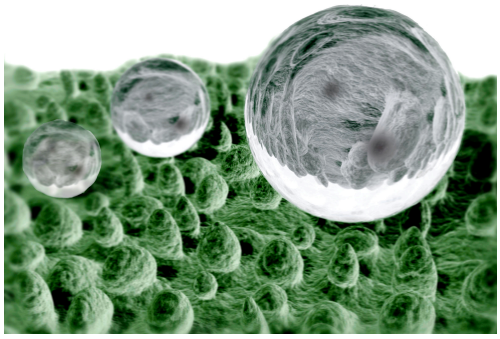
GreenShield®

Nanotechnology that mimics nature

Have you ever heard of the “lotus effect” (or biomimetic? effect)?

Botanists who have studied lotus leaves have found that they have a natural cleaning mechanism. This cleaning mechanism was analyzed in 1997 by Professor Wilhelm Barthlott (however, the Lotus effect dates back well beyond this), the director of the Nees-Institue for Biodiversity in Bonn, Germany. The lotus effect in material science is the observed self-cleaning property found in lotus plants. Their microscopic structure and surface chemistry mean that their leaves never get wet. Rather, water droplets roll off a leaf's surface like mercury, taking mud, tiny insects, and contaminants with them. This is known as superhydrophobicity, or more commonly, the lotus effect.



Whether in upholstery, in office furniture, in healthcare or in apparel, fabrics need protection against stains and water. This protection has, so far, been provided using fluorochemical-based finishes.

The US fluorochemicals industry is large, around $3.5 billion per year; it includes fluorocarbons, fluoropolymers, specialty organics, inorganic fluorine gases, and inorganic fluorochemicals, used primarily as refrigerants, coatings, fluoropolymer precursors, blowing agents, solvents and cleaners. However, fluorochemicals are suspected to be toxic to animals and human beings and are highly persistent in our environment. Fluorochemicals represent an emerging issue of environmental concern due to their global distribution, persistence and bioaccumulation.

Today, fluorochemicals, in all their forms, are widely used in many industrial applications, however, the scientific community as well as governmental authorities have been highlighting and encouraging the need to reduce the use of such chemicals. The need to find alternatives that respect the environment and the quality of life on earth is urgent. Progress has been made in several industries but the textile industry remains among the biggest challenges. This is where nanotechnology comes to the rescue.

By using microscopic surface roughness, surface dynamics and non-carbon based nanoparticles, the GreenShield™ finish on fabrics guarantees superior stain resistance and water repellency while using significantly lower amounts (up to 10 times less) of fluorochemicals. These eco-friendly properties are improved by the fact that GreenShield is predominantly a water-based formulation with less than 1% organic solvent (compared with 7%-10% for typical fluorochemical finishes).

GreenShield takes advantage of nanotechnology's advanced applications. Nanotechnology involves the controlled manipulation of particles smaller than the wavelength of visible light. At this scale, quantum physics starts to apply, making possible some astonishing results and applications. One of the key factors behind the rapid development in the field of chemical nanotechnology for textiles is the further development of surface functionalization; a controlled process whereby molecules are attached onto the surfaces of nanoparticles. This process permits a highly targeted and reproducible production of multi-functional nano-particulate systems. The resulting rain of materials ranges from vitreous-hard to polymer-soft with variable surface properties varying from hydrophilicity (wicking or absorbing effect) to water and stain repellency (lotus or biomimetic effect), which is the effect reproduced by the GreenShield finish.

But, what exactly is nanotechnology?

Nanotechnology is hailed by the US government and industry organizations as "The Next Industrial Revolution." It is a new category of technology that involves the precise

manipulation of materials at the molecular level or at a scale of roughly 1 to 100 nanometers, with a nanometer equaling one-billionth of a meter. How small exactly is a nanometer? As one journalist put it, “If a nanometer were somehow magnified to appear as long as the nose on your face, then a red blood cell would appear the size of the Empire State Building, a human hair would be about two or three miles wide, one of your fingers would span the continental United States, and a normal person would be about as tall as six or seven planet Earths piled atop one another.”

Much of the work being done today that carries the name 'nanotechnology' is not nanotechnology in the original meaning of the word. Nanotechnology, in its traditional sense, means building things from the bottom up, with atomic precision. This theoretical capability was envisioned as early as 1959 by the renowned physicist Richard Feynman.

> *“I want to build a billion tiny factories, models of each other, which are manufacturing simultaneously. . . The principles of physics, as far as I can see, do not speak against the possibility of manoeuvring things atom by atom. It is not an attempt to violate any laws; it is something, in principle, that can be done; but in practice, it has not been done because we are too big.”* — Richard Feynman, Nobel Prize winner in physics

Based on Feynman's vision of miniature factories using nanomachines to build complex products, advanced nanotechnology (sometimes referred to as ‘molecular manufacturing’) allows for positionally-controlled mechanochemistry guided by molecular machine systems.

Nanotechnology is sometimes referred to as a *general-enabling technology*. That's because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general. Some of these advances have appeared already.

So far, many of the applications for nanotechnology have been oriented toward modifying surface properties; modified surface coatings have already been put to good use to provide a competitive advantage in sports. In the 2002 winter Olympics in Salt Lake City, a nanotechnology ski wax was used for the first time to reduce surface friction and gain speed.

The GreenShield nanostructured surface mimics the lotus leaf's natural structure. As discussed above, the lotus leaf surface presents roughness on two scales that prevents the droplet from getting in contact with the actual surface, and it simply rolls off the fabric. Unlike conventional stain and water repellents, GreenShield makes droplets roll off the surface and not slide on it; which means also that droplets tend to collect any dirt particle, thus providing fabric with an auto-cleaning action.

Green Nanotechnology and Sustainability

The practice of environmental sustainability requires a system perspective towards product development and manufacturing. To this end, any nanomaterial modification and/or manufacturing process, should be designed in a way that maximizes product performance while minimizing environmental, health and safety risks. Such a process for the manufacture of green nanomaterial products eliminates waste, uses ambient temperature and pressure, and uses aqueous solvents only to create products that limit or eliminate the use of harmful chemistries while improving their economy of use by "making every atom count". The GreenShield finish is based upon this practice of Green Nanotechnology principles. The philosophy and practice of green nanotechnology offers an opportunity to head off adverse effects before they occur.

References:

- Cheng, Y T, Rodak, D E, Wong, C A and Hayden C A. "Effects of micro- and nano-structures on the self-cleaning behaviour of lotus leaves." *Nanotechnology* 17 (2006) 1359-1362.

- Adam Keiper, “The Nanotechnology Revolution”; *The New Atlantis*, Summer 2003. Issue 2.

- “National Nanotechnology Initiative: Leading to the Next Industrial Revolution”, a report published by US National Science and Technology Council’s Committee on Technology, February 2000.

- *Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing* by C. Jeffrey Brinker, George W. Scherer. 1989.

- K. Eric Drexler, “Engines of creation”; 1986.

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- http://www.nanotechproject.org/file_download/files/GreenNano_PEN8.pdf