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Cellulose as reinforcing material for plastics: an alternative between talcum and glass fiber

FEATURE

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Natural fibers are gaining momentum for reinforcing plastics, offering not only sustainability but also a set of unique technological properties. And it means that companies from other markets have things to offer to the plastics industry. Companies from the paper industry for example and so *Reinforced Plastics* talks to the new business development manager of Sappi.

Sappi (www.sappi.com), originally incorporated in South Africa in 1936, is a globally operating dissolving wood pulp, paper pulp and paper-based solutions company with facilities all over the world. But their largest presence is in Europe. Jacob Hartstra, new business development manager of Sappi, used to work for Sappi's marketing department, dealing with environmental matters, and is now working on the business development of natural fiber reinforced plastics.

'We are a major producer of high quality coated fine papers,' he says. 'That is for applications where the visual aspect and printing quality are very important. And we make high quality packaging and specialty papers. But we also produce pulp. That is: cellulose fiber, the component of wood fiber used for making paper. At the moment, Sappi is looking for interesting non paper related markets worldwide where we can apply our knowhow. For that we have a number of projects, including the one I am responsible for: cellulose reinforced plastics.'

Digitization has caused the paper market to shrink. 'Especially the rise of tablets and smart phones has led to more information being consumed digitally,' Hartstra explains. 'E-books, e-magazines, the decrease of printed newspaper sales... As a supplier of base materials we are feeling that decrease. That is why we are also active in packaging, which is still a growing market. We are a big player in quality paper and cardboard for example in packaging for beauty products and confectionaries. We came to realize that we have very interesting raw materials and side products. They are sustainable. Our whole supply chain already works under constant scrutiny. And we can make more than just paper. So the trend of the EU to go to a competitive low carbon economy is an opportunity for us to obtain a strong position in the future.'

The idea to investigate the possibilities for using cellulose fibers to reinforce plastics came from innovation programs in which employees from R&D, marketing, sales and production take part. These sessions result in pitches to the management of Sappi Europe, of which the best are selected to be developed.

Symbio

'The working name for Sappi's composites project is Symbio, short for symbiosis with nature,' Hartstra says. 'Many natural fibers are already being used for reinforcing plastics. There are wood plastics at the bottom end. And then there are hemp, flax and such. We believe that cellulose reinforced plastics are a good alternative for certain applications, especially in injection molding. Contrary to many other natural fibers, our fiber can be produced at an industrial scale with constant quality, independent of for example seasonal influences. And in order to obtain beautifully white paper, we industrially take the lignin out of the wood fibers. That leaves us with white cellulose fibers instead of a brown material, resulting in flexibility in the color of the end product: you can give it any color and you will not see the fibers, so that gives excellent design freedom.'

According to Hartstra, taking out the lignin also means that the composite does not produce the bad smell associated with many natural fiber reinforced materials: 'The lignin in many natural fibers causes the composite to smell like old books, making it difficult to meet the high standards needed for example for automotive interiors.'

The cellulose fibers in the composite are short and very thin, making them suitable for injection molding. 'Materials filled with our cellulose fibers have a stiffness, strength and impact resistance between talcum and glass fiber,' Hartstra says. 'And they are five to

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It is hard to spot the difference, and indeed granulates of Symbio reinforced polypropylene can be processed just like polypropylene reinforced with conventional fibers.

fifteen percent lighter, depending on the percentage of filler used.' That is because cellulose is about half the density of a mineral like talcum or glass.

They are running their pulp processes totally chlorine free. The lignin is taken out chemically in a sulfite pulping process. 'The waste products that come out, are burnt to generate part of the heat to run the plant,' says Hartstra. 'And they are used for other products and applications.' Lignosulfonates are for example used in the production of concrete, cement and plasterboard. And they can be used in oil drilling mud and for tanning leather.

Sappi is investigating all sorts of possible uses for their byproducts. 'Our main resource and therefore livelihood are trees, so we need to take care of this resource because we depend upon it,' says Hartstra. 'All our wood sources are managed according to sustainable forest management practices. And we are working with PEFC and FSC standards. We need to know the whole value chain, we cooperate with forest managers and wood suppliers, and in South Africa we own a fair amount of forest. All our fibers are from renewable sources and as a paper company we are constantly being scrutinized. We have to be able to say exactly where every fiber came from: country and region. That is necessary so we can prove it really came from sustainable forests.'

Fully biodegradable reinforced plastics

Sappi has cellulose fibers, used for making paper, but also so-called dissolving pulp, used for example for the production of viscose, in abundance. And for plastics they are trying to create stronger fibers as well.

