Germ Warfare

A new breed of antimicrobial polymers is at work waylaying the growth of potentially harmful bacteria, molds, and fungi in an array of industrial, institutional, and consumer products. Developed by a trio of North Carolina biomedical engineers at Microban Products Company, the antimicrobial additives go into the products and materials they protect during the manufacturing process, yielding an inherently effective defense against the growth of microbes—and a protection that won't wash off or wear away. Independent laboratory tests have consistently shown dramatic reductions in microbial populations present on materials manufactured with Microban.

A large number and variety of products now incorporate Microban including kitchen cutting boards, dental instrument trays, surgical incise drapes, socks, bedding, food-service wipes, and even concrete and industrial drains. The list is growing, thanks to the demand by companies seeking to infuse antimicrobial properties into their products and the public's blossoming awareness of the ravages these omnipresent microbes can inflict on the human body.

The Quest for Cleanliness

The quest for cleanliness is hardly new. During World War I, the Germans discovered that antimicrobial treatments for uniforms worn by soldiers engaged in trench warfare lowered the incidence of secondary wound infections. However, until now, virtually all antimicrobial treatments were applied topically.

Topically applied finishes (for example quaternary ammonium compounds in silicone carriers) eventually wear off. Ironically, the same kind of "wear and tear" that erodes these coatings and renders them ultimately ineffective actually triggers the release of more Microban molecules at the surface of the material. The activation of these molecules from abrasion yields permanent effectiveness over the product's lifetime.

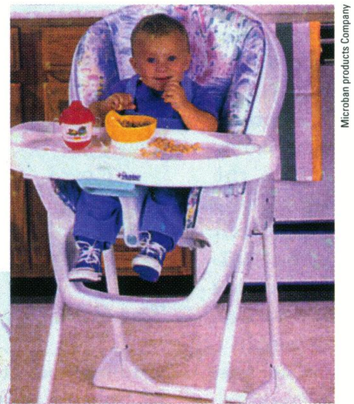
The development of Microban's antimicrobial polymers evolved over a period of several years. Since their days at Bristol-Myers' medical products division, Microban President Glenn Cueman and his cofounders Henry Richbourg and Barnwell Ramsey had product development in their blood. They also understood the critical need for clean medical environments. In 1987, they left Bristol-Myers—each of them with a 15-year tenure behind them—to form Clinitex Corporation, the forerunner of Microban. Clinitex produced orthopedic and specialty medical devices and related products for hospitals and long-term care facilities, as well as for in-home medical care.

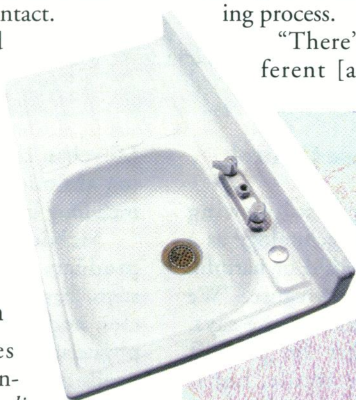
"Back in the '70s and '80s, we were constantly looking for a way to improve medical devices," Cueman recalls. "Control of microorganisms was tops on that list." For years, the medical community relied on steam, gas, or radiation to kill harmful microorganisms. And even with procedures like iodine scrubs and alcohol preps, there was always the fear that a patient might leave the hospital with an illness worse than the one he or she had coming in, Cueman says. The whole environment poses a threat to surgery patients, from surgical drapes that harbor germs to the heating and air-conditioning ducts that spew air contaminated by colonies of molds and mildew.

"That was where we began our quest," says Cueman. He and his colleagues wanted to make a material that would be inherently resistant to microbial contamination. They knew that heavy metals such as arsenic, copper, zinc, and silver were microbe-resistant and could be extruded during the polymer manufacturing process, but that such materials were often unsuitable or unsafe for human contact. Instead, they sought to find a compound that "was well-documented for contact with human skin," Cueman says, then to encapsulate it and introduce it into a product during the manufacturing process.

Antimicrobial Protection

Just how these molecules defeat pathogenic microorganisms including *Escherichia coli* and *Salmonella enteritidis* is a small miracle. Using the Microban process, synthetic fibers or plastics incorporate pellets encapsulating high concentrations of antimicrobial additives. These additives differ according to the chemical makeup of the product for which the pellets are eventually destined. According to Cueman, the pellets look identical to the polymers Microban customers use to make their products, and are handled the same way during the manufacturing process.





