Annihilating Anthrax

NASA- and industry-sponsored research aimed at growing plants in space has led to a device that attacks and destroys airborne pathogens -- like Anthrax.

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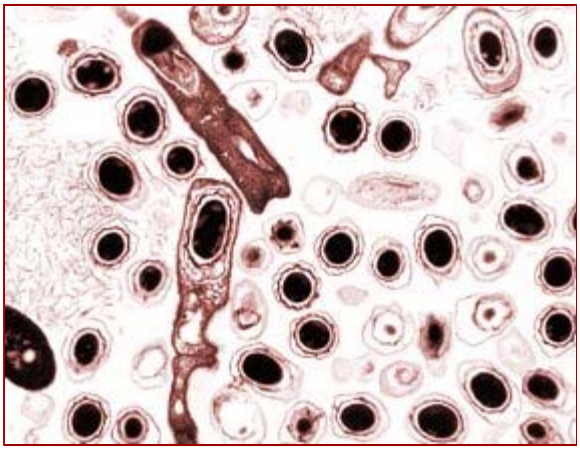


February 1, 2002: Unseen and odorless, a cloud of Anthrax spores wafts through an office. People inside are talking, laughing ... breathing. They have no idea something is in the air. One yawn, one gasp, one happy guffaw could be deadly.

That's how bioterrorism works.

But this office has a defense: Bolted to the ceiling is a curious flat box. It's made of metal, about the size of a table-top, and it's humming softly -- the sound of fans drawing airborne spores toward it and away from the people. The breeze is gentle but insistent. Eight cubic feet of air per minute flow into the box.

Above: Anthrax spores, pictured here in a thin section micrograph, are inactive forms of the bacterium *Bacillus anthracis*. Such bacteria can survive for decades inside a spore's tough protective coating; they become active when inhaled by humans. [more]

What lies inside is bad news for Anthrax. Swirling air forces spores through a bewildering maze of thin tubes bristling with hydroxyl (OH^-) ions that attack and destroy pathogens. Some spores are buffeted against the OH^--lined walls of the labyrinth. Others are caught in windy eddies where they linger, exposed to high-energy (254 nm) ultraviolet photons. Every second, one hundred billion such photons bathe the chamber -- and just one is enough to destroy a spore.

"Spores that pass through the box aren't filtered, they're fried," says John Hayman, whose company, KES Science & Technology, Inc., builds and sells the device called *AiroCide* TiO_2. "That's appealing," he notes, "for people who don't want to change an Anthrax-laden air filter." Tests show that as many as 93% of Anthrax spores that enter *AiroCide* TiO_2 are destroyed. Survivors circulate out of the chamber where they are likely to be sucked back in again for another pass.

Below: Technicians install *AiroCide* TiO_2 on the ceiling of an office.

This extraordinary Anthrax killer is a result of NASA- and industry-sponsored research aimed at building better greenhouses in space. "Greenhouses may seem to have little to do with the war against terror," says Mark Nall,

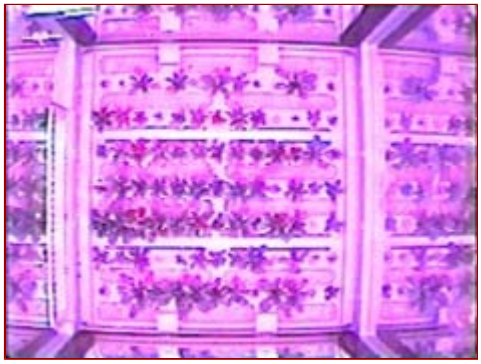
the director of NASA's Space Product Development (SPD) program. "But this shows how space research, along with its direct benefits, also helps people on Earth in indirect and unexpected ways."

Hayman explains: "[Space faring] astronauts will eventually need to grow some of their own food in greenhouses. But there's a problem: the leaves of growing plants release ethylene (C_2H_4) -- a gas that causes fruits and vegetables to mature." In the close quarters of a spacecraft (or inside an enclosed plant growth chamber), ethylene would build up and ripen greenhouse plants prematurely.

