified by a panel of former astronauts
- This exclusive NASA-developed technology has undergone 12 years of testing in space, in hospitals, in operating rooms, in schools, in dental offices, in laboratories, in food processing and packaging plants and other bio-sensitive environments
- It is clinically proven to eliminate" airborne pathogenic and non-pathogenic microorganisms in vegetative and spore states (bacteria, mold and fungi, viruses and dust mites), antibiotic and biocide resistant "super-bugs" and allergens, on contact, as well as harmful volatile organic compounds
- Fan speed is calibrated to maximize air dwell time
- This proprietary technology – EXCLUSIVE TO *AIROCIDE*®, sanitizes air - the slower the air moves the cleaner it gets, with a microbiological elimination rate of 99.99997%
- Purifies the air in any environment
- It will not reintroduce contaminants into room atmosphere because it doesn't trap allergens, microbes, mold spores and dust mites, it eliminates them
- Generates only Clean Crisp Fresh Air
- AiroCide® is proven to extend the shelf life of produce, flowers, and grains.
- No Ozone emissions or other harmful by-products
- Low maintenance
- Self-cleaning
- No filters

12 Years of Intense Study

AiroCide® is air purification that works. We make this claim because we can. It is because we've spent over a decade testing and retesting that we are able to say – this system actually works where others merely pretend to work. This is a totally new way of doing things.

In this book you will find not just one, but three separate clinical studies[1] in the United States and one in Spain.

AiroCide®

1. Achieved a 300% reduction in airborne microbes
2. Generated no Ozone
3. Eliminated mycotoxins (100 times smaller than viruses)
4. Was found to be superior to the HEPA HVAC surgical air systems alone that are currently being used in hospitals.
5. Eliminated VOCs (volatile organic compounds) in test after test.

Why did we go through the cost and time to produce Clinical Studies? When your product actually works dramatically better than anything else (works the way *AiroCide*® does) proof of its effectiveness is worth the investment.

We did not rest on the evidence from the Clinical University Studies; we took the next step. We took the technology to some of the toughest real world environments that could be found and once again put it to the test.

These case studies show how revolutionary this technology really is. And they prove that even in environments that contain excessively high regeneration rates such as operating rooms, child care facilities, and doctors' offices, *AiroCide*® technology significantly reduces the bacteria and mold counts. See for yourself -

1. Surgery - Average results 73% reduction in bacteria and mold
2. Office – Average results 72% reduction in bacteria and mold
3. Households – Average results 75% reduction in bacteria and mold
4. Childcare Center – Average results 60% reduction in bacteria and mold
5. Dental Private Practices – Average results 81% reduction in bacteria and mold

No other air purifier has ever undergone this level of intense study. The question is, why not?

[1] A clinical study is a study with people that is designed to answer a question relating to the diagnosis, treatment, prevention, or course of a disease. The studies conducted surrounding the technology employed in AiroCide® were completed primarily at the University level. PCR biocide unit tested employed the identical NASA licensed technology as is in AiroCide®

Scientific Proof

- **No Ozone** – AiroCide Tested by The State of Wisconsin Hygiene Laboratory
- **Ozone to Oxygen** – Published Paper Photocatalytic Decomposition of Ozone to Oxygen at Room Temperature with Titanium Dioxide
- **Mycotoxins** – Toxic Portion of Mold Spores Decomposition by AiroCide Tested by Texas Tech University
- **Bacillus Anthrax Spores** – University of Wisconsin & The State of Wisconsin Hygiene Laboratory Tested Bacillus Thuringiensis Spores With a 99.9986% Kill Rate In a Single Pass. NASA Published Results
- **Self-Cleaning AiroCide Catalyst** – Mineralization of E. Coli to Water Vapor and Carbon Dioxide Tested and Published by The National Renewable Energy Laboratory
- **Peer Reviewed Published Paper Texas A&M University** – AiroCide In a Hospital Operating Room

Clinical Studies

Clinical Peer-Review Study

Texas A&M University
300% Reduction in Airborne Microbes
Superior to HEPA HVAC Surgical Air Systems

In a Clinical Study and published peer-review paper, Texas A&M University reported that the PCR^2 (Photocatalytic Reactor) biocide unit produced dramatic evidence of its effectiveness: a 300% reduction of airborne microbes. "The NASA technology **proved superior to HEPA HVAC surgical air systems…"** The unit was tested at the University in four clinical settings. The study concluded that it '…has advantages that are not possible with the best HVAC (heating, ventilation, and air-conditioning) high efficiency filter systems." The researchers found the following advantages:

- High elimination rate of disease causing microorganisms
- Eliminates volatile organic chemicals and bioaerosols (odors)
- No ozone emissions
- Energy efficient with low maintenance and long product life

Clinical Study

University of Wisconsin
Environmental Chemistry & Technology Program
Researchers tested and analyzed the effluent from the unit and determined that Ozone was undetectable. Analysis of the data also revealed VOCs (volatile organic compounds) were found to be in the very low parts-per-billion range.

FURTHER - laboratory tests conducted at the University also revealed that the technology employed in AiroCide produces a 99.9937% kill of CFUs. This level of inactivation overwhelmingly meets the definition of 'sanitization' as established by the Environmental Protection Agency (EPA) and the Association of Official Analytical Chemists, which requires that a non-product contact surface have a contamination reduction of 99.9%,

Clinical Study

Texas Tech University
Health Sciences Center
School of Medicine
Department of Microbiology and Immunology
The technology was tested to determine its abilities to inactivate fungal conidia and mycotoxins. Under selected experimental parameters, the device was able to inactivate the tested mycotoxin *roridin A* and the fungal species, *Aspergillus niger.*

Clinical Study

Universidad Politencnica de Cartagena (Murcia) – Spain.
Departamento de Ingeniria Quimica y Ambiental
The technology was proven to efficiently remove ethylene, CFU and VOC concentrations in cold storage indoor air.

PEER-REVIEW PAPER

Reducing Airborne Microbes in the Surgical Operating Theater and Other Clinical Settings

A Study Utilizing a Unique Photocatalytic Reactor Biocide Unit

Nicholas Cram, MEng, CBET, CHSP, Nolan Shipman, MD, and John M. Quarles, PhD

From the Biomedical Engineering Department, Texas A&M University, College Station, Shipman-Cram Medical Research, College Station (Mr Cram); The Physicians Centre, Bryan, Shipman-Cram Medical Research, Bryan, Tex (Dr Shipman); and Department of Medical Microbiology and Immunology, College of Medicine, Texas A&M University, College Station (Dr Quarles).

The authors provide a research study examining the airborne microbial killing efficiency of a unique photocatalytic reactor (PCR) to eliminate fungal and bacterial pathogens. The study examines baseline bacterial and fungal cultures, commonly known as pathogens, collected at specific clinical sites. The cultures were incubated, and separate culture counts (colony-formed units, or CFUs) for specific microbes were recorded for the given clinical area. The samples are identified by gram stain and special growth media and samples of unique clinical interest such as methicillin-resistant Staphylococcus aureus (MRSA) are studied in depth, identifying genus and species in varying culture media. Samples and cultures are collected at specific times for a 24-hour period after the installation and use of the PCR biocide unit, revealing up to a 300% reduction of airborne microbes.

Clinical engineers and biomedical technicians play a vital role in bioterror preparedness because of their extensive expertise regarding new technology assessment. This article details a new technology for maintaining healthy indoor air quality in the event of a bioterror attack.

The study examines 2 outcomes: (1) examination of a reduction of airborne microbial counts in specific clinical areas as a result of implementing the PCR unit in the clinical areas sampled (as identified in Tables 1-7) and (2) statistical evidence related to the cost-related savings due to lessened risk factors of lower microbial counts involving nosocomial and cross-infections. Healthcare economics and patient comfort will be impacted as a result, if lower airborne microbial colonies result from the implementation of the PCR biocide unit. A scientific explanation of the photocatalytic oxidation (PCO) process and the distinct uniqueness of the PCO and ultraviolet (UV) combination process (PCO) utilized by the PCR biocide unit will be examined in depth.

Corresponding author: Nicholas Cram, The Texas A&M University, Shipman-Cram Medical Research, College Station, Tex.

Nicholas Cram, MEng, CBET, CHSP, is a clinical pharmacist, a lecturer at the Biomedical Engineering Department of Texas A&M University, a consultant in healthcare risk management and medical device design, and a certified healthcare safety professional at Shipman-Cram Medical Research, College Station, Tex.

Nolan Shipman, MD, is a board-certified ear, nose, and throat specialist and facial cosmetic surgeon at the Physicians Centre, Bryan, Tex, and a consultant in medical device design at Shipman-Cram Medical Research, Bryan, Tex.

John M. Quarles, PhD, is a professor and the head of the Department of Medical Microbiology and Immunology, College of Medicine, Texas A&M University, College Station, Tex. He was certified by American Society for Microbiology National Registry of Microbiology. His specialties are virology, public health, and medical microbiology.

Air Quality Standards

Several state and national organizations and agencies, as well as the Joint Commission on Accreditation of Healthcare Organizations, regulate and recommend standards for hazard control in the healthcare setting. Air quality is accessed based on the lack of hazardous materials contained in a specific area, department, or facility and the air surrounding that environment. Given this assessment process, there is no specific designation for a medical grade of air contained in the surgical operating theater or the healthcare environment in general. The Occupational Safety and Health Administration states defined clean air as "air of such a purity that it will not cause harm or discomfort to an individual if it is inhaled for extended periods of time."[1] There is a designation and standard for medical compressed gases, which is governed by the Compressed Gas Association and the National Fire Protection Agency

Table 1. CFU Counts in Active Stage Versus Time (ENT Day Surgery Data)				
Volume of air	1423.8 ft^3	Baseline sample	228 CFUs per m^3	June 21, 2003
FPM in: duct 1	80 average	Total no. active sample: off after 4 h	572 CFUs per m^3	June 20, 2003
FPM out: duct 2	140 average	Total active sample: on after 24 h	179 CFUs per m^3	June 5, 2003
Exchanges per hour	5.8	Percent decrease in CFUs per m^3 vs. active off	68.7%	—

Section 50.[2,3] There is also no uniform method of testing the air in the surgical operating theater for microbes or hazardous gases.

Bioterrorist threats, conceivably exposing the environment to airborne toxic gases and microbes, as well as the annual trend of increasing nosocomial infections in the healthcare setting, create an acute necessity for uniform standards of testing, monitoring, and containing hazardous air through active implementation of biocide devices, especially in the surgical operating theater and other clinical areas.

Statistical Verification

The study is statistically a binomial experiment, with probabilities given that the expected value (E) of surviving microbial colonies will be less than the total colonies sampled (S) during a surgical/clinical procedure. Since this is a Bernoulli random variable with only 2 outcomes, the Bernoulli variable is $m = P$. The binomial probability distribution is supported by actual colony counts (CFUs) after the PCR biocide unit was installed during a surgical procedure, compared with the baseline sample, which was taken prior to its installation (see Tables 1-7). The killing efficiency hypothesis will be a demonstration of lowered airborne microbial counts after clinical procedures with the unit off versus those with the unit on. The sampling procedures followed a strict protocol. The full protocol is listed in attachment A, B, and C. The lowered nosocomial rate hypothesis will be verified by a demonstration of Hypothesis 1 and empirical extrapolation of data and existing scenarios.

Sampling Population

Select diverse clinical areas were sampled using the air sampling method of a "slit" sampler. The "slit" sampler has an attached vacuum compressor that samples the air within 5 m^3 every minute. The air sampling method is far superior to surface sampling, where swabs are cultured from the surfaces of equipment and structures. To verify a uniform mechanism of action for the PCR biocide unit in a variety of environments, 4 distinct clinical areas were sampled: (1) ear, nose, and throat (ENT) day surgery, (2) pulmonary spirometry, (3) surgical operating theater (OR), and (4) surgical instrument sterile preparation. The unit is a PCR capable of eradicating fungi, molds, bacteria, viruses, and volatile organic chemicals. Volatile organic chemicals may introduce offensive odors or toxic chemicals, which intensify the problem of indoor air quality.

To maintain a statistically normal population in relation to the area sampled, back-to-back sampling of 4 consecutive days was preformed. This method eliminates variables of cleaning and maintenance regimens as well as the variation in clinical procedures performed.

This is known as a "2 + 2 method" of sampling. The first 2 days gather a baseline with the PCR biocide unit turned off, while days 3 and 4 are run during a typical clinical setting with the PCR biocide unit turned on. The samples were delivered to the testing laboratory at the Microbiology and Immunology Testing Laboratories, College of Medicine, Texas A&M University (College Station, Tex) without any representative plate sample markings of the area being sampled, to avoid any bias in the CFU count(s) or microbial expectation. A single blind study was therefore achieved, which promoted preservation, theoretically and statically of the clinical normality of the population and reduced variance in the samples tested.

Science of Photocatalytic Oxidation

Organic Molecular Bond Theory

To fully understand UV and photocatalytic processes, it is necessary to first understand the concept of organic molecular bonding. Organic material is carbon based, as opposed to inorganic material, which contain no hydrocarbons (C-Hx). A definitive academic definition of *organic*

Table 2. Surgical Operating Theater: OR 1				
Volume of air	6710 ft^3	Baseline sample	7 CFUs per m^3	June 10, 2003 to June 11, 2003
FPM in: 8 ducts	2250 ft^3	Active sample: off	17 CFUs per m^3	July 28, 2003 to July 25, 2003
FPM out: 3 ducts	2603 ft^3	Active sample: on after 24 h	12 CFUs per m^3	July 29, 2003
Exchanges per hour	20.7 ft^3	Percent decrease in CFUs from active off	29%	
OR standard specifications usually call for 14 to 20 air turns per hour. The Texas Department of Health requires a minimum of 20 air exchanges per hour (Hospital Licensing Standards, Texas Department of Health, amended through May 1994, p 77T). The small sample size relates to a smaller percent decrease in CFUs, however, the restive microbes eradicated were significant (see Table 5).				

Table 3. Pulmonary Test Area				
Volume of air	1222 ft^3	Baseline sample	5 CFUs per m^3	June 17, 2003 to June 18, 2003
FPM in: duct 1	50 average	Active sample: off after 2 h	80 CFUs per m^3	June 26, 2003 to June 27, 2003
FPM out: duct 2	110 average	Active sample: on after 24 h	103 CFUs per m^3	July 1, 2003
Exchanges per hour	5.04	Percent decrease in CFUs below baseline	NA	—
Variation in number of patients tested resulted in CFU sample anomalies.				

material is "those containing carbon and one or more other elements, most often hydrogen, oxygen, nitrogen, . . .(and) sulfur."[5] Organic compounds may be connected in a ringlike configuration, such as the hexagon benzene ring or in short or long single-stranded structures. Organic material consists of commonly identified substances, such as plastics, sugar, and pharmaceuticals. Bacteria, viruses, molds, yeasts, and fungi are also organic compounds.

Chemical bonds are forces that connect each atom to the next, sometimes in complex spatial arrangements. There are 3 types of chemical bonds: (1) ionic, (2) covalent, and (3) metallic. Carbon-based materials (organic materials) are confined to covalent bonding. Organic carbon most commonly exists as a 4-bonded molecule. Covalent bonds are the weakest bond forces of the 3 molecular bonds.[5]

Van der Waals forces are also an important atomic bonding force at the atomic and molecular level, which measures the attractive force between molecules and atoms and is especially important in hydroxyl groups.

The ability to break or weaken these covalent bonds results in the destruction or denaturizing of organic materials. All living substances have a form or self-preservation or defense mechanism to prevent the bond forces from weakening. Bacteria and viruses mutate and share gene information, which has caused several antibiotics to become ineffective. Some researchers, including these authors, believe that this antibiotic resistance of microbes could lead to eventual epidemic problematic areas. As discussed earlier, nosocomial infections due to drug resistance could determine a positive or negative clinical outcome or even life itself. Nosocomial infections resulting from microbial resistance are also costly for both the patient and the healthcare facility and they require extended lengths of stay in the hospital. The consequences of nosocomial infections will be discussed in detail in a separate topic in this article.

The pharmaceutical industry continues to make advances in antibiotic research and tissue engineering, and gene therapy could also provide a reduction in resistant strains of microbes. Each of these solutions involves individual one-on-one patient intervention, which is not an efficient epidemiological approach to a mass contamination scenario. A device or system that is active on a larger environmental scale is a more practical means of preventing epidemics. This type of large-scale, broad-spectrum biocide device will be critical for public safety and Homeland Security if future SARS, TB, West Nile Virus, or bioterrorist microbial or toxic gas threats endanger whole metropolitan areas or communities.

Photocatalytic Oxidation Versus Ultraviolet

Not all organic material contains the same elements and the same spatial relationships, and there is actually a wavelength spectrum (range of wavelengths) in the UV range where some organic compounds (microbes, fungi, yeasts, and molds) are more susceptible than others. The sun is the primary source of UV rays. It kills a plethora of viruses, bacteria, and fungi in outdoor exposed areas. It will also cause decay of human cells in the process of the popular youthful tradition of tanning. Certain Microcidal UV bond-breaking energy, in a certain range or spectrum, makes the protein contained in microbes susceptible to protein denaturizing (a means of changing the chemical structure of ribonucleic acid or deoxyribonucleic acid) and ultimately cellular death of the microbe. Spores are more resilient to UV irradiation and may remain on surfaces for months.[6]

The Greek physician Hippocrates (the father of medicine and the originator of the Hippocratic Oath taken by all physicians) was the first to realize that sunlight, which contains UV rays, contributed to his patient's health. He regularly had his patients positioned in outdoor recliners to gain full access to sunlight.

Table 4. Sterile Preparation Testing Area				
Volume of air	5760 ft^3	Baseline sample	32 CFUs per m^3	July 18, 2003
FPM in: duct 1	5 FPM	Active sample: off after 2 h	207 CFUs per m^3	July 21, 2003
FPM out: duct 2	3 FPM	Active sample: on after 12 h	11 CFUs per m^3	July 22, 2003
FPM out: duct 3	3 FPM	—	—	—
Exchanges per hour	<0.5	Percent decrease in CFUs from active off	95%	—

Table 5. *Summary of Organisms Cultured Versus Clinical Area*

Organism	ENT day surgery*	ENT day surgery: active*	Operating room*,†	Operating room active†,‡
Gram-negative rods	Yes: baseline 242 CFUs	None after biocide unit on 24 h	Yes: baseline 5 CFUs	None after biocide unit on 24 h
Gram-positive rods	Yes: baseline 232 CFUs	None after biocide on 24 h	Yes: baseline 8 CFUs	5 after biocide on 24 h
Gram-positive cocci	Yes: baseline 269 CFUs	297 CFUs after biocide on 24 h	Yes: baseline 3 CFUs	2 after biocide on 24 h
Gram-negative cocci	Yes: baseline 9 CFUs	None	None	None
Yeast	Yes: Baseline 1 CFU	None	None	None
Fungus	Yes: Baseline 5 CFUs	None	None	None
MRSA	None	None	3 CFUs	None

*Numbers in Tables 1-4 are the average over 2 days and may differ numerically from those presented in Table 6 as the total count over 2 days. This table is intended to show all organisms present in a normal population.
†Some plates (2-3) showed signs of drying on June 13 and new baseline was sampled.
‡Arthroscopic procedure, with very little blood aspiration into sterile field (3 operations); total surgery time 4.25 h.

In clinical applications, there are several variables that hinder the bond-breaking ability of UV. These include (1) temperature, (2) humidity, (3) room air mixing, (4) maintenance and cleaning schedules, (5) employee carriers, (6) unsterile surgical instruments, (7) healthcare processes that encourage microbial growth (eg, kitchen procedures that allow meat to be uncooked to kill inherent microbes, delivery schedules that expose sterile areas to contamination, etc), (8) dust or other inorganic matter, (9) cross-contamination during surgical procedures, (10) improper hand washing and scrub and sterile techniques for all healthcare personnel, (11) mechanical duct damage, (12) heating, ventilation, and air conditioning (HVAC) damage, (13) control factors of visitors especially in the newborn intensive care unit, (14) improper personal protective measures and garments, and (15) a closed environment of persons in waiting rooms with high transmission capabilities.[7]

The research and study of UV germicidal irradiation is by no means new scientific landscape. Productive and reliable research studies dating back to the early 1930s are well documented for sterilization of microbes.[11] However, this energy is significantly higher than that required by the PCO process.

