The high-tech engineering and chemistry that go into the manufacture of functional fabrics can extend to the molecular or even nanoscale level. This infinitely small dimension, applicable to materials and processes, is making a comeback in a wide array of performance textiles.

When small is big

Trends condition not only fashion and sports but marketing lingo as well. A few years back, a product calling on nanotechnologies would promote its use in boldface, as has been seen in textiles – Schoeller launched Nanosphere in 2000 – and cosmetics. But the tide turned for these infinitely small substances; their presence – whatever their composition – in products worn next to or on the skin raised concerns, and the nanoworld dropped off the radar. The term continues to be best avoided in some countries, but is viewed as positive in others, an industry executive at a nanomaterial company tells *WSA*. Some suppliers have found a clever, if slightly deceptive way to sidestep the issue by describing their materials as "submicron". Now the word seems to be back on-trend with nano-materials and processes returning to the forefront.

Ultrafine filaments

Nano-fine filaments have recently been launched by US-based Eastman and Italy-based Fulgar. Eastman's ultra-fine polyester, Avra, is manufactured using a split filament process, a technology first developed in Japan. Ultra-thin polyester fibres are extruded and held together by a removable polymer, enabling knitting or weaving. Once the fabric is made, the removable polymer is washed away in hot water leaving only a flat, ribbon-like fibre that measures on average 2.5 x 18 microns in size. "The result is a distinctly silky fabric that keeps wearers drier and more comfortable than ever before," Eastman's vice-president Tim Dell said. Performance characteristics attributed to the nanofibre include moisture management and quick drying properties, a non-chemical cool touch, soft handle and drape. A fabric made in Avra is said to dry up to 50% faster than a conventional polyester fabric. Eastman's fibre is produced by Unifi in its Yadkinville, North Carolina, plant, and the two companies have recently announced plans to expand production



Coolest Comfort, a hydrophilic finish by Nanotex, keeps the body cool by wicking moisture away faster.

Nanotex

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capacity. At Outdoor Retailer this summer, Eastman displayed, and gave away, Avra-based garments to its customers and prospects. "Response to the comfort, wicking and dry-time performance of the shirts has been phenomenal," John Cahill, performance fibres marketing manager told *WSA*.

A supplier to the hosiery industry, Fulgar's Nanofiber is a polyamide 6.6 yarn having a diameter of 7 microns, compared to 15-20 microns for conventional microfibres (a human hair is about 75 microns.) Its density and fineness give fabrics a very smooth and silky hand and also make them opaque, according to the company says. Italy-based knitter Maglificio Ripa and weaver Serates have introduced fabrics using the nanotech nylon. In wovens, the high-density structure will resist wind without compromising breathability, and will require no additional chemical finish, Serates states.

Electrospun membranes can also be considered nanomaterials, as Czech electrospinning specialist Nanomembrane demonstrates in the choice of its name. "The thickness of the membrane is in the nano range, but not its surface area," says company sales manager, Marek Hermansky. The Svitavy-based company makes a nanofibrous, non-woven membrane in polyamide 6, a polymer chosen for its thermal stability and wash resistance. Electrospun membranes generally favour vapour permeability over wind- and water-resistance, but certain references at Nanomembrane are waterproof up to 30,000-plus millimetres. The company is currently expanding its range to ready-to-wear materials, Mr Hermansky says, mentioning a wool-based laminate having a water column of 10 metres and a Ret value of 2.2 (the lower the resistance, the higher the breathability).

Nanoscale processes

Founded in 1998, Nanotex was one of the first companies to apply 'nanotechnologies' to textile finishing. The company is now owned by performance fabric maker Crypton, which is itself controlled by investment company Berkley Capital which acquired a majority stake in April 2017. This is good news, says Randy Rubin, who founded the company 25 years ago with her husband, Craig: "We are very excited as Berkley Capital is a hands-off investment fund. It will help us develop our business and brands. It gives us a big boost, and all our executives have stayed on." A branding expert, she views Nanotex's name as an asset: "It is a recognised brand, it is viewed positively by consumers, and it's catchy." Hardy Sullivan, the company's market development manager and technical guru, points out that "we are working with molecules that are nano-sized but each functional nano group is attached to a polymer."



This 41g/sq.m fabric developed by Italian weaver Serates is made with Fulgar's Nanofiber, a 7-micron diameter polyamide yarn.

Serates

Nanotex currently develops a portfolio of products that covers various functions such as repellency, stain resistance, moisture management, odour control or a cooling effect. New products include Dry Inside, a moisture-management finish developed for Cotton Incorporated. "This finish will wick away moisture so that a shirt stays dry and doesn't cling to the skin," says Ms Rubin. Achieving this effect requires a subtle balance of functions, Mr Sullivan adds: "You don't want the fabric to be too hydrophobic, you want to allow some water to get through and prevent it from returning." Another new item, Durable Wear, introduced in 2016, claims to prolong a garment's use. "It reduces the coefficient of friction, making the fabric less prone to abrasion," says Mr Sullivan. In effect lubricating the surface of the fabric, it can also improve its hand feel.

