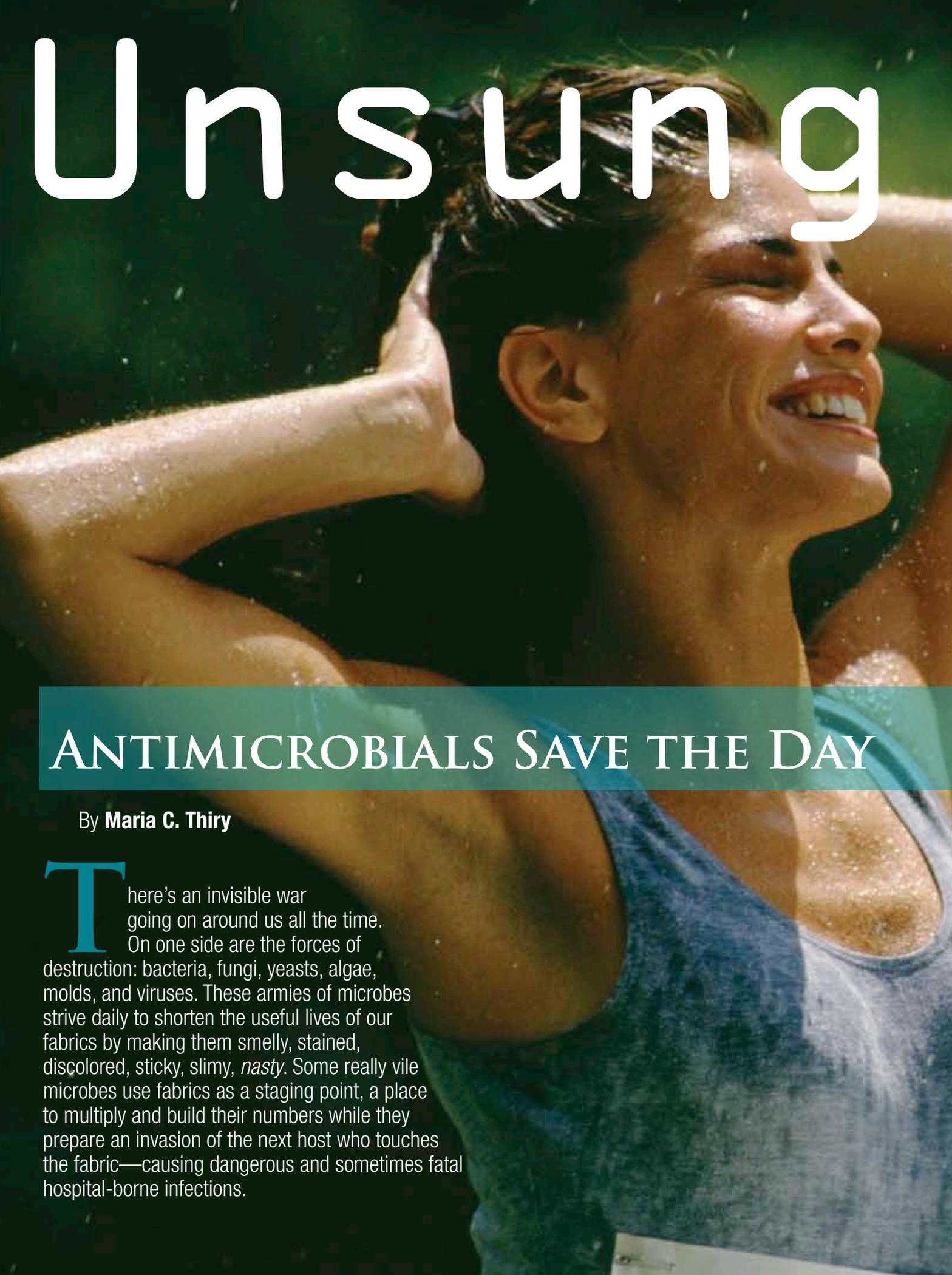


# Unsung

A close-up photograph of a woman with dark hair, smiling broadly and splashing water. She is wearing a blue tank top. The background is dark and out of focus, suggesting an outdoor setting like a pool or beach.