This light spectrum of UV is below visible light and therefore cannot be seen by the naked eye. Organic material of all types, including the human dermis (skin) and eyes, are also damaged by this average wavelength of light produced by the sun. In humans, tanning and/or burning of the skin and eyes result. Prolonged UV radiation from the sun irradiates organic compounds, such as microbes. This is the

Table 6. *Summary of Organisms Cultured Versus Clinical Area—Active Unit On*

Organism	Pulmonary testing*	Pulmonary testing active*	Sterile prep testing*	Sterile prep testing active*
Gram-negative rods	None	29 CFUs some in chains after biocide on 24 h	None	None
Gram-positive rods	Yes: baseline 39 CFUs	5 CFUs some with spores after biocide on 24 h	Yes: baseline 15 CFUs: some in chains	8 CFUs
Gram-positive cocci	Yes: baseline 37 CFUs	6 CFUs after biocide on 24 h	Yes: baseline 61 CFUs	11 CFUs
Gram-negative cocci	None	None	None	None
Yeast	None	None	None	None
Fungus	Yes: baseline 5 CFUs	None	None	None

*Numbers in Tables 1-4 are the average over 2 days and may differ numerically from those presented in Table 6 as a total count over 2 days. This table is intended to show all organisms present in a normal population. There were some anomalies and conditions that require explanations. In Table 6, the number of CFUs for gram-positive rods in the pulmonary testing area after the unit was running for 24 hours indicates that there were more CFUs present with the unit on than when the unit was off. This area is used on inconsistent days and with varying patient loads. Although every attempt was made to normalize the patient population, in the pulmonary testing area, the sampling was not consistent with a normal population. After investigating the anomaly, the authors discovered that the spirometry tests had not been conducted for the prior 3 days. It was also noted that on the active testing days for the pulmonary area, there were 8 patient tests during the "unit off" samples and 17 patient tests during the "unit on" samples. In addition, the door to the test area was found open when the 24-hour final samples were taken. Still, there was evidence of a reduction of gram-positive microbes and fungi, which further confirms that the biocide unit was effective. The timetables of a physician's practice and that of the research team rarely coincide. This anomaly is not considered unusual, and again the authors emphasize the attempt to normalize a population in a single research study, from a given regional area is difficult.

Table 7. *Technical Data for Clinical Areas Sampled*

Technical component	Sterile prep testing area	ENT day surgery	Surgical operating theater: OR 1	Pulmonary testing area
HVAC duct system	Shared common duct	Shared duct common hall	Separate duct	Shared duct common hall
Filter location	Central hallway	Central hallway	In-room per each vent (8)	In-room per each vent (2)
Filter type/rating	HEPA 99%	HEPA 99%	HEPA 99%	Fiber: 0.5 in 50% to 60%
Room temperature	79.4 F	79.8 F	59.3 F	78.2 F
Humidity	80%	72%	52%	65%
Duct size: in	16 in × 16 in	16 in × 16 in	24 in × 48 in (6)	14 in × 14 in
Duct size: out	16 in × 16 in (2)	16 in × 16 in	12 in × 14 in (3)	14 in × 14 in
HVAC management	Honeywell	Honeywell	Honeywell	Trane
HVAC age	2 y	2 y	2 y	9 y
PM change out	Quarterly	Quarterly	Quarterly	Quarterly

main reason that outdoor air has less microbial counts than indoor air.[12] Excessive amounts of toxins and microbial growth inside buildings can result in what is known as the "sick building syndrome." This became a public phenomenon with the outbreak of Legionnaire disease, caused by Legionnaire bacilli.[13]

UV systems must also be louvered (placed in containers with vents pointing downward), so as not to directly expose patients and personnel to the UV rays. Prolonged exposure to UV can create carcinogenic conditions, such as skin cancer. The louvered requirement of UV systems decreases their microbial killing efficiency and also has a negative effect on air mixing. Air mixing is a very important aspect of microbial kill rates and will be discussed in detail in a future section of the article.

Photocatalytic Oxidation and Ultraviolet Catalytic Process

A newer biocide process, which uses a catalyst such as titanium dioxide, is known as PCO. The PCR biocide unit tested efficiently eliminated not only the airborne microbes in the ENT surgical area, but actually reduced the 24-hour CFU count below the baseline count (see Table 1). This would imply that the PCR biocide unit was actively eradicating microbes not only on the ENT surgical area, but also along the entire clinical corridor in 4 proximal offices. There is no other explanation for the lower 24-hour CFU count versus the original CFU baseline count.

The PCR biocide unit tested in this research article is of the PCO with UV catalytic variety. A catalyst is a substance that accelerates or enhances a chemical reaction, or in this case, a photoreaction, without loss of original mass. Titanium is a heavy metal with strong metallic bonding characteristics. In a natural state, titanium always exists as titanium dioxide due to the affinity of oxygen atoms to the titanium atoms. If the surface of titanium is scratched and the oxide coat is removed, it is almost instantly replaced with a new oxide coat when exposed to air or water, due to its natural metallic bonding characteristics. This explains the highly anticorrosive nature of titanium, which protects it from the oxidative process common to other metals commonly known as "rust." Titanium dioxide (TiO_2), when irradiated, produces a high refraction ratio and catalytic reaction, which lowers the intensity field required for UV bulb wattage required to produce the energy needed to break organic covalent bonds. Hydroxyl radicals are produced as the UV strikes the titanium oxide coating. The hydroxyl radicals (negative OH free radicals) attract molecular organic titanium dioxide (TiO_2) constitutes a semiconductor, which can be modeled mathematically with similar electronic semiconductor properties found in common electronic components, such as diodes, transistors, and operational amplifiers. In electronics, the energy required to cause "conduction" of electrons must exceed the "barrier potential." In the case of a simple light emitting diode, when a 0.7 DC voltage potential is exceeded, the light will glow constantly.[8] The end product of the TiO_2 catalyst is a chemical oxidative reaction rather than an electron transfer on a circuit board. The same laws of physics dictate that "energy" is required to free an electron from its atomic orbital shell, whether it is electronic or chemical in nature. Irradiation of TiO_2 with UV lowers the required "band gap energy" to enable an electron to free itself from its orbital shell and partake in chemical reactions. The "band energy gap" of TiO_2 is 3.2 eV. The result of this irradiation is the production of hydroxyl radicals (OH− and H+) and superoxide ions (O_2 + e−) from the dioxide coating surrounding the titanium. The strong metallic bonding properties of titanium, which attracts oxygen atoms and water vapor, allow an almost inexhaustible source of free electrons from the dioxide coating when it is irradiated by UV light.

Free electrons from the hydroxyl molecule and the superoxide ions are extremely potent oxidizing agents. An oxidizing agent is a substance that removes electrons from other atoms or molecules. In the case of carbon-based

microbes, removing electrons causes an oxidation-reduction reaction. This oxidizing potential reacts with airborne organic compounds and creates a chemical oxidative reaction, producing water vapor and carbon dioxide. Carbon is the basic compound in all organic matter. Therefore, the weak covalent bonds of the carbon atom attach to the superoxide ions forming carbon dioxide and the hydroxyl radicals seek out oxygen, which is abundant in the air, to form water vapor.[9,10]

Bioaerosols (the type found in organic aerosol odors) are also subject to an oxidation reaction in which the hydroxyl radicals seek out any local compounds to bind with to neutralize their free electrons. Vinyl wallpaper contains polyvinyl chloride, which over time releases chemical vapors that contain the poison dioxin and chlorine gas. These carbon-based volatile substances also bind with the titanium dioxide catalyst. The binding process produces an oxidation reaction with byproducts of water and carbon dioxide. This process is superior to the standard single UV process, which produces ozone as a byproduct. This catalytic oxidation process eliminates microbes, molds, fungi, and yeast as well as organic odors without producing ozone, which causes respiratory irritation and has been linked in some studies as a carcinogenic enhancing molecule.[6,7]

Significance of the Clinical Areas Sampled

This research study examined 4 clinically disparate areas utilizing uniform testing standards and protocols: (1) ENT day surgery, (2) surgical operating theater (OR), (3) pulmonary testing laboratory, and (4) OR sterile preparation area. In addition, 2 separate clinical facilities were involved in the test samples. Each area had a distinct airflow volume, which will be discussed in the summary and is available for inspection in Tables 1-7. The amount, type, and placement of medical equipment varied in each location. The number and type of medical personnel varied in each location. The physical environment of temperature, humidity, personnel, and equipment traffic varied in each location. Viewing the research parameters and variables from a mathematical modeling, the correlation is staggering. Although the results varied, the research outcomes of lowered CFU counts with the baseline were achieved in all 4 clinical areas. A review of the clinical data in Tables 1-4 and the technical data presented in Table 5 establishes the versatility of the PCR biocide unit and the general PCO concept for aerobic microbial and fungus eradication within a certain "kill block" parameter.[14] The higher and lower "kill block efficiencies" will be discussed in the microbial and fungus summary in Table 6 ("kill block efficiencies" refer to the spectrum of microbes a device/drug is able to eradicate).

There was a single PCR biocide unit in the ENT surgical area during this 24-hour period displayed in Figure 1. Essentially, the air-mixing component of the building HVAC system was nonexistent. The bulk of air mixing was due to the PCR biocide unit. Note also from Table 1 that the HVAC system used a common corridor exposing the ENT surgical area to all microbes in clinical suites along the entire corridor.

The PCR biocide unit efficiently eliminated not only the airborne microbes in the ENT surgical area, but actually reduced the 24-hour CFU count below the baseline count (see Table 1). This would imply that the PCR biocide unit was actively eradicated microbes not only on the ENT surgical area, but also along the entire clinical corridor in 4 proximal offices. There is no other explanation for the lower 24-hour CFU count versus the original CFU baseline count.

These research data from Figure 1 indicate the importance of air mixing as a criterion in factoring the ability of a system to eradicate microbes and fungi. Without the air-mixing factor, the PCR biocide unit was actively killing microbes during and after the procedure. This is an especially important concept when considering situations where back-to-back surgical procedures are preformed. Without the PCR biocide unit, there is no protection from microbes released airborne during the previous case. The PCR biocide unit efficiently eliminated not only the airborne microbes in the ENT surgical area, but actually reduced the 24-hour CFU count below the baseline count (see Table 1).

The PCR biocide unit has its advantages, which are not possible with the best HVAC high-efficiency filter systems. Spores will germinate within the ductworks and collect on refrigerator compressor coils. This is a common source of *Aspergillus* and *Penicillium* fungi. These are often

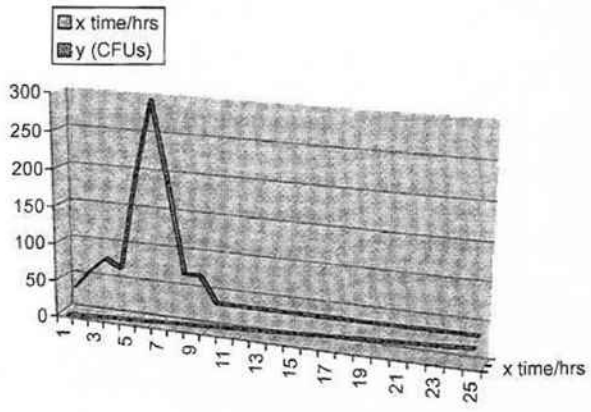

Figure 1. *Total CFU count versus time (in hours). This provides an interesting profile of the action of the PCO process (note the spike at the 7-hour time sample). This graph entices researchers and gives rise to an interest in developing other sampling techniques to better understand the PCO process. Note in Table 1 that the room air exchange is very low relative to most clinical areas.*

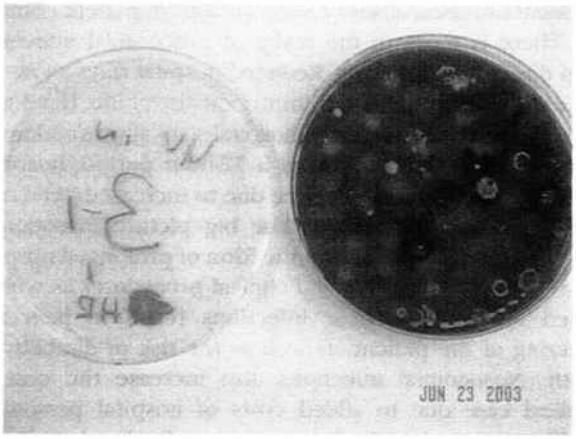

Figure 2. Photos of culture plate from ENT Day surgery suite after biocide air treatment.

released in the ductwork into clinical and waiting areas of hospitals accounting for 80 percent of indoor fungi spores.

Verification of Hypothesis

The research hypothesis was validated with a decrease in CFUs in the "active sample-on" stages of clinical procedures with a similar sampling environment with the unit off. The samples in the pulmonary test area, "active test" day 2, were considered an outlier. The statistical test method was a binomial Bernoulli method with 2 possible outcomes[15]: (a) outcome true: with the biocide unit turned on, it would reduce the number of CFUs in an active clinical setting compared with the number of CFUs with the biocide unit turned off; (b) outcome false: with the unit turned on, it would not reduce the number of CFUs in an active clinical setting compared with the number of CFUs with the unit turned off.

Verifying a Normal Population

Our binomial random variable X is the number of CFUs counted among 16 trials. The trials are identified as success or failure (true or false). The trials were independent and the probability of success is constant dependant on the uniformity of the PCR biocide unit. The same units were not used in all samples. We assume that the quality of PCO in all units is equal. The clinical areas vary considerably. Therefore, a separate binomial probability is required for each area. Since we have a Bernoulli random variable, without a pool of data for the binomial outcome, we will satisfy our experimental outcomes without a binomial probability exercise. After several samples are compared with our research, a true binomial probability can be calculated. In this research we must assume $X(s) = x$, as associated with our sample population. Microbial air sampling is in the neonate stage. To make any statement as to the probability of CFUs as an expected value would be premature. In addition, in a clinical setting, the variables are considerable. A modeling of airflow and an examination of several CFU counts would be more valuable than a binomial probability distribution and linear regression curve at this time.

Research Commentary on the Photocatalytic Reactor Biocide Unit

Clearly, the clinical environment presents challenges not seen in the clinical laboratory. We counted 15 variables that contribute to the possibility of creating a nosocomial infection or cross-infection in the healthcare arena. The PCR biocide unit is normally mounted on the ceiling. Due to time constraints, logistics, and the need to reuse some units in other clinical areas, the units were mounted on stainless steel carts, 36 in above the floor. They were positioned in areas around the patient-care setting to place them in the airflow path. The effect of not mounting the units on the ceiling certainly decreased their efficiency. To what extent the "kill block" was decreased cannot be determined. It is significant that even in this nonoptimal position, the units had a significant effect in decreasing the CFU counts. The addition of personnel or equipment to an area creates air turbulence. Air turbulence is defined as chaotic, nonlinear motion of a fluid. A swirling effect is created in turbulent air. As a result, the direction and force of the air are changed from its original path. Filtering systems depend on a consistent airway path. Certain pathogens (disease-causing microorganisms) are carried by air currents (those pathogens sampled in this study). If the air pathway changes or turbulence occurs, it reduces the efficiency of the filtering system. The number(s) of personnel and equipment were required information on the data sheet for this reason. Each additional nurse,

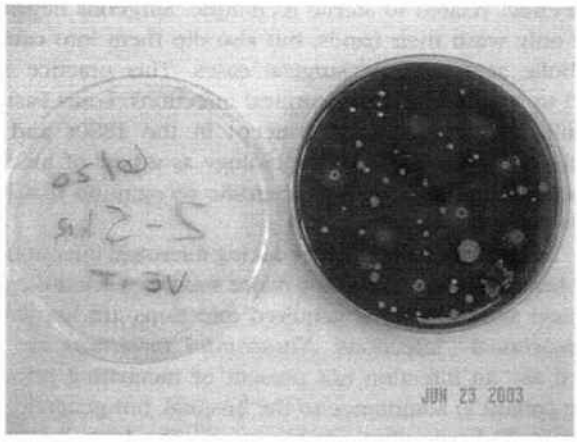

Figure 3. Photos of culture plate from ENT Day surgery suite before biocide air treatment.

physician, or piece of equipment and its placement presents the possibility of creating turbulence. The correlation of this factor may help explain anomalies and provide a modeling base for further research of this system.

Significance of Nosocomial Infections and Airborne Pathogens

Indoor air quality is significant in hospitals due to the continuous exposure of bacteria, viruses, and fungi they are confronted with everyday. Antibiotics used to treat these organisms have become ineffective in recent years due to the adaptation of the organisms' survival instincts. This has resulted in microbial mutations known as "super bugs." Since hospitals serve as a receptacle of microbial and fungi from the patients being treated for diseases caused by these organisms, hospitals are a central source of resistant organisms. Visitors enter the hospital virtually uncensored for pathogens on their clothing or exposed surfaces of their body. The authors conclude that an entryway system for the public, such as the PCR biocide unit tested, would result in a reduction of pathogens and have a major impact on nosocomial infections. Decreasing opportunities for cross contamination is a major factor in the vector of nosocomial infections in patient rooms.

Simmelweis, a Hungarian physician practicing in Vienna during 1847 to 1849, was the first healthcare practitioner to identify the correlation vector of illness caused by healthcare providers. He found that when he washed his hands after visits to the anatomy laboratory and before obstetrical delivery of infants, his patients did not contract postpartum infections (puerperal fever) as did his fellow physicians'.

Although he was initially ostracized by a small group of Vienna academics, due to his initially unexplainable superb clinical outcomes, his sterile technique changed the accepted practice standards of medicine. Dr Simmelweis introduced the medical world to the first concept of cause and effect related to sterile technique. Surgeons began to not only wash their hands, but also dip them into caustic carbolic acid prior to surgical cases. This practice also lead to a decrease in postsurgical infections. Louis Pasteur would later expand this concept in the 1880s and introduce the science of microbiology as a part of medical practice. This was the first scientific recognition that bacteria caused infections.

Today, the challenge of reducing microbial infections in the healthcare arena is still a major source of scientific and clinical study. Hospital acquired infections are known as "nosocomial" infections. *Nosocomial infections* are defined as "an infection not present or incubating prior to (the patient's) admittance to the hospital, but generally occurring 72 hours after admittance."[17] The term is usually used in reference to "patient" disease, but hospital personnel may also acquire nosocomial infection, such as the autoimmune deficiency syndrome's HIV virus, hepatitis, etc, from a self-inflicted needle stick while drawing blood from a patient or tuberculosis or SARS virus from patient contact.

There is more to the realm of nosocomial infections than direct hospital costs. Reduced hospital stays allow the patient to return to his/her former quality of life. Having an available bed due to reduced hospital stays allows additional patients to receive care. After a 72-hour period, hospitals begin to have reduced revenue due to increased personnel and equipment charges. In the big picture, nosocomial infections impact patients in the form of prolonged hospital stays, added medication, and clinical procedures as well as added discomfort. These infections result in pain and suffering of the patient, as well as the risk of disability or death. Nosocomial infections also increase the cost of medical care due to added costs of hospital personnel, medications, and medical device usage. Regional studies in the authors area attribute costs for an average nosocomial infection to be in the range of $12,000 to $50,000 per case.[18] National data on the costs of nosocomial infections reveal fiscal expenditures for hospital care alone above $100,000. Therefore, hospitals and hospital personnel expend enormous time, energy, and resources for educational training in the area of universal precautions, protective equipment (gloves, gowns, masks, etc), and aggressive decontamination and sterilization techniques to eliminate and/or reduce them.

