Photo shows trilobal filaments in a nonwoven media

Filter Media: Using anti-microbial treated media in the pool or spa

The use of anti-microbial treated products has become commonplace and new anti-microbial agents are regularly introduced. However, these materials come under the auspices of the Environmental Protection Agency (EPA) and are regulated. Peter J. Angelini of Fiberweb helps those not familiar with anti-microbial materials to gain an appreciation of what they are and how they can be used as well as the regulatory responsibilities when working with these materials.

The use of an anti-microbial to reduce problems such as odor, staining or fouling can be beneficial. The idea of treating a filter material for use in pool & spa filters with an anti-microbial is straight forward and a seemingly easy task to accomplish. Also as a manufacturer it is important to know that the treated product will continue to perform over its intended life. The EPA regulate anti-microbial filter media and their use, along with any claims made around products treated with anti-microbial materials.

Behind the product

There are a number of considerations involved in developing durable products incorporating anti-microbial protection other than simply finding an anti-microbial that will work under the envisioned conditions of use. Along with demonstrating product efficacy throughout the expected useful life of the product, there is also the need to confirm the treated product is permitted by the EPA under its regulation of products containing anti-microbial materials. A further requirement is to be sure that any market claims for the treated product are within EPA guidelines for anti-microbial claims. This article shares some of what Fiberweb learned in bringing a durable consumer product to market that incorporates an anti-microbial agent. Our product example is a liquid filter media (in this case for home spa use) where the treated media is in constant contact with warm water and is expected to last many months, which is a particular challenge.

The micro-organism problem

The many species of micro-organisms in our environment – such as fungi, viruses and bacteria –are always present and are an essential part of our ecological system. The combination of nutrients, temperature and moisture available for growth determines the type and number of the organisms present. As a nonwoven media supplier our concern is how to protect a substrate from micro-organisms and the problems they can cause, whether it is performance or sensory, and in particular how to protect durable articles produced from those substrates that are intended to last many months. Because our effort here is directed solely at protecting an article, there will be little if any reference to the health issues that arise from micro-organisms but the following background regarding fungi, viruses and bacteria will be useful.

The fungi factor

Fungi come in a variety of shapes and sizes and there are thousands of species, which includes mushrooms, moulds, and yeasts. The size of fungi can range from individual cells to enormous chains of cells. Many of them may look plant-like, but fungi do not make their own food using sunlight like plants do, instead most fungi obtain their nutrition from the breakdown and decay of organic matter and they can thrive in many places. Moulds (also known as mildew) are the most common form of fungi and they exist in a variety of colours causing unsightly staining and discoloration to articles. Aspergillum is the most common genus of fungi found with over 160 different species.[1]

Viruses and bacteria

As single cell organisms, bacteria are the simplest form of life as well as the oldest. Many are beneficial but others can cause illness and damage. Our concern is with the damage bacteria can have on product performance. Bacteria multiply by a process known as binary fission where the single cell grows until there is enough material to form two separate cells. The rate is exponential and is determined by the availability of nutrients, temperature, pH, and chemicals present. It is the growth of large colonies that can lead to staining, odour generation or both. In an aqueous environment bacteria will affix and protect themselves on surfaces by secreting material referred to as biofilm. By so doing they anchor themselves and can grow and multiply on a surface such as a fibre or fabric forming unsightly colonies. Some bacteria types will multiply faster than others. They can, depending on the micro-organism, produce unpleasant odours or eventually breakdown a host material.

Viruses will not be considered here because they will not lead to the types of product performance issues we are concerned with. Viruses are smaller than bacterium with the largest viruses being about the size of the smallest bacteria. Their method of reproduction is the major difference between the two. To reproduce, viruses must invade another living cell. Bacteria on the other hand contain all the genetic codes and material they need for reproduction. It is the reproduction and growth of bacteria that ultimately causes unsightly build-ups, staining or odour generation that we want to inhibit in a spa filter.