The front lines. New products containing antimicrobial polymers include children's chairs, mattress pads, and countertops.

"There's a different [additive development] process for each type of material being made," Cueman says. For example, when the eventual product is socks, "The manufacturer will solubilize our product, then repolymerize it during the fiber extrusion process," Cueman explains. "Basically, we're a custom formulator. We have a database that shows how much [of the additive] to use for each application," he says.

For example, a cutting board with the Microban additive is formed from polyethylene pellets one-tenth of an inch square. Except for containing the antimicrobial ingredient, Microban pellets are the same color and composition as the basic material, Cueman explains, and "become intimately blended, part of the product's molecular structure." The synthetic additive retains its antimicrobial properties for the life of the fabric or plastic into which it is formulated, and it is not water-soluble. According to independent tests by several laboratories, the additives are noncarcinogenic and nonallergenic to the skin. Depending on the application, the additives also bear the stamp of FDA approval or EPA registration.

The trick to the Microban ingredient's function is introducing it into the polymer's amorphous phase. "We don't want it to chemically react or cross-link," says Cueman. Because these molecules exist in the amorphous phase, they are free to migrate within the polymer, and do so when the product's surface is abraded—when, for example, a cutting board, sock, or mattress pad is used or washed.

The additive remains within the interstitial spaces of the fiber or plastic's polymeric backbone. Suspended there, the additive is free to migrate to the surface, reactivating the product's antimicrobial properties. Microban's effectiveness is due in part to the low concentration of Microban additive dispersed throughout the material, with surface concentrations measured in micrograms per gram. Even though the Microban additives are dispersed into lower concentrations in the finished products, thousands of tests have shown them to be effective on a number of microorganisms, including gram-positive and gram-negative bacteria, ammonia-producing bacteria, fungi, dermatophytes, resident skin bacteria, molds, and yeasts. And, says Cueman, the product is both safe and permanent.

The Microban additives lie in ambush, waiting for unsuspecting microorganisms, then rupture their cytoplasmic membrane. This in turn releases a leakage of low-molecular-weight cellular material, which prevents the uptake of amino acids essential to further cellular growth. Like pins patiently poised to pierce a falling balloon, Microban pellets penetrate the thin cellular walls of the tiniest microorganisms. Thicker cell walls—such as those of human cells and insect cells, for example—remain impervious to this cellular invasion. So, while the antimicrobial additive is effective on bacteria and fungi, it is harmless to higher life forms. And, once ingested, the additive is quickly eliminated from the human body.

Because Microban operates as a cell-wall penetrator, it is difficult for microorganisms to build up an immunity to it, a noteworthy advantage in an age of drug-resistant bacteria. The additive has not only inhibited growth of methicillin-resistant *Staphylococcus aureus*, it has also shown similar effectiveness on four other strains of *Staphylococcus aureus*. Microban has also been effective with at least two strains of *Staphylococcus epidermis*, as well as two strains of Enterococcus faecalis.

Power pellets. In laboratory tests, bacteria-free zones surround antimicrobial pellets (red and yellow).

Extensive Testing

Microban Products Company employs a

number of laboratories to run extensive tests on the effectiveness of its antimicrobial additives. Tests include the Kirby-Bauer Antimicrobial Susceptibility Test and AATCC Method 147-1993—both of which generate qualitative data gathered by observing what happens when the Microban product comes into contact with a bacterial or fungal culture in a petri dish—as well as AATCC Method 100-1993, which generates quantitative data collected at intervals and shows a reduction in microbial count on the subject sample.

Various Microban applications are routinely tested on representative microorganisms including *Staphylococcus aureus*, *Esherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, and *Trichophyton mentagrophytes*. In these tests, if a sample shows a decrease in microbes greater than 90%, the sample is deemed to have shown antimicrobial activity. If testers see inactivity on the sample or observe increased microbial growth, then the sample is determined to be ineffective.

North American Science Associates, Inc. in Kennesaw, Georgia, is one laboratory that has run thousands of tests on products containing Microban. "The additive is certainly effective against quite a few microorganisms," says Antimicrobials Section Manager James Kautz. "Microban's products seem to be very consistent in their effectiveness, which probably has to do with the amount of research and testing they've done."

