An unfortunate fact of life is that textiles inevitably don’t remain in the beautiful, pristine state they display on the retail floor. Whether the fabric is part of a nice suit, the living room sofa, or the hall carpet—life happens. People will spill wine on the sofa, drip mustard on the good suit, and track mud on the carpet. Stains are the inevitable result.

Luckily, the textile industry is working to preserve the appearance of fabrics for the life of the product—no matter the textile product and no matter how long or short that life may be. Finishes are available to make stain removal easier, and to prevent stains from happening in the first place. “We don’t think anything should ‘stain your good name’,“ says Davis Crater of 3M Corp.

A STAIN BY ANY OTHER NAME

“Persevere in the path of duty ... bear many things in silence, with unstained virtue” —Officio Sanctissimo, Encyclical of Pope Leo XIII on the Church in Bavaria

Speaking of names, the terms “soiling” and “staining” are not always used consistently by everyone in the textile industry. Sometimes they are used to mean the same thing, sometimes they are used to mean different things, and, confusingly—they can also be used to mean different things in different segments of the textile industry.

According to Bill Kimbrell of Milliken & Co., and current chair of AATCC committee RA56, Stain Resistance, soiling and staining are “two concepts [that] have unfortunately been used interchangeably within [the] industry for a number of years.” The AATCC Technical Manual defines soil as dirt, oil, or other substances not normally intended to be present on a textile substrate. However, according to AATCC, a stain is not the same as soil.

Norma Keyes of Cotton Incorporated says, “Soil is the medium that goes on a textile substrate. It may or may not create a stain. A stain is the deposit of the soil on the fabric.” In other words, “a stain is not a stain without soil,” explains AATCC’s Amy Hammonds. “Soiling is what makes the fabric dirty. Staining is what doesn’t come out.”

This definition of soiling and staining is not necessarily universal throughout the textile industry. “The term ‘soiling’ is generally used for carpets and home furnishings. The term ‘staining’ is generally used more often in relation to apparel,” says Crater.

Kimbrell notes that, while in apparel, the distinction between “soil” and “stain” is generally predicated on the substance’s resistance to initial removal, “In my opinion, a better distinction could be made between dry particulate soil versus liquid based stains. This is very similar to the practice utilized within the non-apparel sectors of the textile industry, such as floor covering and upholstery.”

FABRIC FINISHES

“There is no man hath a virtue that he hath not a glimpse of, nor any man an attain but he carries some stain of it.” —Troilus and Cressida, Shakespeare

Whatever you’re calling them, stains are a problem that the textile industry tackles with specific finishes designed to preserve the appear-
ance of the product. For apparel, typically three kinds of finishes are available: those that repel stains—keep the soiling substances from penetrating the fabric in the first place, those that help release stains—assist detergents in getting to the soiling agents so that it can be more easily removed from the fabric, and combination products that work to both repel stains initially but will also help release them if the soiling substance gets onto the fabric anyway.

**How They Work**

"The mechanisms involved ... include three distinct concepts, stain repellence, stain release, and repel/release," says Kimbrell.

According to Bob Levesque of MIC Specialty Chemicals, repel products work by reducing the surface tension of the fabric, so that anything with higher surface tension is repelled—basically anything water based. However, if the soiling agent is forced into the fabric fibers anyway (say, you accidentally sat on a French fry during lunch), "if you only have a repel agent on the fabric, then you won’t be able to get the stain out, because it won’t let the detergent in to clean the stain," says Levesque.

On the other hand, a stain release product "exhibits high surface energy," according to Kimbrell. "This property enhances the wetting of the fiber surface by the cleaning solution, thereby facilitating the release of soil and stains. Enhanced release of stains, especially oily stains, should be the only expectation from a stain release product."

"It’s a challenge to combine stain resistance with stain release," says Kim Houchoens of Nano-Tex Inc. "Resisting and releasing stains are two opposing technologies. However, combination resist/release products are available that essentially ‘flip-flop’ during laundering—repelling until the need to release comes in." According to Kimbrell, repel/release products have both components for repelling liquids and components for stain release attributes. "A degree of resistance to wetting and enhanced removal of stains can be expected from this type of product," says Kimbrell.