Airborne infections, such as Legionnaire disease and tuberculosis, are difficult to control due to their aerosolized spreading or epidemiological method. These microbes and fungi may remain in the air for days waiting for a host that passes into the infected environment. They may settle in wounds, inhaled, or settle on surfaces, which spread the infection by touch and continue the cycle of spreading from hands that touch other surfaces. These airborne microbes and fungi may also enter the HVAC systems of hospitals, homes, and offices. These are the pathogens that this article addresses.

Summary and Conclusion

The authors' research is an attempt to better understand how a PCO device could impact decreased nosocomial infections in a variety of clinical settings. As noted on the "Verification of Hypothesis" section, the tested unit was effective in reducing the number of airborne microbes and fungi in all sampled clinical environments. This verifies the first objective of this research study and confirms the original hypothesis as true.

Tables 5 and 6 provide dramatic research evidence that airborne microbes are reduced by nearly 300% or greater with the implementation of the PCR biocide unit. Empirical correlation of these research data would suggest that a reduction in nosocomial infections would follow an exponential decrease in nosocomial rates. The authors base this statement on the research evidence in Table 5, where MRSA is cultured during an arthroscopic procedure (a surgical procedure that causes very little aspirated fluid and is minimally invasive). After the unit was activated during

a similar arthroscopic procedure 45 minutes later, no MRSA CFUs were cultured after sampling. Also, gram-positive rods (a microorganism, which is highly resilient to antibiotics) were also dramatically reduced with the unit in the active stage. These facts verify the second objective of the research study, which correlates reduction of airborne microbes to an augmentation and enhancement of risk management in cases of nosocomial infection rates.

Tables 5 and 6 summarize the microbial and fungi eradication ability of PCR more explicitly than any commentary. There are a variety of microbes sampled. PCR was able to reduce the CFU count in each category. This study provides encouraging data of a medical device that provides reduction of microbes and fungi of multiple varieties in multiple clinical settings. The authors can conclude that the PCO process is a viable and practical means of reducing biohazards.

Three surgical cases were sampled in the OR study, all of which were arthroscopic in nature. An arthroscopic surgery causes very little aspiration of blood or body fluids. A 1- or 2-cm cut is made in the indicated joint area and a probe is inserted to remove damaged ligaments and cartilage. This was also a factor in the low CFU counts during the active stage of sampling. During the active phase of sampling in the surgical operating field, an average of 6 personnel entrances and exits occurred. The CFU counts remained low despite this disruption of the airflow. Airflow, duct size, and placement are very critical when examining airborne diseases. Further study of this aspect of nosocomial and cross-infections revealed that the air-mixing process of the tested PCR unit contributes to and enhances the existing HVAC system of the facility. In the areas sampled, the authors found satisfactory maintenance of the HVAC systems. This is also a sizeable factor when considering the normality of the samples taken. The design and flow dynamics of the operating room sampled were superb. This factor further indicates the importance of the air-mixing process, which is part of the tested system. Air mixing has been found to impact cross-infections, especially in prosthetic surgery. In the absence of air mixing, CFU counts are significantly higher.[18] The fact is evident in the low CFU counts from the OR area, where large CFU counts were cultured during the active stage of the arthroscopic procedure, and the CFU samples cultures were lower than the baseline CFU samples after the PCR unit was engaged during the following arthroscopic procedure. This comparison of similar surgical procedures in the same OR is an extremely relevant research comparison, which demonstrates a reenactment where the PCR biocide unit proved superior to HEPA HVAC surgical air systems alone. The HVAC system used in the OR tested was extremely well designed and less than 2 years old with a laminar airflow over the patient. The test unit augmented and enhanced this state-of-the-art HVAC-engineered OR system.

The authors conclude that a medical device that does not produce mutants (which have been documented by UV-only systems) or cross-resistance is the most effective means of eradicating or reducing nosocomial and environmental microbial contamination. The unit tested in this research both enhances and augments existing facility HVAC systems, resulting in lower risk factors for nosocomial infections. It should also be pointed out that the manufacturer recommends that the units be mounted on the ceiling or upper wall for maximum effectiveness. Due to logistics constraints, the authors were confined to placing the units on mobile carts 36 in above the floor. With the superb and startling results achieved in this research scenario, it can only be concluded that ceiling-mounted units would provide an even more dramatic effect. This would contribute to a more economical baseline for any facility considering the cost of nosocomial infections and lost opportunities for revenue due to a prolonged hospital stay. There is also the clinically superior aspect of positively impacting the risk management system of the facility.

In summary, the PCR biocide tested system has the following advantages:

1) an efficiently high destruction rate of pathogens,
2) no chemical additives,
3) no residual ozone,
4) efficient energy requirements,
5) the ability to oxidize and eliminate volatile organic chemicals and bioaerosols (odors),
6) low maintenance and long product life,
7) not effected by humid conditions,
8) does not affect the HVAC duct flow or pressure drop,
9) enhances air mixing with existing HVAC systems,
10) installation does not require any room renovations, and
11) size and placement will not obstruct normal clinical processes.

Acknowledgments

The authors acknowledge the contributions of the following team members:

- Jane Miller, MS, laboratory coordinator and Texas project quality control officer, Medical Microbiology and Immunization Laboratory, College of Medicine, Texas A&M University, College Station, Tex;
- Jack Moreland, director of patient care/clinical services, The Physicians Centre, Bryan, Tex;
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- Chris Allen, RN, infection control and staff education coordinator, The Physicians Centre, Bryan, Tex;
- All of the personnel at Shipman & Associates for logistics coordination, The Physicians Centre, Bryan, Tex;

- Anup Amin, MD, board-certified pulmonary specialist, Brazos Pulmonary Association, Bryan, Tex;
- Denyce Cram, RN, infection control practitioner, College Station Medical Center, College Station, Tex.

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Environmental Chemistry & Technology Program

University of Wisconsin–Madison • 660 North Park Street • Madison, WI 53706-1484 • Telephone: (608) 262-2470 • FAX: (608) 262-0454

June 13, 2002

John Hayman
President
KES Science and Technology, Inc.
3625 Kennesaw North Industrial Parkway
Kennesaw, GA 30144

RE: Performance of UVGI and Photocatalytic Oxidation in Inactivating Bacterial Spores

Dear President Hayman,

Please find here summary statements regarding results from recent testing of a treatment technology, which combines ultraviolet germicidal irradiation (UVGI) and photocatalysis. This technology is employed in the AiroCide device, which is manufactured and marketed by KES Science and Technology, Inc. (Kennesaw, GA).

Microscope slides were coated with a proprietary titania-based photocatalyst and then later inoculated with spores of *Bacillus subtilis*, a surrogate of spores of *Bacillus anthracis*. In bench-top testing, the slides with inoculums and photocatalyst were exposed to UVGI light for test periods of 2 sec, 10 sec, 60 sec, and 300 sec (5 min). [This treatment approach exposes the spores of *B. subtilis* to the combined biocidal effects of 254-nm light of UVGI and highly oxidizing hydroxyl radicals ($OH^{\bullet}$) generated in the photocatalyst upon exposure to UV light.] In replicate (2x) testing at each time point, the average surviving fraction of colony forming units (CFUs) of *B. subtilis* was 7.2×10^{-5} and 5.08×10^{-5} for exposure times of 10 sec and 60 sec, respectively. Interpolation between these data reveals that 6.35×10^{-5} CFUs would survive a 30-sec exposure, which represents 99.9937% kill or 4.61 logarithms (logs) of inactivation (of kill). This level of inactivation overwhelmingly meets the definition of 'sanitization' as established by the Environmental Protection Agency (EPA) and the Association of Official Analytical Chemists, which requires that a non-product contact surface have a contamination reduction of 99.9%, which is equivalent to 3 logs of kill.

Sincerely,

Dean T. Tompkins, PhD, PE
Professional Engineer

June 13, 2002
Date

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

August 14, 2002

John Hayman
President
KES Science and Technology
3625 Kennesaw North Ind. Pkwy.
Kennesaw, GA 30144
(800) 627-4913

RE: Performance of AiroCide in Controlling Bacterial Spores
(June 2002 Test Period)

Dear President Hayman,

Please find below the results from testing the AiroCide device (KES Science and Technology; Kennesaw, GA) as a technology for controlling air-borne concentrations of bacterial spores. These tests were conducted in June of 2002. Several figures are found in the Appendix.

Experimental Methods

The Experiment. The AiroCide device was challenged by introducing a commercial preparation of *Bacillus thuringiensis* (*B. thuringiensis*) spores (Thuricide, American Brand, Thermo Trilogy) directly into the intake of the AiroCide. [NOTE: In lieu of testing a virulent spore form of *Bacillus anthracis* (the anthrax spore), tests were conducted with a non-virulent form of bacillus – *B. thuringiensis* – which is a spore-forming bacillus that is very similar to *B. anthracis*. See Figure 1.] A suspension of *B. thuringiensis* was obtained by dilution with purified (Milli-Q) water. A spore suspension was placed in the receptacle of a Collison™ nebulizer. The nebulizer was connected to a compressed air cylinder, which provided a feed stream of air at 20 pounds per square inch (psi). In this manner, the nebulizer generates a fine particle aerosol (1-5 μm). Prior to introducing spores into the AiroCide, the device (internal fan and light sources) was energized for about 45 min to achieve steady-state (SS) conditions within the unit. [NOTE: The exhaust air from the unit during SS operation measured a constant 55°C.] Once steady-state was reached, the nebulizer was activated to generate an aerosol which was fed directly into the intake of the AiroCide (Figure 2). To allow for direct feed of the aerosol into the AiroCide, the device was placed upright on its side (Figure 3). The time marked by the activation of the nebulizer was the experimental start. Also at the start of the experiment, two large (14-cm diameter) Petri™ plates containing 70 ml of Trypticase Soy Sheep's blood agar were placed side-by-side at the AiroCide exit to completely cover the device's exhaust grille (Figure 4). In so doing, spores exiting the AiroCide will

impact the culture plates and be captured for subsequent growth-plate study. After 10 min of aerosolization, the nebulizer was deactivated, effectively terminating the introduction of spores into the AiroCide device. Then, over the next 60 min, twelve additional blood-agar plates (two every 10-min interval), were placed at the device's outlet as described previously to capture spores exiting the AiroCide. After this hour-long, post-nebulization sampling period, the AiroCide device was deactivated and the experiment ended.

Post Experiment Spore Analysis. Because of the experimental design and the AiroCide configuration, spore distribution within the AiroCide is limited to three locations (Figure 5): 1) spores attach to the surfaces of the fan and ante-chamber located upstream of the AiroCide *reactor zone*, 2) spores are captured, immobilized, and are either active or rendered inactive in the *reactor zone*, or 3) spores exit the AiroCide via the exhaust grille. The approach to determine the colony forming units (CFUs) surviving the experiment for these three locations are as follows, with the procedure to determine the number of spores introduced into the AiroCide discussed first:

Inoculum size) The volume of spores nebulized and introduced into the AiroCide is based on mass analysis of the pre- and post-weights of the nebulizer when containing the spore suspension.

Location #1) After the experiment, the fan and ante-chamber, located upstream of the AiroCide's reactor zone were mechanically removed from the AiroCide. All surfaces to which the spores can contact were sampled for spores by thoroughly swabbing with water-moistened, sterile gauze pads and swabs. The cotton pads and swabs were then placed in a sterile jar containing 100 ml of water and vigorously agitated for 1 min. Duplicate, 100-µl samples of the suspension were plated, incubated overnight at 35°C, and CFUs were counted the following day.

Location #2) The reactor zone consists of 52 glass sleeves and catalyst-coated rings and for the purpose of this study was divided into 3 nearly equally sized zones – Zone 1, Zone 2 and Zone 3, with Zone 1 closest to the fan and ante-chamber. After testing the contents of each zone were removed from the AiroCide and kept separated. Spores attached to the sleeves, chamber walls, sides, top, bottom, and entrance, support and exit grilles were sampled with water-moistened, sterile gauze pads. The rings and sampling pads were placed in a sterile, macerating unit (Osterizer) containing 600-ml sterile saline. The mixer was energized for 5 min, pulverizing the rings and thoroughly mixing the contents. Samples of the solution were plated, incubated overnight at 35°C, and CFUs were counted the following day. All three zones were sampled independently in this manner.

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

Location #3) After each 10-min sampling period, culture plates were covered and labeled. A total of 14 culture plates were incubated overnight at 35°C. The following day, the CFUs of *B. thuringiensis* were counted and recorded for each culture plate.

Experimental Results

A total of 71,750 *B. thuringiensis* spores were introduced into the AiroCide (Fig. 6). The fan was found to contain 10,400 CFUs, or 14.49% of the original inoculum. Likewise, the ante-chamber was found to contain 485 CFUs, or 0.676% of the original inoculum. Therefore, a total of 60,865 spores entered the reactor zone. Of this inoculum, a total of 5 CFUs exited the device and were collected on the surface of the seven sets of blood agar plates over the 70-min sampling period. Zones 1, 2 and 3 had 485, 291, and 0 CFUs, respectively, remaining after treatment.

Terry A. Kurzynski, MS
Advanced Microbiologist

Date: August 14, 2002

Dean T. Tompkins, PhD,
Professional Engineer

Date: August 14, 2002

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

Appendix

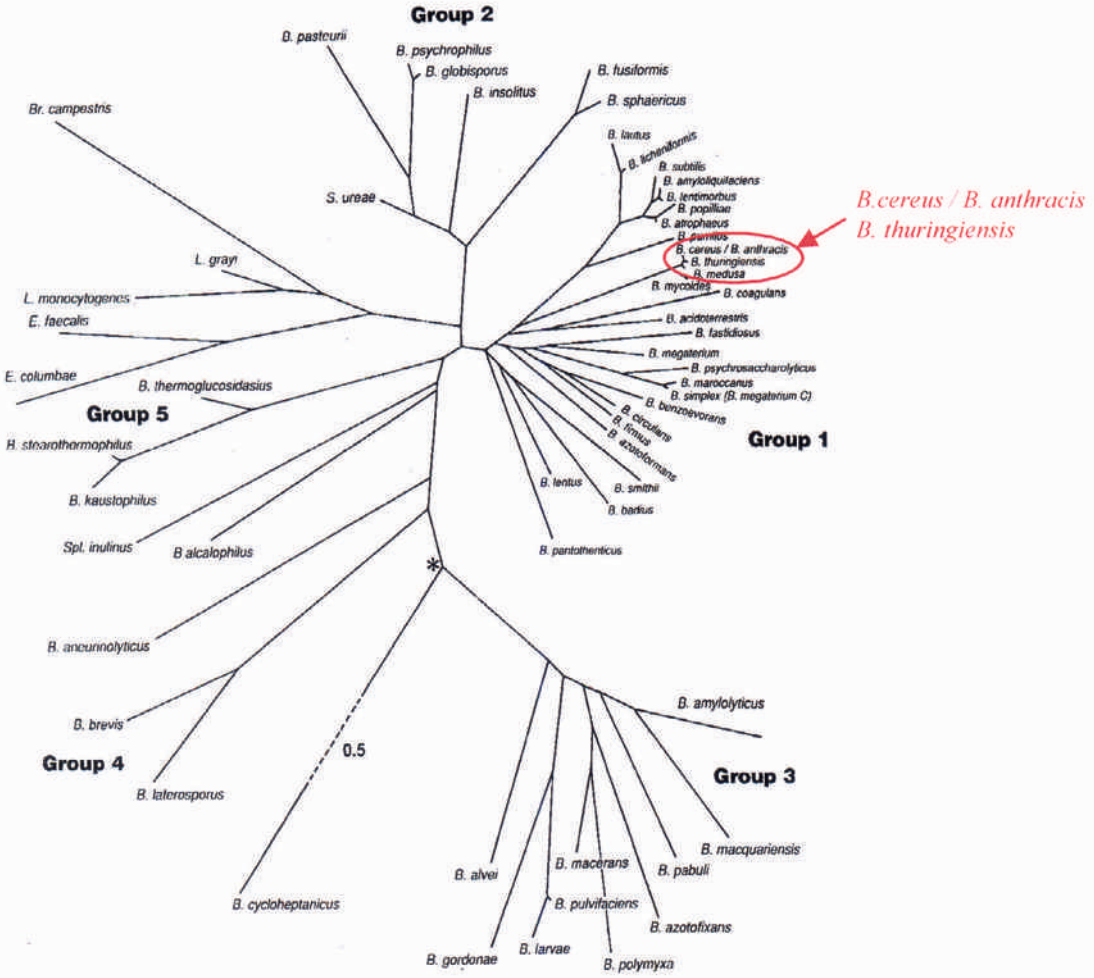

Figure 1 – Phylogenic tree of genus *Bacillus.* Note group similarity between *B. anthracis and B. thuringiensis.*

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

Figure 2 – Suspension of *B. thuringiensis* spores in nebulizer and introduced into the AiroCide.

Figure 3 – Experimental set-up. Air from a cylinder aerosolizes suspension of *B. thuringiensis* spores.

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

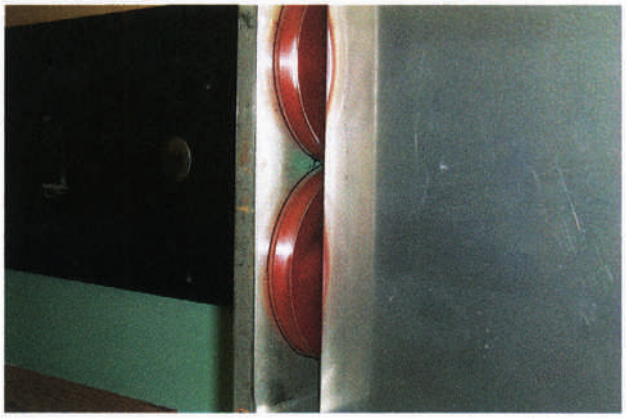

Figure 4 – Experimental set-up. Petri dishes at exit of AiroCide; in position to capture spores in effluent from the AiroCide.

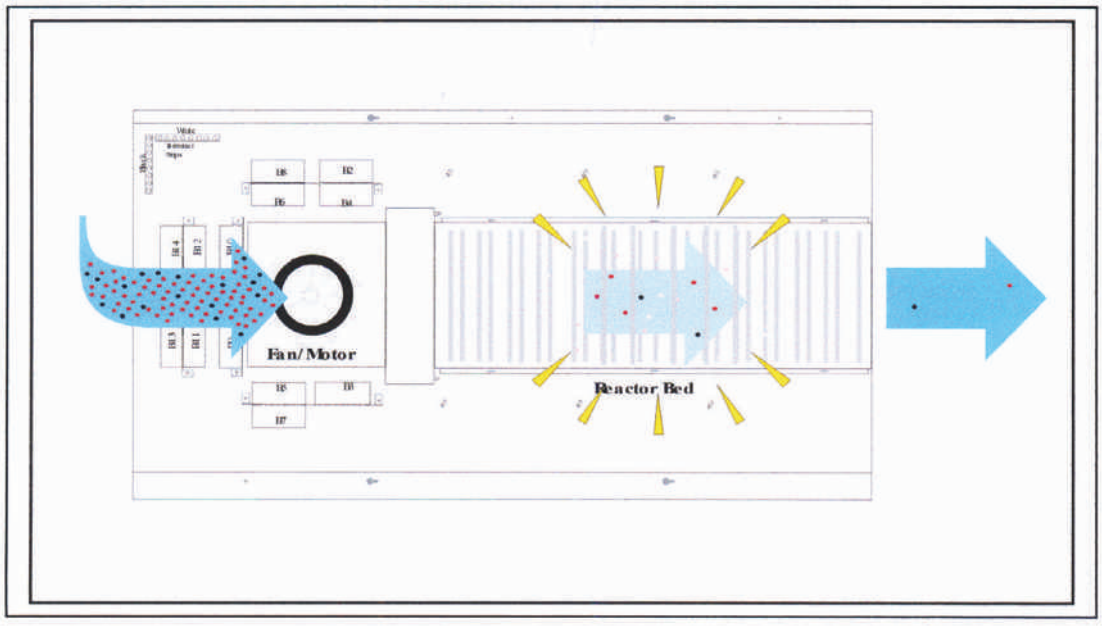

Figure 5 – AiroCide Operation: Spore-filled air enters through the fan and is pressurized into the reactor bed. Spores are immobilized onto the photocatalyst surfaces (and other interior surfaces), where they are exposed to surface-bound radicals (e.g., hydroxyl radical – OH·) and ultraviolet germicidal irradiation (UVGI).