Other tests are being done to test Microban's effectiveness in the "real-world" environment. Greg McNiece, director of research and development at the Greenville Hospital System in Greenville, South Carolina, is responsible for testing a number of products containing Microban, including drains and concrete flooring in hospital decontamination rooms, acrylic flooring, countertops in food preparation areas, carpeting, and surgical drapes.

When a polymer chemist from Microban first approached McNiece with antimicrobial products to try, McNiece admits he was "a little skeptical about bringing [the product] into the health care setting," fearing that the hospital would somehow end up with a "mutated, resistant strain of bacteria." His concerns were allayed when he found that Microban offered a synthetic polymer additive. "This is a passive system that doesn't seek the cell, but sits there like little daggers waiting to burst the bubble," McNiece explains. "It's not transferrable from one cell to another, but locked into the chains of the polymer. That's a safety net right there."

Suggested Reading

Gruender M. Antimicrobial acetate fibers: a step forward in health care textiles. CARING Mag 15(11):34–41 (1996)

Gruender M. New acetate works against bacteria. Am Textiles Int 25(1):FW5–FW8 (1996)

Hanrahan WD, Patil AS. Fighting bacteria from within. Textile Technol Int 173–175 (1996)

The Question of Disease Control

Cueman cautions against viewing Microban's antimicrobial technology as a panacea for ridding the world of harmful germs and the diseases they cause. "We paint a very realistic picture," he says, "which does not mean that the [product containing Microban] is sterile, but is much more resistant." Manufacturers must be diligent about labeling, he adds, and careful not to mislead product users, especially now that Microban is showing up in an ever-growing list of consumer products including high-chair trays, athletic socks, and mattress pads.

Cueman says that some of the company's customers are now doing long-term studies to explore Microban's effectiveness in inhibiting the transmission of infectious diseases. Microban's impressive laboratory results, Cueman says, "are an indicator that you're going to reduce the chance of infection. If you substantially reduce the overall numbers, then that will lead to less cross-contamination."

McNiece agrees that the reduction of microbial populations makes a difference, especially in the hospital setting, where cleanliness is a top health and safety concern. "This [technology] will reduce the bioburden to the point where we don't have other microorganisms coming in to feed on existing microbial populations," McNiece says. The bottom line, according to McNiece, is protecting the patient at two levels: through improving the the physical environment and through keeping any product that touches the patient as clean as possible.

What Lies Ahead

McNiece hopes to expand the use and testing of antimicrobial products into clinics, physicians' offices, and long-term care facilities, where control of microorganisms and the odors they cause is a real concern. "We're gearing up to build a multimillion-dollar family medical center that we hope will be a test site for concrete with Microban," he says. "Half the concrete will be normal, and the other half will be Microban concrete," he explains. Microban concrete is made by incorporating antimicrobial fibers an eighth of an inch long into the concrete.

McNiece envisions a whole team of products containing Microban such as steps, handrails, toilet seats, trash receptacles, and tile, all working together in a physician's office, for example, to slow the production of harmful microbes. "Our infection control people are very excited about these antimicrobial products," he says.

The appeal of antimicrobial products across a broad spectrum of the market in the United States and worldwide, along with a healthy dose of entrepreneurial spirit at Microban, keeps the company's research and development staff continually probing new applications and product possibilities.

"We've pretty much exhausted most of the polymers," Cueman says. "Now we're looking into natural fibers—ways to treat cotton after it is produced." And, he adds, the company has an advanced coating technology in the works as well. "We're working on ways we can apply permanent coatings to things like ceramics, glassware, and tile."

The company will continue its research as a virtual loner in its field. Other companies are working in the field of antimicrobials in the industrial setting and with topically applied products, but Microban is essentially the only company doing so "with proven organic materials similar to those used in soaps and deodorants which are built into the polymers," Cueman claims. He also plans to take several business ventures into Japan, a country that has a long history of preoccupation with cleanliness.

While the jury is still out on Microban's efficacy as a direct disease-fighter, there's no question that antimicrobial products are here to stay. As long as there are germs, there will no doubt be a demand for any proven method that promises to make the indoors a cleaner place.

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