



*A broad range of antimicrobials are incorporated in paint and coatings products. Photo courtesy of California Products Corp.*

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**Heightened awareness of threats to health, safety, and air quality cast a different light on advances in technologies**

# The green revolution enters the antimicrobial fray

**S**wine flu, bird flu, SARS, H1N1, MRSA, toxic mold—all are health hazards we have become familiar with thanks to extensive media attention. The Centers for Disease Control tells us that frequently washing our hands after touching surfaces constitutes our best defense.

But is frequent cleaning and disinfection of painted surfaces practical, or can we take a more proactive approach with the use of functional coatings that can help safeguard our health and environment?

The microbial world is filled with all manner of different life forms—bacteria, viruses, molds, and mildew come to mind. But yeast, algae, protozoa, and others abound, too, even where we don't expect to encounter them.

This diversity of life makes a universal approach to “bug” killing very difficult. Mold, in particular, is widely prevalent and carries significant health risks. Troy Corp., a major manufacturer of antimicrobial agents, observes that “Mold growth on unprotected coatings is unattractive and ultimately may discolor, mar, or deteriorate coatings over time.” For this reason, coatings manufacturers usually add antimicrobial preservatives to protect and extend the life of their coatings products, which in turn protect the substrate.

Mold growth and substrate deterioration are often accompanied by the generation of



*Some fabricators of HVAC equipment use antimicrobial coatings in air-handling ductwork as a defense against indoor air contamination. Photo courtesy of Sureshield Coatings Company.*

as Bioban™ IPBC-40 LE Antimicrobial and Bioban™ Ultra BIT 30 LE Antimicrobial.

It should be noted that all of these antimicrobial agents are highly regulated by the EPA and other agencies, both in the U.S. and Europe. In fact, the European Biocidal Products Directive, which takes full effect in 2010, is likely to severely limit the number of new chemicals and even antimicrobial chemicals currently in use.

No specific regulatory structure has been developed to govern the registration of end-use products intended to provide antimicrobial properties. In the U.S., the term “antimicrobial paint” can only be used for paints that make any health claims such as “kills 99.9% bacteria” or “effective against specific organisms.”

It should also be emphasized that most paints and coatings, particularly zero- and low-VOC water-borne technologies, already contain antimicrobial agents such as bactericide/fungicides for the in-can preservation of the liquid paint as well as fungicide/mildewcide/algaecides to protect the dry paint film. But these are added to protect the paint itself, and not necessarily people.

Nonetheless, the use of antimicrobial additives in coatings is increasing. One contributing factor may be that, effective in 2009, Medicare and Medicaid have ceased paying for the estimated 2 million preventable hospital-acquired infections (HAI) contracted annually in the U.S., placing responsibility for the cost of care on the hospital.

strong odors, which adversely affect indoor air quality. Once the integrity of the coating is compromised, the substrate is vulnerable to more rapid biological attack. In the home and workplace, mold can grow on dust particles, on wallpaper and painted surfaces, in insulation materials, on drywall, on most construction materials, and on fabric and upholstery. If contaminated areas are disturbed, mold will be transported with dust to other parts of the building. Then, if the proper moisture and temperature conditions exist, mold will begin to grow at new sites.

### **The antimicrobial arsenal**

More than 275 active biocidal ingredients are registered in the U.S. Traditional antimicrobial agents have largely been based on various organic chemicals and can work quite effectively, although concerns exist about the health effects of long-term exposure and the perception that they are not very “green.” In response, antimicrobial chemical producers such as The Dow Chemical Company have introduced low-emission carriers such



*Mold can grow on painted surfaces and other areas where the proper moisture and temperature conditions exist. Photo courtesy of Zinsser.*

### **All in a name**

A sizeable number of antimicrobials and biocides are incorporated into products under umbrella trade names, which may make it difficult to identify the specific technology involved. For example, Microban® technology incorporated into polymers and coatings

is based on tricosan and, according to the company that owns the brand, "Microban® antimicrobial product protection is engineered to protect products from bacteria, mold, and in some cases algae that can cause stains, odors, and product deterioration." The company goes on to add, however, that "Microban, protection is not designed to protect users from disease-causing microorganisms."

Recently, Microban manufacturer Microban International Ltd.