Dean T. Tompkins, PhD, PE
Professional Engineer
2843 Charleston Dr.
Madison, WI 53711

Terry Kurzynski, MS
Advanced Microbiologist
5610 Sandpiper Lane
Madison, WI 53716

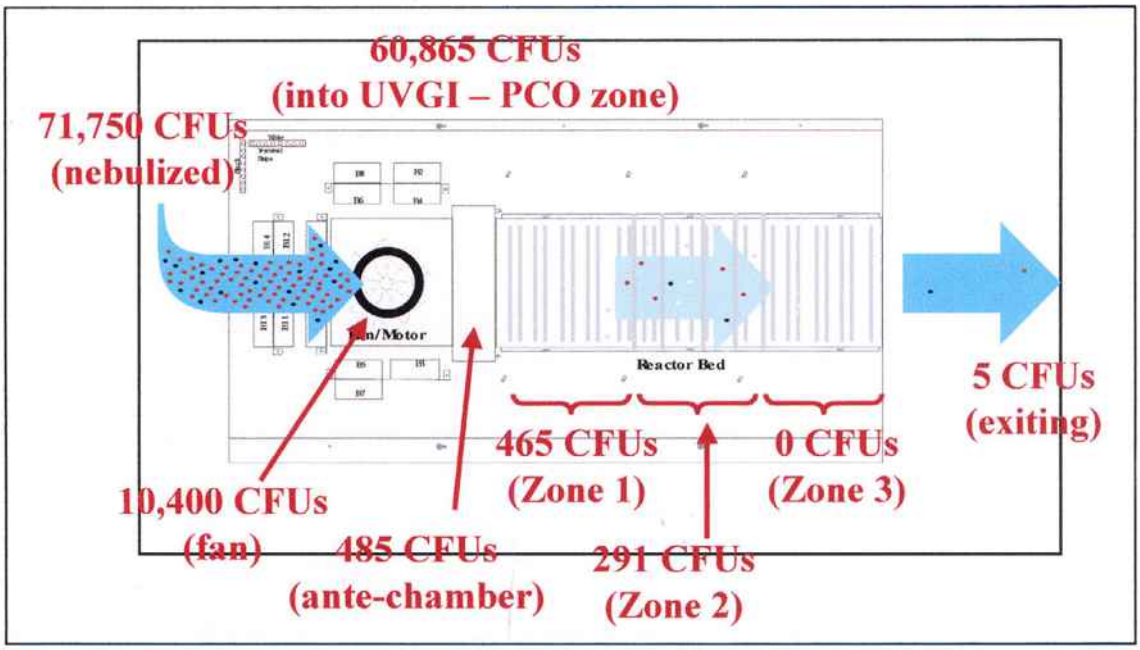

Figure 6 – Summary of testing results overlaid on the AiroCide Zones 1, 2, and 3 had 465, 291, and 0 CFUs, respectively, during 70 min of operation.

Environmental Chemistry & Technology Program

University of Wisconsin–Madison • 660 North Park Street • Madison, WI 53706-1484 • Telephone: (608) 262-2470 • FAX: (608) 262-0454

September 20, 2002

John Hayman
President
KES Science and Technology
3625 Kennesaw North Industrial Parkway
Kennesaw, GA 30144
(800) 627-4913

RE: Analysis of Effluent from AiroCide
(August 2002 Test Period)

Dear President Hayman,

Please find enclosed the results from two recently completed studies of the Bio-KES and the AiroCide:

Study #1 – Bio-KES Testing: A Bio-KES was tested with and without sleeves to determine the effect on performance. A complete discussion of these tests is found in **Enclosure #1.**

Study #2 – AiroCide Testing: Testing and subsequent analysis of the effluent from the AiroCide device (KES Science and Technology; Kennesaw, GA) (refer to **Enclosures 2 and 3**). The AiroCide is a technology for controlling airborne concentrations of microbiologicals. These tests were conducted in August of 2002, with analyses conducted in August and September. Below is a summary of the AiroCide effluent testing. **Several figures are found in the Appendix, which follow the tables.**

Executive Summary: The effluent from the AiroCide device was sampled and analyzed to determine gas species and concentrations. Ozone was found to be below detectable levels (Table 1) and the volatile organic compounds listed in Table 2 were found to be in the very low ppb (parts per billion range).

Sincerely,

Dean Tompkins, PhD, PE

cc: Johnny Hayman, File

Enclosures:

1) Technical Report – Performance Testing of Bio-KES with and without Sleeves
2) Gas Phase Analysis (AiroCide Device); dated August 23, 2002
3) Thermal Desorption Analysis; dated September 10, 2002

TEXAS TECH UNIVERSITY HEALTH SCIENCES CENTER

School of Medicine

Department of Microbiology and Immunology
Lubbock, Texas 79430
(806) 743-2545
FAX (806) 743-2334

June 17, 2003
John J. Hayman, Jr.
Chairman, KES Science & Technology, Inc.
3625 Kennesaw North Industrial Pkwy.
Kennesaw, GA 30144

RE: Results of experiments regarding the effectiveness of the AiroCide in inactivating a selected mycotoxin and fungal species

Mr. John Hayman,

Please find attached the results from our testing of the AiroCide device regarding its abilities to inactivate fungal conidia and mycotoxins. The results of our initial experiments are very encouraging in that under our selected experimental parameters, the device was able to inactivate the tested mycotoxin roridin A and the fungal species, *Aspergillus niger*.

It has been a pleasure to work with you and we look forward to further collaborative work with KES Science and Technology.

David C Straus

David Straus, PhD
Professor,
Dept Microbiology and Immunology
Health Sciences Center
Texas Tech University

S. Wilson

Stephen Wilson, PhD
Director,
Center for Indoor Air Research
Health Sciences Center
Texas Tech University

Released by Air Quality Sciences, Inc.
Date Prepared: February 22, 2006
AQS Project #: 14241
AQS Report #: 14241-02

EXECUTIVE SUMMARY

INTRODUCTION

Air Quality Sciences, Inc. (AQS) is pleased to present to KesAir Technologies, the results of its indoor air efficacy study of two air cleaner devices identified as KesAir 6-Bulb Prototype Unit! and KesAir 4-Bulb Prototype Unit!. Testing of the air cleaners was conducted in controlled environmental chambers following the guidance of ASTM D 6670 at standard environmental room conditions of temperature, T = 23° ± 2° C; relative humidity, RH = 50% ± 5%; and air change rate, ACH = 1.0 ± 0.1 hr^{-1}. Challenge concentrations of three common indoor air pollutants (formaldehyde, toluene and decane) were introduced into the chamber and removal rates were measured based on mathematical decay measurements with and without the activated cleaner units.

Permeation ovens were used to generate known concentrations of formaldehyde, toluene and decane in a controlled environmental chamber. The effect of operation of the KesAir 6-Bulb Prototype Unit! and KesAir 4-Bulb Prototype Unit! air cleaners on the removal rate of each chemical was then measured. Chamber concentrations for the three dosed chemicals were measured over a 4-hour time period to determine the volatile organic compound (VOC) removal efficiency of the air cleaner units under controlled environmental chamber conditions. Ozone was also monitored to confirm that the air cleaner units did not generate unacceptable ozone levels during operation.

TEST PLAN

I. Demonstrate Stable Analyte Concentrations: The chamber was dosed with the following compounds at the listed target concentrations using permeation ovens:

a. Formaldehyde - 500 $\mu g/m^3$ (400 ppb)
b. Toluene - 200 $\mu g/m^3$ (53 ppb)
c. Decane - 70 $\mu g/m^3$ (12 ppb)

The levels of chemicals covered a range of potential indoor air concentrations ranging from normal/typical to elevated. After a minimum 4 hr equilibration period, the air was tested to confirm the levels of dosed chemicals.

II. Empty Chamber Test: Once the feasibility of creating stable concentrations in the chamber was established, the decay rates for the three chemicals were determined in an empty chamber. The permeation sources were connected to the chamber and allowed to come to equilibrium. After the chamber concentrations equilibrated, the permeation sources were disconnected and sample collection began. Sequential 20 minute samples were collected for four hours to monitor the decay of the analyte chemicals.

III. Product Tests: Once the decay rates in the empty chamber were established, the 6-bulb air cleaner unit was tested following the same protocol as the Empty Chamber Test, with 40 minute sampling intervals. The Product Test Protocol was followed under two scenarios:

1. product loaded in chamber, but turned off
2. product loaded and activated.

The 4-bulb unit was then tested in the activated mode only.

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RESULTS

Chamber concentrations of formaldehyde, toluene and decane are shown in Figures 1, 2 and 3, respectively. For each chemical, data from the Empty Chamber Test, the Loaded Chamber (Unpowered) Test, and both Powered Unit Tests are presented together on a single graph. The data are presented as percent initial chamber concentration. For all three chemicals, the decay rates for the Empty Chamber and Unpowered Tests are comparable, with the Powered Unit decay rates for both prototypes ~ 2-3 times faster in the 1m³ chamber, indicating chemical removal by the air cleaning technology. No quantifiable levels of ozone were observed in the chambers at any time during the testing.

The levels of measured chemicals during the cleaner efficacy tests are shown in Tables 2-4 for toluene, decane and formaldehyde, respectively. In a 1m^3 environment, the levels are found to decrease significantly with the cleaner units activated. Table 5 presents the calculated percent reduction of chemicals for every 1 m^3 of air passing through the cleaners. Table 6 shows the predicted operational time of each unit needed to achieve a 50% reduction of the airborne chemical levels for two different room volumes, 1 m^3 and 26 m^3. The data indicate a greater efficiency with the 6 bulb unit, although the response does not appear to be linear with the number of bulbs.

There are many factors that may affect the efficacy of these air cleaners, including effective room air volumes, pollutant concentrations and classifications, environmental conditions, air flow rate through the air cleaner unit, and life span of the cleaner's reactive components. Testing should be considered to cover the range of expectations.

PRODUCT EVALUATION METHODOLOGIES

ENVIRONMENTAL CHAMBER

The air cleaner devices were tested in an environmental chamber 1.0 m^3 in volume, and chemical emissions were analytically measured. Environmental chamber operation and control measures used in this study complied with ASTM Standards D 5116 and D6670 (1, 2). The chamber used is manufactured from stainless steel, and its interior is polished to a mirror-like finish to minimize contaminant adsorption. Airflow through the chamber enters and exits through an aerodynamically designed air distribution manifold also manufactured of stainless steel. Supply air to the chamber is stripped of formaldehyde and ozone, VOCs, and other contaminants, so that any contaminant backgrounds present in the empty chamber fall below strict specifications (< 10 $\mu g/m^3$ TVOC, < 10 $\mu g/m^3$ total particles, < 2 $\mu g/m^3$ formaldehyde, ozone or any individual VOC). AQS chambers are process controlled and are equipped with a continuous data acquisition system for verification of the operating conditions of airflow, temperature, and humidity.

Air supply to the chamber was maintained at a temperature of 23ºC ± 2ºC and relative humidity at 50% ± 5%. The air exchange rate was 1.00 air change/hour (ACH). Environmental chamber study parameters are presented in Tables 1A and 1B.

ANALYTICAL MEASUREMENTS

Formaldehyde

Emissions of formaldehyde were measured following ASTM D 5197-03 and USEPA IP-6A (3, 4), measurement by HPLC, or high performance liquid chromatography. Solid sorbent cartridges with 2,4-dinitrophenylhydrazine (DNPH) were used to collect formaldehyde in chamber air. The DNPH reagent in the cartridge reacted with collected formaldehyde to form the stable hydrazone derivatives retained by the cartridge.

The hydrazone derivatives were eluted from a cartridge with HPLC-grade acetonitrile. An aliquot of the sample was analyzed for formaldehyde derivatives using reverse-phase high-performance liquid chromatography (HPLC) with UV detection. The absorbances of the derivatives were measured at 360 nm. The mass responses of the resulting peaks were determined using multi-point calibration curves prepared from standard solutions of the hydrazone derivatives.

Volatile Organic Compounds (Decane and Toluene)

VOC measurements were made using gas chromatography with mass spectrometric detection (GC/MS). Chamber air was collected onto a solid sorbent that was then thermally desorbed into the GC/MS. Instrumentation included a sample concentrator (Perkin Elmer Model ATD 400 or Model Turbo Matrix ATD), a Hewlett-Packard 5890 Series II or 6890 Series Gas Chromatograph and a Hewlett-Packard 5971 or 5973 Mass Selective Detector (GC/MS). The sorbent collection technique, separation, and detection analysis methodology has been adapted from techniques presented by the USEPA and other researchers. The technique follows USEPA Method IP-1B (5, 6) and ASTM D 6196 and is generally applicable to C_6 - C_{16} organic chemicals with boiling points ranging from 35ºC to 250ºC. Individual VOCs were separated and detected by GC/MS.

Ozone

Ozone monitoring was conducted with a Thermo Environmental Model 49 Ozone Analyzer. This analyzer operates based on the strong UV absorbance of ozone at 254 nm. A ratio of the sample absorbance to that of air with ozone catalytically removed is used to determine the concentration in the sample. The instrument is pre-calibrated prior to use, and satisfies requirements for USEPA ambient ozone monitoring, including an analytical range of 10 to 1,000 $\mu g/m^3$.

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QUALITY CONTROL PROCEDURES FOR ENVIRONMENTAL CHAMBER EVALUATIONS

Air Quality Sciences, Inc. is an ISO 9001:2000 registered testing firm. AQS' quality control/assurance plan is designed to ensure the integrity of the measured and reported data obtained during its product evaluation studies. This QC program encompasses all facets of the measurement program from sample receipt to final review and issuance of reports. As an ISO 9001:2000 registered firm, AQS"product control, testing, data handling, and reporting protocols and procedures are standardized and controlled.

One of the most critical parameters in AQS' product evaluations is the measurement of ultratrace levels of gaseous chemicals, typically in the ppb air concentration range. This necessitates a very rigidly maintained effort to control background contributions and contamination. These contributions must be significantly less than those levels being measured for statistically significant data to be obtained. AQS addresses this control in many directions including chamber construction materials, air purification and humidification, sampling materials and chemicals, sample introduction, and analysis.

Supply air purity is monitored on a weekly basis, using identical methodology to the chamber testing. The supply air is assured to contain less than 10 $\mu g/m^3$ TVOC, < 10 $\mu g/m^3$ total particles, < 2 $\mu g/m^3$ formaldehyde, and < 2 $\mu g/m^3$ for any individual VOC. Preventative maintenance ensures supply air purity, and corrective action is taken when any potential problems are noted in weekly samples. Supply air filter maintenance is critical for ensuring the purity of the chamber supply air. Chamber background samples are obtained prior to product exposure to ensure contaminant backgrounds meet the required specifications prior to product exposure. Results of this monitoring are maintained at AQS and available for on-site inspection.

All environmental chamber procedures are in accordance with ASTM D 5116 and D 6670 (1, 2) and meet the data quality objectives required.

Various measures are routinely implemented in a product's evaluation program. These include but are not limited to:

- appropriate record keeping of sample identifications and tracking throughout the study;
- calibration of all instrumentation and equipment used in the collection and analysis of samples;
- validation and tracking of all chamber parameters including air purification, environmental controls, air change rate, chamber mixing, air velocities, and sample recovery;
- analysis of spiked samples for accuracy determinations;
- duplicate analyses of 10% of all samples evaluated and analyzed;

- multi-point calibration and linear regression of all standardization;
- analysis of controls including chamber backgrounds, sampling media, and instrumental systems.

Precision of TVOC and aldehyde analyses is assessed by the relative standard deviation (%RSD) from duplicate samples, defined as the standard deviation of each data set divided by the mean multiplied by 100. VOC accuracy is based on recovery of toluene mass spiked onto sorbent material. QC data on TVOC measurements conducted for the 12 month period ending December 31, 2005, showed an average precision measurement of 7.1% RSD based on duplicate measurements and 98.6% recovery based on toluene spikes. Aldehyde accuracy is based on Workplace Analysis Proficiency Scheme (WASP) formaldehyde proficiency test results. QC data on total aldehyde measurements (including formaldehyde) for the 12 month period ending December 31, 2005, showed an average precision measurement of 4.0% RSD based on duplicate measurements and an average accuracy of 3.8% RPD based on WASP results. Performance audits have been conducted on-site at AQS by the U.S. Environmental Protection Agency for several industry test programs. They are favorable and are open for review at AQS.

Quality assurance is maintained through AQS"computerized data management system (ADM). An electronic paper trail! for each analysis is also maintained and utilized to track the status of each sample, and to store the results.

REFERENCES

1. ASTM D 5116, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products." ASTM, Philadelphia, PA, 1997
2. ASTM D 6670-01, Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products.! ASTM, West Conshohocken, PA, 2001.
3. ASTM D 5197-03, Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology).! ASTM, West Conshohocken, PA, 2003.
4. USEPA IP-6A, Determination of Formaldehyde and Other Aldehydes in Indoor Air Using a Solid Absorbent Cartridge.! USEPA, RTP, NC, 1989.
5. USEPA IP-1B, Determination of Volatile Organic Compounds (VOCs) in Indoor Air Using Solid Absorbent Tubes.! USEPA, RTP, NC, 1989.
6. ASTM D 6196 Practice for the Selection of Sorbents and Pumped Sampling/ Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air.! ASTM, West Conshohocken, PA, 2003.

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Date Prepared: February 22, 2006
AQS Project #: 14241
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TABLE 1A

ENVIRONMENTAL CHAMBER PARAMETERS

PROJECT 14241

Customer:	Airocide Technologies
AQS Sample Identification:	AQS14241-010AA, -011AA, and -012AA
Product Description:	KesAir 6-Bulb Prototype Unit
Environmental Chamber:	IC4 (volume = 1.0 m^3)
Product Loading:	1 Device
Test Conditions:	1.00 ACH 50.0% RH ± 5.0% RH 23.0°C ± 2.0°C
Test Period:	01/20/06 - 14241-010AA - Empty Chamber Test 01/23/06 - 14241-011AA - Loaded (Unpowered) Test 01/24/06 - 14241-012AA - Powered Test
Test Description:	The product was received by AQS on January 13, 2006 packaged and shipped by the manufacturer. The package was visually inspected and stored in a controlled environment immediately following sample check-in. The device was loaded into the intermediate sized chamber atop a stainless steel table in the center of the chamber. The device was then tested according to the protocol described in the Test Plan.

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TABLE 1B

ENVIRONMENTAL CHAMBER PARAMETERS

PROJECT 14241

Customer:	Airocide Technologies
AQS Sample Identification:	AQS14241-020AA
Product Description:	KesAir 4-Bulb Prototype Unit
Environmental Chamber:	IC4 (volume = 1.0 m^3)
Product Loading:	1 Device
Test Conditions:	1.00 ACH 50.0% RH ± 5.0% RH 23.0°C ± 2.0°C
Test Period:	01/25/06 - Powered Test
Test Description:	The product was received by AQS on January 13, 2006 packaged and shipped by the manufacturer. The package was visually inspected and stored in a controlled environment immediately following sample check-in. The device was loaded into the intermediate sized chamber atop a stainless steel table in the center of the chamber. The device was then tested according to the protocol described in the Test Plan.

