Despite promising potential in terms of performance and reduced use of water and chemicals, the textile industry appears reluctant to shift from traditional wet finishes to plasma processing.

The age of plasma

Commonly applied on plastics, rubber and metals, plasma processing has yet to find its place in the textile industry. Research has been under way for decades, and the first industrial machines were developed in the early 1990s. The slow market penetration of the finish appears to be due in part to the three-dimensional structure of fabrics, which make them more difficult to coat compared to the smooth surface of plastics and metals. UK-based company P2i, one of the main promoters of plasma in the sports market in recent years, appears to have optimised the process for footwear, but not for apparel end-uses.

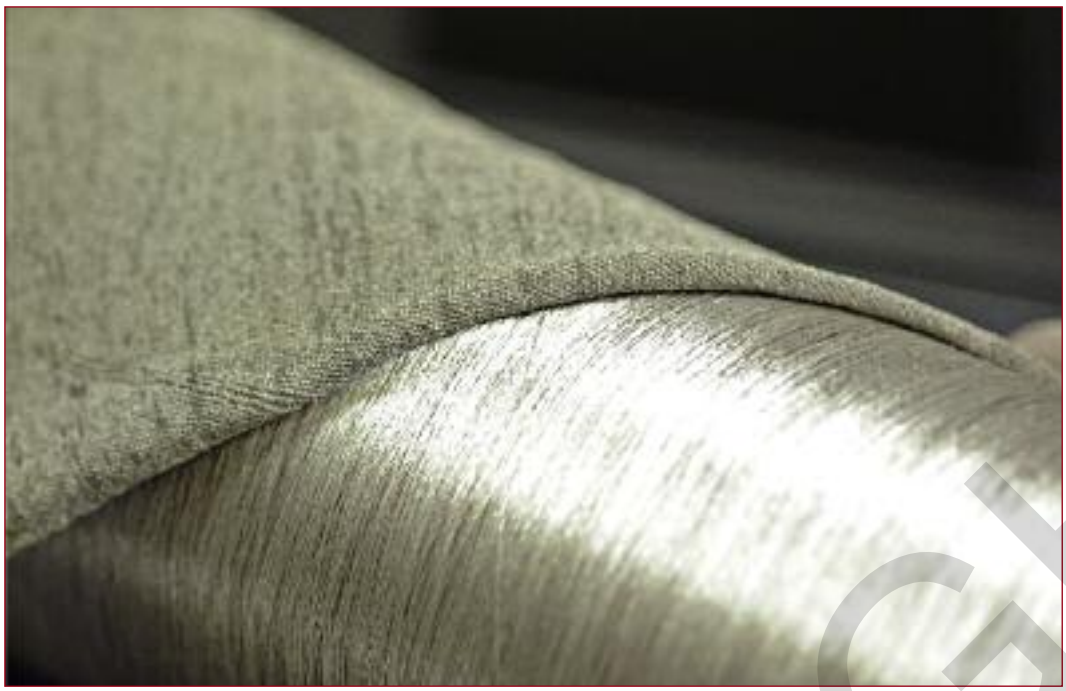
Plasma is commonly called the fourth state of matter. Under increased energy input, the state of matter changes from solid, to liquid, to gaseous. Additional energy input, by applying an electrical field, turns gas into plasma. This so-called 'ionised' form of gas is highly reactive, enabling it to modify the surface or properties of a receptive material.



Earlier this year, P2i doubled the processing capacity of its Chinese facility, now located in Chang'an, and which focuses on footwear applications of ion-mask.

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Textile metallisation via plasma can be applied bobbin to bobbin and could have potential in fashion - for the subtle lustre achieved - as well as in electro-textiles by creating conductive yarns that can then be woven like conventional yarns. The fine, 50 nm deposited layer boasts high conductivity without altering the fabric's properties. A development at EMPA.

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Roughly speaking, on textiles, plasma treatments are used to achieve one of three effects: modify the surface, deposit a fine layer of chemicals or resins on a textile, or graft a molecule to the fabric. In the case of grafting, new chemical functions are bonded to the textile, forming a durable layer that is usually either hydrophobic or hydrophilic. In effect, plasma could potentially put the 'D' for 'durable' back into Durable Water Repellent or DWR finishes. At the Swiss laboratory for Materials Science and Technology, EMPA, plasma treated water-repellent fabrics display a resistance to washing that is said to reach 50 and even 100 wash cycles.

