Far infrared (FIR) reflecting fibres and fabrics are said to provide a subtle form of warmth that affects blood flow, which in turn is believed to have cosmetic and energising properties. To win over sceptics, suppliers are now backing these promises with clinical studies.

Far-infrared: the science behind the magic

With the spread of fabrics featuring far infrared (FIR) radiating properties, which first appeared at least ten years ago, innovative textiles are exploring a whole new semantic field. Solvay's Emana fibre is said to contain "bio-crystals", inspiring some brands to speak of "biostimulating" or "bioactive" materials. The ingredients found in some are marketed as "optically responsive minerals", to quote the terms used by US-based Hologenix, the maker of Celliant, or a "titanium-mineral matrix", which is how Schoeller Technology describes the functional component of its energear finish. The characteristics of these mineral-charged fibres and finishes are slowly becoming clearer as suppliers have moved to fund clinical studies that seek to measure the effect far infrared radiation has on the human body.

The makers of these materials rarely publicise the specific composition of their FIR-reflecting ingredients, but industry insiders believe them to contain, generally, various mineral oxides such as titanium, iron, zinc, zirconium or copper oxides. They may also be carbonised charcoal made from bamboo, coconut shells or coffee. These latter will be familiar to those who use S.Café, a polyester fibre with coffee charcoal made by Taiwan-



Emana polymer producer Solvay states the charges "emit FIR in specific wavelengths, promoting biostimulation in the skin, thus acting as a fibroblasts growth factor and stimulating nitric oxide synthesis which significantly enhances microcirculation."

Tavinho Costa

based Singtex, or with 37.5, a fibre containing carbonised coconut shell developed by Cocona. This "natural" ingredient was, before Cocona was rebranded 37.5, an important part of the company's marketing message.

Whether mineral or charcoal-based, these additives are said to make up a small percentage, from 1% to 3%, of the yarn or finish. Their role is to 'opacify' them. This reduces their 'transparency' to electromagnetic radiation in the far infrared spectrum and makes them reflect the radiation (or energy) back to the body. By increasing the level of reflection, mineral-charged materials increase the amount of infrared red radiation that stays inside the garment. The additional heat warms the body. This is said to expand capillaries and accelerate blood circulation. Though not completely understood, these materials are believed to improve skin texture and athletic performance. While it may be easy enough to measure a material's ability to reflect infrared radiation, the impact it has on the body remains elusive.

Seeing the light

Among the more recent studies that seek to validate these unconventional claims for performance textiles, two providers of FIR reflecting polyamide 6.6 fibres, Solvay and Nilit, both released new data towards the end of 2014, the former in Rome in September, the latter in November in Milan. The two companies had previously reached an agreement to end litigation over the use of far infrared ray technology in fibres in June 2014. Solvay had been granted a European patent in May 2014. As declared to *WSA*, Israeli fibre manufacturer Nilit, the marketer of Nilit Innergy, said it had arrived at an agreement with Brazil-based Rhodia Poliamida, marketer of Emana polyamide 6.6, based on an understanding that both sides will be better off using their budgets to promote and sell their products, rather than on legal fees and court cases.

Double blind clinical tests presented in Rome by Rhodia Poliamida owner Solvay measured three parameters of sports performance: oxygen consumption, strength improvement during anaerobic physical activity and after-sport muscle recovery. "All three showed positive results," says Daniela Antunes, Emana manager for Europe. "These benefits are due to the minerals which, once heated by the body, emit FIR rays that penetrate the skin and improve blood microcirculation on a superficial level. As opposed to near or medium infrared radiation, far infrareds heat the body gently. There is no excess heat, but rather a comfortable level of warmth," she says. Among the brands using Emana, she cited Falke, Mico and Doubleskin. In Europe, Emana yarns are supplied exclusively by Italian polyamide manufacturer Fulgar, using polymer chips provided by Solvay. Sofileta, in France, and Taiana and Piave Maitex in Italy have introduced the innovative yarn to their ranges.



Infini, Rossignol's patented performance cross-country range is made with an Energising Fabric by French fabric manufacturer Sofileta. It offers compression, with Invista's Lycra Sport, and reflects far infrared radiation.

Monica Dalmasso

Academic double blind studies conducted by Nilit with fabrics made by Italian knit manufacturer Maglificio Ripa also confirm some of the benefits FIR materials are said to provide. The two partners claim that the effects of the gentle heat emitted by these fabrics "invigorate, energise and tone up the body". They help athletes "run the extra mile," and they "stimulate skin vitality and flexibility". Tests found increased oxygen levels in blood, decreased accumulation of lactic acid in muscles as well as "energising and recovery" properties. Lab test results conducted in-house by Nilit showed an increase in blood speed of 9.4% and heat transfer improved by 8.5%. Nilit and Maglificio Ripa do however admit that experts recommend further research "to fully understand the potential achievable effects".