Gram-positive vs gram-negative

Microbiologists have different classifications for bacteria according to criteria such as cell structure and shape. For our purposes the only classification of note is the broad category of gram-positive and gram-negative bacteria, which is simply based on the ability of bacteria to either accept or not accept a dye known as crystal violet. The composition of the cell wall varies between these two classes and is an important character for identifying and classifying bacteria. Bacteria with thick cell walls retain the purple stain and are referred to as gram-positive. Bacteria with double cell walls have a thin inner wall and do not stain purple, and so are gram-negative. We will return to this distinction when we discuss efficacy testing.

Anti-microbial Materials

The EPA was charged by Congress to ensure the proper use of pesticides. Since some micro-organisms are seen as pests, anti-microbial materials are considered pesticides. Anti-microbial agents are defined by the EPA as substances or mixtures of substances used to destroy or suppress the growth of harmful micro-organisms whether bacteria, viruses, or fungi on inanimate objects and surfaces.[2] The term 'anti-microbial' is used in this paper to distinguish materials intended to provide protection for the life of the product as opposed to disinfectants, which quickly kill micro-organisms but with efficacy that is short lived. To EPA disinfectants are a sub-set of anti-microbial materials.

Pesticides (anti-microbial agents) that kill microbes such as bacteria, viruses, or fungi are regulated by the EPA under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Manufacturers of anti-microbial agents must have their products registered with EPA and to do so must demonstrate that they pose no unreasonable harm to human health or the environment. This can be a long and expensive process.

Products treated with an anti-microbial material are also regulated and EPA divides them into two broad categories; Public Health products and Non-public Health Products. According to EPA *Public Health Products* are those products intended to control microorganisms infectious to humans in any inanimate environment, while *Non-public health products* are those used to control growth of algae, odor-causing bacteria, bacteria which cause spoilage and deterioration or fouling of materials. This latter general category includes products used in paints, and treatments for textile and paper products[3].

The Treated Articles Exemption found in 40 CFR 152.25(a) however, provides an exemption from FIFRA requirements for qualifying treated articles containing a registered pesticide if; (1) the incorporated pesticide is registered for use in or on the article, and (2) the sole purpose of the treatment is to protect the article or substance itself, not to provide any health benefits.[3] This exemption allows a manufacturer who is going to treat a product with an anti-microbial to avoid having to have the product tested and then registered by EPA, so long as the anti-microbial being used is already registered for use in that application and the reason for the treatment is solely to protect the product itself.

EPA and promoting your product

The manufacturer, having developed a product treated with an anti-microbial, will want to promote it in the market. At the same time EPA is very sensitive to the types of claims manufacturers make about their products. The concern is how consumers might interpret a claim. EPA wants to avoid situations where consumers might incorrectly infer a health benefit from a claim that is not demonstrated; possibly leading the consumer to improperly forego a necessary health precaution. For example a claim that a spa filter "*kills bacteria*" might be interpreted by the consumer to mean it is not necessary to perform a normal chemical treatment of the water. Because an anti-microbial treated filter will not substitute the need to properly maintain the chemistry of the water to provide a healthy environment, any claims must clearly refer only to the protection of the filter itself. EPA's Pesticide Registration Notice 2000-1 provides guidance along with examples of claims and claim language that can be used. For instance using the word antibacterial as a claim rather than anti-microbial would lead to the requirement to register the article as a pesticide product. EPA's reasoning is that in the U.S. consumer market place, the term *anti-microbial* has been typically associated with the protection of articles, whereas *antibacterial* has been more frequently associated with products designed to control human pathogenic microorganisms.[3] Therefore according to EPA, use of the term antibacterial makes a public health claim and recall that treated products with explicit or implied public health claims would have to be registered under FIFRA.

