

Science around us

A news service provided by BASF

BASF

The Chemical Company

Superabsorbent fabric keeps feet dry in all weathers

Luquafleece® from BASF in the IQ·TEX ventilation element clams up tight in wet conditions

Come rain or sunshine, children prefer to run around outdoors. But the fun is soon over if they get wet feet while hopping through the puddles. Rain boots may keep the moisture out, but they quickly turn into miniature foot saunas.

How can a shoe keep out the rain and still allow sufficient air to reach children's delicate feet? The answer is Luquafleece®, a superabsorbent polyester nonwoven material produced by BASF in a unique process. A small piece of this special, moisture-absorbing fleece is the heart of IQ·TEX, the novel ventilation element launched by the Hamburg company IQTEX: "Compared to conventional functional clothing, shoes made with this technology are not only breathable but, depending on the weather, can also be as air-permeable as cotton socks or as watertight as rain boots," says Michael Dehn, managing director of IQTEX. When exposed to water, the tiny polymer granules of the superabsorber, which are permanently bound to the nonwoven fibers by a special BASF process, absorb up to 400 times their own weight of liquid and expand accordingly.

Superabsorbers owe this enormous suction power to their molecular structure consisting of the basic component acrylic acid. BASF chemists have joined together countless numbers of these tiny molecules into long chains that are linked together at large intervals. The result is a loose bundle of molecules that absorbs water like a molecular sponge. But the key factor producing the great absorption is the material's high ion charge. It generates an osmotic pressure that draws surrounding water into the polymer network. Water is absorbed until the elastic restoring force of the polymer network compensates the osmotic forces. The ventilation element utilizes the small particles' thirst to seal the inside of the child's shoe against water from outside: two honeycombed lattices limit the upward and downward expansion of the small Luquafleece® sections. The swelling superabsorbent particles can then only expand sideways where they soon meet up again and seal all the cavities in the nonwoven material. On contact with water, the Luquafleece® – although it was highly permeable just a few moments ago – very quickly becomes absolutely watertight. Back in dry surroundings, the water absorbed by Luquafleece® evaporates

Text, photos, illustration and animation with sound are available at: www.basf.de/science_around_us

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The Story



Luquafleece® superabsorbing fleece in the new "Elefanten" children's shoe keeps feet dry in the wet but is absolutely air-permeable in dry conditions.



This micrograph of Luquafleece® shows the firm linkage between this superabsorber polymer and the nonwoven fiber.

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and the pores reopen within a short time depending on the temperature and atmospheric humidity – allowing the air to circulate freely again.

“The superabsorber permanently surrounds the fibers of the fleece like droplets and with its high loading density provides absolute protection against the wet shoe,” explains Dr. Peter Rudolf, superabsorber specialist at BASF. “The fleece can saturate itself with water any number of times and then release it again through evaporation. It’s exactly this reversible moisture uptake that makes the fleece interesting for a multitude of applications.” A single square meter of the fleece, which is only a few millimeters thick when dry, can absorb up to 26 liters of water. An absolute innovation is the principle of IQ·TEX, in which a small piece of Luquafleece® completely self-seals the system when exposed to wet conditions. “The idea of utilizing the mechanical barrier function of our Luquafleece® came from the development experts at IQ·TEX, who in partnership with us then developed it into a marketable product,” says Dr. Peter Rudolf.

IQ·TEX will be launching the ventilation element in the “Elefanten” brand of children’s shoes in the fall of 2008. “The new technology has performed superbly in practical trials and children’s feet can at last breathe properly. The next stage is to incorporate it into children’s loafers which will be marketed in spring 2009,” says Michael Griesel of the Deichmann Group which owns the long-established “Elefanten” brand. Safety shoes from the Baak shoe company are now also ventilated with IQ·TEX. Men’s loafers from a well-known shoe manufacturer are scheduled to follow from spring 2009. And yet shoes are only one of many possible applications for the new miniature flood barrier with its highly variable size and positioning options. Especially for outdoor uses, many potential applications are feasible for ventilation openings that are self-sealing in the rain; tents, bivouac sacks and jackets that otherwise tend to turn into miniature greenhouses, could be made much airier and still provide 100 percent protection against the wet in rainy weather.

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With an annual capacity close to 400,000 metric tons, BASF is one of the world's largest manufacturers of superabsorbers. More than 90 percent of this output goes in the form of specialty products to the hygiene industry which mainly uses them to produce baby diapers and sanitary napkins. Over and above the classical uses in hygiene articles, there are innumerable other applications for superabsorbers. With their ability to absorb large amounts of water, superabsorbers are also added to potting soils in which they act as a flexible water reservoir for plant roots. Their gel-like texture when saturated also makes them valuable thickening agents and liquid stores for mortars in the construction industry.

In the packaging industry, superabsorbent polymers are used, for example, as soaker pads to absorb excess fluid in food packaging. Luquafleece® as sheet material also offers further applications: already widely used for passive climate control in office chairs, it can improve seating comfort and support in automobile seats, in functional sports clothing and workwear garments.

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The Prospects

The Graphic

Mode of action of superabsorbent fabric Luquafleece®

The diagram illustrates the mode of action of superabsorbent fabric Luquafleece® in a shoe's ventilation element IQ·TEX. It shows two states: dry weather and wet weather. In dry weather, the fabric is air-permeable, allowing air to flow through. In wet weather, the superabsorbent particles swell and seal the cavities, making the shoe watertight. In dry conditions, the absorbed water evaporates, and the pores reopen, making the shoe air-permeable again.

- The fleece is absolutely air-permeable in dry weather.
- In wet weather water is absorbed, the superabsorbent particles swell and rapidly seal the cavities in the fleece – the shoe is watertight.
- Back in dry conditions, the absorbed water evaporates and the pores reopen – the shoe is air-permeable once again.

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From acrylic acid to the weatherproof shoe

Superabsorbers: Chemically speaking, superabsorbers are polymers of acrylic acid and one of its salts, usually a sodium acrylate. In the polymerization reaction, these two basic components form long chains that are crosslinked by additionally incorporated chemical bridges to produce a loose yet water insoluble bundle of molecules. The high water absorption is mainly due to the high osmotic pressure generated by the sodium acrylate, which in this case is actually osmotic suction: positively charged sodium ions which together with negatively charged chloride ions also form our familiar common salt, draw up long water molecules into the superabsorber until it can expand no further. The absorption capacity of a superabsorber therefore greatly depends on the salt content of the liquid – it is highest for distilled water. Salt water, however, which already contains large amounts of free sodium ions, is much less easily absorbed. The properties of the superabsorber can be tailored as required by changing the number of crosslinks in the molecule bundle: fewer bridges increase the absorption; more bridges increase the firmness of the resulting gel.

Luquafleece®: BASF's superabsorbent fabric Luquafleece® is produced by applying the starting materials directly onto the nonwoven fibers and only then polymerizing them to create the superabsorber. This stable combination is the key factor for the long-term applications in moisture-regulating office chairs or the IQ·TEX ventilation elements.

IQ·TEX: While the loose knitted fabric of the coated polyester fibers of Luquafleece® is extremely air-permeable when dry, in wet conditions the cavities fill up with the expanding superabsorber particles. The mechanical limits imposed by the honey-combed lattice of IQ·TEX allow the material only to expand in two dimensions, causing all the cavities in the fleece to close tightly and prevent further water entering.

The Info Box

Further information can be found at:

<http://www.Luquafleece.basf.com>

http://www.iqtex.biz/iqtex/innovation/iq_tex-e.htm

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