

Most developments are industry-led, but research in academia also has a role to play.

# Universities add value

Most sportswear-related innovations are the result of in-house research and development, come via chemical or textile companies or are funded by brands, perhaps working in collaboration with academia—and more than likely under confidentiality agreements. However, there have been a number of university projects over recent months that could be of interest for the sports and outdoorwear industries, and which are attracting interest from commercial organisations.

One such development is SLIPS (slippery liquid-infused porous surfaces), an oil and stain-repellent coating originally created in 2011 that researchers at Harvard University in the US have recently applied to fabrics.

It is inspired by the carnivorous pitcher plant, which locks in a water layer to create a slick coating that causes insects that land on it to hydroplane and fall into the plant. The SLIPS coating anchors a slippery lubricated film infused to a nanoporous solid surface, creating a material that performs well under pressure, and can resist liquids.

"We took a page out of nature's book, and are finding that it has the potential to help us develop solutions to a variety of age-old challenges: ice we don't want on refrigeration coils, bacteria that we don't want on medical devices, and now stains we don't want on clothes," says Joanna Aizenberg, professor of materials science at Harvard.

Many stain-resistant fabrics draw their inspiration and design from the lotus leaf, explains Cicely Shillingford, a research assistant at the Wyss Institute, which partnered Harvard on the project. "Tiny nanotextures on the surface of lotus leaves resist water, causing droplets of water to bead up on a cushion of air at the edge of the surface. Lotus-inspired textiles therefore use air-filled nanostructures to repel water."

While these are capable of repelling most aqueous liquids and dirt particles, they suffer from a series of shortcomings, she says. "They require a stable solid-air layer for the beading process to occur and thus fail easily under pressure, such as in a heavy rainstorm, and do not withstand physical damage, such as twisting and abrasion, very well. They also stain

*Harvard researchers have based a new textile coating on the mechanism a carnivorous pitcher plant uses to trap prey.*
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more easily from organic or complex liquids, such as oil."

To create a fabric with SLIPS functionality, the team looked at ways to treat cotton and polyester fabrics. One involved coating them with tiny particles of silica and another required a treatment with sol-gel based alumina. They were treated with a liquid-infused coating that changes the fabric's chemical properties. Oil, water and other substances then bead up and roll off the fabric. "The SLIPS fabric showed an unprecedented ability to repel a wide range of fluids and resist staining, and it handles physical stresses and strains," says Ms Aizenberg.

However, she admits some treated fabrics were not as breathable as the researchers hoped, and suggests immediate applications could be types of specialty workwear.

## Water repelling

Researchers from the Massachusetts Institute of Technology (MIT) have also found a way to make textiles more water repellent but this time by reducing the time it takes a water droplet to bounce away from the surface. "The time the drop stays in contact with a surface is important because it controls the exchange of mass, momentum and energy between the drop and the surface," says Professor Kripa Varanasi. "If you can get the drops to bounce faster, that can have many advantages."

The minimum time a bouncing droplet can stay in contact with a surface depends on the time period of oscillations in a vibrating drop, known as the Rayleigh time. But Prof Varanasi's team found that increasing the surface interaction in a particular way can speed the process beyond that limit. Most developments have previously been based on minimising interaction between the water and the surface, he says. The team added ridges that break a droplet's symmetry and can split it, causing it to recoil in irregular shapes, reducing contact times by as much as 40%.

"We've demonstrated that we can use surface texture to reshape a drop as it recoils in such a way that the overall contact time is significantly reduced," says James Bird, the paper's lead author. "The upshot is that the surface stays drier longer if this contact time is reduced, which has the potential to be useful for a variety of applications."

## Longer cotton

A couple of thousands of miles away, a team from Texas A&M University says it has figured out how to make a longer cotton fibre through a project funded by the US Department of Agriculture.

The majority of cotton harvested worldwide is upland cotton, Gossypium hirsutum. A higher-end cotton called Gossypium barbadense (frequently known Pima or Sea Island) is more desirable because of the longer fibre length and strength but is late-maturing, low-yielding and more difficult to grow because it requires dry climates with significant irrigation and is less resistant to pathogens and pests.

"For a long time, cotton breeders have been trying to develop upland cotton with the fibre qualities of barbadense cotton," says Alan Pepper, an associate professor in the Department of Biology. "Economically, it's a huge deal, because every millimetre you add to fibre length adds to the price of cotton when the farmer sells it."

The researchers' method increased the length of the fibre by at least five millimetres, or 17%, compared with the control plants. He says while the cotton plants are genetically modified organisms (GMOs), the usual criticisms of GMOs focus on that fact that genes from other species are used. "What we're doing is a little different. We're knocking down the effect of one



*Prof Alan Pepper, from Texas A&M University, whose discoveries could make cotton more profitable for farmers.*

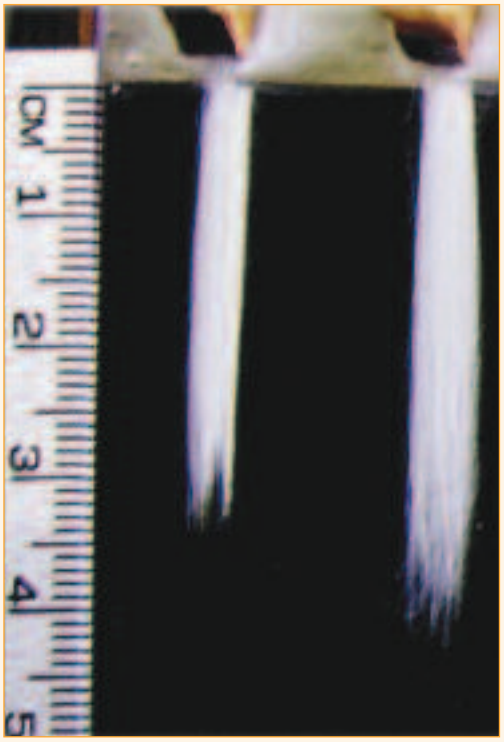
*Texas A&M University*



*Tak-Sing Wong, a former post-doctoral fellow from Harvard, demonstrates the difference between SLIPS-coated (on arm) and untreated fabrics.*

*Eliza Grinnell, SEAS Communications*

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*Texas A&M University creates a longer, stronger cotton fibre, shoot and root (right) compared with normal plants.*

Texas A&M University

of the genes that's already in the plant."

