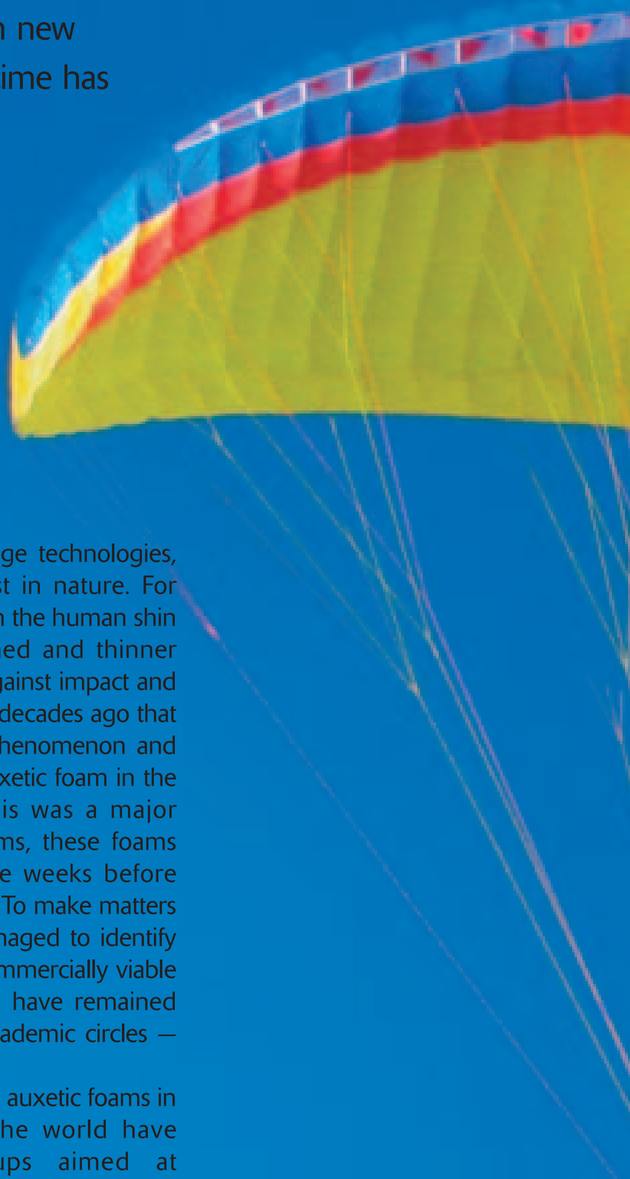
Although it may be 20 years since Roderic Lakes developed the first synthetic auxetic polymer foam, many people remain totally unaware of the word (from the Greek 'to increase') or the unique properties that auxetic materials possess or the numerous benefits they could provide in the performance and sports textiles sectors. But, with new commercial developments in this innovative field of fibres, the time has come for both the military and the sports industries to look at widening their horizons.

Auxetics expand their horizons



Consumer goods designers and manufacturers have adopted a certain mindset in recent years that 'small is superior'. From mobile phones, computers and MP3 players through footwear and backpacks to fibres and nanotechnology, companies are constantly competing to launch the smallest, slimmest and lightest product. But auxetic fibres could well be on the verge of turning this ethos on its head as, whilst small items may be more convenient in the right circumstances, big can be better – especially when it can offer new design possibilities and even save lives.

Whilst most 'new' fibre technologies are no more than an improvement on existing knowledge, auxetics is a new phenomenon and one that remains untapped by the sports textile industry. Whereas most fibres and materials have a positive Poisson's ratio and get thinner when they are stretched, auxetic materials have a negative Poisson's ratio and therefore expand under tension. This results in improved impact resistance, fracture toughness and energy absorption, all of which are invaluable properties in terms of protection and durability, and opens up opportunities in numerous fields. Therefore it may appear surprising that the sports and performance textiles industries, including the military and law enforcement sectors, have not embraced auxetics earlier. This is especially so considering the increased pressure to develop new products in such a highly competitive market. There is a growing trend towards more 'extreme' sports, an increased threat of violent crime and terrorist attacks, as well as an increasing consumer demand for technical products. The specific problem for auxetics, however, was that until now they simply weren't available.

Stepping out of the lab

As with so many cutting edge technologies, auxetic materials already exist in nature. For example, the cancellous bone in the human shin becomes wider when stretched and thinner when compressed to protect against impact and fractures. And it was some two decades ago that Roderic Lakes recreated this phenomenon and developed the first synthetic auxetic foam in the USA. However, although this was a major breakthrough in scientific terms, these foams only survived for about three weeks before becoming too brittle to handle. To make matters more complicated, no-one managed to identify a way to produce them to a commercially viable standard. As a result, auxetics have remained well and truly ensconced in academic circles – until now that is.