## ANTIMICROBIALS SAVE THE DAY

By **Maria C. Thiry**

**T**here's an invisible war going on around us all the time. On one side are the forces of destruction: bacteria, fungi, yeasts, algae, molds, and viruses. These armies of microbes strive daily to shorten the useful lives of our fabrics by making them smelly, stained, discolored, sticky, slimy, *nasty*. Some really vile microbes use fabrics as a staging point, a place to multiply and build their numbers while they prepare an invasion of the next host who touches the fabric—causing dangerous and sometimes fatal hospital-borne infections.

# Heroes

On the other side of this war are the unsung heroes: textile antimicrobials that battle those microscopic enemies, preserving fabrics' appearances and keeping them smelling pleasant. In some cases, they also help prevent "doctors' necktie syndrome"—cross-contamination from other fabrics.

"Antimicrobials bring benefits that make them part of the solution instead of part of the problem," says antimicrobial supplier Aegis Environments' president, Curtis White. "And they have been doing this job all along—un-hangtagged, unsung." Glenn Runciman, director of sales for Thomson Research Associates, suppliers of UltraFresh and Silpure brand antimicrobials, says, "Antimicrobials are routinely used in all kinds of textiles, but that isn't advertised. The products that are branded are only the tip of the iceberg."

According to Donald P. Satchell, director of liquids and formulations for antimicrobial supplier Microban, hangtags and similar devices calling the consumer's attention to the presence of an antimicrobial on a fabric is a fairly recent phenomenon. "A branded antimicrobial provides an assurance of quality for the consumer," he says.

Whether their presence is acknowledged or not, antimicrobials serve a vital role. Because their tiny microbial enemies are diverse and cause an assortment of problems, different antimicrobial technologies have benefits and limitations that make them appropriate for various end-use applications.

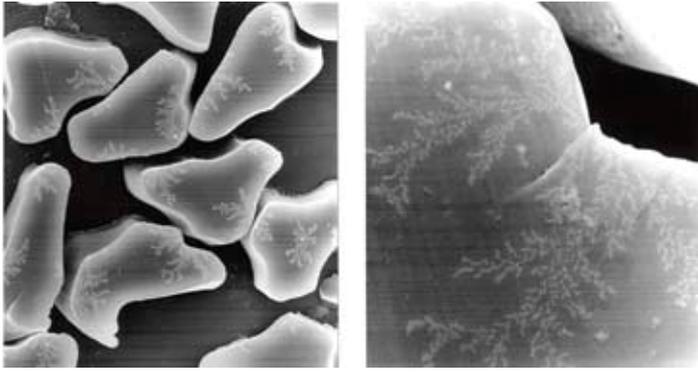
## DECIDING FACTORS

The growing awareness of antimicrobials for textiles in recent years has come from "the demand for improving the overall functionality of textiles," says Sandeep Khatua, director of softlines technical services for testing laboratory Bureau Veritas Consumer Products Services Inc.

However, achieving this functionality isn't always simple. Jeff Gabbay, president of antimicrobial fiber producer and textile medical equipment provider Cupron Inc., says, "Depending on the end-use, certain considerations may affect the type of antimicrobial you choose."

## Dosage

"What do you want your antimicrobial to do: kill microbes, or keep microbes below a certain level?" asks Gabbay. You may not *need* a killing machine. "You don't get better odor control by applying a higher dosage than necessary," says Gabbay. He says it's also important to keep dosage in mind when *comparing* antimicrobials. "Compare apples to apples," he says. "One antimicrobial might need a much higher dosage to get the same job done."



SEM (scanning electron microscope) images of Makspec fabric, made by Toray Industries Inc. Makspec fibers include antimicrobials applied to the fiber in a process similar to dyeing, for exceptional durability. *Courtesy of Toray Industries Inc.*

### Speed and Spectrum

*Spectrum* refers to the array of microorganisms vulnerable to a particular antimicrobial. What must the antimicrobial kill? Again, end-use determines which spectrum is appropriate. A broad-spectrum antimicrobial that can kill everything from fungus to viruses may sound wonderful, but it can be like bringing a nuclear weapon to a barroom brawl. Odor control often requires just an antibacterial.

