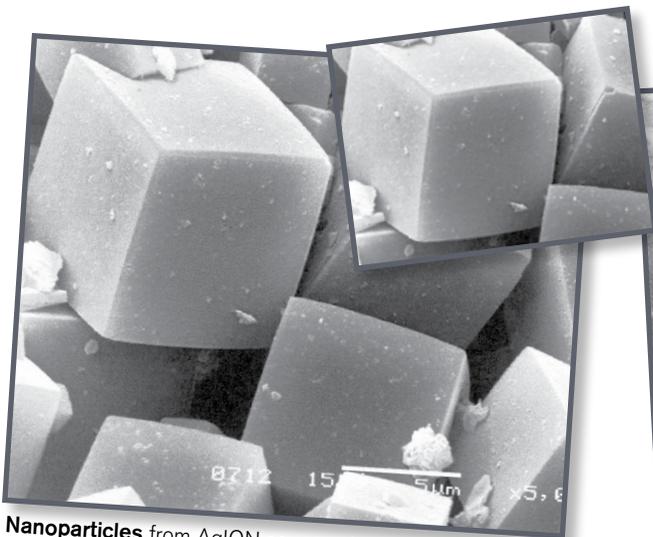
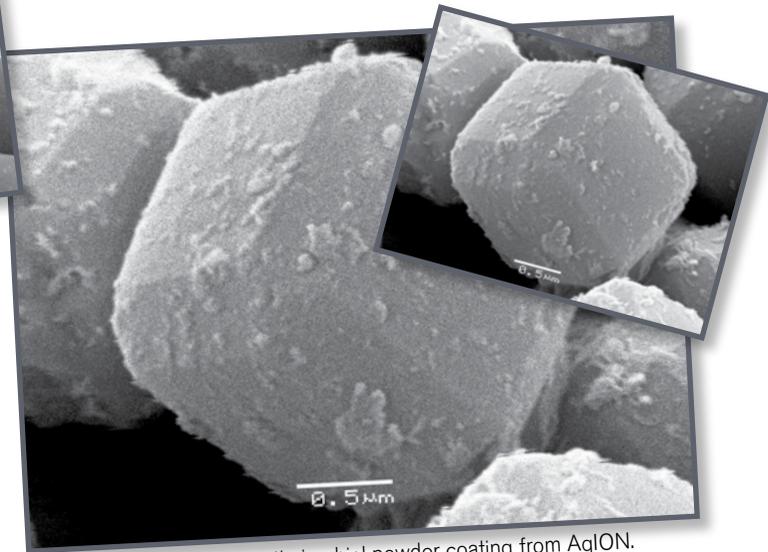


SAFER SURFACES



Nanoparticles from AgION as seen through a scanning electron microscope.



A nanoparticle for an antimicrobial powder coating from AgION.

Antimicrobial coatings kill bacteria and inhibit their growth.

by larry adams

Antimicrobial coatings are being increasingly used to improve the hygiene of many types of appliances, including foodservice equipment, medical devices, home appliances, and, recently, even consumer electronics. As a general rule, suppliers say that an antimicrobial coating is one that consistently kills greater than 99 percent of the bacteria that it encounters within a 24-hour period and inhibits bacteria multiplication. At the same time, the suppliers say the coatings offer long-term efficacy through the use of slow-releasing ions.

In years past, some suppliers of antimicrobial products made inflated claims about the efficacy of their products. Subsequently, this issue was addressed by the Federal Insecticide Fungicide and Rodenticide Act, passed in 1972 and amended in 1996. Today, new antimicrobials must be registered with the EPA and their claims of effectiveness are closely monitored. Coatings that may come in contact with food or liquids must also

meet FDA standards.

Most suppliers test the effectiveness of their coatings through independent laboratories that use the Japanese international standard, JIS Z 2801:2000. Laboratories test against numerous bacterial strains (see sidebar, "Beating Back Bacteria"), attacking everything from simple *E. Coli* to *MSRA*, the "superbug" that evolved from the more common *Staphylococcus aureus* that has become resistant to many antibiotics.

Numerous studies have backed up the claims made by the coating suppliers. For instance, the Carrier Corp., Syracuse, N.Y., evaluated the effectiveness of antimicrobial coatings from AgION Technologies, Wakefield, Mass, by testing a silver and zinc-containing zeolite matrix, which is the carrier medium delivering the coating to the test coupon. The coating, used on stainless steel, was tested for antimicrobial property against *E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Listeria monocytogenes*.

Coating / Washing method	Percent reduction on Trial #1		Percent reduction on Trial #3		Percent reduction on Trial #5	
	4h exposure	24h exposure	4h exposure	24h exposure	4h exposure	24h exposure
Wet process / test tube brush	97.170	99.999	69.608	99.907	54.506	99.851
Wet process / towel	92.536	99.999	92.077	99.999	15.933	99.997
Powder coat / towel	99.998	100	99.999	100	86.372	100

In testing by Miami University, Oxford, Ohio, conducted for Carrier, the ability to kill or inhibit *E. Coli* after repeated washing is reduced, but still tops 99 percent after 24 hours.

