



Effective Odor Control Prevention in Textiles

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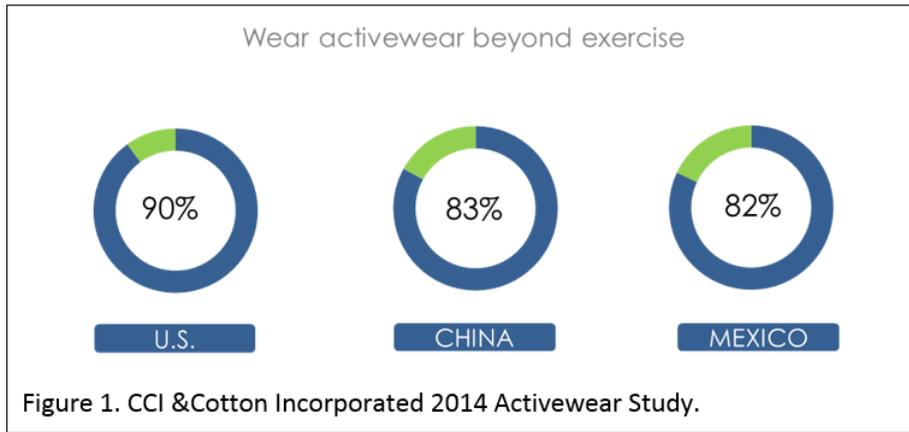
Body Odor, A Growing Issue In Synthetic Apparel

Let's start with how odor is generated, then the solutions to control it. There are two elements involved to generate body odor. One is sweat – fuel for body odor such as water lipids, fatty acids, proteins, sugars, water, electrolytes. Our bodies can produce a lot of sweat. Believe it or not, when we partake in very rigorous exercise or physical activity, our bodies can produce up to 10 liters of sweat per day. Though most sweat evaporates, a significant amount transfers to our clothing.

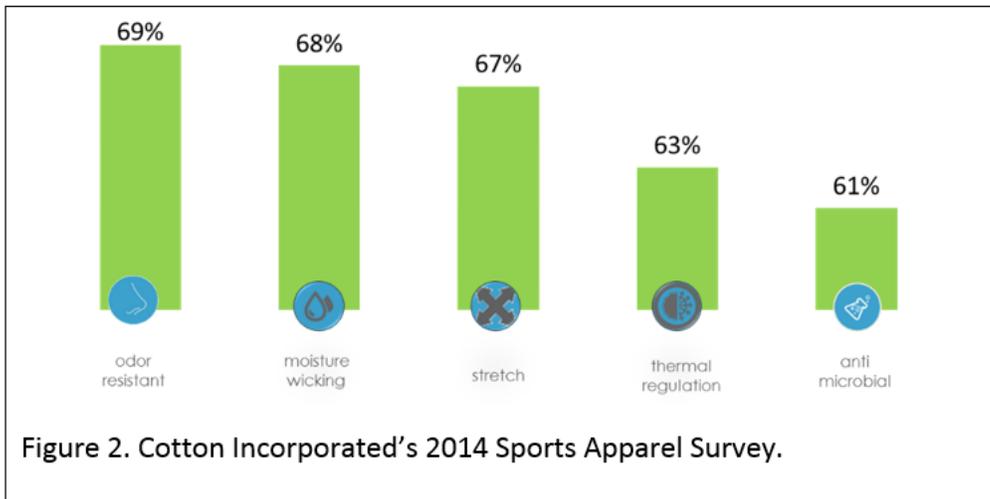
The other element of body odor is bacterial skin flora that covers us from head to toe. A recent study found there were 8 trillion more skin flora bacteria on us and inside of us than human cells. Flora consists of a variety of gram negative and gram positive organisms. A large portion of the gram positives are *Corynebacterium* and *Staphylococcus*. The sweat itself is generally odorless. Body odors are generated on apparel when certain bacteria metabolize sweat compounds and release malodors.

Generally speaking, odors of higher molecular weight such as carboxylic acids, aldehydes and ketones, tend to build up on synthetic fabrics. This is because these molecules have larger non-polar regions that tend to have a high affinity for hydrophobic synthetic fibers. These odors by virtue of being hydrophobic themselves are very difficult to remove during washing. Over time they build up and saturate the fiber surface. At this point, a garment will typically develop a very persistent malodor we affectionally call “permastink”. As a result, these garments are often discarded, before the end of their useful life, adding cost to consumers.

