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Natural biopolymers - the sustainable almost-all-rounders

Wood pulp as well as hemp and flax are renewable raw materials that can be processed into fibres of a new performance class using innovative technologies. They are environmentally friendly and help to solve waste problems. Products and processes for these fibres of the future are being developed at the DITF Denkendorf. They are suitable for textile and technical applications.

When it comes to biopolymers, we first need to define what exactly this implies. Not all polymers are biodegradable, so not all polymers are therefore biopolymers, says Dr. Frank Hermanutz, the head of the Biopolymers and Wet Spinning Technology department at the DITF. He explains, "Biopolymers such as many biodegradable esters can, but do not have to be derived from natural raw materials. They can equally be made from petroleum; this does not change their biodegradability. We are particularly interested in biopolymers made from renewable raw materials, i.e. natural resources." These native polymers are as diverse as the products that can be made from them. In addition to the most common raw material, which is wood and wood pulp, Hermanutz and his team also process chitin and alginate into fibres. The cellulose-based fibres are used in composites alongside hemp and flax.

Dr. Frank Hermanutz is the head of the Biopolymers and Wet Spinning Technology department at the DITF.

Spinning environmentally friendly fibres with "green solvents"

Researchers at the DITF have developed a special process involving "green solvents" that is used to produce cellulose fibres in a sustainable and environmentally friendly way. For cellulose to be spun into fibres, the material must first be dissolved. However, since cellulose does not dissolve in water, conventional processes involve using toxic solvents. Hermanutz and his colleagues have found an alternative, i.e. ionic liquids, that works just as well without producing toxic wastewater. They use a liquid organic salt which has relatively large cations and is therefore liquid at room temperature. It dissolves the cellulose directly, and it can then be spun into fibres without adding stabilisers. The solvent can simply be washed out with water. This process was developed and established at the DITF. "Ionic liquids also enable us to produce super-microfibre filaments that absorb a lot of water and can be processed, for example, into medical and hygiene textiles," adds Hermanutz.

A variety of products can be produced from cellulose IL fibres, such as nonwovens and reinforcing fabrics.

A flagship use originating from the DITF's innovative cellulose fibres is the reinforcing fibres in "PURCELL", a composite material made entirely of cellulose. "If we incorporate the cellulose fibres into a cellulose matrix, we get a composite with excellent fibre-matrix adhesion. This is because the fibres and matrix both consist of the same material," says Hermanutz. PURCELL is a composite material that can be used in many ways, for example in the automotive industry. "We started off with mouldable semi-finished products, i.e. plates with a certain amount of water. The water evaporates when the plate is heated in the hot press to 160 degrees Celsius and moulded into the desired shape," explains Hermanutz. As far as surface modification is concerned, the PURCELL composite is superior even to glass fibre-reinforced plastics: Tests carried out at the German Institutes for Textile and Fiber Research Denkendorf (DITF) have shown that the surface can be coated with paint or effectively dyed, which is not possible with fibre-reinforced plastics. "Since the material does not stick, we do not need a release agent to remove it from the mould after it has been pressed," adds Hermanutz.

Natural polymers are hugely versatile and fully recyclable

The greatest plus with regard to the sustainability of the new material becomes obvious when the products made from it reach the end of their life: The cellulose composite material is fully recyclable and generates no waste. In the DITF laboratories, PURCELL-based products have been recycled up to four times and processed into new composite materials. The

product properties have not deteriorated under laboratory conditions. "We have already simulated ageing and found no loss in quality. However, we still need to investigate how the material behaves under real environmental conditions after ten, fifteen years," says Hermanutz. The recycled material can be reused or composted, and thus reintroduced into the material cycle. But there is another interesting possibility: the cellulose material can be mechanically crushed and processed into fish food. "The material is guaranteed free of microplastics and fish will eat it in the same way as they do conventional plant residues," says Hermanutz.

The cellulose composite material PURCELL can be used, amongst other things, as a lightweight construction element for vehicle interiors.

In the medium and long term, the new material can help counteract the increasing waste problem associated with composites. Around 250,000 tonnes of fibre glass-reinforced plastic waste that cannot be recycled are currently produced each year in Germany alone. At the moment, glass fibre-reinforced plastic waste is simply burned and the glass fibre content used as a cement additive after combustion. "The blades of wind turbines, for example, are made of glass fibre-reinforced plastic. Funding is expiring for more and more wind turbines, which means that many can then no longer be operated economically. They will be dismantled, and huge quantities of glass fibre-reinforced plastic waste will accumulate, further aggravating the problem of non-recyclable waste," says Hermanutz. He hopes that PURCELL and the resulting materials will provide a technically comparable and sustainable alternative to glass fibre-reinforced plastics.

Despite the excellent prospects the new material (still) has some limitations. Pure cellulose material is not suitable when high-strength, structural components are required, for example for producing car bodies, "That's why we've developed a hybrid material with a 30 percent carbon content. This has the required strength and rigidity," says Hermanutz. However, not every conceivable product requires maximum strength. In such cases, hemp and flax can be used as raw materials for composite materials. Hemp and flax plants naturally possess fibres of very different thicknesses and lengths. That's why hemp and flax cannot be used to produce high-strength products. The material can, however, be pressed into excellent mats, which can be used as rear car seats, for example. But that's not all. In principle, any cellulose fibre, no matter which raw material is used and in which mixture, can be woven, knitted or otherwise processed into textile, for example for use in building interiors.

Article

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Further information

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