Space greenhouses needed a new technology to remove that ethylene.

In the 1990's, University of Wisconsin professor Marc Anderson and colleagues from the Wisconsin Center for Space Automation and Robotics (WCSAR) made a crucial discovery: They found that ultra-thin layers of titanium dioxide (TiO_2) exposed to ultraviolet light would efficiently convert ethylene into carbon dioxide (CO_2) and water (H_2O) -- substances that are good for plants. Titanium dioxide itself is a harmless, non-toxic coloring agent used in many consumer products. It is a catalyst for the ethylene-destroying reaction; no TiO_2 is consumed.

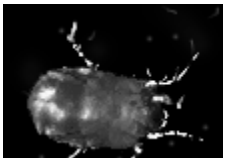
TiO_2-based ethylene removers have since flown to space inside a pair of plant growth chambers: ASTROCULTURE™ on board NASA's space shuttle and ADVANCED ASTROCULTURE™ on the International Space Station (ISS). The devices were built by WCSAR -- a NASA Commercial Space Center at the University of Wisconsin. WCSAR is one of 17 such centers around the country sponsored by NASA's Space Product Development program to encourage the commercialization of space by industry.



Above: A top-down view of the ADVANCED ASTROCULTURE™ plant growth chamber on the ISS, where reddish light illuminates the leafy heads of *Arabidopsis* plants. [more]

The technology worked so well that the University of Wisconsin collaborators joined forces with KES Science and Technology, Inc., to develop an ethylene scrubber for Earth. The device, called *Bio-KES*, works wonders in supermarkets where ethylene in the air of produce aisles reduces the shelf life of vegetables. *Bio-KES* was nominated as Discover Magazine's Product of the Year in 1998, and it's since been shipped across the globe for use by grocers and florists.

Moreover, *Bio-KES* is the parent of *AiroCide* TiO_2.



"It was a serendipitous discovery," recalls Hayman. Tests showed that *Bio-KES* not only removed ethylene, but also killed airborne dust mites. Marc Anderson quickly realized why: When ultraviolet (UV) photons

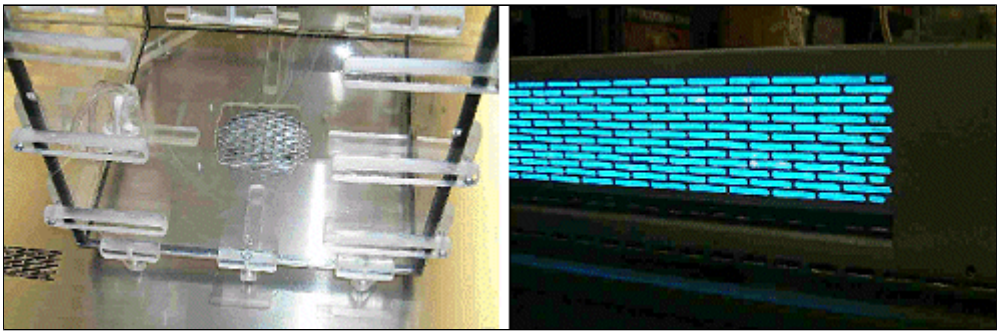
strike something coated by TiO_2 -- like the tubes inside *Bio-KES* -- positive and negative charges appear on its surface. Those charges tear apart nearby water molecules. The OH^- ion, a by-product of the reaction, disrupts organic molecules. It's deadly to dust mites, Anthrax and many other pathogens.

Above: The droppings of microscopic dust mites like this one trigger human allergies. [more]

Technicians modified *Bio-KES* -- adding higher-power UV lamps, for example, to give it "an extra kick," says Hayman -- and *AiroCide* TiO_2 was born.