Most activewear is made of synthetic fibers. As shown in Figure 1, a great majority of consumers around the globe are wearing activewear as leisure or casual clothing – 80% or more in US, China and Mexico according to 2014 CCI &



Cotton Incorporated activewear study. It can be awkward to wear stinky activewear during social activities. This is evidenced by the statistics data in Figure 2 from Cotton Inc that shows that consumers value odor resistance most among all performance perspectives. Therefore, odor control is becoming more and more important as an objective for future textiles.



The leading antimicrobial solution for controlling odor

Direct control of odor generating bacteria on cloth is a straightforward approach. Putting antimicrobials (AM) on textiles is nothing new. Over the years, numerous chemistries with antimicrobial properties have been proposed with a handful of leading antimicrobial technologies as options. However, just because an antimicrobial technology has been commercialized for textile application doesn't mean it's a great choice for all end use applications. All AM technologies have their strengths and weaknesses.

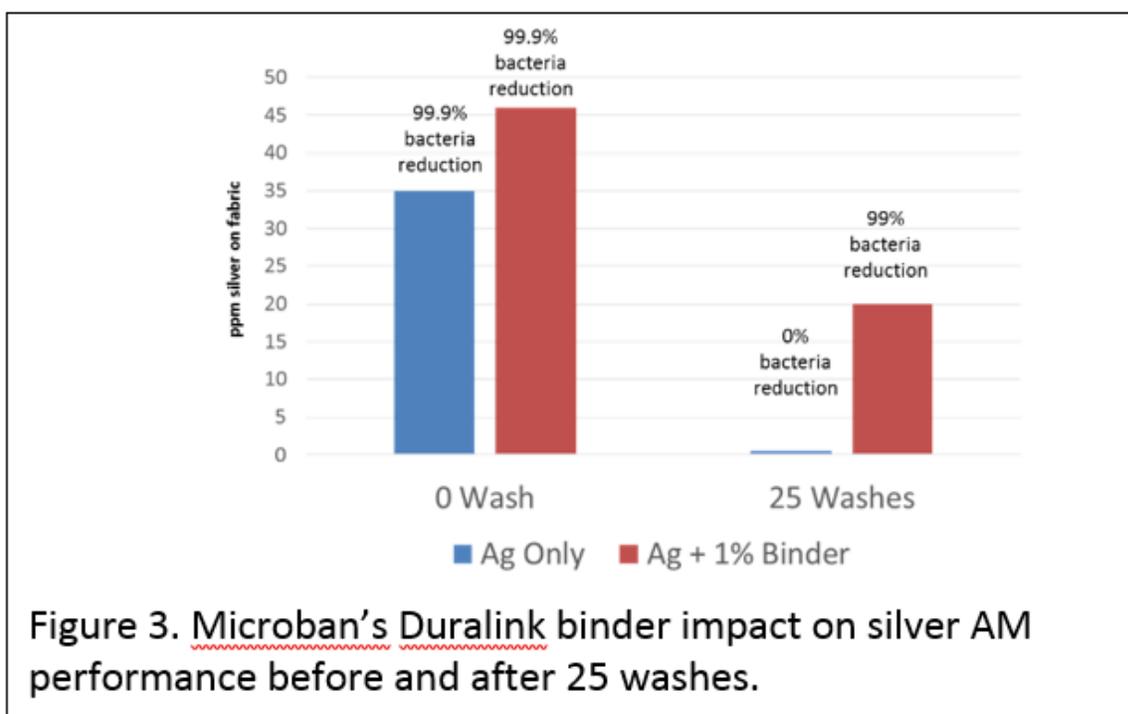
There are a number of technical and even non-technical factors you need to consider before selecting an AM, including fiber compatibility, water repellency requirements, regulatory restrictions and of course, cost. We will look at factors applicable to typical outer wear and sportswear applications. The three technologies covered in this paper emerge as the most suitable options.