In addition to the mineral-charged polyamide 6.6 fibres, Hologenix, based in Santa Monica, California, markets an FIR-reflecting polyester fibre under the brand name Celliant (formerly Holofiber). The company says the human body at rest produces 100 watts of energy, which is potentially radiated back by the "13 optically responsive minerals" embedded in the yarn. Celliant tests each product brought to market in its in-house laboratory (and on humans) for its effect on transcutaneous oxygen pressure (TcPO2), a measure of oxygen levels in skin tissue. The company says that increased TcPO2



Upmarket Swiss skiwear brand Mountain Force chose a ceramic membrane made in Japan for its climate-regulating properties. The ceramic particles reflect the cold outwards and body heat inwards, it claims. The warming function also means padding can be thinner and the silhouette more elegant.

Mountain Force

levels signal an increase in blood circulation, which implies enhanced muscle performance. More oxygen in the blood also suggests that muscles will produce less lactate, leading to reduced soreness after physical activity. "Our standard requires a fabric to achieve an average increase of 7% in TcPO2. Most often we get 8% to 14%," says Alexander Foyle, Celliant's managing director for Europe. If it passes the tests, the fabric then gets a certificate "that specifies exactly what the brand can say. No opposition or contestation of the claim has ever come in," Mr Foyle points out and for a fabric to provide these effects, it needs to contain at least 42% Celliant. Brands using the material include Isaora, which offers a jacket made with Celliant-coated down, Puma in its Usain Bolt range, Reebok in its Zigtech clothing range, Xcel in wetsuits as well as adidas, Saucony and LL Bean.

This January Celliant is introducing several new references, including a polyamide 6.6, as well as intimate blends with Dri-Release and Peruvian Pima cotton. Wellman International (a division of Indorama Ventures) produces Celliant fibre for the European market in its plant located in Ireland.

A far-infrared reflecting viscose fibre is also set to launch, as German cellulose fibre maker Kelheim has announced the success of a pilot-scale production line of mineral-charged viscose. Like the functionalised synthetic polymers, the additive used by Kelheim does not wash out over time.

Cosmetic or performance properties?

French fabric manufacturer Sofileta conducted a series of academic double blind tests to validate the effects of its Energizing Fabrics range, which uses both Nilit Innergy and Solvay Emana yarns. These showed varying results. The cosmetic tests suggest a possible effect on slimming (0.8 cm reduction), firming (for 80% of the participants) and on the elasticity and softness of skin (subjective considerations which 40% of the participants found to be improved). To ascertain that the cosmetic benefits were not due to the possible mechanical effect of wearing a close-fitting garment, the same tests were conducted with a compressive fabric. They did not show any significant improvement. "We consider these results to be positive," says Dominique Heuillard, in charge of R&D for Sofileta. French lingerie and hosiery manufacturer Dim launched a range of slimming products based on these findings.

Tests conducted on Sofileta fabrics to measure the possible sports-enhancing properties of FIR-reflecting fabrics were less conclusive. "We tested three claims," says Mr Heuillard: "enhanced energy, speed of recovery and postural balance. The first two showed positive results, but not significant enough to be relevant." With regards to postural balance, the company decided to back away as "it comes too close to the false claims of power bracelets". One of the two sports studies showed a statistically significant effect on performance for athletic individuals. "Not enough however to have an impact on a non-athletic person," says Mr Heuillard. He concludes that "all we can say is that these fabrics are 'active' products. Wearing a FIR material accelerates blood flow, which has an effect on red blood cell levels and on cellular metabolism." He believes their performance characteristics could be linked to mass, "the mineral content has to be high to obtain a powerful effect". This, he says, is not possible on clothing as the surface to cover is too large.

Damart, a French mail-order company, has a long history of keeping people warm through an array of thermal materials, including

Damart's new generation Thermolactyl is said to be "bioactive" because of its ability to offer just the right temperature in varying conditions, due to the presence of FIR-reflecting yarns.

Damart



its historic chlorofibre garments, to which far-infrared reflecting ranges labelled "Bioactive" have recently been added. The term was chosen to evoke a product that offers "just the right temperature, with an ability to adjust temperature to activity levels," says Michel Caillibotte, R&D manager for Damart. While he considers the cosmetic claims of FIR materials to be valid, the effect on physical performance is "minimal at best, and not measurable". Vasodilatation is expected to improve drainage and blood flow, "but available data is not significant," he says, an opinion shared by Mr Heuillard at Sofileta.

Bioactive is the term used by Matteo Taiana, R&D manager of Kinetech, the sports fabric division of Italian weaver Tessitura Taiana, to describe how FIR-reflecting materials work. By this he means the fabric is not passive: "It sends a signal to the body and the body reacts." He believes this new category could be a first step in a new direction for textiles. The company weaves 100% Emana polyamide yarns into high-density fabrics (200 threads per centimetre), which will have a higher proportion of the so-called bio-crystals compared to a knit fabric, says Mr Taiana, adding that the higher the concentration, the greater the reflection will be. This will increase the price of the fabrics, but he says "our fabrics are 'race day' fabrics, we target the upper echelon of the market". The company promotes three FIR-based functions: cosmetic, sports performance and thermoregulation, which he considers a secondary, though useful, property. He says performance depends on the length of time the garment is worn: "To have an impact on cellulite, the garment must be worn eight hours a day for 30 days. During a sports activity, the sensation may only be felt after a few hours."