Since Lakes produced his first auxetic foams in 1987, universities around the world have established research groups aimed at investigating and developing a wide array of auxetic materials. This has resulted in commercial companies being formed, one of which, Auxetix Ltd., a spin-off from the University of Exeter in the UK, has become the first to start producing auxetic fibres on a truly commercial scale. It is confident that its products are set to be the next 'big' thing. The company has already attracted widespread interest and even won an international award for the best technical textile development of the year at Techtextil in Frankfurt in June this year.

Expanding on the research carried out during his PhD on helical-auxetics at the University of Exeter, Dr. Patrick Hook set up Auxetix in 2003 in order to transform auxetic materials from what he terms "classroom curiosities" into commercial products with a real market value. Since then, the company has gone on to develop a number of different auxetic materials

for various sectors including the textile, healthcare, automotive, aerospace, construction, and communications industries.

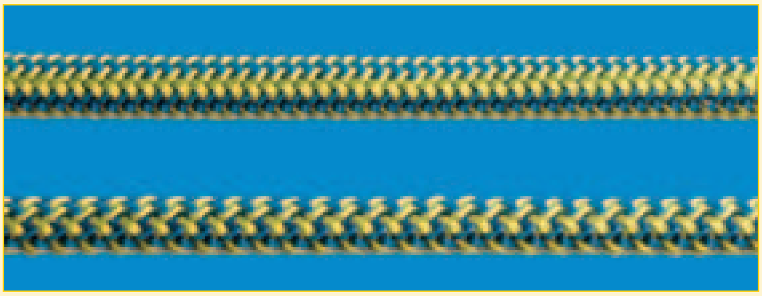
Blasting off

The company was presented with an award at Techtextil for its Zetix blast-mitigation fabrics — developed in conjunction with Heathcoat Fabrics in the UK and Exeter University. These materials — when used as window curtains — allow light in but protect people from the flying debris resulting from a bomb blast, accidental explosion or extreme weather conditions such as a hurricane. Whilst this application may appear far removed from the apparel and sporting goods industries, the possibilities that this technology opens up in these sectors is immense. Many parameters, including changing the fibre winding angles, the relative diameters of the winding fibres and core elements, as well as the basic characteristics of the materials used can all be tailored to refine the system to suit different applications. For example, the technology has already been adapted to produce blast-resistant protective panels for vehicles and Auxetix is currently in discussions for its use in personal body armour, where it offers several advantages. Not only is it said to be significantly lighter than conventional materials such as Kevlar, Hook states that in preliminary trials the auxetic material also outstripped the performance of traditional technologies.

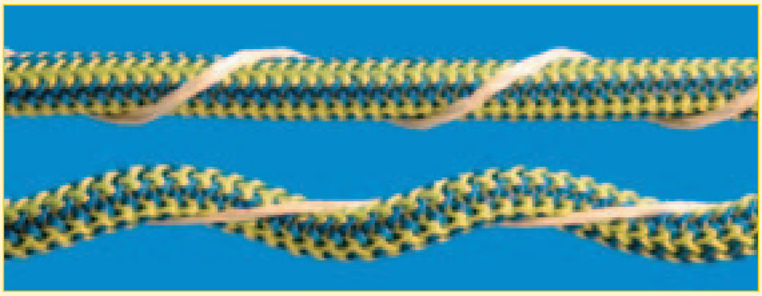
In fact the possibilities resulting from Hook's research could have a significant impact in the sports sector as a whole at a time when extreme sports such as climbing and parachuting have become mainstream activities. The auxetic effect could offer significant safety advantages in parachute cords and climbing harnesses to create self-locking stitching threads to prevent thread slippage and knots coming undone. As Hook comments, "Having your shoe laces come untied may not be a major drama, however, if a stitching thread works loose from a parachute cord, or an eye suture comes undone, it is going to be very bad news indeed." With conventional fibres the thread gets thinner as it is pulled, thus increasing the likelihood of failure whereas, because auxetic threads expand as tension is applied they lock themselves in place, preventing both knot and stitch slippage.

