

Application of NASA Technology in Animal Laboratories

Photocatalytic technology developed for aerospace can reduce occupational exposure to laboratory animal aeroallergens.

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Air quality in laboratories is important to the welfare of the animals, human health and safety, and scientific research. Airborne contaminants that may commonly affect air quality in the laboratory include volatile organic compounds (VOCs), airborne microorganisms, and laboratory animal aeroallergens. This article describes an application of a method developed by The American National Aeronautics & Space Administration (NASA) — photocatalytic technology — that has been demonstrated to have excellent remedial potential for laboratory animal facilities in research and the pharmaceutical industry by reducing occupational exposure to laboratory animal aeroallergens.

Thirty percent of persons who are exposed to laboratory animals may develop a permanent allergy (LAA); some of these persons will also develop occupational asthma. Although LAA is more likely to occur in people with previously known allergies, it is not known if an individual will be susceptible until he or she has prolonged exposure in the working environment over a period of weeks, months, or years.

Animal allergens are protein molecules that, as the name suggests, are allergenic in some humans. An allergic reaction may develop when susceptible individuals are exposed to allergens produced by laboratory animals. These forms of allergy are most associated with exposure to fur, saliva, and urine of rats, mice, guinea pigs, and rabbits. The allergens that cause allergy from laboratory animals are potent. Exposure to just one millionth of a gram of animal allergens may trigger such symptoms. Because animal allergens cause symptoms at such low concentrations, and so quickly, only complete avoidance of the allergens is an effective measure for the prevention of symptoms. Other methods of protection are limited in both their availability and effectiveness. Animal allergens are so sticky that they may be carried on an exposed person's hair or clothing. In so doing, non-exposed co-workers or family members may be sensitised to the allergens and develop allergies.

Feeding the animals or cleaning the cages can generate ten times the amount of airborne allergens relative to undisturbed conditions. Handling or injection of animals may generate six times the airborne allergens.

All persons working with laboratory animals should follow procedures and wear appropriate personal protective equipment (PPE) to reduce exposure to animal allergens. Significant design, engineering, and environmental steps have been taken in recent years to minimise airborne transmission of allergens and provide a safer environment for the laboratory animal worker, including improved ventilation, filtration, and screening systems. Engineering controls, such as individually-vented cages (IVCs), filter top cages, and laminar flow bedding change stations can limit the amount of allergens released into the airborne environment. Hand washing and showers after occupational routine with animals will minimise transfer to co-workers, associates, and family members. Removing PPE such as gloves, masks, coats, and headgear when leaving an animal area or cage wash area will further reduce

the risk of transmission of allergens.

However, what all of these technologies do is to provide a physical barrier between the producer and the consumer. In the case of clothing, it is obvious exactly what this barrier is and how it serves to protect the individual. In the case of filters, the barrier is the filter itself which collects animal allergens, but also decreases in efficiency with the passing of time. In the case of IVCs and laminar flow cabinets, the barrier is the plastic pipework and airflow, which can move the allergens from the laboratory to the external environment.

The surest way to protect against LAA is to avoid exposure to the allergens themselves. Photocatalytic technology (in the patented, commercial product AiroCide®) has been shown to destroy airborne laboratory animal allergens.

DESTROYING LAAS WITH UV AND PCO

NASA initially developed the photocatalytic technology for growing food in space. It was used on missions aboard the space station to prevent the plant hormone ethylene reducing the quality of plants grown in confined areas. The Wisconsin Centre for Space Automation and Robotics (WCSAR) and the University of Wisconsin, developed a unique photocatalytic oxidation technology that removed ethylene gas — the causal hormone of plant deterioration.

The AiroCide® technology combines two known pathogen-killing techniques, photocatalytic oxidation (PCO) and ultraviolet light to destroy harmful airborne microbes. A titanium dioxide (TiO₂) microporous photocatalyst is used in the PCO process. These active elements will oxidize volatile organic compounds (VOCs) and denature airborne pathogens. In December 2001, a team of researchers at the University of Wisconsin conducted tests and published results, which showed that this technology killed 99.99998% of anthrax-like spores. *Bacillus thuringiensis* is a spore-forming, non-virulent bacillus very similar in all properties to *Bacillus anthracis* (the anthrax spore) and was used in this test. Non-virulent cousins of anthrax are widely accepted in the scientific world as sufficient substitutes for testing the effectiveness of

killing anthrax.

The electromagnetic spectrum between the wavelengths of 100 to 400 nm is known as ultraviolet radiation (UVR), not visible to the naked eye. It is estimated that 40% of the sun's energy is UV composed of UV-A, UV-B, and UV-C. The most effective wavelength, known as ultra violet germicidal irradiation (UVGI), used for killing microbes is between 100 to 290 nm. UV-C (260 nm) is the optimum frequency for killing or deactivation of microbes. UVGI kills or deactivates cells by damaging DNA or RNA inside the cell. The purine and pyrimidine bases of the nucleic acids absorb UVR at frequencies of close to 260 nm leading to an alteration or inhibition of the base pair. When this happens, a dimer is formed, inactivating the reproductive ability of the cell, or destroying the cell by inhibition of metabolic activity, specifically protein production.