Dean Tompkins, a colleague of Anderson's at the University of Wisconsin, is in charge of testing *AiroCide* TiO_2. "We don't use real Anthrax," he notes. "That would be too dangerous. Instead, we experiment with one of its non-virulent cousins: *Bacillus thurengiensis*." During a typical experiment, Tompkins propels a cloud of approximately 1000 spores through the *AiroCide* chamber. Only 100 or so emerge intact.

Below: In a laboratory at the University of Wisconsin, a plexiglass chamber (left) containing airborne spores covers the entrance to an *AiroCide* TiO_2 unit. Few microbes survive a journey through the machine. The exit port (right) reveals glowing UVC lamps inside.



Spores that enter *AiroCide* TiO_2 spend at least 5 to 10 seconds in transit through the device. "That's important," adds Hayman, "because pathogens that remain inside longer are more likely to die." To slow the spores, TiO_2-coated tubes within the unit are randomly arranged -- there's no direct path through the machine. When air moves across the jumbled tubes, the flow becomes turbulent -- forcing spores to linger where they can be attacked by OH^- and illuminated by germ-killing ultraviolet light.

Such powerful tools against bio-terror indeed seem a far cry from star-trekking greenhouses, but that's how many discoveries are made: You never know what new invention might emerge -- like *AiroCide* TiO_2 -- or what might be annihilated in the process -- like Anthrax!

To learn more about AiroCide TiO_2 *and similar space technologies, visit NASA's Space Product Development web site: http://spd.nasa.gov.*

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More Information

Space Product Development -- The goal of NASA's Space Product Development (SPD) program, managed from the Marshall Space Flight Center, is to help American businesses explore the potential--and reap the rewards--of doing business in space. SPD helps bring the benefits of space down to Earth where it enriches the everyday lives of the American public.

KES Science & Technology -- makers of *Bio-KES* and *AiroCide* TiO_2.

Wisconsin Center for Space Automation and Robotics -- a NASA-sponsored Commercial Space Center (CSC) at the University of Wisconsin. Says Weijai Zhou, "In 1995, WCSAR developed a first-generation ethylene scrubber based on TiO2 coating technology, which was integrated into the ASTROCULTURE™ Plant Growth Unit for the Space-Spud Experiment conducted on the STS-73/USML2 mission. Since then, the design of space-based ethylene scrubber has undergone several refinements. At present, the third generation of the scrubber is used by the Advanced ASTROCULTURE™ Unit and has demonstrated effective performances on board the International Space Station (ISS)."

Professor Marc Anderson -- a scientist at University of Wisconsin-Madison investigating and developing state-of-the-art photocatalytic oxidation technology. Anderson invented techniques for coating surfaces with layers of TiO_2 less than one micron thick. "That was the key for *Bio-KES*," says Hayman. "Such thin films of TiO_2 are very active chemically, and they don't peel off despite constant exposure to UV light."

Interactive Anthrax Tutorial -- an excellent introduction to *bacillus anthracis* from the National Institutes of Health.

Right: According to the National Institutes of Health, a person won't likely grow ill by inhaling a single Anthrax spore. Thousands are required to trigger an infection by *bacillus anthracis.* So many spores still doesn't add up to much material. Anthrax spores measure just a few microns across, so many thousands of them could fit on the head of a pin. [more]

More anthrax links: Encyclopedia.com entry on Anthrax; Anthrax FAQ from the Center for Disease Control (CDC); another CDC Anthrax FAQ; CDC images of inhalation Anthrax; Department of Defense Anthrax information site.

Leafy Green Astronauts -- (Science@NASA) NASA scientists are learning how to grow plants in space. Such far-out crops will eventually take their place alongside people, microbes and machines in self-contained habitats for astronauts.

Space Seeds Return to Earth -- (Science@NASA) Seed pods from a commercial gardening experiment aboard the ISS are back on our planet. The far-out pods could hold the key to long-term habitation of space.

Teaming Up on Space Plants -- (Science@NASA) Students, scientists, and astronauts join forces to learn more about how plants grow in space.

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