*Some makers of antimicrobial agents have incorporated zinc and silver ions to boost the effectiveness of the products. Photo courtesy of California Products Corp.*

has incorporated other antimicrobials such as silver or zinc ions into custom formulations for greater efficacy, so it is not always possible to identify the composition of the technology. Many coatings companies employ proprietary marketing or simply label the coating product as "antimicrobial."

A number of interior paints that incorporate Microban are currently available, including:

- California Paints 2010 Super-Scrub Ceramic; Kitchen & Bath Enamel Low/Odor/Low VOC, and Elements zero-VOC acrylic interior paints
- Color Wheel Solace™ Low Odor, Low VOC Interior Flat Latex DAP® Kwik Seal Plus® Basement Paint with Microban®
- Davis Paint Solace™ with Microban antimicrobial product protection
- Hirshfield's Platinum Ceramic™ interior latex paints
- O'Leary Paint Ceramic Coat Interior Premium 100% Acrylic Waterborne Latex Enamel with Ceramic Stain-Release Technology and Microban®
- Absolute Coatings Last-n-Last floor coatings


### 'Greener' approaches

It must be emphasized that, despite regulation, health concerns remain regarding exposure to antimicrobial chemicals, which may leach or volatilize into the environment. This concern is par-

ticularly acute with regard to long-term exposure or exposure among individuals of greater sensitivity such as children or the chronically ill. In addition, as mentioned earlier, many traditional chemical approaches are not viewed as being very "green," and as a result coatings manufacturers continue to consider alternative technologies.

The antibacterial properties of the silver ion (Ag<sup>+</sup>) has been well known for some time, and silver is routinely incorporated into medical devices and polymers. The use of antimicrobials based on silver in paint and coatings is increasing, although incorporation in coatings has been slow to develop due to concern about possible discoloration from the reaction of silver with sulfur compounds and reduced bioactivity due to light sensitivity that can result in the photoreduction of ionic silver to metallic silver.

In an effort to limit these effects, novel delivery mechanisms have been developed, such as embedding the silver in zeolites, glass, or other encapsulants. The objective here is slow release of silver ions from the treated surface to inhibit the propagation of microbes. This is accomplished by interference with enzyme chemistry and energy production that generates fungi, yeasts, and bacteria such as MRSA, E-coli, salmonella, pseudomonas, and legionella.



Burke Industrial Coatings introduces its waterborne high-performance paint system, containing an antimicrobial that is effective against a broad spectrum of bacteria, for protection in HVAC (Heating, Ventilation, Air Conditioning) ductwork systems in buildings (sick building syndrome), hospitals, and medical clinics, to name just a few.

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AglON® Technologies offers a commercial silver-ion additive that is incorporated into a number of coating products. Sherwin-Williams has formulated the product into its General Polymers FasTop™ floor coatings, and Bostik has done the same in select Durabond moisture vapor-barrier coatings.

One notable application where silver has been more readily adapted is in HVAC air-handling ductwork, where the technology has been exploited by number of custom manufacturers and fabricators including AK Steel, Seal-Tite Duct, and McGill Airflow SilverGuard™. In this type of application, AglON-based coatings are factory applied to the ductwork. Another coating product employing AglON is Burke Industrial Coatings' Silver Bullet AM™ waterborne epoxy clear for interior applications over metal.

It should be noted that while considered generally safe, any chemical antimicrobial containing silver can potentially be harmful to health or the environment if used in the wrong concentrations.

In addition to liquid coatings, silver-ion technology can be incorporated into powder coatings used as factory-applied finishes for exterior curtain walls and interior building panels as well as fixtures and equipment. Spraylat Corp. has developed the

SilverSan™ antimicrobial powder coating using AlphaSan®, a silver-containing zirconium phosphate based on ceramic ion-exchange particles. Also, DuPont has introduced the Alesta® powder coatings incorporating AglON silver.

### Titanium dioxide 'repurposed'

The use of titanium dioxide (TiO<sub>2</sub>) as a bright, white hiding pigment in coatings is well known. But TiO<sub>2</sub> in its untreated form also is characterized by photocatalytic activity. In this photoreaction process, ultraviolet light reacts with the titanium and moisture (including humidity) to form various free radicals and hydrogen peroxide. These free radicals can cause coating degradation, which is why "weatherable grades" of TiO<sub>2</sub> require special inert surface treatments to render them less active. But it is this same photoactivity and free-radical generation that can act as a powerful destructive agent against organic molecules, including the biomolecules found in viruses. Zinc sulfide also possesses a degree of UV photoactivity.