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TABLE 2

CHAMBER CONCENTRATION EVALUATION OF TOLUENE

PROJECT 14241
PREPARED FOR: AIROCIDE TECHNOLOGIES

Time (hrs)	Toluene ($\mu g/m^3$)			
	Empty Chamber	Air Cleaner in Chamber (Un-powered)	4-Bulb Unit Activated	6-Bulb Unit Activated
0.00	233	214	220	199
0.33	187	157	93.7	70.4
0.67	125	---	---	---
1.00	94.5	79.3	8.2	3.7
1.33	63.4	---	---	---
1.67	46.0	39.3	1.5	0.7
2.00	31.6	---	---	---
2.33	21.9	20.7	1.0	0.6
2.67	15.2	---	---	---
3.00	10.3	---	0.9	0.5
3.33	6.9	---	---	---
3.67	4.5	---	0.8	0.4

Results based on 1 unit operating in a 1.01 m^3 environmental chamber
Environmental chamber operating at 1.0 air changes per hour
--- = no data available.

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AQS Project #: 14241
AQS Report #: 14241-02

TABLE 3

CHAMBER CONCENTRATION EVALUATION OF DECANE

PROJECT 14241
PREPARED FOR: AIROCIDE TECHNOLOGIES

Time (hrs)	Decane ($\mu g/m^3$)			
	Empty Chamber	Air Cleaner in Chamber (Un-powered)	4-Bulb Unit Activated	6-Bulb Unit Activated
0.00	78.0	73.9	74.4	66.3
0.33	62.9	54.1	28.4	21.4
0.67	43.2	---	---	---
1.00	32.0	27.6	3.0	1.9
1.33	22.9	---	---	---
1.67	16.8	14.7	1.2	0.9
2.00	12.4	---	---	---
2.33	9.0	8.3	0.6	0.7
2.67	6.3	---	---	---
3.00	5.1	---	0.7	0.6
3.33	3.8	---	---	---
3.67	2.5	---	0.5	0.6

Results based on 1 unit operating in a 1.01 m^3 environmental chamber
Environmental chamber operating at 1.0 air changes per hour
--- = no data available.

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TABLE 4

CHAMBER CONCENTRATION EVALUATION OF FORMALDEHYDE

PROJECT 14241
PREPARED FOR: AIROCIDE TECHNOLOGIES

Time (hrs)	Formaldehyde ($\mu g/m^3$)			
	Empty Chamber	Air Cleaner in Chamber (Un-powered)	4-Bulb Unit Activated	6-Bulb Unit Activated
0.00	496	489	488	488
0.33	400	348	213	190
0.67	268	---	---	---
1.00	197	179	42.0	38.6
1.33	141	---	---	---
1.67	108	94.3	27.9	26.4
2.00	72.8	---	---	---
2.33	56.1	55.9	21.4	22.9
2.67	43.8	---	---	---
3.00	33.9	---	19.9	25.2
3.33	27.3	---	---	---
3.67	22.8	---	18.4	20.2

Results based on 1 unit operating in a 1.01 m^3 environmental chamber
Environmental chamber operating at 1.0 air changes per hour
--- = no data available.

TABLE 5

CALCULATED INITIAL PERCENT REDUCTION OF EACH CHEMICAL PER 1m^3 AIRFLOW THROUGH UNIT

PROJECT 14241
PREPARED FOR: AIROCIDE TECHNOLOGIES

Chemical	Unit	% Reduction
Toluene	4-bulb	13
	6-bulb	16
Decane	4-bulb	15
	6-bulb	18
Formaldehyde	4-bulb	12
	6-bulb	14

Assumes a static environment with no air exchange and 7 cfm airflow through the air cleaner unit.

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TABLE 6

CALCULATED AVERAGE AIR CLEANER EFFICIENCY FOR EACH CHEMICAL

PROJECT 14241
PREPARED FOR: AIROCIDE TECHNOLOGIES

Chemical	Unit	Time to Achieve 50% Removal in a:	
		1 m^3 space	26 m^3 space
Toluene	4-bulb	26 minutes	11.2 hours
	6-bulb	20 minutes	8.5 hours
Decane	4-bulb	21 minutes	9.0 hours
	6-bulb	17 minutes	7.3 hours
Formaldehyde	4-bulb	27 minutes	11.7 hours
	6-bulb	23 minutes	9.8 hours

Assumes a static environment with no air exchange, 7 cfm airflow through the air cleaner unit, and a constant removal efficiency rate.

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FIGURE 1
DECAY CURVES FOR TOLUENE

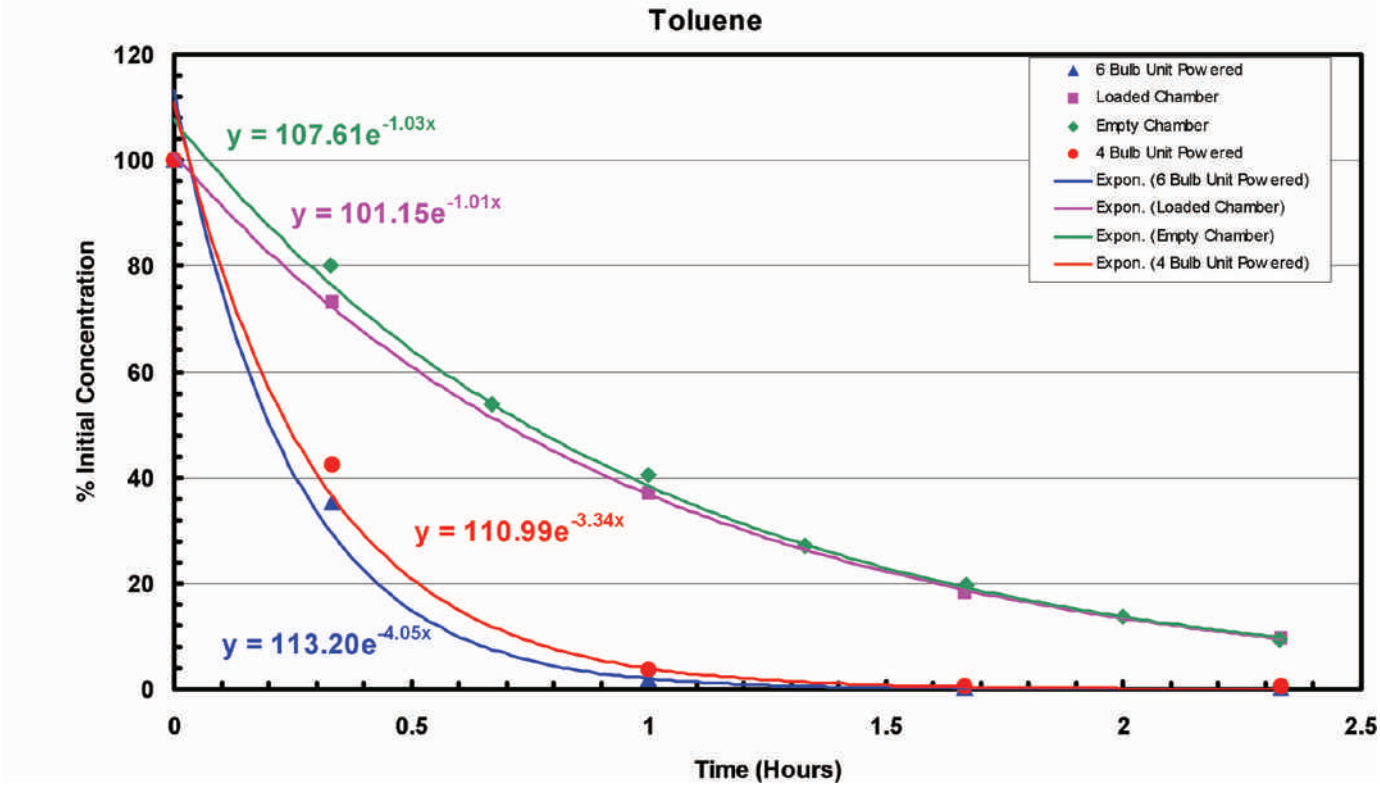

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FIGURE 2
DECAY CURVES FOR DECANE

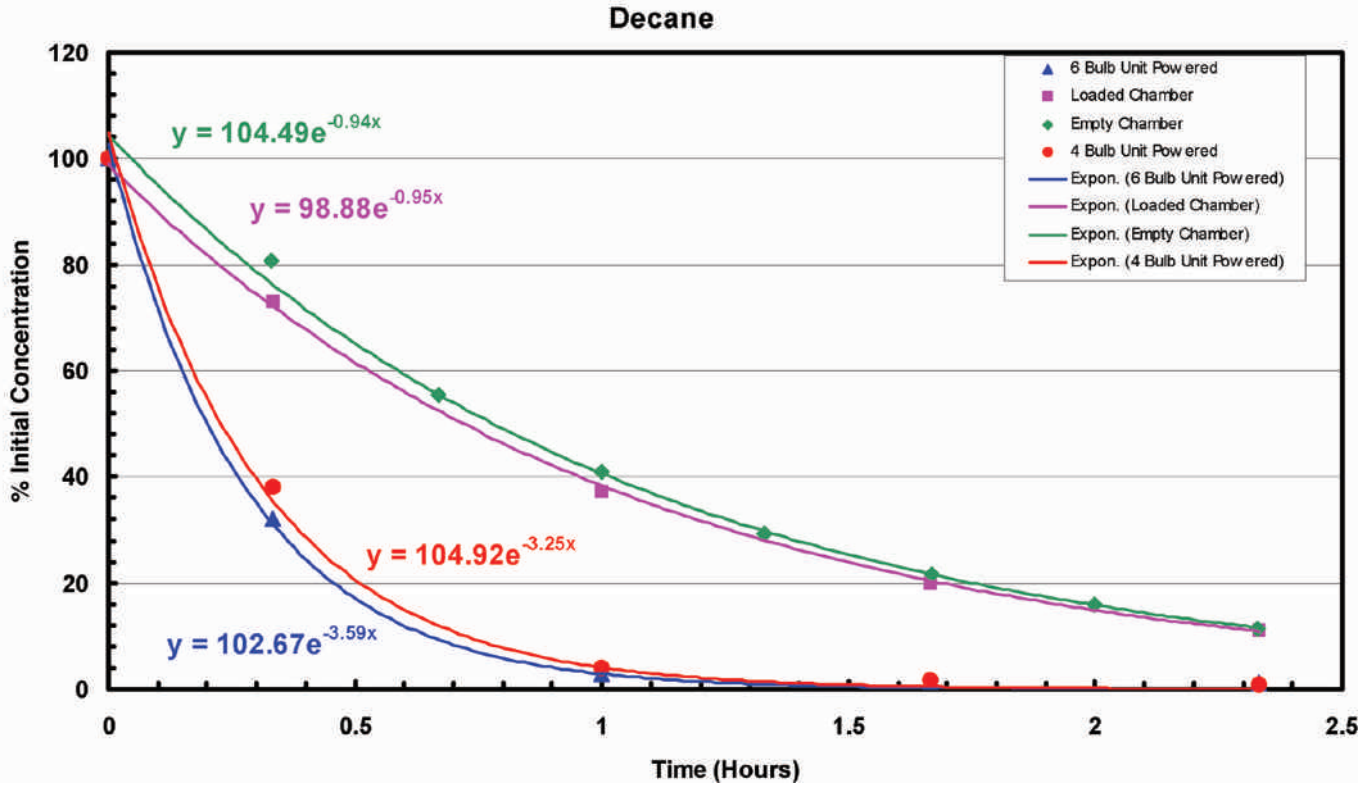

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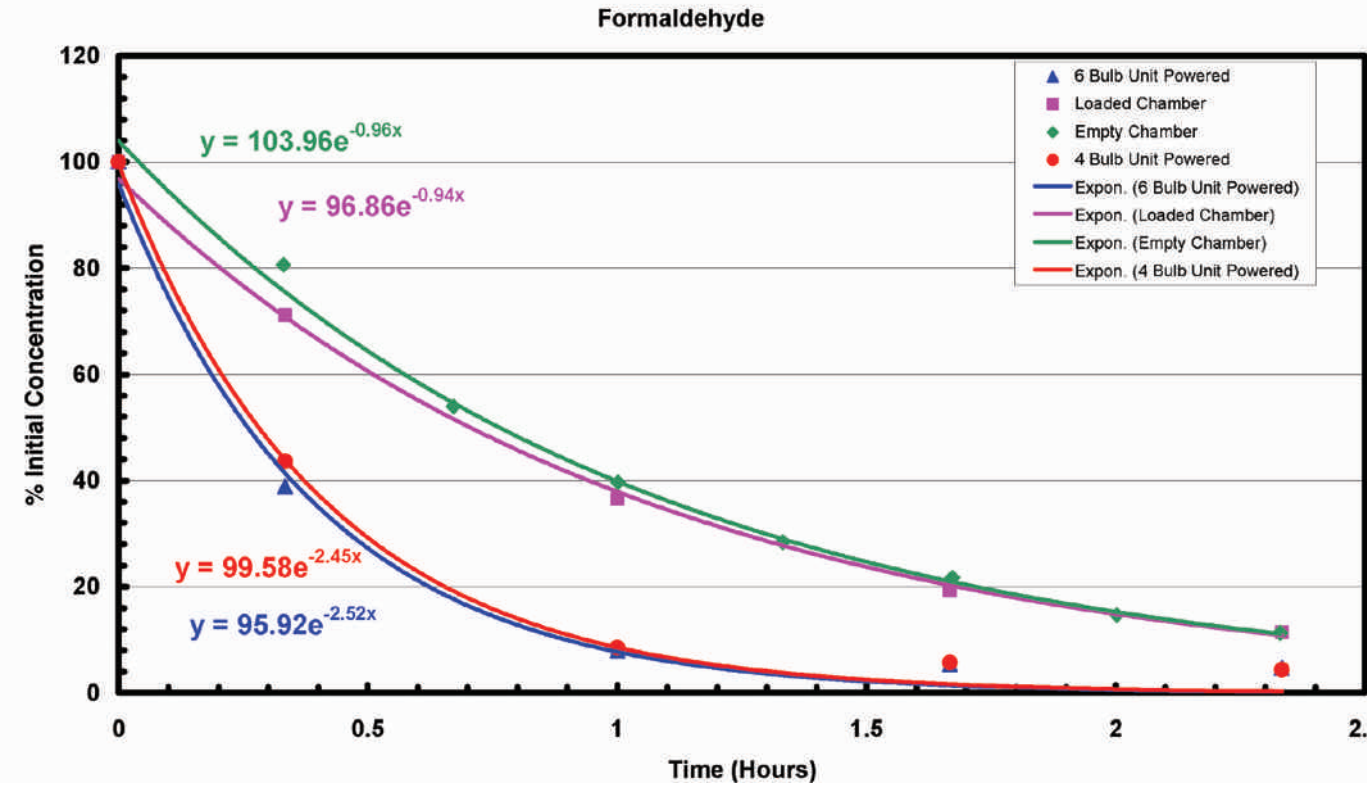
FIGURE 3
DECAY CURVES FOR FORMALDEHYDE



Case Studies

Surgical/Dental /Peridontal Settings

HARMOT Medical Center
Surgery
Operating Room #6
Erie, PA
Airborne Bacteria Reduction Testing

Modern operating rooms have high velocity and highly efficient HEPA type filtering systems that effectively reduce CFUs in the operating room prior to the doctors, staff, patient and equipment being introduced into the OR. As all the necessary personnel arrive in surgery, a sudden "spike" of bacterial CFUs takes place.

A baseline air sample showed 565 CFUs before surgery with HEPA filtering in use, and the initiation of the NASA-developed technology. Following the surgery and implementation of the PCR units, the bacterial count was lowered by 50%. When the room was allowed to return to a baseline level, normal for the room, 566 CFUs were found. When an additional unit was introduced into the operating room, the post operative condition of the OR was an 85.57% reduction in airborne bacterial CFUs.

Notchview Dental
Airborne Bacteria Reduction Testing

Researchers performed tests in multiple locations inside the offices of a 26,800 ft^3 dental practice. Air samples were taken in accordance with protocols and procedures established by the Indoor Air Quality Association (IAQA) and the National Industrial Hygienists Association. The tests resulted in an average 45.3% reduction in airborne bacteria in 24 hours and an average 80% reduction in airborne mold/fungi in the same 24-hour period.

Out-patient Surgery Center
Operating Room
Two Studies
Airborne Bacterial Reduction Studies

Baseline samples showed 112 CFUs of airborne bacteria (bacterial colony forming units). After a single hour of operation, CFUs dropped by 47.3%. In a second experiment where measures were taken at the beginning and end of a 24-hour period in the operating room, a 92% drop in bacterial CFUs was found.

Oral Surgery and Periodontal Facility
Mold/Fungi/ Bacteria Reduction Tests

Air sampling tests were performed in an active oral surgery and periodontal medical facility to measure the efficacy of the technology in removing airborne bacterial CFUs. The tests resulted in airborne mold/fungi reduction of 66% in the operating room and 100% in the adjacent corridor in 48 hours. Airborne bacteria were reduced by 82% in the corridor in the same 48 hours.

Residential Settings

Austin TX, /Atlanta, GA
Mold / Bacteria Reduction Tests

A clinical study was conducted to determine the initial and sustained reduction of airborne mold and bacteria in two residences of similar size, design and structure. The two three-level residences were 67,000 ft^3 and 70,000 ft^3 respectively, with two adults and two children living in each home at the time the tests were conducted. Airborne mold was reduced in the homes by an average of 60% in 24 hours and even further to an average of 87% in 6-months. Bacteria in the air inside the homes were reduced to an average of 57% in 24 hours and maintained a level of 49% lower than baseline in 6 months.

Educational Facility

Atlanta, GA
Private High School
Varsity football locker room
Bacteria / Mold Reduction Testing

A clinical test of the system was conducted at the athletic complex of a private high school in Atlanta, Georgia to test the ability of the NASA-developed technology to reduce the amount of airborne mold/fungi and bacteria and associated odors inside the varsity football locker room. Airborne bacteria were reduced by an average of 60% over a 3-week test period and mold/fungi by 70% during the same period.

Correctional Facility

County Corrections Facility
Georgia
Bacteria Reduction Testing

A clinical test of the system was conducted at a Georgia corrections facility to determine the ability of the technology to reduce the amount of airborne bacteria inside the facility. The system that was installed in the facility reduced the amount of airborne bacteria by 53% in 16 hours.

Food

Esmeralda Farms
In Vitro Propagation Laboratory
Miami, FL
Mold /Bacteria Reduction Testing

Airborne pathogen killing technology tests were conducted in the Pre-cooler at Esmeralda Farms in Miami, FL. The results show an average airborne mold reduction of 95.45% and bacteria reduction of 73.18% in a 72-hour period.

Chateau St. Jean Winery
Wine Barrel Storage Room
Kenwood, CA
Mold Reduction Study

After 21 days of continuous operation in the 130,000 ft^3 wine barrel storage room the average mold reduction inside the facility was 57%.

ArtFlor
Major Flower Wholesaler
Madrid, Spain
Airborne Mold Reduction Study

A study was conducted in the floral cooler and retail area of a major flower wholesaler in Madrid, Spain. Average airborne reduction in the retail area was 99.9%. In the cooler the result was total elimination of all airborne mold (100%).

Case Study Results Summaries

Type of Location	Approx. Size CF	% Reduction Bacterial Mold	Time Interval Hrs.	Comments
Surgery Average (5)	3097	73	48	Time Requirement Equipment Source
Office Average (4)	5748	72	48	Active People Movement Incoming Generation
Households (2)	68500	75	48	Chronic Respiratory Asthma Meds Out
Childcare Center	180k	60	6 wk +	Active Movement Complex multi room
Dental Private Practices (2)	30900	81	48	Multi Operatives

Type of Research: CFU Air Sampling – Hospital Operating Rooms During Actual Operations

Dates: 9.24.02, 10.15.02, 12.04.02 & 12.11.02

Test Site: Hamot Medical Center
OR #6
201 State Street
Erie, PA

Abstract:

Air sampling of an of an operating room was facilitated by Ann Schlimm RN, CIC Infection Control Hamot Medical Center to measure the change in airborne bacterial levels before and during the use to the AiroCide™ Air Quality Improvement™ System. Two rounds of testing were conducted, implementing four (4) ACS-100 units in the first test and five (5) ACS-100 units in the second test. The resulting data supports the hypothesis that there would be a significant reduction of airborne bacterial colony forming units (CFU's) with an AiroCide™ system operating continuously during a surgical procedure.

