Waterproof, breathable footwear for all

A small, young company, with a solution that could revolutionise the outdoor footwear sector, believes it is on the brink of success. But rather than plunge towards the prizes, this company, P2i, has proceeded carefully along the road, pausing many times to check it was going in the right direction and that it had all the right equipment. Perhaps you'd expect no less from a company employing a team of plasma scientists; of 15 members of staff, nine have PhDs.

One of them, Dr Stephen Coulson, was carrying out research at the University of Durham in northern England until a few years ago. His specialist interest was in making textiles water and oil resistant and he caught the attention of the military. The authorities believed his ideas could lead to a potential defence tool against nerve agents and provided funding for P2i to start up.

Then, one-and-a-half years ago, Dr Graham Hine, chairman and CEO, joined the company and moved it into the commercial technology hub of Oxford to a smart new science park—it has its own bank and bistro—in Abingdon, within sight of the dreaming spires of Oxford.

Gas mask

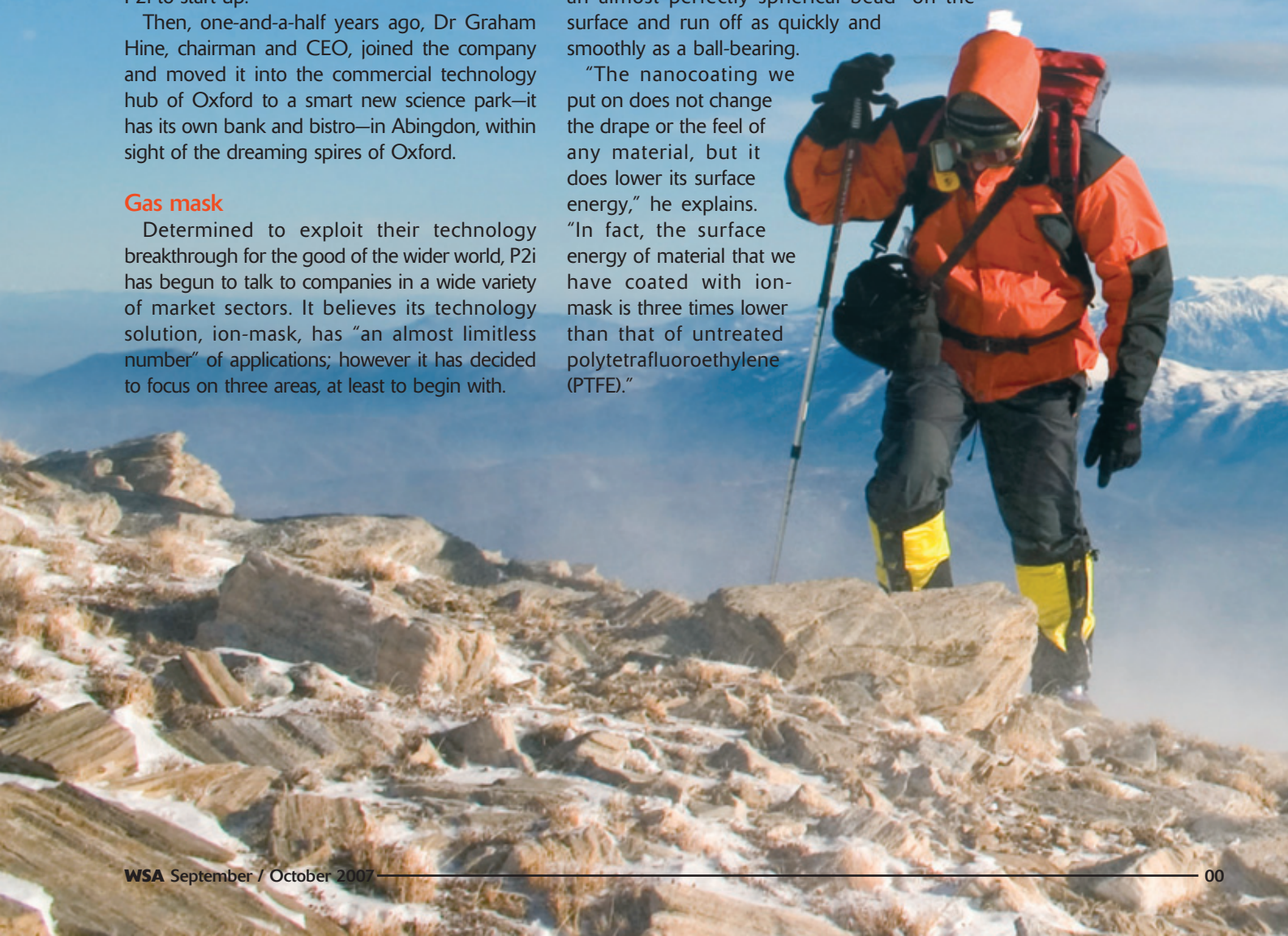
Determined to exploit their technology breakthrough for the good of the wider world, P2i has begun to talk to companies in a wide variety of market sectors. It believes its technology solution, ion-mask, has "an almost limitless number" of applications; however it has decided to focus on three areas, at least to begin with.