Quaternary ammonium silane (QS), has been around a long time. This AM was first developed by Aegis and approved by the EPA back in 1975. There are good reasons as to why this AM has been around so long. It is very effective on a wide array of fiber types such as nylon, polyester and cottons. It also has an excellent safety and ecological profile. In the environment it decomposes to basic stable elements. Also, it is very easy to work with at the mill level, and applicable at various stages of textile manufacturing.

Looking at QS it can be noted that chemistry tends to make fabrics more hydrophobic. Treatment levels need to be optimized and paired with a moisture management agent. Also, because the technology is cationic it does tend to be neutralized by anionic chemistries. QS should only be paired with nonionic and cationic finishing agents. When appropriately applied, Qs will undergo condensation polymerization forming a durable coating on the fiber surface. It can also covalently bond with functionality on the fiber surface enhancing durability. Aegis is an effective odor control option for shoes, and apparel. It is an excellent choice for outer wear applications as well. It can be applied to jacket liners, fleece, treated jacket fill or even foams. Because of its hydrophobic nature, Qs are ideally suited for applications where water repellency is important.

Silver technologies are also finding use in today's apparel market. Silver products come in many forms including silver salts, intercalated silver (silver ion is incorporated into a ceramic matrix) and silver polymer complexes. All these operate under the same basic principle in that they release silver ion, which inhibits odor causing bacteria. The key issue with silvers is that they have little to no affinity for textile fibers. Despite what some may say, a binder is typically required to prevent silver from being washed off the textile very rapidly.

To develop Microban silver technology, we purchased some apparels from a well-known outdoor garment retailer which were claimed to have permanent antimicrobial capability as controls. Before 25 home launderings (HL), we found the shirts were able to inhibit almost 100% of bacteria growth. However, after 25 HL, they lost their antimicrobial capability. To address this issue, Microban developed a silver formulation with only 1% Duralink binder. It was able to inhibit 99% of bacteria growth after 25 HL (Figure 3).



A third AM option is Microban ZPTech®. It's perhaps the most effective option in synthetic apparel. It is a broad-spectrum technology for both antibacterial and antifungal (AF) protection. Perhaps its greatest strength is its durability on synthetic fabrics. Because of its chemical structure, ZPTech has a high affinity for polyester. ZPTech behaves in a very similar manner as disperse dyes under higher temperature dyeing or curing conditions. Under these conditions, as the polyester fiber structure opens, ZPTech will incorporate itself into the fiber surface. As the fabric is cooled and the fiber structure closes, ZPTech becomes trapped in the fiber surface. The net effect is that the ZPTech treatment becomes nearly permanent on the fabric without the use of external binders.

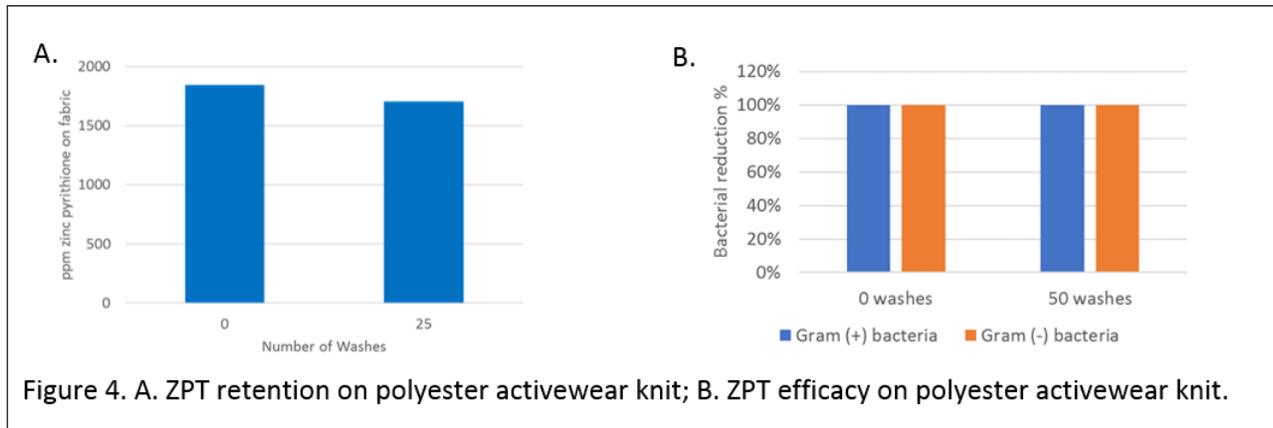


Figure 4A illustrates after 25 washes, over 90% Zinc pyrithione was retained and figure 4B showed its efficacy after 50 washes remained unchanged, inhibiting almost all bacteria as tested by JIS L 1902 method. As polyester dominates the active wear segment it is applicable to nearly any end use sports garment. Other apparel applications include outerwear, shoes and foams.