Mr Pepper's interest is in a type of photoreceptor called a phytochrome, which is responsive to different wavelengths of red light. The phytochromes regulate many plant traits, including the length of leaves and stems and flowering time. Using a genetic cross between a long-fibre plant and a short-fibre plant, they used a technique called RNA interference to change with expression of the gene, Pepper says.

The discovery was especially important to Ibrokhim Abdurakhmonov, the lead author of the study who received his master's degree in plant breeding from Texas A&M in 2001 and is now a professor in his native Uzbekistan. "Sustainability and biosecurity of cotton production is pivotal for the Uzbekistan economy because agriculture accounts for 24% to 28% of the country's gross domestic product," he says.

"Our anticipation of possible improvement of resistance to abiotic stresses via phytochrome RNA interference further adds to its commercial potential."

## Innovation awards

In Geneva, Switzerland, students and researchers from the Hong Kong Polytechnic University were among winners at the 42nd International Exhibition of Inventions held in April.

Two textile developments were presented: a high-performance protective textile, developed from a 3D spacer fabric treated with impact-hardening polymers based on stress-responsive micro-gels. The treated fabric is flexible during normal use but becomes rigid on impact, transmitting the impact force onto a big area, and becoming flexible again after impact, and could be of use in protective clothing.

The team from the university's Institute of Textiles and Clothing, in collaboration with the Hong Kong Research Institute of Textiles and Apparel, also presented a light, washable conductive material with provision to heat targeted regions, for use in outdoor apparel and medical products.

## UK developments

Wearable technology was on the agenda at the San Francisco-based conference Smart Fabrics, where a team from Nottingham Trent University in the UK pitched an idea for a cycling jacket made from LED-embedded yarn.

"Just as brands like Rapha have enabled fashion to cross over into functionality in the cycling market, we believe that C-Velo can use wearable technology to take this to the next level," says the university's business relationships manager, Si Beales.

The jacket incorporates red LEDs in the back of the jacket and white in the front. Orange indicator LEDs are used in the sleeves to allow the cyclist to show direction of travel. "Future versions of C-Velo could include tracking and monitoring facilities for areas such as performance, wellbeing, location and communication," adds Mr Beale.

Harnessing advances in 3D printing, a start-up borne out of the University of Edinburgh and Heriot-Watt is hoping to rid skiers of foot pain by producing customised insoles that provide tailored cushioning. AIPrint's clients use

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an app to take photos of their feet, standing on a calibration mat that can be printed at home. The dimensions of the foot are calculated and, along with other data such as the person's weight, used to determine the density of various parts of the insole. Cushioning levels are tailored to their skiing style.

Chris Balmer, one of AlPrint's founders, says: "We have benefitted hugely from having such a developed support network from both universities. The University of Edinburgh is also a great scene for competitions and entrepreneurial experience lectures and events."

## Next steps

Xeros, a UK-based company which has developed a novel way to clean clothes using little water, has recently taken the next spin-out step from Leeds University to fully fledged commercial entity with a flotation on the London AIM stock market. It has raised about £27 million selling one third of its shares, and the company is now valued at around £80 million.

"Polymer bead cleaning is the first real innovation in the laundry industry in more than 60 years," says Jonathan Benjamin, president of Xeros North America.

The idea for the company began after lecturers posed the question: if we can anchor dye on to fabric, can the process be reversed to remove unwanted stains? Xeros founders developed a process which combines mechanical action and absorption, reducing the consumption of water by 70%, and which needs less energy and fewer chemicals throughout the cleaning process. "I am very confident and enthusiastic about our future as we begin the next stage of significant growth as a public company and British university spin-out," says CEO Bill Westwater.

The most successful university-based innovations eventually follow the Xeros route into the commercial sector, through investments, being spun-out or sold off. In 2011, the US government signed the America Invents Act, which encouraged universities to commercialise inventions. That year, universities in the US earned more than $1.8 billion for their academic research, according to data compiled by the Chronicle of Higher Education.

However, many universities have had to scale back research in recent years due to reduced budgets, or because they have been forced to concentrate on student numbers and government targets. Private equity-style firms such as Imperial Innovations in the UK and US-based Allied Minds therefore play an important role in the fostering of innovation and entrepreneurship and in the cycle of returning money back to universities.

"We spend a lot of time at the beginning of the life of these companies making sure they're set up with strong management teams and we build in quality co-investors," says Imperial Innovations CEO Russ Cummings.

The firm has $80 million of capital available to invest, including £30 million ($50 million) provided by the European Investment Bank; the challenge is to explain to shareholders and new investors the value in the portfolio as companies are valued on an historic basis.

"There is an opportunity to unlock that value as companies mature and are either brought to market or acquired by trade parties," he says. "And there is no shortage of opportunities for us to deploy that capital and to add new companies to our portfolio."




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