Selecting the Right Anti-microbial for the Application

There are, according to the EPA, about 300 different active anti-microbial agents on the

Table 1

Class	Chemistry	EPA Product Code
Organic	Silane quaternary ammonium	107401
	Triclosan	054901
Inorganic	Silver	072501
	Silver sodium zirconium	072560

Table 2 Efficency Testing Methods

DC Shake Flask	AATCC TM 100	AATCC TM 147	Kirby Bauer	AATCC 30-1999	ASTM G-21
Quantitative	Quantitative	Qualitative	Qualitative	Qualitative	Qualitative
Bacteria	Bacteria	Bacteria	Bacteria	Fungi	Fungi

Filtration+Separation January/February 2007

Table 1A EPA List of Registrants

	EPA Registrant	EPA Product Code	Registration No.	Trade Name
Triclosan		054901		
	Ciba Specialty Chemicals		070404-2	Irgasan DP 300
			070404-5	Irgaguard B 1000
	Schering-Plough Health Care		004001-3	Triclosan
	Microban		042182-1	Microban Additive B
Silane Quaternary Ammonium		107401		
	GIS Environmental		064881-1	AEM 5700
			064881-2	AEM 5772
			064881-3	GIS Antimicrobial
			064881-5	AEM 5772 MUP
	BioShield		070871-1	AM 500
			070871-2	AM 500 I
			070871-3	BST Protectant C15
			070871-4	BST Protectant RTU 50
			070871-5	BST Protectant RTU 75
			070871-12	BSTI 1860
Silver		072501		
	Nobel Fiber Technologies		070927-1	X-static
	Kanebo USA		059824-3	Bactekiller A
	Sinanen		071227-3	Zeomic Type AJ10H
			071227-3	Zeomic Type AK
			071227-5	Zeomic Type AW
			071227-6	Zeomic Type AV
	Ishizuka Glass		073148-1	Ionpure WPA
			073148-2	Ionpure ZAF
			073148-3	Ionpure IPL
Silver Sodium Zirconium		072560		
	Milliken Chemical		011631-2	AlphaSan RC5000
			011631-3	AlphaSan RC5000
			011631-4	AlphaSan RC7000
Silver/Copper		072501/022501		
	Kanebo USA		059824-1	Bactekiller AC
Silver/Zinc		072501/129015		
	Ciba Specialty Chemicals		040810-19	Irgaguard B502 I
			040810-18	Irgaguard B5000
			040810-22	Irgaguard B400
			040810-21	Irgaguard B502 J
	Kanebo USA		059824-2	Bactekiller AZ

market today.[3] Many of these anti-microbial materials have a long history of use, and can be found in a wide variety of products ranging from consumer to medical and industrial applications. Common examples are hand soaps, kitchen and bathroom wipes, surgical drapes and dressings, toothbrushes, spa and tub enclosures, etc.

An important consideration when selecting anti-microbial materials to work with is to determine that they are registered with EPA and whether or not they are also registered for the use intended. Suppliers of anti-microbial products can answer these two questions. If an anti-microbial is not registered with the EPA for the particular use intended, then it should not be used. It may be possible to petition the EPA for a label amendment allowing for its use. There are three types of change that can be sought. The easiest is a minor use extension to an existing label, which involves little more than asking EPA to review the current label and whether or not the petitioned use fits within the uses already listed. There is a 90-day time limit in which EPA must respond. More involved is requesting a minor amendment to an existing label, which requires a supporting argument but no new data. This has a 180-day time limit for EPA response. The addition of a totally new use however, will require testing, data generation and EPA review. This can be expected to take many months or more.

Organic or not?

Anti-microbial materials can be classified as organic or inorganic. Table 1 is a list of a few commercially available anti-microbial products that have been of interest to nonwoven producers. It is by no means intended to be an exhaustive listing but rather to show the array of product types available. Chemically the active ingredients for these anti-microbial materials include silver (mostly produced in Japan), triclosan, and silane quaternary ammonium. The EPA product codes included in the tables can be used to pull up all registered products based on that active ingredient by using databases available on the Internet. Table 1A has more detail and lists the EPA registration holders and their registration numbers.

Is one class or chemical type better than another? Not necessarily. The choice is determined based on various factors including the method of anti-microbial incorporation into the article to be treated, the intended application and the conditions during use. What may work for one product form may not work for another. Many of these anti-microbial materials are said to be broad based inhibitors; they will be effective against a wide variety of micro-organisms. How effective will be determined by the level of anti-microbial used. For example, E. coli is a hardy bacteria and depending on the anti-microbial used may require a higher level for efficacy than another organism. Similarly moulds may require different levels of anti-microbial addition than for bacteria. The point here is to have an idea of the organism(s) to be inhibited and work with the supplier to arrive at the best product and recommended level for efficacy.