'We would like to increase the strength and stiffness to equal or surpass glass fiber by making nanocellulose,' Hartstra says. 'For that we have set up a pilot factory at the Brightlands Chemelot Campus in Geleen, the Netherlands. A cellulose fiber is made up of bundles of fibers. You can take them apart until you end up with the primary fiber: nanocellulose. That has very promising properties, which are interesting for many different applications. For example as a thickener for water based products like paints and foods but also as possible replacement for plastic films in packaging. One promising application is to use the nanocellulose to reinforce plastics.'

With the planned market introduction of Sappi's cellulose reinforced plastics this year, the first resin to be used is polypropylene because there is a large market for it. 'We are also looking at other resins, but the processing temperature has to be low enough to prevent the fibers from being scorched,' Hartstra says. 'We need to keep the temperature preferably below 200 degrees Celsius at the moment. Engineering plastics like polyamide are currently still outside that range. Polyamides will however be possible with nanocellulose, because that has a higher scorch temperature. And we are looking at fully biodegradable plastics like PLA (polylactic acid). That is one of the biggest bioplastics at the moment. It is used for all sorts of applications. Packaging for example. By the way, ''bioplastic'' does not necessarily mean biodegradable. But PLA and cellulose are biodegradable, so combining them would indeed result in a biodegradable composite. For me as a business developer that is very interesting, but the properties of the composite are crucial. And cellulose reinforced bioplastics have to fulfill a need from the market. The current focus is therefore on reinforcing polypropylene.'

The advantage of paper is that it has already been recycled for decades now. In the EU for example over 70% of all paper is being recycled. It would be great if some day that could be achieved with plastics as well.

'The carbon footprint of cellulose fiber is much lower than that of polypropylene and glass fiber,' Hartstra says. 'On average a neat polypropylene produces around 1900 kilograms of CO_2 equivalent per ton of product, glass fiber reinforced plastics produce a multiple of that. Our pulp produces between about 200–800 kg of CO_2 equivalent per ton. So the more cellulose you put into the composite, the lower the carbon footprint of the resulting material. That is largely due to the fact that wood fibers have already stored CO_2 during the growth of the tree and many byproducts of the cellulose production are used to power the pulp mill.'

Market

Symbio was created as a startup within the larger company Sappi to ensure flexibility. 'More and more startups and spinoffs are now being set up within larger companies to be able to operate without being slowed down by all the company red tape,' Hartstra explains. 'We have a small team and report directly to the highest management of Sappi. And we develop these new materials and applications as much as possible in response to actual questions and needs from the market. We try to steer clear from purely technological developments in order to prevent developing something nobody wants.'

Many companies are interested in Sappi's cellulose reinforced plastic and they are already testing the materials. 'We went to the testing phase very quickly,' Hartstra says. 'We started from very little, less than two years ago and quickly approached the market to see which direction to take. And we ran tests with potential clients with so-called ''minimally viable products'', i.e. materials not ready for market introduction yet. You can use the feedback from that to develop something that caters to an actual market niche. I am proud at what we have accomplished as a paper company to get from idea to market introduction in less than two years. And all that in markets which are completely new for Sappi.'

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A Symbio reinforced plastics part for a car door. The mechanical properties of the cellulose fibers are between talcum and glass fiber.

Sappi is running a lot of tests with consumer electronics companies, mainly for audio equipment. Hartstra explains that for that application the material behavior of cellulose reinforced plastics is between wood and plastic: 'We have discovered that acoustically it is a very worthwhile material to use for enclosures of for example loudspeakers. It can be used as an alternative for the typical plastics used in these applications – like filled ABS – but of course also as an alternative for wood based enclosures.'

They are also conducting tests with companies that make professional audio monitors and high end loudspeakers. Further talks and tests are going on with automotive, furniture and appliances producers.

The automotive industry already uses some natural fibers and considers weight to be very important. So it is a logical market. Sappi's lignin-free fibers should meet all the high visual and olfactory requirements of the automotive industry.

In the range of possible reinforcing materials, cellulose (and soon nanocellulose) is offering a real alternative to product developers and engineers. The material comes in between talcum and glass fiber, as far as mechanical properties are concerned, but offers further value, for example: good acoustic damping, better scratch resistance, low wear on equipment, good heat deflection temperatures and good cycle times. It has the additional bonus of lower density and a lower carbon footprint. It will be interesting to see how much market penetration this material is going to realize in the coming years.

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