Slower-acting antimicrobials work well to control odor, but for some end-uses an antimicrobial speed-demon is necessary. Generally speaking, healthcare settings and wound care require the fastest-acting and broadest-spectrum antimicrobials to rush to the job.



C. F. Stinson upholstery fabric with antimicrobial. *Courtesy of Agion.*

### Environment, Health, & Safety

Since it's the job of antimicrobials to *kill* things, it's not unreasonable to be cautious about their effect on the environment. Satchell says that important considerations include metal

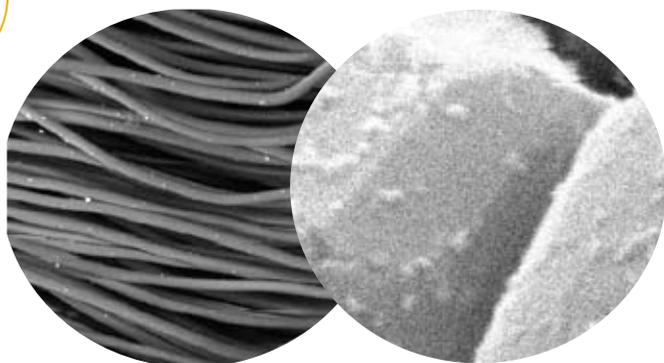
discharge, biological oxygen demand (BOD), and whether particular chemicals have been banned or regulated. Gabbay says that it's important to remember that antimicrobials can affect the environment "when the chemical is *produced*, when it is *applied to the fabric*, and when that fabric is *laundered*." Not to mention what may happen when the fabric with the antimicrobial ends up in the landfill or incinerator.

On the other hand, White points out that antimicrobials may affect the environment beneficially as well. "The preservative value of antimicrobials can't be overemphasized," he says. "Antimicrobials are very green because they extend the usable life of the fabric, keeping it out of the landfill." Microbes cause problems for textile products and textile users at all stages of production. "In the textile mill, fibers and yarns can be stored wet and vulnerable to microbes," notes White. "A damp warehouse can foster mold—then you get discoloration and odors." Even during transport, fabrics aren't safe from microbial enemies. "Five to seven years ago," relates White, "A big dock strike meant that hundreds of container ships were kept offshore for months. Many of the textile products in those shipments were degraded and unusable." Without their antimicrobial protectors, fabrics are too vulnerable. By extending fabrics' useful lives, antimicrobials benefit the environment by protecting the resources used to manufacture those fabrics in the first place.

Antimicrobials also reduce odors in garments, leading to less frequent laundering and laundering at lower temperatures, says Kristofer Skantze, head of sales and marketing for antimicrobial supplier HeiQ Materials AG. Cumulatively, consumers washing clothing less frequently and at lower temperatures is of benefit to the environment as well.

Besides being benign to the environment, antimicrobials also must be safe both to end-users, and workers applying the chemistry to the fabric. Gabbay says health concerns include skin irritation or sensitivity, allergenicity, biocompatibility, blood absorption, and cytotoxicity. Textile medical devices meant to be implanted or held against an open wound must satisfy even more stringent requirements, says Mark Wiencek, senior microbiologist at antimicrobial supplier Milliken.

Antimicrobial Applications	
End-uses	Examples:
Medical	Bandages, dressings, wound care, hernia fabrics
Military	T-shirts, underwear, socks
Apparel	Activewear, sportswear, socks, shirts, shoes
Industrial	Uniforms/workwear, for odor control and protection against cross-contamination
Healthcare	Fight against hospital-borne infections and cross-contamination. Cubicle curtains, bed sheets, patient gowns, uniforms
—Joel M. Furey, Noble Biomaterials, X-Static brand	



SEM images of fibers coated with Agion antimicrobial, and closeup of antimicrobial on the fiber. *Courtesy of Agion.*

### Regulatory Concerns

In the US, antimicrobials must be registered by the Environmental Protection Agency (EPA), unless they are medical devices with textile components, which are regulated by the US Food & Drug Administration (FDA).