The idea works with a sealed box, a chamber or anything that can hold a vacuum. You create the vacuum by removing all the air, obviously. After this, the ion-mask solution involves pumping in a tiny amount of a special chemical, a fluorinated acrylate monomer, which can be liquid at room temperature, but turns to gas on hitting the vacuum. Inside the chamber, the gas penetrates every fibre, every substance, and every surface that's in there and the creation of the plasma allows it to attach to the surface of the product.

Then comes the final stage of the process, which is to apply a plasma treatment. This bonds the gas to every part of the product to form a nanocoating of between 10 and 60 nanometres. Business development director, Dr Ian Robins, explains that the effect of this is to lower the surface energy of an object causing oil, water and other liquids to form a droplet—an almost perfectly spherical bead—on the surface and run off as quickly and smoothly as a ball-bearing.

"The nanocoating we put on does not change the drape or the feel of any material, but it does lower its surface energy," he explains. "In fact, the surface energy of material that we have coated with ion-mask is three times lower than that of untreated polytetrafluoroethylene (PTFE)."

P2i does not claim to have invented liquid repellency for footwear, but it does believe its ion-mask process can make liquid repellency available to more brands and more consumers.



Three applications

Over the years, P2i has found the process to work not just on textiles, but on metals, ceramics, leather and a host of other materials too. However, the three applications it has decided to focus on initially are laboratory consumables, filtration products and footwear.

For the first two, clients have been in place for some time. For example, interested parties in the biotech space have derived great benefit from applying ion-mask to pipette tips. A simple test with green dye has shown that drops of expensive chemicals always stick to untreated pipettes. The quantities may be tiny, but it all adds up over time. Pipettes with the nanocoating retain no liquid; it all runs off. In the filtration arena, automotive companies are becoming keen for the simple reason that the more oil-resistant filters are, the longer they will last.

That leaves footwear, the most exciting application of all.

New generation of waterproof footwear

In spite of having built up a healthy business in nanocoating automotive filters and laboratory equipment, it is a recent series of important breakthroughs in footwear that P2i believes marks its real arrival. It insists that these developments mean a new generation of truly-breathable, yet waterproof shoes will be in retail stores by this time next year.

P2i is building equipment to go into two Chinese footwear factories by the end of this year for two major brands.

