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Technology for growing plants in space leads to device that destroys pathogens, like anthrax

Terrorism may seem to have little to do with growing plants, but building miniature greenhouses for the International Space Station has led to the invention of a device that annihilates anthrax — a bacteria that can be deadly when inhaled. Space research often results in products that benefit people on Earth in unexpected ways.

Photo: Anthrax-killing device installed on wall (NASA/MSFC)

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Building miniature greenhouses for experiments on the Internationa Space Station has led to the invention of a device that annihilates anthrax -- a bacteria that can be deadly when inhaled.

"Space-based greenhouses may seem to have little to do with the war against terrorism," said Mark Nall, director of the Space Product Development Program at NASA's Marshall Space Flight Center in Huntsville, Ala. "Yet this invention shows how commercial space research can benefit people on Earth in unexpected ways."

The anthrax-killing air scrubber, AiroCide Ti02, is a tabletop-size metal box that bolts to office ceilings or walls. Its fans draw in airborne spores and airflow forces them through a maze of tubes. Inside, hydroxyl radicals (OH-) attack and kill pathogens. Most remaining spores are destroyed by high-energy ultraviolet photons.

"Spores that pass through the box aren't filtered -- they're fried," said John Hayman, president of KES Science & Technology Inc., the Kennesaw, Ga.-company that manufactures AiroCide Ti02. "That's appealing because you don't have to change an anthrax-laden air filter."

The technology to build the anthrax killer emerged from another product, Bio-KES, which is used by grocers and florists to remove ethylene and thus extend the life of vegetables, fruits and flowers. Ethylene (C2H4) is a gas released by the leaves of growing plants --

but too much of it can build up in an enclosed plant growth chamber or produce storage facility.

Too much ethylene causes plants to mature too quickly, fruit to ripen prematurely, and it even accelerates decay. This hinders researchers' efforts to harvest healthy plants grown in space and would also be undesirable when space travelers build larger space-based greenhouses for growing fresh food.

The research that led to the invention of Bio-KES started with a crucial discovery made in the early 90's by scientists at the Wisconsin Center for Space Automation and Robotics - a NASA Commercial Space Center at the University of Wisconsin-Madison. These scientists collaborated on the discovery with Dr. Marc Anderson, a professor and chemist who also works at the university.

The research team found that ultra-thin layers of titanium dioxide (TiO_2) exposed to ultraviolet light converted ethylene into carbon dioxide (CO_2) and water (H_2O) -- substances that are good for plants. Subsequently, they developed a coating technology that applies TiO_2 layers to the surfaces of many materials.

The Wisconsin Center for Space Automation and Robotics, which specializes in developing robotics/automation technologies for agriculture and biotechnology research in space, used the TiO_2 coating technology to design an ethylene scrubber. This first-generation ethylene scrubber was used effectively inside the ASTROCULTURE™ plant growth unit, which grew potato plants during Space Shuttle mission STS-73 in 1995. Over the years, scientists refined the ethylene scrubber, and currently, the third-generation scrubber is being used successfully inside the ADVANCED ASTROCULTURE™ for plant experiments on the International Space Station.

This Space Station experiment and the Wisconsin Center for Space Automation and Robotics are part of NASA's Space Product Development Program, which encourages the commercialization of space by industry. There are 17 Commercial Space Centers across America, each specializing in a variety of areas such as agriculture, materials and biotechnology.

"Through our program, companies invest resources to do experiments in space that can benefit their businesses," said Nall. "This results in new and improved products and services for the American public."

Commercial Space Centers and their industry partners also explore how technologies, like the ethylene scrubber, created to conduct space-based research can be used for a variety of purposes, like killing anthrax, on Earth. In this case, KES Science and Technology licensed the TiO_2 coating technology from the University of Wisconsin, which allowed them to

develop an ethylene scrubber and an anthrax-killing scrubber for use on Earth.

The first product the company developed for Earth-use was the Bio-KES -- used to remove ethylene in the air of produce and floral storage rooms and warehouses, thus increasing the shelf life of flowers, fruits and vegetables. The device, nominated as Discover Magazine's Product of the Year in 1998, is used across the globe by grocers, warehouse owners, and florists.

"Our tests showed that Bio-KES not only removed ethylene, but also killed airborne dust mites," said Hayman.

When the ultraviolet light strikes the TiO_2 tubes inside Bio-KES, it creates positive and negative electrical charges. These charges tear apart nearby water molecules (H_2O) and produce hydroxyl radicals (OH-).

"This hydroxyl by-product disrupts organic molecules and is thus deadly to dust mites, anthrax and many other pathogens," said Hayman. "We put higher-powered ultraviolet lamps in the AiroCide TiO_2, so more hydroxyl radicals are produced, giving it an extra kick."

Scientists at the University of Wisconsin tested the AiroCide TiO_2 with a non-virulent cousin of anthrax. During a typical experiment, a cloud of approximately 1,000 spores was sucked into the chamber and only 100 or so spores emerged. Spores spend at least 5 to 10 seconds traveling through the device's jumbled tubes and often become trapped by turbulent airflow. They linger and are attacked by the hydroxyl radicals, or are zapped by the germ-killing ultraviolet light.

"The longer pathogens stay inside, the more likely they are to die," said Hayman. "Tests showed that as many as 93 percent of anthrax spores that enter the device are destroyed. Survivors are usually drawn back in on later passes through the reactor bed and are killed."

This is not the first serendipitous discovery to come out of the Wisconsin Center for Space Automation and Robotics program. The light source used to help grow plants in the ASTROCULTURE™ hardware has been adapted for use in a variety of medical treatments. Quantum Devices Inc., a Barneveld, Wis. company, makes light emitting diodes for the plant chambers. The company has been collaborating with NASA and the Medical College of Wisconsin in Milwaukee to study the benefits of using a similar light source to treat brain and skin cancer, and heal wounds. Preliminary results from human clinical trials have been encouraging.

Commercial activity through Commercial Space Centers, such as the Wisconsin Center for Space Automation and Robotics,

has resulted in the development of numerous products and new technologies, licensing agreements and patents.

NASA has scheduled several more commercial experiments for upcoming Space Station expeditions. To learn more about Space Station experiments and science operations, visit:

http://www.scipoc.msfc.nasa.gov/

Related Web Sites

Space Commercialization: http://www.commercial.nasa.gov/

Space Product Development: http://www.spd.nasa.gov/

Office of Biological and Physical Research: http://spaceresearch.nasa.gov/

Wisconsin Center for Space Automation and Robotics: http://wcsar.engr.wisc.edu/

KES Science and Technology, Inc.: http://www.kes-pro.com/

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