Textile antimicrobial consultant William Hanrahan says EPA registration requires listing the *specific* end-use for the antimicrobial—whether for general apparel, upholstery, uniforms, or intimate apparel. Another area where special regulations come into play is any end-use that involves food, says Satchell.

Antimicrobial products need to pass regulatory demands where they are produced, where the fabric is processed, and where the end-products are sold. Europe’s Biocidal Products Directive (BPD) regulates antimicrobials somewhat like the US EPA. Japan, Taiwan, Korea, Australia, and New Zealand, among others, also have strict registration regulations for antimicrobials.

Not only are the chemicals themselves controlled, but regulatory bodies also control what *claims* can be made for the antimicrobial. The EPA makes a fundamental distinction between protecting the *textile* and protecting *persons*—public health claims. For example, manufacturers can claim an antimicrobial will protect a fabric from developing odors due to bacteria, but can *not* claim that the antimicrobial will protect the user from bacteria.

### Manufacturing Concerns

A final concern is how to get antimicrobials onto the fabric in the first place. Don A. Alexander, president of Anovotek LLC, says the antimicrobial can drive up total manufacturing costs if the application is difficult or if it’s not compatible with other finishes. “Antimicrobials can affect moisture wicking, fire retardants, and abrasion-resistance,” says Satchell. “They can affect the durability or efficacy of certain ceramic coatings.” Wiencek notes that some antimicrobials with poor thermostability may not survive certain textile processes. Additionally, the antimicrobial should not alter any desirable textile properties like hand or shade.

Cost is often the bottom line. No matter how effectively an antimicrobial performs, if it adds too much to the cost of manufacturing an item, its use will be limited.

### Durability

Durability is a key consideration when choosing antimicrobials. According to Alexander, two important aspects of durability are “How long does the antimicrobial stay on the fabric surface?” and “How long does it work?” Also consider: to what challenges must the antimicrobial durable?

Durability requirements vary with end-use. General apparel requires home laundering durability, while uniforms are typically subjected to industrial laundering. “Home laundering durability can be achieved, but industrial laundering durability is much more difficult for most antimicrobial technologies,” says Wiencek. Upholstery antimicrobials need far less laundering durability than apparel, notes Alexander, although the need for durability to abrasion and sunlight is far greater. Quaternary silanes are cationic antimicrobials, while detergents are anionic, says Wiencek. “A detergent can ‘put a cover’ over them,” he says. “Therefore, quaternary silanes are more suitable for things that don’t get washed often.”

Fine-Tuning Protection		
End-Use	Exposure & Incubation	Antimicrobial Protection Required
upholstery boat covers tents awnings airline seats automobile seats	infrequent cleaning—high micro-organism exposure; long incubation period	physical and aesthetic deterioration of the product
towels uniforms padding liners	multiple uses between cleanings—lower microbial exposure; long incubation period	aesthetic deterioration and odors
underwear innerwear	frequent cleaning cycles—very high exposure to microbes; very short incubation period	odor control
—Don Satchell, Microban		

## ANTIMICROBIAL TECHNOLOGIES

The most widely used antimicrobials, according to Satchell, are triclosan, quaternary silanes, polyheximethylene biguanides (PHMBs), silver, and zinc pyrithiones. The first three are the most traditional textile antimicrobials—what Wiencek refers to as the “organics.” Silver has gained in popularity in recent years, as new methods of application have arisen. Wiencek says that many times what drives an antimicrobial’s popularity is safety and regulatory approval. Several otherwise very effective antimicrobials cause irritation or allergic reactions, and must be relegated to applications where there is no contact with human skin.

## END-USES

“All antimicrobials have advantages and disadvantages,” says Hanrahan. “You have to look at what you’re trying to achieve and how you’re trying to achieve it. Which antimicrobial to use depends on the end-use, use pattern, processing, and the application of the antimicrobial.”

End-uses for textile antimicrobials can be grouped into three main functions: preservation (of appearance and function), odor control, and therapeutic and pathogenic control for healthcare.