Plasma processing is also used as a pre-treatment: to clean the surface impurities of the receptive layer prior to coating or laminating. It can also be used to improve the quality of adhesion and thereby reinforce the subsequent composite material. For soft shells, for instance, the finish is said to reduce the risk of delamination within the layers.

Low pressure versus atmospheric

There are two radically different ways to use plasma. In low pressure processing, materials are placed in a chamber and subjected to ionised gas in a void. This implies a batch-by-batch process. It is the system developed by P2i and though practical for treating shoes, it is less suited to large volumes. On the upside, low pressure requires smaller quantities of gas.

Atmospheric plasma is favoured for textiles as it enables reel-to-reel or linear processing, but consumes larger quantities of activated gas. This can be costly if one chooses expensive gases, such as argon (to reinforce abrasion resistance) or helium (to create a hydrophilic surface), says Dirk Hegemann, head of the Plasma and Coating Group at EMPA.

As mentioned earlier, plasma processing is slightly more difficult to apply on the three-dimensional textures of textiles. "In a void, plasma will cover the entire surface; this is less true for atmospheric processes," says Brunot Chevet, in charge of research and development at IFTH-Lyon, the Lyon branch of the French textile and apparel institute.

In both cases, plasma is considered a dry process that has the potential to save time, energy and water since there is no need to dry the treated fabric and no chemical waste. Plasma consumes smaller quantities of chemicals as well, as P2i is often quick to underline. Dr Eric Yung, researcher at Chang-Ho Fibre, a Taiwanese company, estimates that chemical consumption in plasma processing is 1/1000th of the levels in traditional wet processing. Chang-Ho's plasma process, IGP, for Ionised Gas Process, has been in development for the past 20 years.

For fluorocarbon finishes, used for water repellency, the reduction in chemicals use offered by plasma may lead to a lesser impact on the environment and workers, in addition to lower costs. Plasma could also simplify the end-of-life treatment of textiles, says Mr Chevet, at IFTH-Lyon.

A 'green' technology

Environmental considerations were the first reason the textile industry began working with plasma, but Mr Chevet believes the main motivation is now performance as "plasma can achieve results that are not attainable otherwise". Foremost among these is the possibility of treating each side of a fabric with a different function: grafting a hydrophilic finish onto the

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back to absorb moisture and a hydrophobic layer on the face to repel water. This is not possible with traditional wet processing, says Dirk Hegemann at EMPA.

The "green footprint" of ion-mask, P2i's solvent-free process, "has never been a show-stopper," says Dr Stephen Coulson, P2i's chief technology officer, as brands look primarily for performance and cost benefits. In footwear, he points out that ion-mask offers a "fully repellent solution for the shoe industry, whose value at retail can represent $10-$15 compared to other methods, such as waterproof-breathable membranes". P2i has built a footwear processing centre in China and says it has sold 100 of its plasma machines in Europe, the US and Asia. The company has also recently completed a new round of financing, receiving £12 million in funds. A process for treating garments, which P2i worked on in the past, was sold back to the UK Ministry of Defence (out of which P2i was originally spun off) in 2010. "We would consider developing apparel applications in conjunction with an industrial partner," says Mr Coulson.

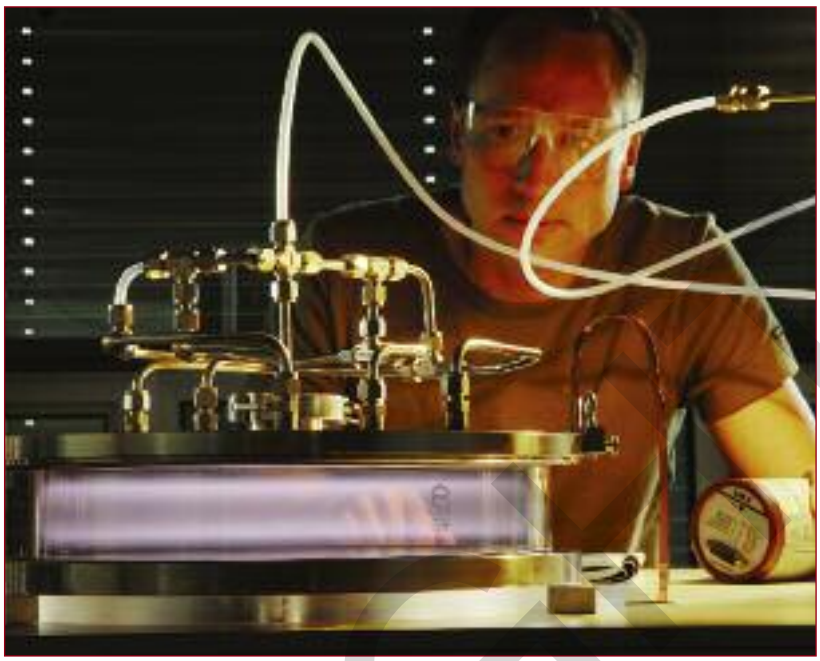
Mectex, an Italian textile manufacturer recently come under new ownership (by the Italian Adler Group, which has €1 billion in sales), has been developing low-pressure plasma finishes for the past three-four years. The PlasmaMec treatment can be applied to all of the company's functional fabrics, including polyamide, polyester and stretch textiles. "The hydrophobic finish we apply reduces a fabric's drying time by 50%," says Davide Tagliabue, at Mectex. The company claims the plasma-activated water-repellent finish is three times more resistant than conventional wet processing, retaining 80% repellency after 12 washes. Mectex also uses plasma to improve the adherence of two-way stretch laminates.