"Only recently have products that exhibit high levels of stain repellency, stain release, and durability begun to appear in the market."

Ray Miller of DuPont Bio-Based Materials adds that "Stain-resistance [can be] created by either blocking the dye sites in the substrate from the dyes in the contaminant, or by making the substrate out of a composition that the dye cannot attach to in a permanent way." For instance, in carpets, "stain blockers" are clear acid dyes used to block the dye sites in nylon so that they are not vulnerable to the acid dyes found in some foods, which can stain—and, in fact, dye—the fibers if they are spilled onto the carpet.

According to Kimbrell, "in addition to the application of polymers to the surface of the textile ... various other fiber surface modification techniques have been [used to effect stain protection]. Chemical modifications, including hydrolysis, aminolysis, oxidation, or reduction of the fiber surface, have been practiced. In addition, grafting monomers and low molecular weight polymers onto the fiber surface by chemical methods, plasma technology, and various other techniques have been proposed and practiced." In addition, Kimbrell mentions the "so-called lotus effect. The lotus effect combines low surface energy with surface roughness on the appropriate scale. This allows water, passing over a surface, to remove soil," he explains.

"The fundamental challenge with [any] technologies is that they must be cost effective and must be safe for workers and the environment," warns Houchoens. "They must not affect the hand or the color of the garment, and must be easy to manufacture."

**Different Needs**

No matter what technology is used, there are a variety of treatments out there designed to somehow protect fabrics from stains and keep the textile product’s appearance "like new" longer. However, the treatment used depends on a variety of factors.

Lisa Pfrommer of Invista says, "The reason we have a portfolio of products is because need depends on end use. Apparel needs generally will be different from upholstery needs. Different fibers and different uses often require different chemistries optimized for the fiber or fabric types. You have to look at what fiber, what stain technology, and what garment care is expected to determine the optimum product to use for the particular application."

There are also different products for apparel and home furnishings, according to Crater. "A product developed for one application may or may not perform in a different application," notes Kimbrell. Carpets and furniture aren’t laundered the
way that apparel is. Not only must the treatment used to protect them from stains be fiber specific and care specific, the different types of soils the substrates face will be different. For example, as noted earlier, carpets are vulnerable to acid food dyes because of their typical fiber substrates. "Carpet treatments typically emphasize high stain resistance," notes Crater. "But they don't need a stain release treatment because they're not laundered."

Even in apparel, there are a variety of different needs. "Apparel is vulnerable to a mix of oil and particulates which adhere to the surface and carry particulates into the fibers," says Crater.

"Repel-only treatments give the best line of defense in the initial stain assault," notes Bill Ware of Nano-Tex. "So for applications like formalwear, they give the best stain protection." There are also stain release-only treatments available for applications such as workwear, "where you're not as concerned with the initial soiling so much as getting the stain out later," according to Crater. Ware says that in combination repel/release dual-action chemistry, "you give up a little in the initial stain repellent defense to be able to get the release action. You'd want this treatment for applications like kids' clothing, where you want some stain resistance, but expect the apparel to get stained anyway—and still want to be able to clean it."

Michelle Watkins of Invista says that for activewear, a stain repellent finish may be inadvisable, because it may interfere with moisture management. However, a combination of stain release with a moisture management finish is generally more optimal for activewear.

**Testing Finish Effectiveness**

With the technologies available for all these different applications, it is important to be able to test the effectiveness of stain repel and stain release treatments so that retailers—and consumers—are getting the function they expect, and pay for, in that particular application.

AATCC has developed test methods to measure the stain release, repellency, and stain resistance of textile products. "For stain release performance, AATCC Test Method 130 accurately measures the ability of textiles to release oily stains in the home laundry," says Kimbrell. Keyes adds that "Test Method 130 has been adapted by various companies to test other soils as well. Work is being done in the committee to develop a test method to judge these other soiling mediums."

"For repellence," says Kimbrell, "a number of test methods have been adopted. These include Test Method 118 for oil repellency, Test Method 193 for aqueous repellency, Test Method 22 (Spray Test), and various others." According to Hammonds, Test Method 118 indicates how well a finish keeps oil from penetrating the fabric.