Applying the anti-microbial

There are basically two ways of incorporating an anti-microbial agent with a nonwoven substrate; either on it or in it. Since anti-microbial products all work by contacting the micro-organisms they must be present on the treated article's surface. Continuous liquid contact applications present a special challenge where the anti-microbial to be effective, needs to be on the surface while at the same time locked in so it is not "washed off". Incorporating an anti-microbial into the fibre, although not necessarily the most economical method, does accomplish this. In this case a diffusing material is useful since it will continually migrate from within the fibre to the surface where it is effective. With non-diffusing types it would be best if the anti-microbial were in a thin sheath, to locate most of it at the fibre surface.

Testing

It is always desirable to have a recognized testing protocol to follow that everyone can use, especially one that projects performance out in time. It was evident with the applications we are interested in that there wasn't anything like this and we would have to develop our own protocol. The protocol requires the test method for efficacy itself, the appropriate organisms to be used with the test and the exposure or simulation of use with the test specimens themselves. There are a number of tests available for determining product efficacy. The most important thing to realize in selecting a method is that not all methods will work for a particular anti-microbial chemistry, but each supplier will tell you which test method is best for their product. Table 2 lists the more common test methods for evaluating microbial inhibition.

Along with selecting the appropriate test method you will also need to select the organisms to be used. When it comes to bacteria there are several thousand species and so we must determine which species are germane to the application of interest and to select the representative organisms. Most anti-microbial agents are considered to be broad based; they are effective against many different types of organisms so when it comes to selecting which test bacteria to use it will be important to select one from both the Gram-positive and Gram-negative category to demonstrate broad effectiveness. As an example of trying to be relevant with spa filters, we reasoned that one of the main contaminants being filtered is dead skin cells. Protein from skin cells is an excellent source of nutrients for many micro-organisms. Staphylococcus aureus (staph), which is Gram-positive, produces large colonies, is highly mucoid and commonly found on the skin of healthy people, and we considered it a good choice. Our choice for gram-negative bacteria was Klebsiella pnuemoniae, which is naturally found as a free-living soil bacterium. Other appropriate choices could have been Escherichia coli or E. coli, which is present in our bodies, is fast growing with simple nutritional needs or Pseudomonas aeruginosa, which is common in water.

We felt it important to be able to simulate, at least in part, the exposure that our product would see in a spa and to come up with a way to project efficacy with time. This would be especially useful in evolving other products. We thought about accelerated launderings as a surrogate but concluded that it would require hundreds of laundering cycles to simulate a relatively few days of continuous use the filter would see in the field. We ended up installing a test spa that could test both filter elements as well as flat samples. We also have the capability to measure the amount of active ingredient remaining after every 30 days of exposure. With this data we have been developing trend lines to project how long a product can be expected to exhibit inhibition. ●

To remember

When working with anti-microbial products keep in mind that:

- Pesticidal (anti-microbial) products are registered by EPA.
- The anti-microbial to be incorporated must be registered for use in or on the article to be treated.
- An article treated with an anti-microbial must be registered with EPA if a health claim is made.
- Qualifying articles treated with an anti-microbial solely to provide protection to the product itself are exempted from registration in CFR 40 152.25(a).
- EPA PR Notice 2000-1 provides clarification and guidance with product claims.

Footnotes

[1] *Toxic Black Mold Information Center*

[2] *EPA excerpt from Anti-microbial Pesticide Products Fact Sheet*

[3] *EPA excerpt from Applicability of the Treated Articles Exemption to Anti-microbial Pesticides Fact Sheet*

About the author
Peter Angelini is Senior Product Development Engineer-Filtration for Fiberweb, one of the world's leading nonwovens providers. Currently overseeing all laboratory testing, he has spent many years in the nonwovens industry, including ten years working with filtration media.