An upswing in demand has cellulosic fibre producers increasing production capacities while a handful of enterprising start-ups is slowly making progress in recycling fabric waste into lyocell-type fibres.

Cellulose regenerated

They have a soft touch and a fluid drape and are made from a renewable natural resource. A visit to any high-street womenswear retailer gives an indication of the volumes of viscose and viscose-like materials that are on the market. In active and casual sportswear, brands tend to choose modal or lyocell, because of their moisture absorption and easy-care properties. These newer cellulosic fibres are also lighter on the environment, and their popularity is growing.

Producers of cellulosic fibres are scaling up production to meet increased demand. This August, Austria-based Lenzing announced a €100 million investment to expand production capacity of its specialty fibre business by 35,000 tonnes by mid-2018. This is part of its plan to increase the share of specialty fibres in its sales to 50% by the year 2020, from 41.7% currently. In 2015, the company's global sales reached €1.98 billion from a fibre volume of 965,000 tonnes.

In Japan, a new Bemberg cupro production plant began operations in June 2014 on the site of a former polyester plant at Nobeoka, Miyazaki Prefecture. This almost-$30 million investment increased the group's production capacity by 10%, from 15,000 to 16,500 tonnes per year. The company says enquiries about athleisure-style fabrics are up, thanks in part to the material's breathability, and the expansion in the range of knitted fabrics in the past two or three years. Cupro is made with a waste material, the cotton linters that are not used in spinning.

Closing the loop

While production capacity increases for conventional cellulosic semi-synthetics, research into producing a lyocell-type fibre from used clothing is also making progress. In virgin as well as waste form, cellulose is an abundant raw material. And the chemistry used to dissolve wood pulp into fibre could theoretically be applied to cellulose-rich fabrics and clothes. It is a simple enough theory, but it has yet to become a reality. Evrnu in the United States along with several Scandinavian start-ups including Re:newcell and Ioncell are betting on the possibility.

As Europe's largest cellulose fibre producer, Lenzing is as well, and may actually be the most advanced. It has developed a process that breaks down cotton fabric waste into pulp that can then be processed like a lyocell fibre. Lenzing has already formed a partnership with Inditex. The



An outfit designed by Ina Budde and made in Re:newcell in collaboration with Textiles Back to Textile, presented at the Berlin Ethical Fashion Show 2016.

Louise Norlin / Re:newcell

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Spanish fashion retailer (parent company of Zara) has agreed to supply Lenzing with cotton waste materials from its garment-making factories. At the time of announcement, in July, it mentioned sending 500 tonnes of textile waste to Austria and said it was aiming to reach 3,000 tonnes within "a few years".

The first products made from the regenerated waste fabrics could be in stores by Spring 2017, and would be the first, small but commercial-scale closed loop cellulose fibres to come to market. Lenzing has been working on the patent-pending process for several years now, says Sonja Zak, who is in charge of the programme. She is quick to point out that at the moment it can only recycle pure cotton waste materials, not used garments of any composition. The off-cuts that are delivered to the plant are already sorted by colour. This is the raw material that Lenzing converts into pulp that will be used in the standard lyocell process. To distinguish the Tencel with recycled cotton from the wood pulp-derived variety, or other fibres in the final garment, Lenzing has implemented a new type of identification procedure. With regards to production capacity, "we are equipped to respond to market demand," says Ms Zak. an indication that Lenzing does have a head-start over rival technologies.

In development since 2012, Re:newcell, a Swedish start-up with ties to the forestry and paper industries, is now in the process of building a demonstration plant. It is located inside a former AkzoNobel factory in Kristinehamn. "It will be capable of processing several thousand tonnes of waste material. This is not yet large scale, but enough to show that our process can be scaled up," says the company's head of business development, Henrik Norlin. Re:newcell has just completed a round of financing, raising nearly €5 million from Fouriertransform, a Swedish government-owned investment company, and private venture capital firm Girincubator. This will contribute to the €8 million investment in the construction of the first production line. Mr Norlin says it could begin operations by the end of this year, noting that the first heavy machinery was delivered in September. The plant is expected to be finished in early 2017.

Re:newcell has been working on a dissolving process to produce pulp in a more sustainable manner for the past five years. The company says its textile recycling technology transforms a high cellulosic portion fabric into recycled dissolving pulp that can then be fed into a commercial lyocell production chain and that its process is cheap and does not require any chemicals that are environmentally harmful. These are claims that Re:newcell will be able to confirm when its demonstration plan is up and running.