On 9.24.02 BEFORE the AiroCide system was operating, a total of 565 CFU's (an average of 70 CFU/m^3) were sampled and cultured in OR #6 during an operation. On 10.15.02 AFTER four (4) AiroCide ASC-100 units were operating during an operation, a total of 284 CFU's were counted (35 CFU/m^3.) This is a reduction in CFU/m^3 of 50.00%.

On 12.04.02 BEFORE the AiroCide system was operating, the total CFU count in OR #6 during an operation was 566 (70 CFU/m^3). On 12.11.02 AFTER five (5) AiroCide ASC-100 units were operating during an operation, a total of 83 CFU's were counted (10 CFU/m^3) This is a reduction in CFU/m^3 of 85.57%.

Background: Operating Room #6 is approximately 3,600 cubic feet. The AiroCide units were mounted on the ceiling of the operating room as evenly placed as possible.

Protocol: Please see attached air sampling reports from AEGIS Co., Inc.

Lab Results Airborne CFU Bacteria

Bacteria Summary

Please see attached air sampling reports page 1 under Interpretation from AEGIS Co., Inc.which identified airborne bacteria such as Staphylococcus species to include aureus.

Environmental

Overview:

Bacteria, Mold and Fungi are naturally occurring everywhere in our world and are plentiful in our environment. Modern operating rooms have high velocity and highly efficient HEPA type filtering systems that effectively reduce CFU's in the OR prior to the doctors, staff, patient and equipment being introduced into the OR. When all the necessary personnel have arrived in the OR there is a sudden "spike" of bacterial CFU's in all operating rooms. These "spikes" as identified in the tables below is one of the variables that cause the increase of nosocomial infections.

Air Sampling CFU Testing Summary

Location	Date of Test	Date of Test	Date of Test	Date of Test
Hamot Medical Center	**September 24, 2002**	**October 15, 2002**	**December 4, 2002**	**December 11, 2002**
Areas That Were Air Sampled In Operating Room # 6	Baseline Test **Before** AiroCides Operating	Post Test **After** 4 AiroCides Operating	Return to Baseline Test **Before** AiroCides Operating	Post Test **After** 5 AiroCides Operating
Incision Area	24	24	141	12
Back Table (Sterile Area)	82	24	94	<12*
Foot of table (Sterile Area)	47	71	71	12
Perfusionist Station	130	47	94	12
Anesthesia Work Area	59	47	71	12
Exhaust Vent	94	71	47	35
Area Above OR Lights	47	<12*	24	<12*
Under Sterile Table @ Foot	82	<12*	24	<12*
Total CFU's	**565**	**284**	**566**	**83**
Percentage of CFU/m³ Drop		**50.00%**		**85.57%**

IMPORTANT NOTE:
Areas outside of OR #6 are not included in this data.

* Numbers less than 12 are not countable and therefore are considered 0 for the percentage of change in this table.

Conclusions:

On 9.24.02 BEFORE the AiroCide system was operating, a total of 565 CFU's (an average of 70 CFU/m^3) were sampled and cultured in OR #6 during an operation. On 10.15.02 AFTER four (4) AiroCide ASC-100 units were operating during an operation, a total of 284 CFU's were counted (35 CFU/$m^{3.}$) This is a reduction in CFU/m^3 of 50.00%.

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Ms. Ann Schlimm RN, CIC
Infection Control
Hamot Medical Center

_____

Date: _____

Case Study

Pediatric and Medical Intensive Care Units
Wockhardt Hospital and Bombay Hospital Research Center – Mumbai India
Airocide® Photocatalytic Air Purifying Technology
Photocatalytic Oxidtion in conjunction with Ultraviolet Irradiation

The technology: Airocide® is a unique airborne pathogen killing technology that was funded, developed and used by NASA. It uses a patented combination of ultraviolet light and a proprietary titanium based photocatalyst that is capable of killing a wide range of airborne pathogens including bacteria, viruses, and molds, and is adept at promoting the breakdown of volatile organic compounds (VOCs). This study expands upon earlier documented proof that this technology has a direct application in all medical healthcare environments as it addresses the elimination of airborne infectious disease and improves overall patient care.

Purpose of the Study

Evaluate and quantify the affect of the installation of AiroCide devices in the Pediatric ICU unit of Wockhardt Hospital and in a Medical ICU of Bombay Hospital and Research Center both located in Mumbai, India. The study counted the microbial levels for both bacteria and fungi/mold and identified and quantified microorganisms present in the two Intensive Care Units.

The expected performance outcome was a significant reduction of microorganisms responsible for the airborne transmitted nosocomial diseases.

Therefore AiroCide's objective value for the hospital systems is to minimize the risk of nosocomial infections achieving four primary objectives:

1. Improve the health care services provided by the hospital.
2. Reduce the morbidity and mortality due to this cause.
3. Enhance' best practices' for infection control.
4. Cut down the healthcare costs generated by such diseases.

Background and Expectations

In hospitals it is important to keep in mind that there is a high population of immune-compromised patients. These infection susceptible patients include AIDS patients, geriatrics, neonatal patients, recent surgery patients (especially organ transplant recipients), chemotherapy and radiation therapy patients, cystic fibrosis and diabetics and the chronically ill and others whose immune system is suppressed or under stress. For these individuals, even low levels of pathogenic spores can be potentially fatal.

Protocol

Air sampling tests were taken for both bacteria and mold/fungi taken in both a Pediatric ICU and Medical ICU to prove the efficacy of the AiroCide system in removing airborne bacterial and fungi colony forming units (CFU's).

ICU Background Information

The intensive care units chosen to conduct the tests consisted of a nine bed ICU at Wockhardt all devoted to Pediatric patients most of which were infants requiring post op critical care following cardiac surgery, and the other at Bombay also a nine bed unit devoted to medical intensive care.

Both hospitals utilized a central nurse station located on one end of the unit. Entry into the unit required in the case of Wockhardt substitution everyday shoes with hospital sandals in favor of everyday shoes (left in the outside corridor), and the wearing of a lab coat, head cover and mask to further reduce outside bio burden transmission into the clinical space. At Bombay access into the ICU was through a double door corridor and only mask protection required for staff and caregivers. Visitors were free to come and go at Bombay while granted very limited access at Wockhardt.

During the four (4) day regiment of testing, patient populations were relatively stable, averaging three (3) – five (5) babies at Wockhardt and three (3) – four (4) adult patients at Bombay all requiring varying degrees of intensive care attention. The attending medical staff was typically comprised of five (5) MDs (surgeons and intensive care specialists) and eight (8) nurses.

Both Bombay ICU and Wockhardt Pediatric ICU area each had a dedicated air handling system operating without any form of central air filtration.

AiroCide Unit Placement

ACS 50 systems were installed in 7 patient rooms/areas and 9 patient rooms respectively. Because of the openness of the rooms, and the proxmity to the nursing station area, only one additional unit was deemed necessary in the open common space at Bombay mainly to address incoming contamination from an active cleaning and linen processing corridor. Units were affixed to walls and in most cases were located behind the patient's bed. They were powered from the available power strips common to all rooms for powering vents and monitoring systems. The hospitals bio engineering staff assisted with placement and actual affixing to the walls.
Note: UPS protection was centralized and delivered across the entire ICU areas.

Air Sampling Protocol

Sampling points were selected after observing the room layout and flow of staff and patients. Five key sample points were selected at each hospital including 3 patient rooms, an open area adjacent to the nursing station (called NS in the study summary) and lastly a location in the entry area (outside corridor OC). Throughout the study when each sample was taken activities were noted such as general activity in proximity to test site, whether the room/bed was occupied by patient and whether both nursing and MD presence was unusual.

Anderson Sampling

The air samples were accomplished using an Anderson-Type sampler set at a constant flow rate. In addition, the samples were taken from the same floor

height and air was drawn through and into the agar media for the same time duration to guarantee a constant volume of air for each and every sample taken regardless of day, time or media type. This was essential to be able to render comparisons from different conditions and days of AiroCide purification of the space.

Baselines were taken on day 1 after installation and before the units were powered on. Mold/fungi and bacteria plates were obtained, sealed, labeled and then shipped off to the US via an air express service. Units were then powered on and the samples repeated each day for 3 successive days at approximately the same time of day and in the same sequence for each of the five (5) testing points. (3 beds, nursing station and outside corridor)

Each day the sampled plates were sent to a third party microbiology lab for preparation, incubation of contents and analysis. The reported results included a total CFU/m3 count as well as genes and species where indicated

Results

As anticipated Airocide technology had a significant impact on the environment:

Wockhardt results showed

- **An airborne bacterium was reduced 72.9% over a three (3) day period of AiroCide purifying the air as compared to a baseline prior to AiroCide being activated.**
- **Fungi/mold level was reduced 60.2% over a three (3) day period of AiroCide purifying the air as compared to a baseline prior to Airocide being activated.**

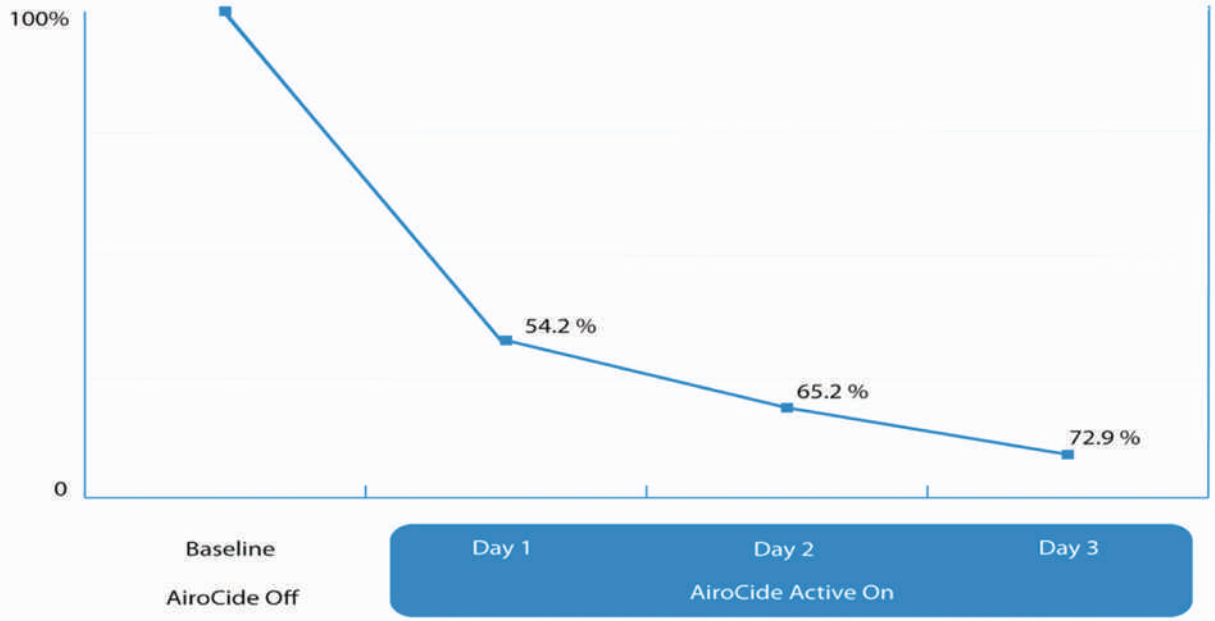
Bombay Hospital results showed

- **Airborne bacteria was reduced 85% over the three (3) day period compared to baseline**
- **Fungi/mold level was reduced 63.8% in CFUs/m3 over the same 3 day period**

As is typical, the largest percentage reduction occurred during the initial 24-hour period as baselines samples showed the highest levels of contamination. As time passed various spikes were encountered as new contamination threats entered the area, but AiroCide repeatedly brought those back down to lower safer levels. Results demonstrated one of the key operating advantages of the Airocide technology, namely ongoing 24/7 steady microorganism protection.

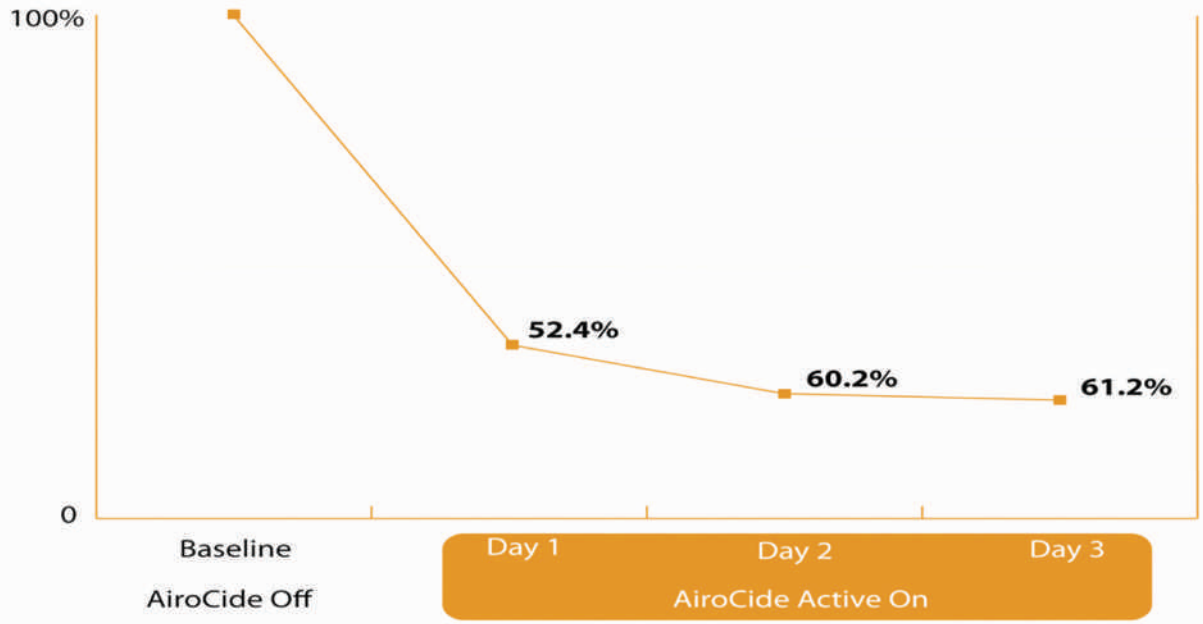
Results show a significant impact on the environment during the three (3) day period. Continued Airocide use is expected to result in a long term trend to lower bacteria and mold/fungi levels. Be aware that microorganism reductions of this magnitude are not linear. As the result of this reduction, coupled with diffusion and dispersion, the statistical probability of contracting an airborne pathogen has been geometrically lowered.

Wockhardt Hospital - PICU - Bacteria Analysis



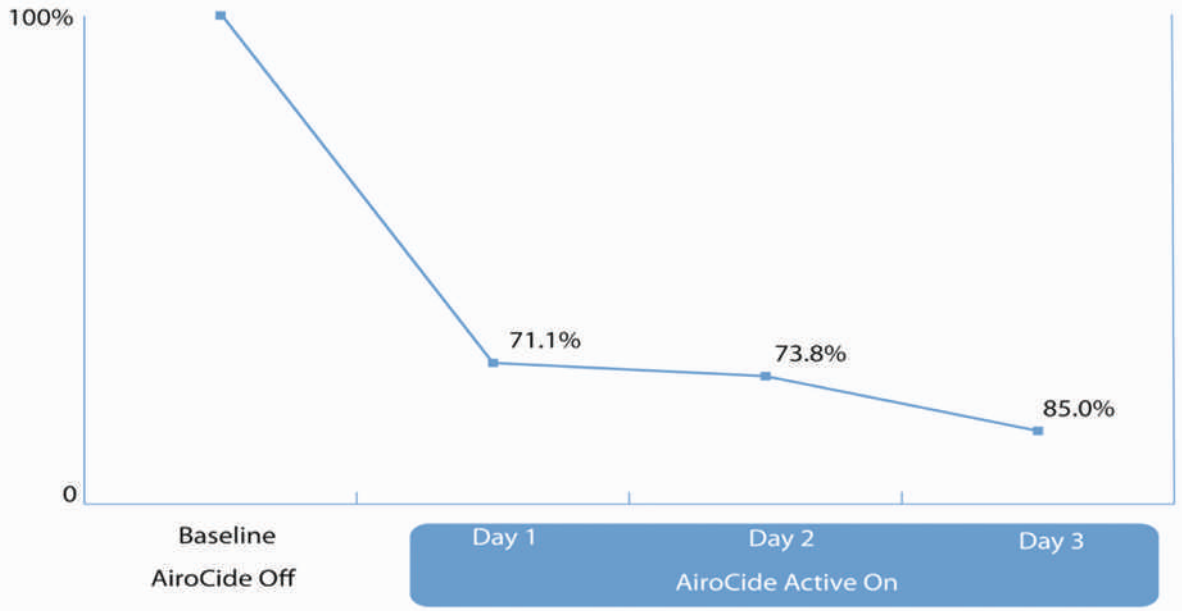
Each day on the graph represents a percent reduction

Wockhardt Hospital - PICU - Mold Analysis



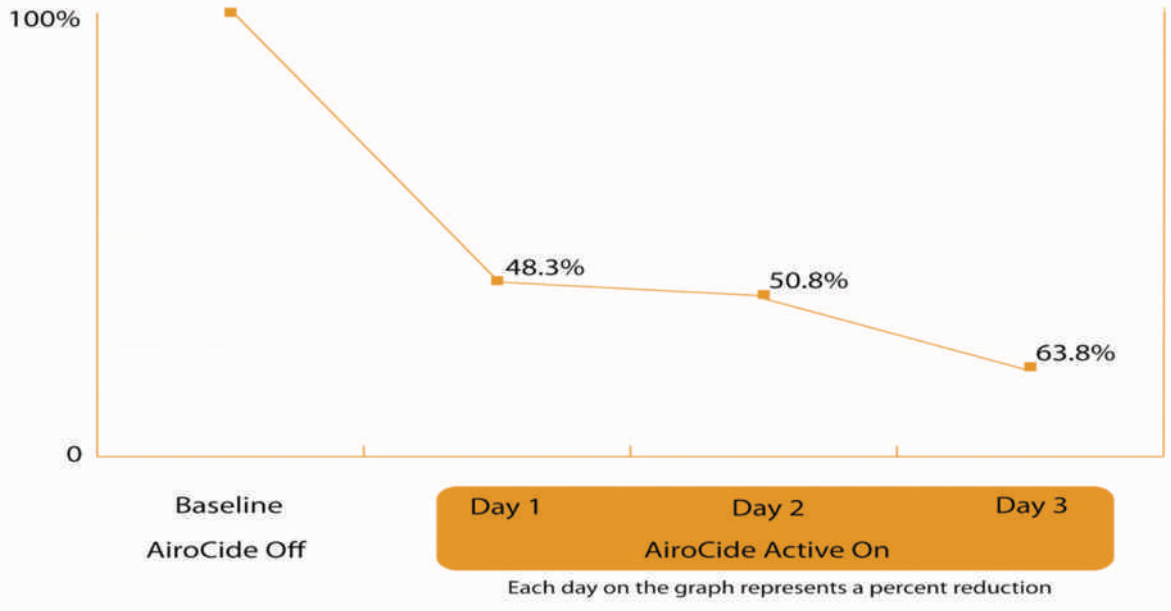
Each day on the graph represents a percent reduction

Bombay Hospital - ICU - Bacteria Analysis



Each day on the graph represents a percent reduction

Bombay Hospital - ICU - Mold Analysis



Each day on the graph represents a percent reduction

Despite sound cleaning practices witnessed within the ICU including surfaces disinfecting, entry precautions including clothing coverage and footwear, and continual surveillance for cross contamination, relatively high baseline levels were measured. Our initial speculation for likely sources for ongoing generation of contaminates would be air communication from the outer entry hallway and the cycling of the dedicated HVAC air handling system which may also introduce bio burden.