Remaining hurdles

When the global cost of a fabric, including energy and water consumption, is factored in, plasma may not be the expensive technology it is often touted as being. Newly developed machines, made by Europlasma in Belgium, Grimp in Italy, or CPI (for Coating Plasma Industrie) in France, are suited to industrial needs and are easy to implement in existing production lines, says Bruno Chevet, at IFTH-Lyon. Atmospheric plasma is considered the easiest to integrate because it does not interrupt the textile production cadence, points out Christine Campagne, professor at ENSAIT, French higher education textile institute specialised in Fibre Science and Technology which includes a research laboratory known as GEMTEX.

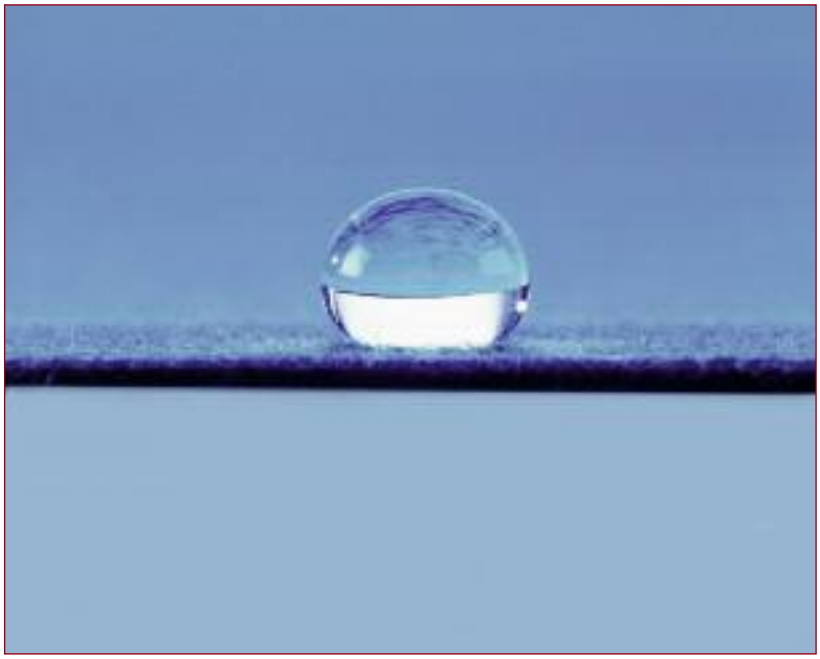
Thierry Heim, founder of HT Concept, a French converter, was considering developing plasma finishes, but decided not to after studying the different options. "Plasma may be a way to reduce chemicals and water consumption, but it requires high levels of energy. The machinery is expensive and quite complex to handle," he says.

While many manufacturers show interest in the process, few have made the decision to invest in it. "Pressure on the market to replace wet treatments is not high enough yet," says Dirk Hegemann, at EMPA. To balance the investment cost, a company would need to have a certain level of throughput. This means that to offset the high cost of the initial investment, textile manufacturers must secure high volumes down the line.



A lab-scale plasma reactor. An electrical field is necessary to activate or ionise a gas to achieve the state of plasma, known as the fourth state of matter.

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Plasma finishing requires smaller amounts of chemicals to achieve durable water repellent surfaces. The dry process is considered a greener technology.

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