Keyes notes that lately there has been a movement towards developing a test for combination repel/release dual finishes. "The combination finishes have been tested using both Test Method 118 and Test Method 130, but it has been pointed out that the tests may not accurately measure a finish's performance under real world conditions. Typically, consumers immediately would attempt to remove the fabric stain by wiping it away, not leave it sitting on the fabric. On the other hand, some soils have extended dwell time in the laundry basket. There is no existing test method that mimics the wipe off/dwell time behavior. Work is being done to develop a test method that will more closely align with this consumer behavior and may be more accurate in determining the effectiveness of the repel/release dual finishes."

"AATCC Test Method 22, water repellency, is important as well," notes Ware. "Because spills are often propelled onto fabric—it is a dynamic situation and you need a dynamic test. We think it's more consumer relevant."

**FACTORS AFFECTING STAINING**

"Even the waters of the Ganges cannot wash away the stain of hatred, yet the water of virtue is able to do so." —*A Treatise on the Paramis*, Acariya Dhammapala

"Even when a textile product is properly finished ... it is unreasonable to expect complete resistance or release of all stains," notes Kimbrell. A variety of factors affect staining: the fiber, type of the substrate, the type and chemistry of the staining agent, and even the color and construction of the fabric.

According to Miller, "Oily soils typically are the worst for soil appearance, as they tend to stick to the fibers. Foods may contain acid-type dyes that stain by attaching chemically to amine groups in polyamides (nylons). These are different sources and mechanisms, but sometimes are found in combinations, such as spaghetti sauces."

"Anything with a dye or bleaching agent is a very tough stain," says Watkins. "It also depends on how long the substance has been on the substrate.
and how deeply it was ground into the fabric."

The fiber of the substrate obviously makes a difference. Cotton and other natural fibers tend to be hydrophilic, making them more susceptible to water-based stains, but also making the removal of water-based stains easier. Synthetics are oleophilic, making oil-based stains more problematic either to repel or release.

"The color of the fabric makes a big difference," says Crater. "Darker colors show stains less. The construction of the fabric may also make a difference. With a tightly knit or woven fabric, fluids are more likely to roll off than with something more loosely woven." Ware notes that, as well as color, patterns on the fabrics can also mask stains. Hammonds notes that the "hairiness" of certain yarns or fibers may contribute to holding on to stains.

According to Kimbrell "the perception of the intensity of the visible stain depends upon color differences between the textile and the stain and upon the uniformity of the boundary between the stain and the unstained textile. In addition, there are stains like paint that can crosslink during ageing, thereby becoming almost impossible to remove unless immediately laundered."

**THE FUTURE**

"Stainless virtue be your shelter, virtue be your wealth on earth!" —Ramayana Book XII, Aswa-Medha, Valmiki and his Pupils

No matter what the stain, "The Holy Grail is 100% stain repellency and 100% release," says Ware. "Consumers want effectiveness on both fronts. The technology out there today compromises between repel and release characteristics. How well you minimize the loss of repellency while maximizing the release capabilities is important. You try to achieve the best balance of both properties for each application."

The durability of these stain-fighting finishes is also important. "We're looking at increasingly durable treatment," says Crater. The industry is working on improving the durability of stain-fighting finishes to make sure they last the life of the product, whatever that life might be, whatever the textile product might be.

Another concern is environmental sustainability. Many of these finishes are fluorocarbon based. "Treatments should be environmentally sustainable as well," notes Crater. "3M has completely changed our technology in the last few years to have a much improved environmental profile. We are confident that our products are sustainable and our customers can count on them in the future."

Maybe the real Holy Grail is "self-cleaning" textiles. Kimbrell mentions research into "Photocatalysts [that] enhance the degradation of organic material by sunlight, yielding only CO₂ and H₂O." He says that this technology is "the object of considerable research interest worldwide."

What can we all count on in the future? All the crystal ball says for sure is that the industry will continue to search out new and exciting technologies to battle staining and soiling and maintain the beautiful appearance of fabrics.