When irradiated by UVR, TiO₂ produces a high refraction ratio and catalytic reaction that lowers the intensity field required for the UVR to produce the required energy to break organic covalent bonds (i.e., a high bactericidal activity). Hydroxyl radicals are produced as the UVR strikes the TiO₂ surface. These



Airocide® unit positioned in corridor

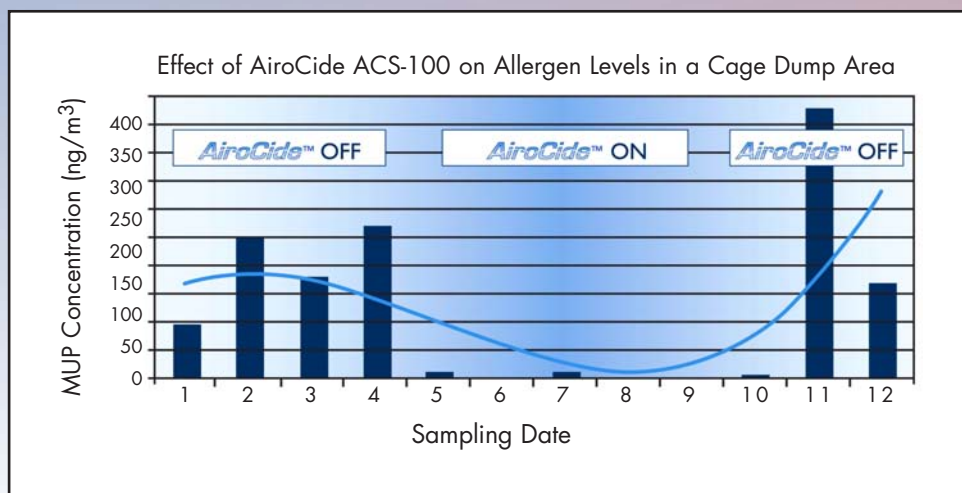


Figure 1. Cage dump area allergen trial

free radicals are extremely potent oxidising agents. An oxidising agent is a substance that removes electrons from other atoms or molecules.

In the case of (carbon-based) micro-organisms, the removal of electrons causes an oxidation-reduction reaction. The oxidative actions induced by the TiO₂ catalyst results in damage to cell membrane phospholipids, lipoproteins, and nucleic acids, placing the cell in a state of oxidative stress, and eventually to cell death.

Contaminated air is drawn into the system by a fan. It passes over the reactor bed where it is immobilized on the TiO₂ catalyst and treated with UV-light until it is completely broken down to gaseous products. The combination of TiO₂ catalyst and UV-light has been shown to destroy hydrocarbon bonds in allergens, airborne organisms, and VOCs. The system reduces allergen levels and organism numbers with a single passage through the PCO + UVGI oxidation process, but since it is designed for constant operation a sustained reduction is maintained. Bad odours are just VOCs and hence are also removed.

This technology is the first to utilise complementary bactericidal methods (UVGI and PCO) to oxidise the organic matter of whole cells to carbon dioxide and water vapour. Collaborative studies were undertaken into the reduction of airborne laboratory animal allergens using this technology. The results of some trials show the effectiveness of the system in reducing background aeroallergen levels.

Figure 1 shows the concentrations of airborne Mouse Urinary Proteins (MUP in a cage dump area where there were no external fans. The room was under

positive pressure with 42 cubic metres of air, and the animal unit contained IVCs. Measurements were taken for 12 consecutive days. Average levels of 197ng/m³ dropped to 5.6ng/m³ with the AiroCide™, a reduction of 97%. Although the UK has not yet identified a workplace exposure limit for LAA, analysis methods established by Gordon and Newman Taylor thought that exposure to airborne allergens below 6ng/m³ could reduce the risk of sensitisation.

The results of the trials that show the effectiveness of this technology in reducing background aeroallergen levels. Used in conjunction with other methods for reducing allergen exposure, the incorporation of appropriate technology can help an allergen-free, safe occupational environment.

REFERENCES

- Childs G., Thorpe M., Jethwa S. (April 2007). The effectiveness of the AiroCide system in reducing the concentration of mouse urinary protein within the working environment. *Animal Technology and Welfare*.
- Eisthen H. L. and Wyatt T. D. (2006). The vomeronasal system and pheromones. *Current Biology* 16(3) R73-74.
- Gordon S., Tee R.D., Lowson D. and Newman Taylor, A.J., (1992). Comparison and optimisation of filter elution methods for the measurement of airborne allergen. *Ann Occup Hyg* 36:575-587.

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