Artificial turf with upstanding qualities

A "soft" shell and a "hard" core – for once, the reverse situation. Novel fibres enable the creation of artificial turf which meets the highest demands when playing football. Empa researchers, together with TISCA TIARA, a Swiss manufacturer of artificial turf, have developed a bi-component fibre with two impressive qualities: thanks to a hard core it returns to an upright position again and again, and because of a soft sheath it avoids abrasions and grass burns.

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Maybe it's cold and wet outdoors, or perhaps it just snowed. It's not exactly the best time of year to play football, or is it? Thanks to artificial turf, for decades it's been possible to play during winter, too. The artificial grass is robust and stands up to any weather. Even so, a few of us might remember some painful injuries we got on artificial turf. The first generation of that material was manufactured using polyamide fibres with excellent recovery properties and which always stood upright. But it's exactly these resistant fibres which frequently led to grass burns and abrasions whenever someone took a tumble.

That's why second-generation fibres consisted of polyethylene whose properties were much gentler to the skin. In practical use, however, these fibres also exhibited a serious defect: their resilience, or ability to stand upright after repeatedly being trampled upon, was very poor. Over time, the load on the fibres led to a downright flat pitch. That was not only visually unattractive, the "bent over" blades of artificial grass also changed how well the turf could be played on. As a result, an attempt was made to support the blades with sand or granulated material. Today, turf with a granulated infill is very common.

Modern artificial turfs such as SPORTISCA from TISCA TIARA, a manufacturer of textile-based floor coverings, meanwhile consist of three fibre layers which give them a relatively high degree of resiliency. Because the polyethylene fibres' lack of shape stability created problems even early during production, this firm, which is based in the Appenzell region of Switzerland, sought out Empa to help them find solutions. "The requirements on artificial turf are quite varied," notes Andreas Tischhauser, head of marketing at TISCA TIARA. "For instance, footballers want an especially soft grass surface while pitch operators want one with a long service lifetime. And, of course, it must also meet ecological requirements."

A development with many challenges

It was soon clear that a completely new fibre had to be developed. It should exhibit high resilience as well as optimal sliding friction behaviour. Two properties implies the need for two components, thought Rudolf Hufenus of Empa's Advanced Fibers Laboratory to himself. According to this idea, such a fibre should contain a hard polyamide core surrounded by a low-friction sheath of polyethylene.

With the support of Christian Affolter, a modelling expert in the Mechanical Systems Engineering Laboratory, they simulated a variety of cross-sections which would best fulfil the desired requirements.

However, the development of the new fibre was no easy task, as was discovered within the scope of a project financed by the Swiss Innovation Promotion Agency CTI. "At half-time, we were clearly behind our project plan," recalls Hufenus. The problem was that the modelling of all the various cross-sections was clearly more complex than had been assumed and took more time than anticipated. The input parameters for the models were the fibre's cross-section geometry along with the material properties of both polymers, which were determined through mechanical tests. In addition, the loading on the fibre, in other words how

it should bend, was part of the model. All of this data finally resulted in a simulation of the fibre's stress-strain characteristics.

A further challenge arose because a new spinning head had to be developed for Empa's pilot spinning system in conjunction with the Institute for Rapid Product Development at ETH Zurich. The unusual aspect about this spinning head was that the two polymers could be processed at different temperatures. The basis for the construction was the assumption that the two polymers being used had to be extruded at different temperatures. In the course of the project it was determined that this isn't necessary.

The industrial production of the fibres also proved challenging because they need spinning systems designed specifically for fibres going into artificial turf, which are generally not two-component systems. "After we worked very hard to persuade him to do so, the fibre manufacturer we brought into this project told us he was prepared to modify his spinning systems as required," explains Hufenus. The time from planning to construction was a full year.

With trial and error to the optimum fibre

Even at the conclusion of the project, when the completed fibre was on hand, yet another difficulty arose – the fibres did not pass the Lisport test, which checks for long-term mechanical wear. The sheath of the two-component fibres separated from the core with time when placed under load. TISCA TIARA then further optimised the fibre after consultation with and support from Hufenus. "We proceeded according to the trial-and-error method in which we simply tried out various options until we found the best possible cross-section," says Tischhauser.

Finally everything was complete; with much patience they had succeeded in creating an optimal cross-section: instead of a thick core, the fibre consists of five thin ones. The fibre's resiliency qualities are guaranteed for years, as a new Lisport test was able to prove. "We're the first ones who have followed such a project through from the development of the fibre to the laying of the artificial turf," boasts Hufenus proudly. Tischhauser is also very pleased, saying, "We could hardly believe that all at once everything worked out."

The turf, which visually comes very close to the natural grass which it is intended to imitate, has already been laid on two football pitches, one in Ecublens near Lausanne and the other in Bürglen in the canton of Thurgau – and to the complete satisfaction of the footballers. "With this, we fulfilled the essential requirements of our industrial partner TISCA TIARA for a new fibre used in artificial turf," adds Hufenus.

A FIFA certification isn't anything to worry about, however, because at this time the standards are in fact trailing technological developments and effectively give a chance only to artificial turf with a granulated infill. Nevertheless, because of its clearly superior properties, the new artificial turf will surely be a market success because most football pitches don't require FIFA certification. In addition, it's more important for the teams that they can play, and more importantly train, in grey, wet weather and in snow than it is to be on certified turf. //

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A footballer's skin injuries caused by stiff polyamide fibres.

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Artificial turf made of polyethylene: continuous loading results in bent fibres, which besides degrading playability are a visual annoyance.

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The strips of turf are attached to an adhesive carrier with polyurethane glue so that the entire pitch can be laid in a floating manner.

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These fibres are stable due to their polyamide cores but are also gentle on the skin because of their polyethylene sheaths.