Auxetics also open up many opportunities for the production of composite hard goods such as climbing and motorbike helmets, which have to withstand impact. In traditional composite materials, the fibres get thinner when pulled and this causes them to de-bond from the glue, removing their ability to absorb energy. Conversely, the fibres developed by Auxetix swell when pulled and this not only reduces their propensity to de-bond, but they also continue to absorb energy after initial failure has occurred. This could present significant safety enhancements in many product applications. Furthermore, they could provide benefits in other goods such as hockey sticks or even squash and tennis rackets that have to endure high levels of energy and impact for extended periods of time.

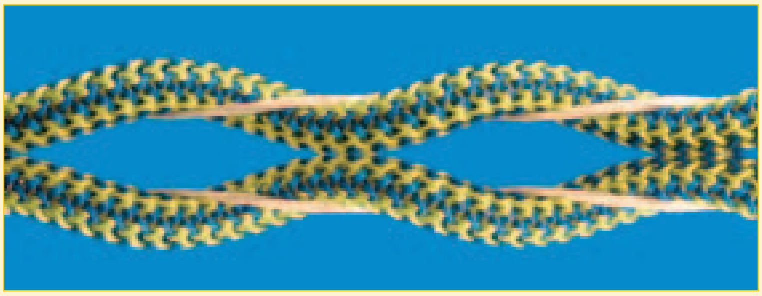
The concept of auxetics



If you stretch a bungee cord it gets thinner.



If another cord is wrapped around the bungee, then it is stretched, in effect it becomes wider.



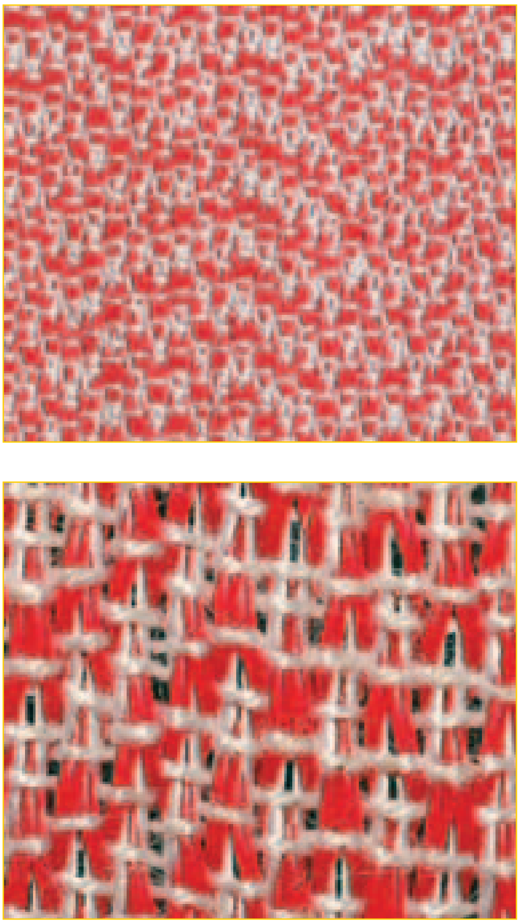
When paired it forms an auxetic structure.

Auxetix Ltd.

Sensing an expanding market

Auxetix has also developed a further use for the helical-auxetic principle for sports apparel and the textiles industries. This is in the form of special optical sensors that could be used in the growing market for wearable electronics. There are two variants of the sensor — one has an optical fibre wound around an elastomeric core, whereas the other uses an optical core with a high-strength fibre wrapped around it. Both work on the same principle — light is passed through the fibre, and the amount that reaches the other end measured. When load is applied to the sensor, the deformations caused by the fibres create a strain amplification system that magnifies the change in light transmission. This gives a linear and noise-free signal that, according to Hook, is around 600% more sensitive than the output from conventional sensors made from the same materials. The electronic components are therefore much simpler and more cost-effective; the sensors can be used to measure bending, stretching torque or mechanical load. They could, for instance, be used to monitor an athlete's limb articulation, foot pad pressure or even posture. The sensors can be incorporated into knee or wrist braces, as well as more conventional clothing. And the device is primarily aimed at the smart apparel market because of its light weight, flexibility and low physical profile. It would therefore be well-suited to applications such as sportswear and instrumented clothing.

Through ongoing research and innovation Auxetix has developed numerous applications for helical-auxetics that could offer real performance and commercial benefits in the sports and performance textiles fields. Technical scouts from sports manufacturers have already picked up on the technology and Hook is currently in talks with several international companies. Auxetic materials have spent the last 20 years in the laboratory — it's now time they reached the international sporting arena.



A piece of the Zetix blast-fabric can be seen (top) unstretched, and (bottom) stretched. The application of load in the vertical direction has opened up the structure providing pathways for pressure waves to pass through.

Auxetix Ltd.