It is important to keep in mind that any environment is continually faced with contamination spikes occurring at irregular intervals as new microorganism is introduced. Meaning at any single point in time, the graphical analysis of the environment could show a higher or similar level of contamination than that of a sample taken just a few minutes earlier. For example, what happens to a room's bio burden level when a medical staff of two (2) are present versus the same room when seven (7) are present? Clearly, the opportunity for increased contamination exists when more people enter a room - which could result - in an upward or similar contaminate reading even though the AiroCide unit had been working. For clarification, the point here is not to focus on any singular sample – good or bad – but rather particular attention should be focused on the longer term trend and the fact that AiroCide provides continuous air purification capability.

Summary - Conclusions

- Airborne bacteria was reduced 72.9% and 85% respectively for the 2 hospital ICUs over a three (3) day period of AiroCide purifying the air as compared to a baseline prior to AiroCide being activated.

- Fungi/mold level was reduced 60.2% and 63.8% over a three (3) day period of AiroCide purifying the air as compared to a baseline prior to Airocide being activated.

- The results prove that the AiroCide system provides a high level of effectiveness, reducing cross-contamination between health staff and patients and also improving the working conditions of the caregivers within the ICU.

- Hospital acquired infections are a threat to patient safety and require improvement in clinical practice. We believe that AiroCide implementation will help the hospital reduce these known risks.

- AiroCide's low cost implementation and maintenance should be considered when weighing the cost/benefit analysis of reduced nosocomial infections. It is our belief that the reduction and prevention of such infections, as a result, will translate into significant savings for the hospital, patient and/or public health system.

- An opportunity for a unique public awareness position is supported by AiroCide installation. Specifically, its ability to deliver unequalled air purification could be effectively marketed to the affluent local Indian population, as well the foreign medical tourism consumer.

- AiroCide® seems a natural fit within Wockhardt's stated commitment to

exceptional patient care as expressed in the statement, "***World-class Professional Treatment with Care®".***

- AiroCide would provide additional infection control capability to Bombay Hospital given it's commitment to the community it serves and prove it's leadership position among the Indian healthcare establishment.

AiroCide™ Air Quality-Improvement™ Systems
Photocatalytic Oxidation in conjunction with Ultraviolet Irradiation

AiroCide a unique airborne pathogen killing technology that uses a patented combination of ultraviolet light and a proprietary titanium based photocatalyst. The AiroCide technology and developing product line is capable of killing a wide range of airborne pathogens including bacteria, viruses and molds, as well as breaking down volatile organic compounds (VOC's) in medical healthcare, residential, food storage, and a variety of other commercial applications.

Summary:

Tests were performed in multiple locations inside the offices of a dental practice to measure the efficacy of the AiroCide system in removing airborne bacterial and mold/fungal colony forming units (CFU's). The tests resulted in an average 45.3% reduction in airborne bacteria in 24 hrs. and an average 80% reduction in airborne mold/fungi in the same 24 hours period.

Protocol

Two AiroCide systems (model ACS-100) were installed in the offices of a 26,800 ft^3 dental practice.

Air samples were taken using an Anderson type Aerotech 6 vacuum air pump sampler and agar petri dishes in accordance with general protocols and procedures established by the Indoor Air Quality Association (IAQA) and the National Industrial Hygienists Association. These samples serve as the data for the following recommendations and conclusions in this report. All agar plates were exposed to 28.3 l/m of air for 3 minutes.

Initial "Baseline" air samples were taken on 9/16/2004, outside, in the common lobby area. One (1) AiroCide ACS-100 (total of two (2)) were installed at each end of a common hallway that permits access to the individual offices and one (1) AiroCide ACS-50 was installed in the patient waiting room. All AiroCide's were turned on after the baseline samples had been obtained.

"Active On " air samples were taken after the three (3) AiroCide systems processed the entire office air for 21 hours. Care was taken to ensure there were no environmental changes between samples (i.e. room cleaning, HVAC filter changing, etc.) The number of patients and staff only varied by three (3) individuals from day 1 baseline testing vs. day 2 "Active On" testing. There were three (3) more people in the offices on the second day "Active On" testing then there were on the previous day 1 baseline testing. A variance of plus or minus three (3) individuals in this large dental office is not significant enough to adversely effect the results.

Results:

The tests resulted in an average 45.3% reduction in airborne bacteria in 24 hrs. and an average 80% reduction in airborne mold/fungi in the same 24 hours period.

Bacteria

Air Sampling Sites	Day 1 Baseline CFU/m³	Day 2 Active On 24 hr. CFU/m³	Percent Change	Average % Change
Common Lobby Outside Dental Office	530	712	+ 34%	36% + 49% +51% / 3
End Of Hall Near Dr. Offices In Common Hallway	48	31	- 36%	- 45.3%
End Of Hall Opposite Dr. Offices In Common Hallway	95	48	- 49%	
Patient Waiting Room	154	75	- 51%	

Fungi/Mold

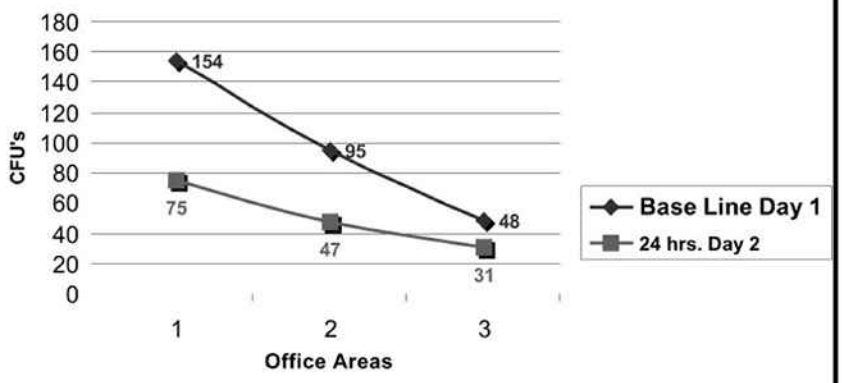
Air Sampling Sites	Day 1 Baseline CFU/m³	Day 2 Active On 24 hr. CFU/m³	Percent Change	Average % Change
Common Lobby Outside Dental Office	106	47	- 56%	74%+66%+100% / 3
End Of Hall Near Dr. Offices In Common Hallway	47	12	- 74%	- 80%
End Of Hall Opposite Dr. Offices In Common Hallway	35	12	- 66%	
Patient Waiting Room	36	<12 = 0	- 100%	

Copies of tests mentioned in this paper can be obtained by writing KesAir, Research & Development, 3625 Kennesaw N. Ind.Pkwy., Kennesaw, GA 30144.

www.kesair.com 800-627-4913

Notchview Dental Airborne Bacteria Testing

Day 1 AiroCide Turned ON After Base Line Air Samples
Day 2 Air Samples Taken After AiroCide Operated For 24 hrs.



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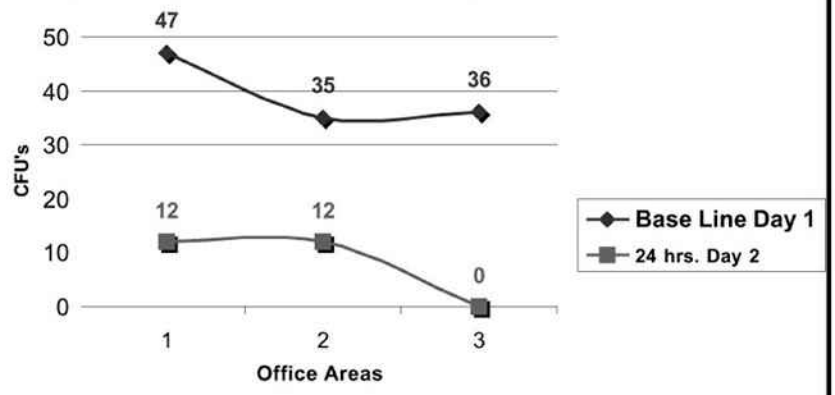


Type of Research: Clinical Study – Notchview Dental

Date(s): 09/16/2004 - 09/17/2004

Test Site: Notchview Dental LLP
1037 Route 46 East
Clifton, NJ 07013
(973) 473-4371
Dr. James Fisher – Office Contact Person

Objective

1) Measure the efficacy of the AiroCide photocatalytic air-cleaning device in removing airborne mold/fungi colony forming units (CFU's) in a normal Dental office environment.
2) Subjectively determine via staff and Dentist interviews the effect of AiroCide's Volatile Organic Compound (VOC) removal ability in their normal dental office environment.

Date(s): 09/16/2004 - 09/17/2004

Conditions/Facility:

The Notchview Dental Office is a large three-dentist office with four to six staff personal. The offices are approx. 12 years old and are part of a larger commercial building. The office has 9 rooms that the three (3) dentist or hygienists work in. There is a large 22' x 10' waiting room where an ACS-50 will be installed and a 67' hallway where two (2) model ACS-100's will be installed.

The approx. square footage of the dental offices (40' X 67') is 2,680 or approx. 26,800 cubic feet. The office has two (2) HVAC systems that do not exchange outside air. The office has no outside windows. The office hours are Monday 9 AM to 6 PM, Tuesday 9 AM to 7 PM, Wednesday 9 AM to 6 PM, Thursday 9 AM to 7 PM, Friday 8 AM to 3 PM and Saturday 8 AM to 1 PM. The office is cleaned every night Monday thru and including Friday. The dentists are aware they have a build up of the VOC's they use which are as follows: 3.4% glutaraldehyde, chloroform, formocresol, eugenol, camphorated parachlorophenol, KAVO Quattrocre, copalresin varnish, bleach and x-ray developer/fixer. There is no past history of Mold or any extraordinary problems from construction.

The dental practice is located on the first floor of a professional office complex and staff enters the office via a common central lobby that has elevators the floors above the dental offices. The common lobby area in closed off from the offices and it only access is from the other offices on the first floor, elevator and a double door that leads outside.

The dentist's as well as the staff commented that the air in the offices prior to turning the AiroCide's systems ON felt "heavy" and usually would burn or sting their eyes by the end of the day. Additionally a new staff person with the

practice for just a few months was experiencing a runny nose, nasal irritation and other allergy symptoms within a few days of starting to work in the dental practice.

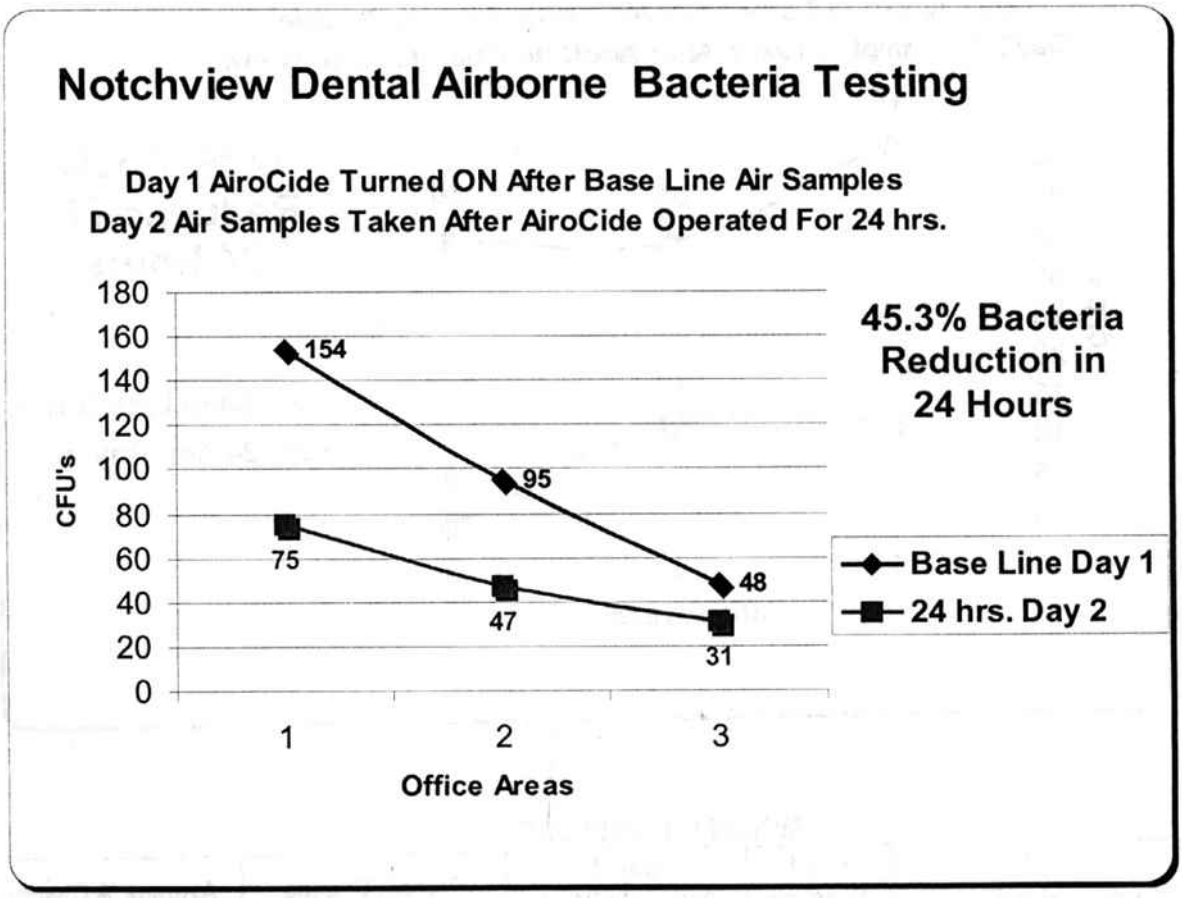
Protocol:

Air samples were taken using an Anderson type Aerotech 6 vacuum air pump sampler and agar petri dishes in accordance with general protocols and procedures established by the Indoor Air Quality Association (IAQA) and the National Industrial Hygienists Association. These samples serve as the data for the following recommendations and conclusions in this report. All agar plates were exposed to 28.3 l/m of air for 3 minutes.

Initial "Baseline" air samples were taken on 9/16/2004, outside, in the common lobby area. One (1) AiroCide ACS-100 (total of two (2)) were installed at each end of a common hallway that permits access to the individual offices and one (1) AiroCide ACS-50 was installed in the patient waiting room. All AiroCide's were turned on after the baseline samples had been obtained.

"Active On " air samples were taken after the three (3) AiroCide systems processed the entire office air for 21 hours. Care was taken to ensure there were no environmental changes between samples (i.e. room cleaning, HVAC filter changing, etc.) The number of patients and staff only varied by three (3) individuals from day 1 baseline testing vs. day 2 "Active On" testing. There were three (3) more people in the offices on the second day "Active On" testing then there were on the previous day 1 baseline testing. A variance of plus or minus three (3) individuals in this large dental office is not significant enough to adversely effect the results.

Results: Chart A and B below compare **Day 1 Baseline** air sampling ***all AiroCides OFF*** and **the Day 2 "Active On"** air sampling 24 hours after baseline CFU's for airborne bacteria and mold/fungi.



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End Of Hall Near Dr. Offices In Common Hallway	48	31	- 36%	**- 45.3%**
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Patient Waiting Room	154	75	- 51%	

BACTERIA RESULTS

Notchview Dental Airborne Mold Testing

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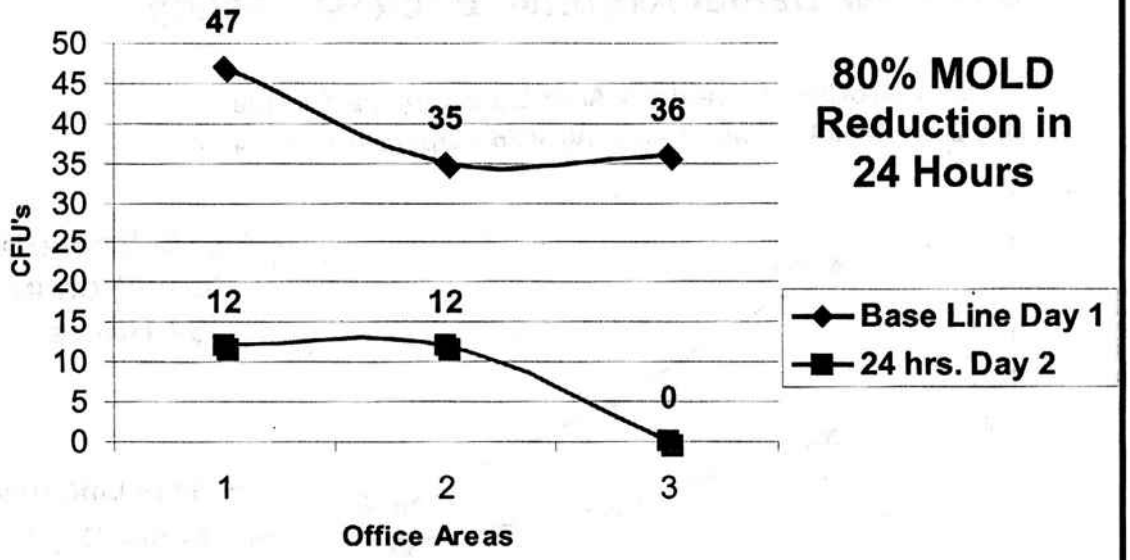
Day 2 Air Samples Taken After AiroCide Operated For 24 hrs.



MOLD/FUNGI RESULTS

Air Sampling Sites	Day 1 Baseline CFU/m³	Day 2 Active On 24 hr. CFU/m³	Percent Change	Average % Change
Common Lobby Outside Dental Office	106	47	- 56%	74%+66%+100% / 3
End Of Hall Near Dr. Offices In Common Hallway	47	12	- 74%	**- 80%**
End Of Hall Opposite Dr. Offices In Common Hallway	35	12	- 66%	
Patient Waiting Room	36	<12 = 0	- 100%	

Research Summary
Out-patient Surgery Center

AiroCide™ Air Quality-Improvement™ Systems
Photocatalytic Oxidation in conjunction with Ultraviolet Irradiation

AiroCide a unique airborne pathogen killing technology that uses a patented combination of ultraviolet light and a proprietary titanium based photocatalyst. The AiroCide technology and developing product line is capable of killing a wide range of airborne pathogens including bacteria, viruses and molds, as well as breaking down volatile organic compounds (VOC's) in medical healthcare, residential, food storage, and a variety of other commercial applications.

Summary:

Duplicate tests were performed in an operating room of an out-patient surgery facility to measure the efficacy of the AiroCide system in removing airborne bacterial colony forming units (CFU's). The tests resulted in a 92% reduction in 24 hrs. and a 47% reduction in one (1) hour.

Protocol

Two AiroCide systems (model ACS-100) were installed in a 2,000 ft^3 operating room. In Test #1 and Test #2 air samples were first taken during surgical procedures with no AiroCide systems running. This established baselines for the tests. The AiroCide systems turned on after the baseline air samples were taken.

In Test #1 a second set of air samples (the "active" set) was taken after 24 hrs. of continuous AiroCide operation to measure the reduction of airborne bacteria. The 24-hr. air samples were taken during comparable surgical procedures as the baseline samples.

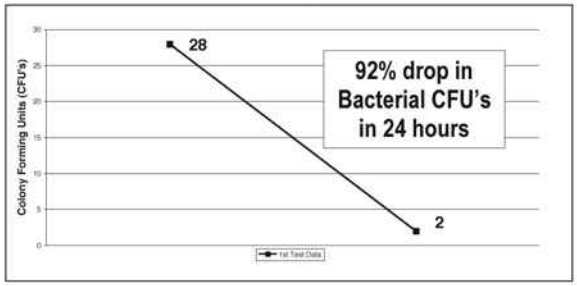
In Test #2 the active air samples were taken one hour after the baseline. The one hour samples were taken during comparable surgical procedures as the baseline samples.