### Preservation

Preservation generally involves maintaining the function and aesthetics of a fabric. The main microbial enemies in this arena are molds, algae, and fungi. Outdoor fabrics like tents, tarps, and awnings, and industrial fabrics, like geotextiles and filters, often need the support of antimicrobials. Most of these applications do not require textile antimicrobials that are approved for next-to-skin use.

According to Runciman, some of the antimicrobials used in this category include the arsenic-based OBPA (not much in use anymore) and the isothiazolinones (ITs) which have taken their place. Wiencek also lists zinc pyrithione, polysulfone, and tri-butyl tin-based chemistries.

### Odor Control

Controlling odor usually means controlling the bacteria that cause odor. According to Wiencek, “this is more a niche application for users that have truly experienced foul odors from garments, so they can tell if a product works and is durable.” In other words, the consumer has to be able to truly *notice* the benefit of the antimicrobial product, thus end-uses are limited to where odor problems are most noticeable. Textile antimicrobials used to control odor on garments most often include triclosan, quaternary silanes, PHMB, and silver.

## Medical and Healthcare

At first, says Damien Fruchart, textile engineer with Asix International Development Consultancy, “the medical community’s initial preoccupation [with textile antimicrobials] was limited to wound healing and infection treatment.” But with the rise of hospital-borne and antibiotic-resistant infections, healthcare facilities have become interested in using antimicrobially-treated fabrics in bed linens, curtains, upholstery, and uniforms to control cross-contamination.

“Textile materials can become a breeding ground for microorganisms. Microbes can be transferred via textiles. Antimicrobials applied on fabrics both reduce the dose of microbes on fabrics and reduce the transfer routes of those microbes,” says White. “People normally carry bacteria all the time. When they come in contact with textiles, the bacteria proliferate,” says Gabbay.

Additionally, in the US, “medical insurance companies have severely limited the coverage they provide for the costs of hospital-acquired infections, so hospitals are increasing their use of antimicrobial-treated fabrics,” says Runciman. Some of the antimicrobials used in this category include silver and n-halamine binders for chlorine.



Courtesy of Huntsman.

## NEW TECHNOLOGIES

New antimicrobial technologies are few and far between. One of the reasons is concern about safety and performance. Or, as White says, “finding the groove where the antimicrobial kills microbes but is safe to use and environmentally safe.”

Another reason is regulatory. “There are not many new antimicrobial technologies because they have to register under the US EPA or the European BPD,” says Wiencek.

“Companies need to submit data to back up their claims of safety and effectiveness to these agencies, and the testing is very expensive.” He says the necessity to register products stifles the innovation of brand new technologies and therefore many new products will just be tweaks on existing technology.

The third hurdle for any new technology, says White, is compatibility requirements with existing manufacturing methods and end-uses.

Many new antimicrobial products can be grouped under the rubrics of “natural” or “nano.” Darrell Burnette, business development manager for Sanitized NA, says, “Interest is increasing for antimicrobial technologies... developed out of natural resources. However, it must be mentioned that performance is often less impressive than with today’s known and used technologies.”

“Many ‘natural antimicrobials’ are neither durable, nor suitable for textile application,” says Runciman. He says that bamboo is the newest antimicrobial fiber being explored because of its renewable “green story.” However, he points out that the processing of

bamboo into fabric is very environmentally unfriendly. He also notes that if bamboo is truly antimicrobial, it should be registered with US EPA to be able to make antimicrobial claims.

Wiencek says another natural antimicrobial is chitosan—made from crab and shrimp shells. Chitosan is most often used in wound dressings and bandages, because as well as having a natural antimicrobial effect, it coagulates blood. However, the product has not made substantial inroads into general use as an antimicrobial textile.

On the “nano” end of the scale, much attention has been paid to nano-silver products. “Nanoscale silver optimizes the use of our raw materials and permits better binding properties, providing excellent antimicrobial performance and durability while conserving resources,” says James L. Delattre, vice-president of global sales and marketing for nanosilver supplier NanoHorizons Inc. He says other benefits of nanoscale silver include “particles so small, that they don’t compromise the hand, stretch, or strength of textiles...for example microdenier fiber can be extruded without clogging spinnerets.” On the other hand, some consumer groups have expressed concerns about the safety of nanotechnologies in general, including silver nanotechnology. Regulatory agencies may investigate these concerns.