Q36.5, a new high performance cycling apparel brand founded by Luigi Bergamo, features FIR fabrics developed by Kinetech, chosen to meet the brand's promise encapsulated by its name: the letter Q stands for "quaerere," meaning search in Latin, and 36.5 refers to what is considered an ideal body temperature. Mr Bergamo, a former member of the Veloce Club Bolzano cycling team, compared different fabrics, with or without Emana (and a silver yarn). "I did not find a big difference, but there is a slight difference," he says. "When I ride, I begin to feel the effect after a few minutes. It is a good feeling, I don't feel cold and I don't feel I am sweating too much." He says the first tangible effect is that the garment offers just the right temperature, an important feature for cyclists who face highly varying conditions when racing up and down hills. Mr Bergamo also raises the point that a jacket made with a FIR-reflecting fabric can be worn comfortably during three seasons, and can thus be considered a smart buy.



The goal of new high-tech cycling label Q 36.5 is to maintain a stable body temperature. The brand seeks to achieve this by using FIR-reflecting Emana fabrics made by Kinetech, the performance materials division of Italian weaver Taiana.

Q&E srl

The carbonised particles found inside 37.5 branded materials also interact with far infrared radiation, leading hockey brand Bauer to promote its 37.5 range for its ability to "turn sweat into energy". The particles have two effects, says Edouard Liffran, sales manager for 37.5 in charge of the French market: "They are hydrophilic and thus absorb humidity and they reflect infrared energy." Tests on merino wool blends with 37.5 were found to dry faster than pure merino fabrics.

HT Concept's Gold Reflect Line, a membrane or printed motif containing ceramic mineral oxides, was one of the first FIR-reflecting materials introduced in Europe. The French company continues to invest in clinical studies to back its performance and wellbeing claims. One recent study showed positive results on moderate chronic back pain and a study on balance is currently being reviewed for publication. "All the properties we intuitively believed the material offers are being confirmed," says company owner and director, Thierry Heim. He has recently launched apparel using the finish under the brand name CeramiQ. The initial success of the functional underwear line has brought the company to expand the ranges that will be shown at ispo with new colours, soft shells, running and cycling clothing.

HT Concept's compound is supplied by Solar Res, which was patented by Jacques Casper in 2006. It is the same ingredient that is used by Schoeller in energear and Mectex in a finish called Superlife.

Advanced thermoregulation

Of all the benefits FIR materials are said to provide, heat retention is arguably the easiest to prove. The Nilit Innergy knits made by Maglificio Ripa show an increase in temperature of up to 1.14°C. For Enrico Sarafini, export manager for Italian knitter Piave Maitex, thermal insulation is not the same as thermoregulation. "Our fabrics made with Emana adjust temperature to the body. It is not an easy function to explain as it implies a form a reactivity," he says. Companies using these materials should be careful when they word their claims, he adds. Piave Maitex's PM Reflecting range has recently been expanded to include a light and a mid weight fabric, the latter offering compression for cycling and fitness leggings. Both are given a bacteriostatic and hydrophilic Hydrofresh finish.

To obtain this extra measure of thermoregulation, the functionalised layer does not need to be worn next to the skin, says Alexander Foyle, at Celliant. Dominique Heuillard, at Sofileta, agrees, saying: "The mirror effect of the electromagnetic waves goes through fabric layers." He adds that a membrane would contain a greater amount of minerals, and would therefore have a stronger effect than an FIR-reflecting yarn.

It remains unclear whether the supposed cosmetic properties of FIR-reflecting materials function through layers. Both polyamide producers, Solvay and Nilit, say the skin enhancing effects of their yarns are best achieved when the fabric is worn next to the skin.

Mental or medical benefits?

In the US, Celliant is currently seeking FDA 510K certification for medical devices. "This will open up the medical market to these materials," says Mr Foyle. He points out that Celliant was chosen by Jean Criss for a line of breast cancer bras that are said to speed up recovery after surgery.

Jacques Casper, who patented the FIR-reflecting Solar Res compound, is happy to see new sportswear brands adopting FIR materials, but has reservations regarding possible medical applications in Europe. "Regulations have changed and are more restrictive than before. I wouldn't make any medical claims without backing based on European standards," he says.

For its energear finish, launched in 2010, Schoeller Technologies promotes the effects of FIR-reflecting materials on mental performance, based on tests conducted by the Hohenstein Institute in Germany. Response times for visual and auditory stimuli were found to be faster (compared to those wearing placebo T-shirts) as well as speed of information processing. "Today the technology is still new and used only in niche markets, but we can perceive a growing interest in energear and in the effects of far infrared rays," says Hans U. Kohn, Schoeller Technologies COO. German manufacturer Art Novel is now offering a range of upholstery fabrics with the energear finish.

For Celliant and Schoeller, there may be a market for FIR-reflecting materials in agriculture too as the mineral-charged textiles have been found to accelerate plant growth.

Despite mounting scientific data on the effect of FIR radiation on the human body, this product category has been slow to come to market. The companies developing ranges all admit that these textiles are made for upmarket brands that can carry their high price. And while the impact of the technology is mild, its cost is high, further limiting its widespread market adoption.