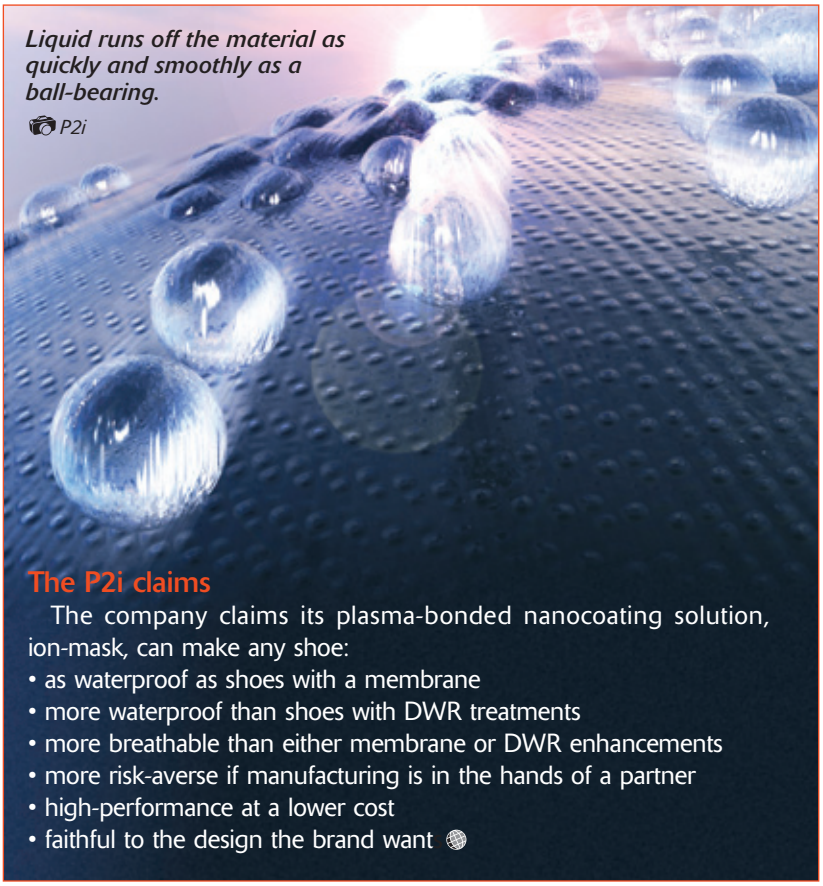
One of the models involved is a running-shoe, one is a leisure shoe and the third is a golf-shoe. The company will put no customer names into the public domain at the moment, however its lead-client has described the waterproof and hydrophobic functionality ion-mask makes possible as "an exciting evolution".

P2i's claim is that a shoe with the ion-mask nanocoating will be as waterproof as shoes with membrane technology, and more than those with a durable water repellent (DWR) treatment. It will also be more breathable, cheaper to treat and will make no impact on a footwear brand's design rules.

Whole shoe philosophy

These claims require some explanation. Graham Hine believes it's important to emphasise that when his company talks about making a shoe waterproof, it means the whole shoe.

Treating only the material that goes into a shoe is not enough, he contends, and he believes ion-mask is the first technology to make it possible and affordable for manufacturers not to limit themselves to this, and to make the whole shoe waterproof instead.



Liquid runs off the material as quickly and smoothly as a ball-bearing.
P2i

The P2i claims

The company claims its plasma-bonded nanocoating solution, ion-mask, can make any shoe:

- as waterproof as shoes with a membrane
- more waterproof than shoes with DWR treatments
- more breathable than either membrane or DWR enhancements
- more risk-averse if manufacturing is in the hands of a partner
- high-performance at a lower cost
- faithful to the design the brand want

"Consumers are interested in the performance of the shoe," he points out, "not just the performance of the fabric. If you don't apply protection to the whole shoe, you can't apply protection to the foot."

Because of the plasma treatment, his company's nanocoating goes onto every part of a piece of footwear, including the laces. Holes above the featherline will stay holey, they won't become clogged up (the benefits of which we shall see in a moment), because the decrease in surface energy around them means beads of liquid will run past and over them rather than into the shoe.

Lasting effect

The next of his big themes is the durability of the treatment, which is essential if ordinary water-resistance is to turn into "dynamic" water-resistance. He thinks that waterproofing footwear is only worthwhile if the treatment you apply can withstand the stresses and strains we subject our shoes to.

