Biobased materials used in the field of architecture

Straw replaces plastics – a material revolution

Junior professor Dr.-Ing. Hanaa Dahy and her team from the ITKE in Stuttgart are developing everyday biobased materials that have a wide range of possible applications. The materials can be used for thermal insulation, designer furniture, yoga mats or resilient flooring in sports halls. The researchers use techniques from the plastics industry to process recyclable and compostable materials.

The Egyptian scientist Hanaa Dahy, junior professor and head of the Biobased Materials and Materials Cycles in Architecture research group at the University of Stuttgart Institute of Building Structures and Structural Design (ITKE) develops sustainable materials with a wide range of possible applications.

Wouldn't it be wonderful to have a solid material that is biodegradable, flame retardant, flexible and recyclable? Wouldn't it be better still if 90% of the material consisted of a virtually unused residual material such as wheat straw? Impossible? – No! Hanaa Dahy, junior professor and head of the Biobased Materials and Materials Cycles in Architecture research group at the Institute of Building Structures and Structures (ITKE) at the University of Stuttgart, has developed such a material. The composite, which is called "BIOFLEXI", is made of compostable plastic and straw and has already won several prizes. Samples of the material are currently being shown at exhibitions across Europe, in Paris, Hannover, Amsterdam and Jönköping in Sweden. "There is huge interest in the material. We have had a massive amount of feedback, not only from the industry, but also from consumers. Even IKEA has expressed interest in BIOFLEXI," says Dahy.

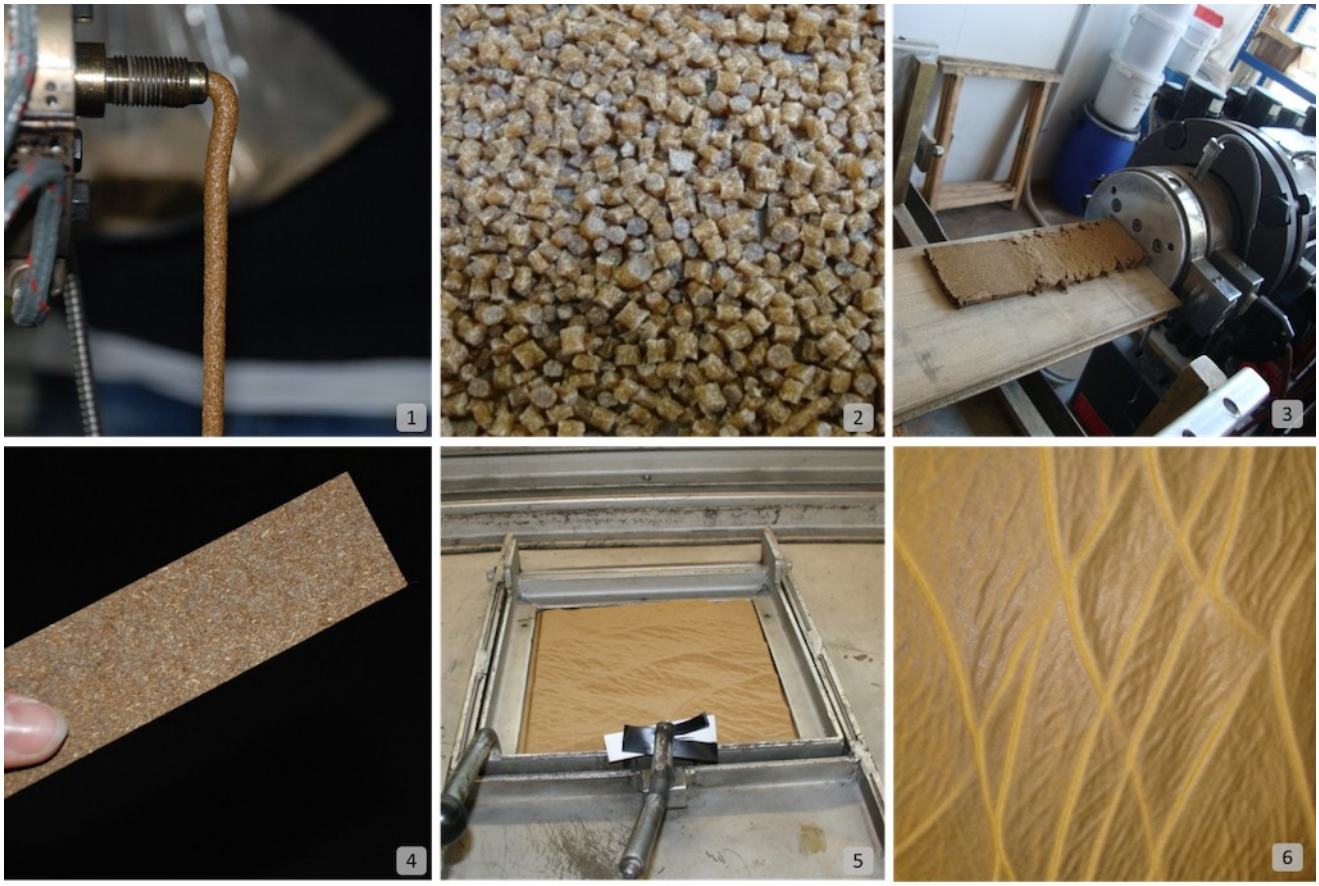
Hanaa Dahy, an architect from Cairo, came to Stuttgart in 2009 to do her doctorate, with a scholarship from the Egyptian government. She had to learn German in just six months, but the effort paid off. "For me and my family, Stuttgart has become a second home. It is a wonderful city and I particularly love the close connections between industry and research. It is also an Eldorado for architects. Stuttgart has the largest architecture faculty in Germany and is an excellent platform for the exchange of information between architects, construction engineers, designers and the industry. It is very fertile – I cannot think of any other region in the world that would be better for my research work. "