The same number of people were present in the room during all air samples and there were no environmental changes between baseline and active air samples (i.e. room cleaning, HVAC filter changing, etc.)

Results:

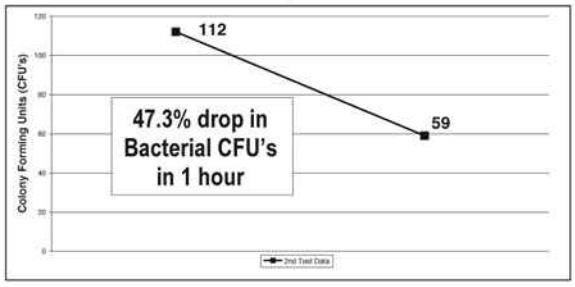
Test #1 baseline samples showed 28 CFU's of airborne bacteria. After the AiroCide ran for 24 hrs., there were only 2 CFU's in the room. These numbers represent a 92.8% drop in bacteria in the operating room.

Test #1



Test #2 baseline samples showed 112 CFU's of airborne bacteria. After the AiroCide ran for one (1) hour, there were 59 CFU's in the room. These numbers represent a 47.3% drop in airborne CFU's in the operating room.

Test #2



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Summary:

Air sampling tests were performed in an active oral surgery and periodontal medicine facility to measure the efficacy of the AiroCide system in removing airborne bacterial colony forming units (CFU's). The tests resulted in airborne mold/fungi reduction of 66% in the operating room (OR#3) and 100% in the adjacent corridor in 48 hours. Airborne bacteria was reduced by 82% in the corridor in the same 48 hours.

Note: Airborne bacteria levels were found to be at or near zero in OR#3 throughout the test.

Protocol

One AiroCide system (model ACS-100) was installed in both the OR#3 and the adjacent corridor.

Initial "Baseline" air samples were taken on Aug 30, 2005 outside of the waiting room entrance doors adjacent to the parking spaces to establish an outside level for both bacteria and mold. It is important to know the outside levels given the transport of contaminates with the ingress of patients entering the facility. Additionally samples were taken in the most interior corridor next to the wall area where an AiroCide ACS 100 was mounted at eye level. This location was selected given its proximity to all entry ways into the individual OR and procedure rooms. The third sample location was inside OR #3 with the sampling point immediately adjacent to the dental chair. A baseline sample was taken BEFORE AiroCide was activated on the day of installation by the KesAir technician.

"Active On " air samples were taken at the three designated locations on August 31 and Sept 1 and after office air was processed by AiroCide for approximately 48 Active On hours. The number of staff did not vary by from day 1 baseline testing vs. "Active On" testing.

Air samples were taken using an Anderson type Aerotech 6 vacuum air pump sampler and agar petri dishes in accordance with general protocols and procedures established by the Indoor Air Quality Association (IAQA) and the National Industrial Hygienists Association. These samples serve as the data for the following recommendations and conclusions in this report. All agar plates were exposed to 28.3 l/m of air for 3 minutes.

Results:

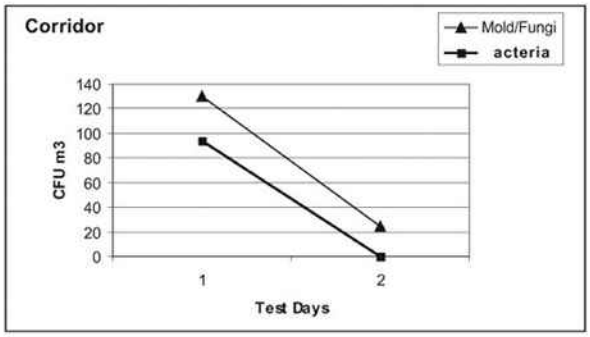
Bacteria

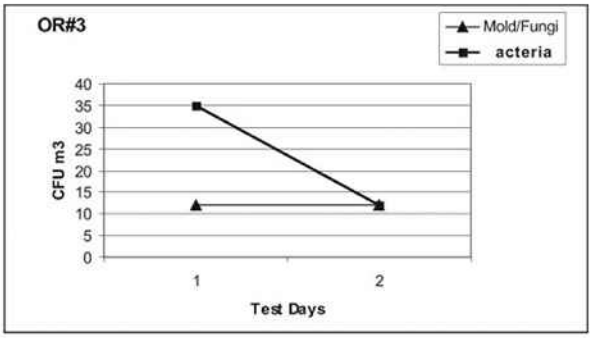
Bacteria was reduced substantially in the corridor space 82% and held very low at 12 CFUs in the OR from the baseline despite normal activities. Bacteria was not being generated and transmitted into the OR from the corridor and AiroCide functioned well to sanitize the high activity corridor. Much of the contamination in the corridor will come from patients and staff while the OR bio

Copies of tests mentioned in this paper can be obtained by writing KesAir, Research & Development, 3625 Kennesaw N. Ind.Pkwy., Kennesaw, GA 30144.

Sampling Location	Reading CFUs	Bacteria	Mold
Outside - Parking			
WITHOUT AIROCIDE	**Baseline**	**82**	**153**
WITHOUT AIROCISE	**48 hours**	**71**	**212**
WITHOUT AIROCIDE	**Change**	- 13%	**+39%**
Corridor – Outside Procedure Rooms			
WITHOUT AIROCIDE	**Baseline**	**130**	**94**
W/ AIROCIDE	**48 hours**	**24**	**< 12 = 0**
W/ AIROCIDE	**Change**	- 82%	- 100%
Main OR #3			
WITHOUT AIROCIDE	**Baseline**	**12**	**35**
W/ AIROCIDE	**48 hours**	**12**	**12**
W/ AIROCIDE	**Change**	nc	- 66%

burden originates from equipment as well as generation from the oral cavity during surgery.





Mold

Mold was virtually eliminated in the corridor from base line tests. While mold levels increased outside baseline to second day the corridor's air dropped to an unmeasureable sub 12 level which is interpreted at zero. The AiroCide system was able to keep the corridor mold free. Within the OR the mold levels dropped 66% proving the affect AiroCide had on the circulatory air being cleansed of mold spores floating in the total space. Here again the corridor placement of AiroCide has a positive and pronounced affect on protecting the OR air quality with respect to mold.

AiroCide™ Air Quality-Improvement™ Systems

AiroCide is a unique airborne pathogen killing technology that uses a patented combination of ultraviolet light and a proprietary titanium based photocatalyst. The *AiroCide* technology and developing product line is clinically proven and field tested to kill/remove/eliminate airborne pathogenic and non-pathogenic microorganisms in vegetative and spore states (bacteria, mold & fungi, viruses and dust mites), allergens, odors and harmful volatile organic compounds (VOC's) in Medical/Healthcare, Child Care, Consumer Household, Mold Remediation, Athletic and Sports Facilities, Corrections Facilities and Food Preservation applications.

Summary:

A clinical study was conducted to determine the initial and sustained reduction of airborne mold and bacteria in two residences of similar size, design and structure.

Airborne mold was reduced in the homes by an average of 60% in 24 hours and even further to an average of 87% in 6 months. Bacteria in the air inside the homes was reduced an average of 57% in 24 hours and maintained a level of 49% lower than baseline in 6 months.

Facility

The two three-level residences were 67,000 ft^3 (Residence A) and 70,000 ft^3 (Residence B) and made of brick. Two adults and two children were living in each home at the time of the tests. The children and one adult living in Residence A reported suffering from asthma and allergies.

Protocol

The test period consisted of three (3) individual days of air sampling that spanned a 3-month time frame. A baseline reading, with no *AiroCide* systems operating, was conducted at each residence for comparison to all other test days. Air samples were taken the next day after the *AiroCide* systems were operating for 24 hours. Air samples were then taken six (6) months after baseline to measure the sustained effect of the *AiroCide* systems. The *AiroCide* systems continued to operate 24/7 during this timeframe.

Results:

Airborne mold was reduced in the homes by an average of 60% in 24 hours and even further to an average of 87% in 6 months. Bacteria in the air inside the homes was reduced an average of 57% in 24 hours and maintained a level of 49% lower than baseline in 6 months.

After six months of AiroCide use one of the adults in Residence A reported: " First, I was able to discontinue using two of my asthma medications and have maintained very well without them…Second, only one of my children has been seen by her pediatrician this entire winter season. She was diagnosed with bronchitis and the bacterial virus never spread from one child to another (in our house)."

Copies of tests mentioned in this paper can be obtained by writing KesAir, Research & Development, 3625 Kennesaw N. Ind. Pkwy., Kennesaw, GA 30144.

www.kesair.com 800-627-4913

Case Study:

Concept Paper for a pilot study to address:
Can AiroCide technology (see AiroCide Technology Description below) improve quality of life for families with asthma?

The technology: Airocide® is a unique airborne pathogen killing technology that was funded, developed and used by NASA. The technology has been developed to kill/ remove/ eliminate airborne pathogenic and non-pathogenic microorganisms in vegetative and spore states (bacteria, mold & fungi, viruses and dust mites), allergens, odors and harmful volatile organic compounds (VOCs) in air and a variety of commercial, government, and residential applications including the medical healthcare industry (AiroCide air purifiers are FCA Class II listed medical devices).

Population: Twenty families receiving care at National Nursing Center Consortium nurse-managed primary care sites in Philadelphia with children up to 18 years of age with moderate to severe asthma symptoms, causing at least 2 emergency room visits or a hospitalization in the past 6 months.

Intervention group: Receives an AiroCide unit to be used in their home, plus the usual Asthma Safe Kids program which includes a pre-test of knowledge about asthma, a home environmental assessment and educational program to reduce exposure to triggers for the child that includes incentives to reduce exposure to trigger, (e.g. mattress and pillow covers, boric acid in an applicator and caulking to seal the boric acid into cracks in the walls and woodwork, rodent traps, detergent, dust clothes, etc.), plus a follow-up visit to evaluate retention of knowledge and changes in the home environment.

Control group: Receives the Asthma Safe Kids program without the AiroCide unit.

Comparisons to be made regarding emergency room visits, hospitalizations, home environmental assessments, quality of life tools for children with asthma and their families.

Conclusions: As a member organization of nurse-managed centers, our interest in improving the health of our patients and their families extends beyond the quality of health care they receive at our primary care centers. Over the past few months we have had the opportunity to evaluate and test a new innovative, NASA-developed air purification system in the bedroom of one of adult patients with daily asthma symptoms requiring her rescue medications during the night and in the morning. After the first four days (January 19, 20, 21 and 22, 2008) of placing the AiroCide® Air Purification System, when she reported wheezing but at a lesser level, she has had no symptoms requiring her rescue medication during the night or in the morning (through March 19, 2008). We might add that she shares the bedroom with two large birds in cages and reports, " now, when the sun shines in there is hardly any dust that I can see floating in the air."

Notchview
DENTAL GROUP L.L.P.

James W. Fisher, D.M.D. Joseph E. Ralph, Jr. D.M.D. Philip A. Rispoli, Jr., D.M.D.

John J. Hayman, Jr.
President
KesAir Technologies, LLC
3625 Kennesaw North Industrial Parkway
Kennesaw, Georgia 30144

Dear Mr. Hayman;

I am pleased to advise you that the AiroCide systems that we purchased from your company have had some wonderful effects on our office environment.

My two colleagues Dr. Joseph E. Ralph and Dr. Philip A. Rispoli, Jr. and I agree that we on longer suffer from red, itching or burning eyes after a long day at the office. We also noticed that all three of us had much more energy at the end of the business day then we have had in the past prior to the installation of the systems. We all noticed this wonderful change within 48 hours of the KesAir AiroCide systems being installed in our offices.

Additionally, my staff of seven persons noticed that the air feels lighter. It is easier to breathe, their eyes are not itchy or burning, the office air is crisper and a previous mold smell is gone.

My office manager believes that this last winter her staff did not share as many colds and viruses than in years past. It seemed when a staff member came down with a cold they kept it to themselves instead of spreading it through the office as they had always done in the past.

Best regards,

Dr. James W. Fisher
For Notchview Dental Group Dr.'s Ralph, Fisher & Rispoli

1037 Rt. 46 East • Suite CG1 • Clifton, NJ 07013 • 973-473-4371 • Fax 973-473-20171037

WILLIAM S. GROVE, D.M.D.
12685 CRABAPPLE ROAD
ALPHARETTA, GEORGIA 30004
TEL: (770) 475-3700
FAX: (770) 664-2284

April 4, 2005

John J. Hayman, Jr.
President
KesAir Technologies, LLC
3625 Kennesaw North Industrial Parkway
Kennesaw, Georgia 30144

Dear Mr. Hayman:

I wanted to tell you how very pleased I am with my purchase of the AiroCide system.

Upon entering my office in the morning for the last 25 years, I have become
familiar with different odors unique to dental offices. This would include eugenol, x-ray solutions, serilization solutions, and most annoying, fumes from newly installed carpet. Most of these odors contain Volatile Organic Compounds (VOC's) , some of which are carcinogens. Within 72 hours after installtion of the AiroCide system, there was NO ODOR whatsoever.

Also, my staff members feel safer and report less eye and sinus irritation at the end of the day than they had previously experienced.

Many thanks again.

Best regards,

William S. Gove, DMD

STOCKWELL
FAMILY DENTISTRY

August 20, 2005

John J. Hayman, Jr.
KesAir Technologies, LLC
3625 Kennesaw North Industrial Parkway
Kennesaw, GA 30144

Dear Mr. Hayman,

The timing of the installation of our AiroCide System couldn't have been better! Our office had just been flooded due to a broken pipe and after drying out we were still getting a residual musty smell; that is until we started using the AiroCide. I am confident that this system worked to kill airborne mold and prevented us from needing any further remediation.

Our clinical staff members are also pleased that they no longer notice the fumes from the surface disinfectants and chemical sterilizer that we use.

In a dental office where bacteria laden aerosols from drilling, spraying, ultrasonic scalers and ultrasonic cleaners are constantly being created, it is comforting to know we are doing everything possible to reduce our patients and our exposure to airborne pathogens as well as chemicals. And to top it off, our dental office doesn't smell like a dental office! Another plus is it doesn't produce that funky ozone smell that other air filtering systems we had previously tried always produced. Our office smells fresh and clean!

The units low maintenance requirements, low energy consumption and low noise are other pluses. We plugged it in and have literally forgotten about it.

We owe it to ourselves, our staff members and our patients to do whatever is possible to lessen our exposure to airborne bacteria, viruses, mold spores, allergens, odors, and volatile organic compounds and to do all we can to improve infection control. Air purification, especially in a dental office makes sense from the perspectives of both health and comfort. I know I tend to breathe easier knowing that we are scrubbing the air as we work every day. Who doesn't want to breathe healthy air?

Sincerely,

Karyn L. Stockwell, DMD

ROSWELL PEDIATRIC CENTER, P.C.

Fredric B. Flax, M.D
Evan N. Landis, M.D.
Judith R. Tolkan, M.D.
Howard W. Silverman, M.D.
Edward S. Salzberg, M.D.
Catherine B. Bowman, M.D.
Robert D. Burnham, M.D.
Douglas S. Josephson, M.D.

Melissa G. Eaton, M.D.
Sue H. Ross, PNP
Faith A. Ludwick, PNP
Kelly M. Jacchia, PNP
Ellen M. Degnan, PNP
Tara L. Marcus, PNP
Debbie A. Gaynor, PNP
Mary Katherine White, PNP

August 23, 2005

David W Heffner
Executive Vice President
KesAir Technologies, LLC
3625 Kennesaw North Industrial Parkway
Kennesaw, Georgia 30144

Dear Mr. Heffner

I am pleased to advise you that the AiroCide system from your company installed at our Crabapple office April 12, 2005 has had some positive effects on our office environment.

The overall air quality has improved considerable with the noticeable elimination of any, mold, mildew or cleaning chemical odors. It was a primary objective to address these bothersome environmental odors offensive to our patients and staff.

Additionally our staff has commented that the air feels lighter and crisper, it is easier to breathe, and there are fewer itchy throats and chronic allergic discomforts.

Many patients and families visiting our offices have expressed curiosity with the AiroCide system prominently displayed at the reception desk. It has raised numerous questions related to its purpose and affect. I would suggest Kes Air supply the practice with consumer brochures that we would be more than happy to pass along to interested parents and particularly those managing children prone to asthmatic episodes triggered in their homes.

We will consider additional units for the other RPC offices. The matter will be discussed at the group practice meeting later in August.

Than you for introducing this exciting and effective air quality technology to us.

Best regards,

Dr. Evan N. Landis
Roswell Pediatric Center

12385 Crabapple Rd., Ste. 100
Alpharetta, GA 30004-6653
Phone: 770-343-9900
Facsimile: 770-343-8759

3400-C Old Milton Pkwy., Ste. 545
Alpharetta, GA 30005-3747
Phone: 770-751-0800
Facsimile: 770-751-7198

110 North Corners Pkwy., Ste. 100
Cumming, GA 30040-2077
Phone: 770-888-2882
Facsimile: 770-888-5562

R. Keith Broome, Jr., D.D.S.
3875 HOLCOMB BRIDGE ROAD
SUITE ONE
NORCROSS, GEORGIA 30092

July 5, 2005

Mr. Dave Heffner
Vice President
KesAir Technologies
3625 Kennesaw North Industrial Blvd
Kennesaw, GA 30144

Dear Dave,

We are very pleased with the AiroCide unit recently installed in my dental office. Prior to the installation, several members of my staff and I had routinely experienced red, itchy eyes at the end of the work day, as well as seasonal allergy symptoms. Since we have had the AiroCide unit, my office is the only place where my eyes are clear and comfortable. Once I leave the office, my eyes become irritated and itchy.

Overall, my staff has recognized a difference in their general health in that at the end of the work day they have no respiratory/allergic symptoms. However, upon leaving the office, two of my assistants have experienced coughing and sinus irritation as they become exposed to outside air and the air within their cars. We have even had patients who have come into the office with allergy symptoms and by the time they were leaving the office, they mentioned they no longer had sinus congestion. They even requested information on the AiroCide unit.

I like knowing that I am providing a clean, healthy environment for both my staff and my patients. Having an air purification system with NASA technology gives me security that I'm offering the best technology available.

Best regards,

Dr. Keith Broome
3875 Holcomb Bridge Road
Suite 1
Norcross, Georgia 30092

February 13, 2004

Mr. John J. Hayman, Jr.
KesAir Technologies
3625 Kennesaw North Industrial Parkway
Kennesaw, Georgia 30144

Dear John:

I wanted to share with you and your company some interesting information regarding the Airocide units installed in our home last year. I would especially like to express how very blessed I feel, to have been referred to KesAir Technologies by our pediatrician, Dr. .

I am an asthma patient, and most of my breathing problems seem to be triggered by environmental allergens. Last year, my two children were at Dr. office more times than I'd like to remember. Most of those office visits ended up as upper respiratory infections. On most of those visits, we would leave with a prescription for a nine day antibiotic regimen.

The two Airocide units were installed and over the course of the next few months many things seemed to change and improve. First, I was able to discontinue using two of my asthma medications and have maintained very well without them. I haven't had to use my inhaler but once in the past year, while in my home. Second, only one of my children has been seen by her pediatrician, this entire winter season. She was diagnosed with bronchitis. This time the bacterial virus never spread from one child to another. Third, we have a room in our basement which is used for storage of swimming pool chemicals. My husband and I were going to have an outdoor storage built this summer because of the odors produced by these chemicals. Since the Airocide units were installed the odors have completely subsided.

We are so grateful for the positive improvements to our living environment. It is obvious that the Airocide units have improved the air quality in our home as well as our families well being. I am very excited about KesAir Technologies and the future prospect of others benefitting from the Airocide product line.

Sincerely,

Debbie Rosen