Fig. 1. Durability of antimicrobial efficacy against *E. coli* after repeated testing and washing.

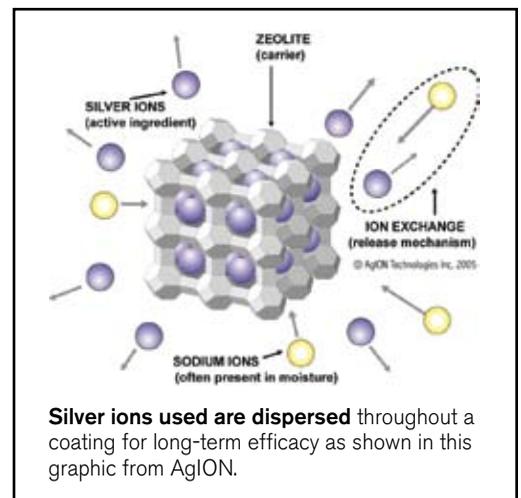
The tests, performed at the Department of Microbiology at Miami University, Oxford, Ohio, found that the silver-zeolite mixture reduced microbial colony-forming units from 84.536 percent to 99.999 percent after 4 hours of exposure, and from 99.992 percent to 100 percent after 24 hours. Some reduction in effectiveness was noted after several washings, but the kill ratio still topped 99 percent after 24 hours. (See Fig. 1).

By reducing the growth of bacteria, the antimicrobials can help stop the build up of biofilm, which are formed when “fast mutating versions of individual planktonic bacteria attach to a surface where they multiply, colonize, and form a polysaccharide covering to protect the colo-

nies,” according to white paper by Bruce L. Gibbins, chief technology officer for AcryMed, Beaverton, Ore. In essence, a biofilm acts as a biosphere that not only dispenses bacteria on contact, but also attracts additional bacteria to future populate its colony.

A microbe’s ability to adapt and evolve has led to resistance to antibiotics, and a worldwide concern exists that soon bacteria will be resistant to all antibiotics. This resistance has given rise to “superbugs” such as MRSA. However, because silver ion is an inorganic material, bacteria are not able to develop a resistance to it, as they do on synthetic materials, says Jeff Trogolo, Ph.D. and chief technology officer for AgION.

Carrier, along with American Air Filters, produces a complete line of filters that use AgION antimicrobial coatings. Honeywell, too, use antimicrobial coatings in their



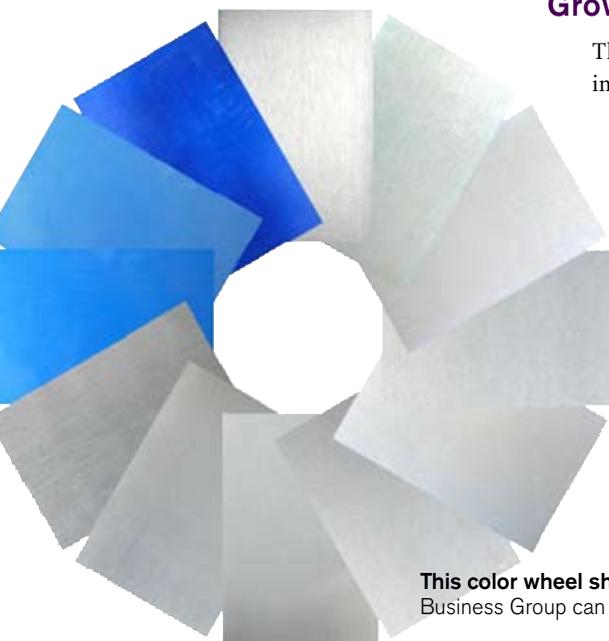
Growth in use

The use of antimicrobial coatings have expanded in recent years, as market acceptance has improved and designers and production personnel have come to understand the different coating products and the testing regimen that they undergo. The list of products using these coatings is extensive, but include HVAC systems, clothes washers, refrigerators, microwaves, humidifiers, vending machines, ice-makers, and commercial refrigeration.

humidifier filters.

This activity has caught the attention of market watchers such as Marlene Bourne, who monitors nanotechnology for Bourne Research LLC, Scottsdale, Ariz. She calls silver-based antimicrobial materials an “it” product for the near future.

As a rationale, she points to an LG Electronics refrigerator (GR-G227STBA) that has an antibacterial coating, and products manufactured by Samsung under its Silver Nano banner including refrigerators, clothes washers — which infuse the clothes with silver ions — and



This color wheel shows how Sureshield coatings from Horizon Business Group can be used on clear and pigmented coatings.