Using industry's know-how

Dahy has managed to breathe new life into existing manufacturing processes and machines used for the extrusion of plastics, or rather change them somewhat by filling them with a biobased compostable material. A mixture of bioplastics and natural fibres such as chopped straw is processed into pellets and liquefied in a heatable cylinder, resulting in a tough raw material. Different profiles through which the molten mass is pushed can be mounted on the end of the cylinder to create objects with a specific cross-sectional profile. Extrusion process is a standard, well established process. It is used to manufacture Lego bricks, window profiles, pipes, insulation boards and a broad range of many other products. At the moment, the material used in extrusion is mainly traditional plastics produced from petroleum. This is expected to change in the near future.

"It was important for me that we were able to use existing technologies and industrial know-how from the plastics processing industry. In the search for a suitable natural fibre, we chose straw, which is available in large quantities in Germany. It is cheap and barely used for industrial applications. If straw is used, it is only for generating energy," says Dahy. The use of straw as basic raw material has numerous advantages. It is a renewable resource that is part of an annual cycle, does not compete with food production, and accumulates in huge quantities in agriculture worldwide.

Interdisciplinary research with practical relevance



Production of a natural fibre-based material: compounding (mixing of plastic with natural fibres, pelletising) (1) (2), extrusion of the tough mass through a mould (3) (4) and thermal deep-drawing of the material to achieve the sought-after design (5) (6)

"The problem with straw is that it has a very low density. We therefore have to mix a huge volume of straw with a small amount of plastic. An effective method for doing this is not yet available," says Dahy. Together with the Institute of Agricultural Engineering at the University of Hohenheim, and thanks to novel biobased plastics, Dahy has solved the problem and produced a versatile material with no harmful additives that is recyclable and compostable. The material is strong and highly flexible and can be formed into virtually any shape using extrusion moulding. The material is also much less inflammable than petroleum-based plastics. When wheat straw is replaced by rice straw that has an extremely high proportion of silica, the material even complies with the most stringent fire protection requirements.

There is virtually no limit to the imagination as far as the design of the process is concerned, as other natural substances can also be used. Dahy's students have used coconut fibres and even the ash left over from barbecues to create a large number of different structures and colours. Some materials have smooth surfaces with a modern look; others have a rough or honeycomb-like structure. Some of the materials are flexible, others are rigid. Some have the potential to improve the acoustics of rooms, others look more like a conventional Styrofoam board. The material can be coated with a thin wood laminate. Thanks to its flexibility and mouldability, BIOFLEXI can respond to virtually every design requirement. In the second development phase, which has just begun and is being funded by the University of Stuttgart, Dahy's team is working with a chemist on different formulations in order to bring further applications to market.

Biobased home refurbishment

In another project called PLUS, Dahy is working closely with Florian Rapp from the Fraunhofer Institute for Chemical Technology (ICT) in Karlsruhe. The Fraunhofer researchers specialise in the production of biobased foams, so-called foamed biopolymers. The aim of the cooperative project is to develop biobased thermal insulation boards for home renovation. Dahy explains: "We already have a foamed board and are now planning to integrate natural fibres into the biopolymers. This reduces costs and improves the breathability and fire resistance of the material." Most insulation boards used in Germany are made of polyurethane or polystyrene and therefore petroleum-based; they are difficult to dispose of and expensive. A biobased insulation board could solve several problems at once. Dahy points out that the price of the new biobased materials will be comparable to that of conventional products.

From eco-niche into the market

Material samples with different surfaces and natural fibres made by the ITKE in Stuttgart.

Dahy and her doctoral students would like to take biobased materials out of the eco-niche and encourage architects to think out of the box. Dahy always encourages her students to look at things from different, unusual perspectives, and take the material as a starting point rather than the design of a product they want to develop. Dahy also wants to remain close to practice: “As architects, we sit in offices, making plans and drawings. That’s what we do. But I also love practical work. And I also believe that we have the responsibility to transform our research into practical application.“