Nanotech finishes are also appearing in start-up brands in the premium performance wear arena, as seen at NY-based Rhone, which uses gold nanoparticles in its GoldFusion Technology. The process is said to give fabrics a soft hand, make them dry fast and neutralise odours. After 100 washes (four times the average life of a garment the brand claims), the anti-odour particles are still 99% effective, and they are, it



The gold nanoparticles embedded in Rhone's GoldFusion Technology speed up drying, neutralise odours and are said to last 100 washes.

Rhone Apparel

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emphasises, safe for humans and the environment. This technology was first applied on Polartec fabrics (a merino wool knit and a Delta fabric) and launched on Indiegogo in December 2016. The company aimed to raise $35,000 and ended up gathering $112,986.

Plasma processing, a textile finishing technique based on ionised gas (plasma), falls in the nanotechnology category as it also modifies a textile surface on a molecular level. It can furthermore be considered sustainable as it uses chemicals in minute quantities. "Plasma is a dry process, requiring no water, and it deposits an atomic layer on a textile," says Europlasma sales manager, Wim Huijsman.

The Belgian plasma specialist has recently developed a new PFC-free chemistry and machine to treat footwear in batches. "Our technology enhances a shoe's abrasion resistance and water- and mud-repellency. It also leaves no creasing marks," says Mr Huijsman. The new solution is based on alternative formulas that, he says, "have very tangible advantages over PFC technologies," without specifying its nature to protect the IP. In 2016, the company reached a milestone with 1,000,000 items of footwear and apparel coated with PlasmaGuard.

Molecular tagging

Yet another molecular-based technology is coming forward with DNA-based tags used for supply chain authentication and traceability.

Based in Stony Brook, USA, Applied DNA Sciences has developed various types of DNA-based markers, some derived from botanical sources. "Some tags are originally derived from plant genome sections, rearranged for security purposes. Other tags are designed from the start to use the molecules of DNA in an encrypted way. All of our molecular tags are built from the same DNA building blocks found in nature (A,C,G,T), however, the DNA sequences of our molecular tags are in no way similar to a gene or any organism, and thus they cannot have any gene function," says MeiLin Wan, vice-president of textiles. In addition to the billions of individual tags that can be created, one of the technique's advantages appears to be its scalability. The company's SigNature T tags can be applied to millions or billions of products, she says.

With regards to the additional cost of embedding these tags, Ms Wan points out that brands should bear in mind that "the reputational risk of 'not doing anything' is much greater for them." Case in point, she adds: it cost Target $90 million dollars to recall products falsely labelled 100% Egyptian cotton in 2016. And that doesn't cover "the reputational cost of having to explain to the customers that their products did not meet their quality standards."

DNA is a powerful and cost-competitive solution for securing a supply chain, Alain C. Jeanren, at Haelixa, a Swiss spin-off of ATH Zurich, said in a conference held at the Outdoor Show in Germany this June. Haelixa encapsulates short DNA sequences in nano-sized (100 nm) silica particles and they cost from €0.10 to €0.50 euro per tonne. The start-up, founded in 2016 by ETH researchers Michela Puddu and Gediminas Mikutis, first targeted the oil industry and is now seeking to enter the textiles and cosmetics markets.



When a brand invests in a sustainable supply chain, such as organic cotton shown here, it is essential to certify and guarantee the provenance of the raw materials says DNA-tagging specialist Applied DNA Sciences.

Applied DNA Sciences

Tagging and tracking technologies are considered particularly useful for companies looking to protect and certify sustainable raw materials. This is an important business driver for Applied DNA Sciences, which sees recycled polyester and organic cotton as key markets. It has also recently launched a leather certification programme with the British Leather Consortium, an initiative supported by Puma, Clarks and the Scottish Leather Group.

Health concerns

The European Union's chemical agency, ECHA, have placed 11 nanomaterials under surveillance. These include the usual suspects such as fullerenes and single- and multi-walled carbon nanotubes, but also metals (silver, gold) and other materials such as dendrimers, silicon dioxide, nanoclays, titanium dioxide, cerium dioxide and zinc dioxide. An Observatory for Nanomaterials has also been launched, by ECHA, with a website providing information on nanomaterials present on the EU market.

In the textile industry, concerns regarding nanotechnologies seem low. While researching this article, many have pointed out that when nanoparticles are present, they are attached to conventional-size materials. This suggests that consumers face little or no risk, but does not rule out a possible effect on the health of those who handle or come into contact with them during manufacturing.

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