When TiO<sub>2</sub> is produced at the nano-level, it becomes transparent in addition to possessing photoactive properties. Photoactive TiO<sub>2</sub> has found extensive use in sun-powered water purification and disinfection products and self-cleaning windows, as well as protective functional coatings for the military.

One company, Enviroclean®, has developed the BioShield coating system based on nano TiO<sub>2</sub>, which is suitable for interior and exterior applications. The NuTiO™ system consists of the photoactive clear coat which may be applied to almost any surface. To enhance the efficiency for non-sunlit interior applications, the company has developed an "Any Light Responsive" primer technology to manipulate the wavelength of various light sources to produce the photocatalytic reaction. The product is sold only to licensed OEMs and certified applicators.

The use of nano TiO<sub>2</sub>, though well known in antimicrobial applications, has been slow to enter the realm of commercial coatings, perhaps due to the effects of the photocatalyst on coating degradation when the coating is exposed outdoors.

### Additional alternative approaches

Yet another developing technology is the Miocrobe Shield® technology offered by



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Effective antimicrobial technologies are important in paint and coatings formulas used in bathrooms and other areas where moisture is prevalent. Photo courtesy of California Products Corp.

Aegis Environmental Management, which utilizes a non-leachable, non-chemical antimicrobial approach. The Microbe Shield active ingredient is based on a molecular silane backbone, which bonds to the treated surface. Positively charged nitrogen groups attract microbial cell membranes that carry a negative charge, which are impaled and ruptured on long, molecular-chain “spears”; the positive charge also electrically disrupts cell activity in a two-pronged attack.

Microbe Shield may be directly applied to porous and non-porous surfaces or incorporated into custom OEM coating products. Bio Barrier™ LLC has incorporated Microbe Shield into its ISO-ONE® spray-applied Pathogen Control System

### Back to basics

A number of effective “low-tech” antimicrobial strategies can also be found in coatings applications. Simix Solutions uses a combined approach to exterior surface treatment in its NP Self Cleaning Technology products; one such product, Oxi Seal concrete and paver sealer, was used to protect outdoor school areas against mildew in a project highlighted in the *Journal of Architectural Coatings’ 2009 Top Green Coatings Picks* (JAC, May 2009).

While the product does utilize nano TiO<sub>2</sub>, additional antimicrobial action derives from the formulation’s highly alkaline potassium silicate base, as microbes cannot live on surfaces with a pH level above 9.5. Since a traditional polymer resin base is not part of the product formula, the issue of photocatalytic degradation of coating binder is avoided.

Alistagen’s Caliwel™ antimicrobial paints are another example of a hygienic coating offering intriguing potential. This coating is a waterborne, zero-VOC formulation based on a poly-

ethylene resin, and contains calcium hydroxide [Ca(OH)]—also known as hydrated lime—encapsulated in a specially designed semi-permeable membrane. The Bi-Neutralizing Agent (BNA™) is based on a cellulosic membrane that prevents carbon dioxide from deactivating the calcium hydroxide while allowing moisture and pathogens to come in contact with the antimicrobial agent.

These paints have been shown to eliminate the growth of gram-positive and gram-negative odor-causing bacteria, mold, mildew, algae, fungi, and viruses on the coating surface, the company says.

Alistagen has registered the product with the U.S. EPA for surface applications and OEM applications in HVAC systems. The company says it is safe to touch and can be washed without reducing its effectiveness, which is reported to last for six years. Formulations are available for DIY and commercial application.

### On the horizon

So what’s next in the microscopic-warfare arsenal? On one front, other metals such as copper and brass have been shown to possess antimicrobial properties. Then there are bio-engineered antimicrobial ionic peptides and proteins that could be incorporated into surface coatings.

Regardless of which individual or combination technology is employed, the use of antimicrobial coatings in large-scale architectural applications is sure to increase, particularly in light of fears about the threat of pandemic spawned by microbial or bacterial sources.