The Evrnu process begins by stripping dyes and other contaminants from cotton textile garment waste before pulping. During extrusion, the fibres can be engineered to customised weights and cross-sections, according to the company.

Evrnu

Cotton-rich recycling

In Seattle, Evrnu is also making progress of its own on a cellulose regenerating process of waste materials. Its method breaks cotton waste down to "molecular level" and it refers to cotton as a "distant cousin of viscose". Co-founder and CEO Stacy Flynn explains that wood pulp contains 30% to 40% cellulose whereas cotton clothing contains up to 90% cellulose. She says: "This is a case in which the recycled raw material has higher-quality cellulose than the virgin raw material."

The company currently has a functioning lab-scale dissolving apparatus and micro-extruder that it is using to research the feasible "hybrid" fibres it could make. "Our process is entirely customisable, we can create any cross-section we want by changing the machine's accessories," says Ms Flynn. "There is much we don't know yet about the fibre's mechanical properties. But we have not seen any limits and have produced a fibre that is three times stronger than steel." Well aware of the price sensitivity of brands and

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Cupro captures intense colour, as seen in this fabric made by Italian textile manufacturer Jackytex.

Jackytex

retailers, she believes that once its volumes are up, its costs will go down. While still working on many elements of the technology, the start-up has partnered with Levi's, and a first pair of jeans made in recycled Evrnu fibre was revealed in May. The company is working with another early adopter it cannot yet name.

Stacy Flynn founded Evrnu with Christopher Stanev in 2014 and has a long background in textiles and apparel. She worked at DuPont, Target and Eddie Bauer, in the US and in China, before deciding to quit her job, go back to school to get an MBA in sustainable systems, and dedicate her energy to reducing the great quantities of textiles and clothes that are being landfilled. "We're throwing money down the drain, it makes no sense! This is a massive problem that can be turned into a great product. It's just a matter of time," she says.

Ioncell, a Finnish project, has just been granted €300,000 by H&M's Global Change Award. Developed by a team of researchers at Aalto University, it uses ionic liquid, as its name suggests, to dissolve wood into pulp to make a lyocell-type fibre. Wood processing is the initial goal of the start-up, but the new funds will be applied to convert the process to regenerate used cotton clothing. "The main focus of the Ioncell project is to make wood pulp, using recycled cellulose waste is an upside potential," project manager, Professor Herbet Sixta, tells *WSA*. Ioncell is still a work in progress. "For the next two years we will be focusing on developing a solvent-recovery system. If a technically viable solution is found, we could start production in a continuous pilot plant, but this depends on how much financial support we obtain," he says.

Securing feedstock

Much research remains to be done to obtain a fabric-dissolving process that is both viable and cost-efficient. Like any technique that involves waste materials, these projects also rely on securing a steady source of scraps to recycle. These must be pure cotton and pre-consumer. "We spend a lot of time analysing waste stock and our process can also recycle shoddy," says Ms Flynn at Evrnu. Shoddy, a term normally associated with waste wool, in this case refers to fibre waste made of short staple cotton. Available feedstock is not her main concern, as she says "there are many options to pool from. The problem is sorting and separating it. But we have a solution for that, and our research is incredibly promising."

"One of our main challenges is turning a heterogeneous raw material into a homogenous finished fibre," says Sonja Zak at Lenzing. This is



Munich-based sportswear brand Protective has introduced Flocus-filled jackets in its Fall/Winter 2016 range and expects to use kapok fibre fabrics made by Taiwanese mill GAC. The natural wax coating on the kapok fibres provides water-resistance.

Protective

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Without cutting trees

Since its beginnings in the early 20th century, cupro is made from cotton linters, a by-product of the cotton industry, making it the only semi-synthetic cellulosic fibre that doesn't come from trees. Its eco-friendly origins may not however be enough to cancel out the corrosive chemistry (ammonia and copper) used to turn it into textile filaments. With the revival of kapok, by Shanghai-based Flocus, another cellulose-based fibre that does not involve the cutting down of trees is being made available. The company, founded by Jeroen Muijsers in 2014, has developed a spinning process that can turn the very short fibres (10-20mm long), harvested from the seeds of the kapok tree, into yarns suitable for industrial weaving and knitting.

Flocus is now supplying yarns to weavers and knitters in Asia and Europe, including Taiwanese mills GAC and Singtex. Mr Muijsers tells *WSA* that 50 to 80 new fabrics should be ready for the winter shows. The latest performance product to be developed is a yarn blending kapok with Unifi's recycled polyester Repreve. "We develop the basic yarns and fabrics, such as flannels, in house, and depend on outside mills to develop higher-end fabrics, and specifically performance fabrics," he says. Production is not an issue, he adds, as "the partner companies we work with are used to producing small volumes and will welcome higher quantities."