Dr Hine insists that ion-mask can offer this and that he has the test data to prove it. P2i scientists have worked extensively with CTC in France and Hong Kong, and with SATRA and Intertek in the UK to subject their solution to a wide range of laboratory tests. These include obvious waterproofness and abrasion tests, but, at P2i's insistence, the test centres have also run extensive flex-tests on shoes coated with ion-mask.

"SATRA thought we were mad," recalls Dr Coulson, "but we wanted to see not just if the materials we were working with could withstand water penetration, but if they could do so after 100,000 flexes. Even the leading DWR brands fail when you flex the material, but ion-mask passed."

Stern test

Without having probed too deeply into the question of flex-testing, we can confirm that a senior member of the SATRA testing team has said in conversation with *WSA*: "With P2i , the way the bead of liquid forms on the surface and then runs straight off, I've never seen anything like that before. Never."

In case anyone thinks SATRA and P2i are forming a mutual appreciation society, it's worth pointing out that Dr Coulson has also applied his critical eye to the footwear operations of all the testing centres he has had contact with. And he has drawn the conclusion that "certain test processes" are set up to work better with certain types of shoe. "We don't agree with some of the tests," he says, "and we want to develop our own."

In spite of what he says about the need to test the whole shoe, you can see from the above account that his company does take part in fabric-testing. For the moment, he argues that this is the only method it has for measuring itself against others. It takes nothing away from P2i's whole-shoe commitment. "That's what matters to consumers," he insists.

Besides, outer material that has water-resistant qualities can let liquid in after it has been made into a shoe if the seams, the stitching or the locally sourced in-shoe material let it down.

His contention is that the P2i plasma treatment produces the same result every time and can, therefore, overcome any shortcomings in manufacture that result from local supply conditions. This includes the need to rely on manufacturing partners to check and reject shoes or entire batches that don't come up to scratch, even when they have little or no vested interest in getting this part of the job right.

Bellows effect

Of course, there are other ways to make footwear waterproof, with membrane technology proving to be the most successful, at least commercially, to date.

Dr Coulson's counter-argument here is based mainly on breathability. Footwear with membrane technology inside is more breathable than, say, a plastic bag, he says, but you could not call it breathable in comparison with an ordinary shoe. Ion-mask, on the other hand, as the statement above regarding holes shows, makes no difference to the airflow of shoes, or to wearers' ability to push hot air out and draw cooler air in, by means of a bellows effect, as they walk or run.

He points out that this is the reason brands don't build membranes into the majority of running-shoes: the runner's feet would become uncomfortably hot. Still on the subject of comfort, he says membranes can easily be abraded from the internal construction and material choice in the shoe and eventually split.

Designer freedom

The next part of the argument in favour of ion-mask focuses on aesthetics. Brands that choose to use P2i can still define the design rules that they feel best meet the requirements of consumers. No matter what they put into their shoes (and Ian Robins stresses that the average athletic shoe could easily have six different types of material in its construction) or where, the plasma treatment will bond the special monomer onto the surface and protect it.

"With a membrane, you need to have a special manufacturing set-up and a particular design," he explains. "Plus, membrane technology is compromised by the mass-production process because you have to use adhesive to incorporate the membrane into the shoe. Designers have to keep this in mind right from scratch, so it limits them. We can treat any shoe of any design, without the need for any special quality control or for the membrane itself, all of which add cost."

Graham Hine and his colleagues believe this whole message is a powerful one to put across to footwear brands, many of whom they describe as being design-houses, plus marketing. He concludes: "We haven't invented liquid repellency but we've invented a process that will allow more people to benefit from liquid repellency. We're as waterproof as membrane technology, far more waterproof than DWR and offer more breathability than either of them. And we don't dictate to anyone what their designs should look like. We're just saying that whatever footwear brands have got today, we can make it better."

Having waterproof material is one thing, but constructing waterproof footwear from it is a different challenge altogether.