Like the other technologies, it has long history of safe use and it is a cost effective, highly durable option. It is readily applied using typical dyeing or finishing equipment and has negligible impact on critical fabric properties such as hand, colorfastness and wicking. It has a very good safety profile and long track record of use in not only textiles but in shampoos and other personal care products.

ZPTech is readily applied either by exhaust or pad. It is compatible with typical polyester dyestuffs and dyeing auxiliaries and, therefore, can be applied to fabrics during the dyeing process. This is an obvious advantage to mills as it eliminates the need for extra processing steps. If desired, ZPTech can also be applied via pad-dry-cure application. One limitation of ZPTech is that it's not durable on cellulosic fibers like it is on synthetic fibers.

Traditional Odor Capture Technologies and a Newly Commercialized Technology by Microban

While antimicrobials are very effective options for odor control, there are other solutions which can be employed. Some odor capture technologies can physically or chemically adsorb odorants, reducing their volatility and hence reducing the smell on fabrics.

To evaluate odor capture efficiency, gas chromatography techniques are employed. With these techniques, an odor capture treatment's ability to eliminate odor can be quantified.

Traditional odor capture technologies include activated carbon, cyclodextrins, and zeolites. When it comes to activated

carbons, their greatest appeal is breadth of odors they can adsorb. These particles contain a tremendous number of pores within their surfaces and the wide distribution of pore sizes can accommodate odorants of all different sizes.

Carbons can be used in numerous applications including chemical warfare, medical or wound care, industrial personal protection equipment or filtration. However, it has limited use as a finishing agent due to fabric discoloration, application challenges and cost.

Cyclodextrins are another odor capture option on the market today. They are derived from starch using an enzymatic process and come in three different ring sizes. Cyclodextrins are structured such that they act like molecular buckets or reservoirs that can accept and trap a wide array of chemical compounds.

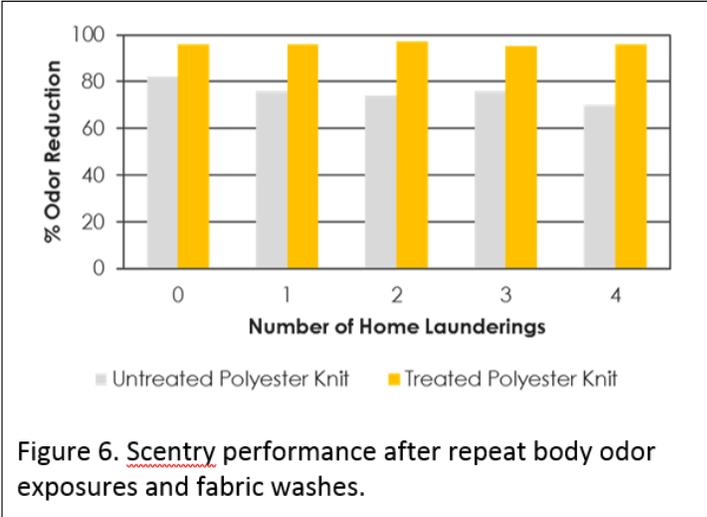
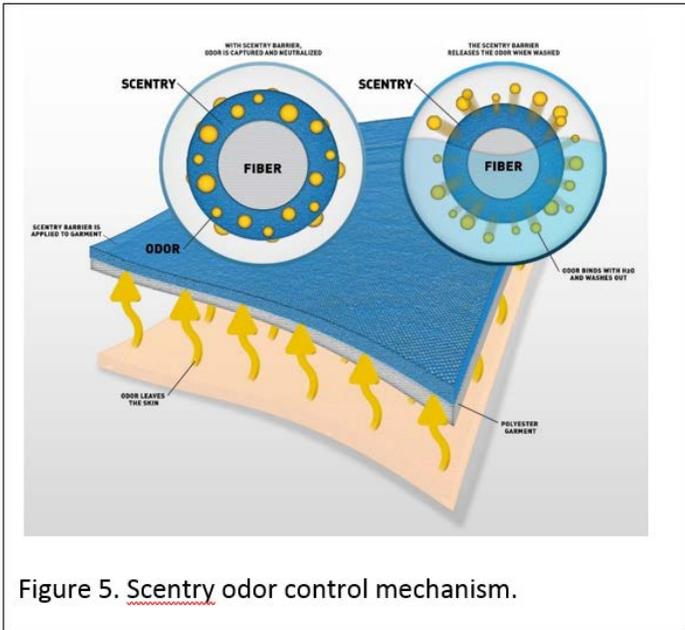
Given the diversity of molecules they can trap, cyclodextrins have been used as fragrance and pharmaceutical carriers- in addition to their use in textiles. The exterior functionality of cyclodextrins are such that they can be crosslinked to functional groups on fibers. In particular, the technology can be made durable on cottons and other cellulosic materials. However, binding it to less reactive fibers such as polyester can be quite challenging. Also, research has shown that the binding strength of the molecule is very much dependent on the size and polarity of the odorant- given the fixed size and hydrophobicity of the inner cavity. For some key odorants, particular carboxylic acids (body odor), the binding constants are fairly low.