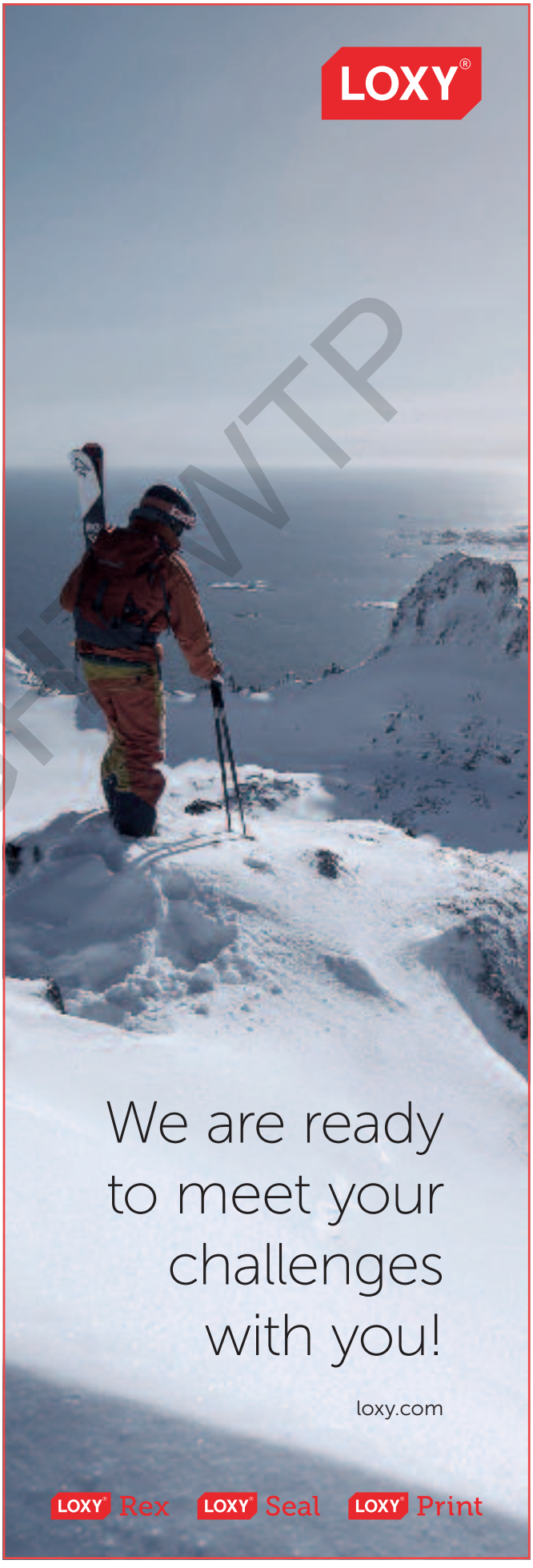
Flocus is currently investigating the possibility of using kapok to cover a corespun filament, for performance fabrics. Thermal insulation, for clothing and sleeping bags, is another potential end market. "A kapok filler will be very lightweight yet have a high CLO value," says Mr Muijsers.

With its soft hand feel and fluid drape, kapok is similar to other viscose-type materials. It may also have the lightest environmental footprint. One of the tasks the kapok specialist now faces is to validate and certify its claims. Mr Muijsers says kapok farming is organic by nature, but its upscale clients are requesting third-party certification.

a point also raised by Henrik Norlin at Re:newcell: "The output will never be as good as the input material." We allow ourselves to be picky, he says and believes there's enough waste to feed the recycling circuit.

This stage of the process could be made simpler if the issue were addressed at the start of the design process, Ms Zak points out: "designers could help simplify this stage by creating clothing made in a single material." There is also room for improvement in cutting and sewing. "Manufacturers need to be more material efficient," says Mr Norlin.

These projects depend on a chain of actions to optimise the recycling process. The sorting of cotton-rich materials from other cellulosic fabrics is a challenge in itself. One would have thought that viscose-type materials could be reprocessed infinitely. This is far from being the case, though Sonja Zak doesn't see why it is not possible in the long term. Re:newcell believes there could be other applications for its technology. "Our innovation is inherently open, there are many different channels to investigate. It is possible that our technology will be useful for other materials," says Mr Norlin. This opens the prospect that these dissolving techniques may offer solutions to other high-waste industries.



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