Jeff Trogolo, chief technology officer for antimicrobial supplier Agion, says that his company has developed a treatment for high-tech wicking fabric, and the bacterial odors in vapor form that are wicked out from the fabric along with the sweat. Instead of killing the bacteria themselves, the treatment is meant to neutralize the odor compounds produced by the bacteria.

Khatua says that a new antimicrobial has been developed to act like a direct dye for a durable antimicrobial for polyester and polyamide fibers and their blends.

Wiencek says that research is being done on antimicrobial peptides. “All animals have antimicrobial peptides,” he says. “They’re the first line of defense against bacteria.” Other research is focusing on disrupting or interfering with the way that bacteria communicate with each other to secrete new molecules and form biofilms on the surface of a textile. “The potential benefits of cell-cell signaling disruption is that there would be low toxicity, except to bacteria,” says Wiencek.

## MARKET TRENDS

A new market for antimicrobials, says Joel M. Furey, marketing manager for antimicrobial supplier Noble Biomaterials’ X-Static brand, is airline seats. “They are integrating antimicrobial protection into seat covers to inhibit the growth of bacteria on the seats,” he says.

Hanrahan says the “sleeping giant” of a new market for antimicrobials is residential carpeting. Antimicrobials are already routinely

used in commercial carpeting, especially in schools and healthcare facilities. “I foresee growth in residential carpeting,” says Hanrahan. “A decade ago, consumers paid a premium to stain-protect their carpet. Today, they don’t pay extra for stain-protection anymore. Carpet manufacturers have to swallow the cost of stain protection. They don’t want the same thing to happen with antimicrobials, so are resisting it for residential carpeting. It’s a case of who is going to blink first, though.”

At the same time, Hanrahan says the market for, “antimicrobials in sportswear is growing and will continue to grow.” Another trend is that “triclosan and organic products will have smaller market share. Market share will move much more toward silver,” says Skantze. Part of the reason for that recent trend toward silver is the growth of the healthcare market for antimicrobials. The healthcare market has a history of using silver and a certain confidence level that make silver-based antimicrobials an easy entry into this market.

“Medical uses appear to be growing rapidly with the increased awareness of hospital- and community-acquired infections,” says Delattre. According to Helmut Mucha, executive scientist at the Hohenstein Institute for textile research and testing, “the most important area for antimicrobial textiles is the medical sector. The general aim of these textiles is the prevention of hospital-acquired and social-acquired infections.” By “social acquired,” Mucha means in home care and nursing homes.

According to Robert Curtis, product support manager for antimicrobial supplier Eastman Kodak Co., the growing trend of using textile antimicrobials in healthcare facilities includes fabrics with the highest potential for transmission: lab coats and uniforms, cubicle curtains, bed linens, and upholstery.

Mucha says that “more and more functional textiles have an antimicrobial treatment, such as diapers, antidecubitus support, neurodermatitic cloths, socks, wound-dressings, and threads for wounds.”

Wiencek sees copper as an emerging antimicrobial technology for textiles, and sees interesting trends for copper. “Last year, the Copper Development Association (CDA) got approval from the EPA for copper alloys with at least 60% copper to make health claims for treated articles,” Wiencek says. “Textile antimicrobials may be able to follow that path for development.”

Along with these new markets and developments, Runciman sees a trend toward more branding and marketing of a product’s antimicrobial features. “Antimicrobials have been ‘under a rock’ for years,” he says. “Now companies want to point out the features they are putting into the product to the consumer, to differentiate their product in the marketplace.” Textile antimicrobials may not be unsung heroes for much longer. 

**NOTE:** For an in-depth look at Antimicrobial Testing, please see the June issue of our e-newsletter, *AATCC News*. Subscribe at [www.aatcc.org/media](http://www.aatcc.org/media).

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