Zeolites are inorganic materials whose crystalline structures form well-defined pores. They are appealing from a green perspective because many forms of zeolites occur naturally. The zeolite pore size can accommodate metal ions. Forms of the material have been impregnated with silver and copper ions and commercialized as antimicrobials solutions. Unlike carbons with larger pores that can accommodate larger odorants, the zeolite crystal structure forms very small pores of uniform size. The diameter of the pores is on the order of angstroms so the pores are unable to physically adsorb larger carboxylic and aldehyde based odors. Zeolites also require a binder for wash durability as there is little to no affinity to fibers. Their application levels ultimately need to be finely tuned to avoid issues with crock and colorfastness.

Scentry® is a newly developed odor capture technology from Microban. This whitepaper will cover what it is, how it works, and discuss its performance and safety features.

Odor capture is an area we've investigated over the last couple of years. Our work has resulted in the launch of a couple of new technologies for the active wear market. Scentry is a technology we launched at 2015 summer outdoor retailer show. Scentry is a novel odor capture technology that traps and neutralizes key body odorants. The technology is pad applicable to synthetic fibers and creates a durable coating on fabrics without the use of an external binder.

Figure 5 shows how Scentry works. After application, Scentry forms a protection layer on the surface of each fiber. Odors become trapped within the scentry coating, preventing them from absorbing into the fiber. The technology releases the odorant during laundering which recharges its activity. As a result, Scentry forms a regeneratable odor control barrier on the fabric surface.



The Microban research team studied Scentry performance in the past (Figure 6). We took both treated and untreated fabrics and exposed them to the odor repeatedly, and washed the fabrics in between each exposure. This was how we simulated the wearing and washing cycles. After 5 cycles, we tested the odorants from the fabric. Normally, the stains should be washed away by 5 washes. What we found was that the amount of odor that came off from the untreated fabric was over 200 times more than that from Scentry treated fabric. In addition, Scentry treated fabric didn't show much difference in odor reduction capability every time, while the untreated sample showed decreased odor reduction capability. This clearly demonstrated that Scentry was very effective in preventing odor buildup.

Table 1. Odor rating of Scentry treated and untreated fabrics by human panel

Treatment	Odor Rating (Out of 5)
Untreated Polyester	3.9
5% Scentry Treated Polyester	0.8

In our research, we also wondered if humans could detect the odor because human noses are more sensitive than the GC method. When we dosed IVA to the fabric and smelled it, we found a dramatic difference in odor rating. Table 1 shows that the average rating for untreated polyester fabric was 3.9, while that for 5% treated polyester fabric was only 0.8. This result suggested that our Scentry technology was able to significantly reduce body odor. This was just an illustration to show how powerful this technology can be.

Scentry products are broadly compatible with synthetics, cellulose and blends. It can be applied to a variety of fabrics made of polyester, poly-cotton, cotton, nylon and poly-spandex fibers.