COATINGS

| Beating Bacteria |

Coating suppliers test their antimicrobial products against a number of bacteria. Here is just a sampling of them.

- ▶ *Listeria monocytogenes*.
- ▶ *Escheria coli* 0157.
- ▶ *Salmonella enteritidis*.
- ▶ *Staphylococcus aureus* (resistant strain).
- ▶ *Bacillus subtilis*.
- ▶ *Pseudomonas auruginosa*.
- ▶ *Salmonella typhimurium*.
- ▶ *Streptococcus faecalis*.
- ▶ *Legionella pneumophila*.
- ▶ *Vibrio parahaemolyticus*.
- ▶ *Enterobacter aerogenes*. ■



vacuum cleaners.

Samsung's Silver Nano Refrigerator uses silver-based antimicrobials on the inner surfaces of refrigerators for an overall anti-bacterial and anti-fungal effect. As air circulates, the coated surfaces allow the silver ions to control the airborne bacteria, the company says. The Silver Nano particles react with odor particles, which are "captured" and "taken" into the filter, along with unpleasant odors.

In October, Motorola released its i870 Multimedia phone that uses AgION Antimicrobial coatings. In December, I-Flow Corp., Lake Forest, Calif., received clearance from the FDA to market the ON-Q SilverSoaker, a silver-coated, antimicrobial catheter. The instrument is treated with SilvaGard, a silver agent licensed from AcryMed.

Types of antimicrobials

Antimicrobials come in two specific types: synthetic and natural. Synthetic antimicrobials as those used in cleaning wipes and hand soaps, while inorganic antimicrobials come from metals, primarily nanosized silver ions, but may include a variety of other metal materials including zinc oxide and copper oxide.

Typically, antimicrobial coatings are tailored to fit the application. Formulations can be designed using a mixture of metal compounds, but silver

is one of the most often used components because of its high efficacy against microbes and low toxicity levels. Silver ions are released over a period of time and these ions attack a microbe from several sites, with some researchers saying as many as 10 sites on each microbe.

When silver nano particles come into contact with bacteria, they suppress the respiration of bacteria. This, in turn, adversely affects bacteria's cellular metabolism and inhibits cell growth. According to Samsung, a colloidal silver solution is dispersed as sub-microscopic particles (1 nm – 100 nm) that penetrate the microbe cells.

Andrew Cockcroft, Global Business Development Manager for Akzo Nobel Powder Coatings Interpon, based in Felling, U.K., says for long-term effectiveness against bacteria, the silver-ions must be released slowly.

To accomplish this, a support medium is required, often an ion exchanger such as a zeolite. A zeolite, according to a producer of the material, Zeolyst, Valley Forge, Pa., are three-dimensional, microporous, crystalline solids that have well-defined structures that contain aluminum, silicon and oxygen. The aluminum and silicon ions are bound to each other through shared oxygen atoms. Because of the zeolite's innate ability to exchange ions, it absorbs the silver ions, and releases them when needed.

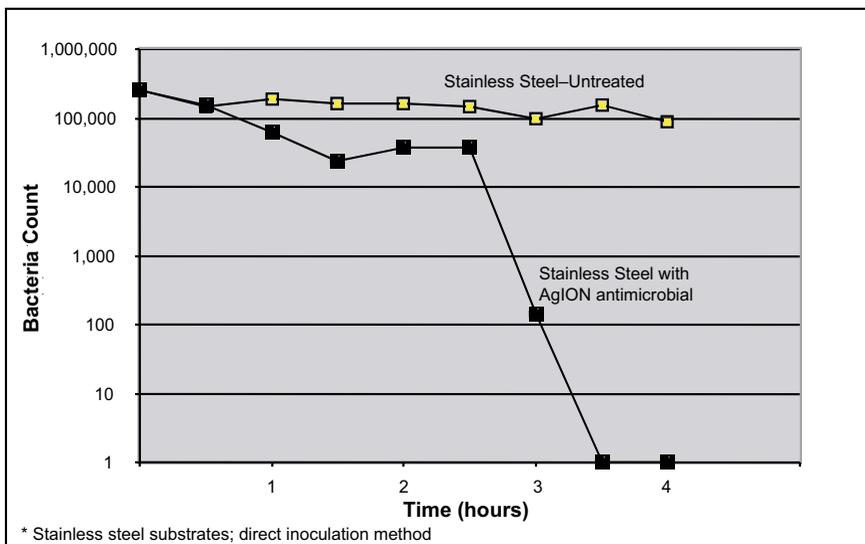
AgION also uses zeolite for its antimicrobial materials, says Trogolo. He adds that extended coverage happens because the silver ion toxins are released when it senses the release of enzymes that are secreted by the bioorganism. "Microorganisms need moisture and nutrients to live and reproduce and those two things trigger the release of the silver ions," he adds.

After the silver is released, the coatings shut off. "In a sense it is a smart material," Trogolo says. "It is recognizing the environment and responding in a functional way."

Not all silver

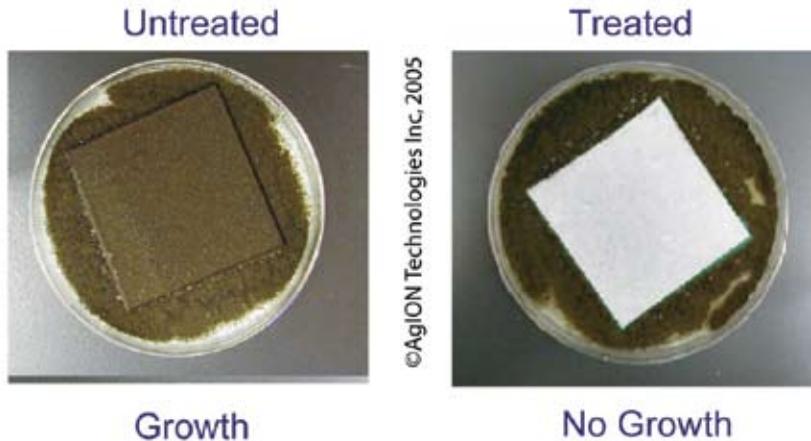
Not every company uses silver as its primary material. Most companies use a variety of materials and mix and match them as the application allows.

Comparison Of Microorganism Growth*



In this AgION graphic, the bacteria count on a treated part drops as compared to an untreated part.

10-Day Fungal Tests



Treated vs. untreated test coupons from AgION.

Nanophase, Romeoville, Ill., a company that licenses nanotechnology, including an exclusive agreement with coating supplier Industrial Nanotech, Naples, Fla., uses a variety of nanomaterials including zinc oxide, copper oxide and doped zinc-oxide products in its antimicrobial products.

Horizon Business Group, Northbrook, Ill., produces antimicrobial coatings, but rarely uses silver as a primary material. The company sells a coating called Sureshield, which can be made from more than 20 compounds, the exact mixture depending on the application. The antimicrobial compound that goes into Sureshield is called Ultra-Fresh, a product developed by Thomson Research Associates, Toronto.

HBG president, Michael Jacobs, says that the company does use some silver, but that it prefers to use other materials because silver is expensive and depletes over time. Sureshield may also help eliminate odors, stop fingerprints being left behind, and prevent microbial induced corrosion, a degradation of the metal surface caused by the differences in the coefficient of expansion of the coating material and the metal.

Jacobs says that another reason Sureshield does not use silver is because it may affect appearance. Silver can have a graying effect on clear coatings, especially when the silver is in the form of larger, non-nano particles.

In general, most experts say that the difference in appearance is often marginal, especially in pigmented coatings. But, the experts say that working closely with the supplier is key to achieving the wanted appearance. Often colors can be matched, clears can be made satisfactory, and scratch and abrasion resistance can be attained.

Product designers need to understand the environment in which their products are used and why they might want an antimicrobial coating. Having established that, they must be confident the coating will act as indicated.

So, choosing the antimicrobial coatings may come down to the idea of "trust, but verify." Trust should be placed with reputable suppliers with proven track records, but claims should be verified by studying the documentation and data to ensure that the suppliers meet federal regulations and have passed independent testing in labs using internationally accepted standards. ■

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Silver in History |

- 4000 B.C.E. – Egyptians line water cisterns with silver as a way to reduce illness caused by contaminated drinking water.
- 1200 – Phoenicians use silver-lined containers during long sea voyages to maintain water purity
- 78 C.E. – Pliny the Elder, a Roman naturalist, describes silver's healing properties in wound care
- 700's – Chinese emperors use silver utensils to prevent the transmission of disease.
- 980 – Avicenna, an Islamic philosopher and physician uses silver pills and filings as a blood purifier
- 1000 – The Vatican decrees that communion chalices should be made of silver to reduce the spread of disease between parishioners and priests
- 1350's – Wealthy families in Europe use silver utensils and plates to protect themselves from the plague.
- 1819 – Silver first used as an ingredient in dental fillings
- 1850's – Pioneers place silver coins in water and milk container to prevent the growth of bacteria and algae
- 1881 – Carl Crede, a German obstetrician, pioneers the use of silver nitrate drops in the eyes of newborns to prevent eye infections
- 1893 – Karl Wilhelm von Nageli, a Swiss botanist, publishes research demonstrating silver's antibacterial properties
- 1900's – Numerous silver-based medical products appear on the market, including Argyrol, a silver-based antibiotic
- 1960's – NASA uses silver to purify water on spacecrafts
- 1970's – Silver becomes commonly used as a topical ointment for wound and burn care ■

Source: AgION