Castor oil has long been a non-food-crop source of biopolymers for fibres and plastics, specifically Arkema's Rilsan (PA 11) and Pebax. The options are now expanding as Toray and Radici are both working on polyamide 6-10, partially derived from castor oil, introducing a new eco-material that sports brands tend to eye favourably, and making progress in the textile industry's often proclaimed intentions of 'greening' its processes.

New yields in castor oil polyamides

Castor oil-based materials have made a number of appearances in sportswear and sports equipment over the past few years. In 2011, The North Face introduced a waterproof breathable castor-bean membrane in one of its jackets, and sunglass brands Smith Optics and Zeal Optics have offered frames made from the bio-sourced polyamide. Pebax users may or may not know that a percentage of the plastic produced by Arkema is derived from castor seed oil (see panel).

The biomass substance has been used for a long time, in fact since the early days of synthetics. DuPont de Nemours is said to have studied possible uses for castor oil in new materials in the late 1920s. Polyamide 11, or Rilsan, was patented in 1944 by French scientists working for Organico, a subsidiary of Pechiney, which went on to become Arkema in 2004.



French spinner Sofila introduced bio-sourced Greenfil in 2009, made from Arkema's Rilsan PA 11 polymer, and has since launched a range of socks branded Jingo. Due to the fibre's high resistance to wear, socks are one of its main areas of application.

Sofila

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The castor oil plant, or Ricinus Communis, also known as wunderbaum, is used in the manufacturing of Arkema's Rilsan polyamide 11. A non-edible, non-GMO crop, it requires few pesticides and grows on poor soil in semi-arid regions. Arkema sources castor seeds in China, Brazil and India.

Stocksnapper/Shutterstock

Now Toray and Radici believe the market is ready for another castor oil-derived polyamide, PA 6-10. The Japanese fibre producer presented the first fabrics at ispo in January 2012. They are made in polyamide 6-10, the result of a process the company calls hybrid engineering. Conventional petrochemical PA 6 makes up 40% of the material, and PA 10, derived from castor oil, the remaining 60%. The company offers a wide array of deniers, like any nylon, but the price of the bio-sourced polyamide is said to be 20% to 25% higher than that of a standard nylon.

Toray has announced its intention to produce a 100% castor-oil fibre in the future. A challenge for the moment, which the company spokesperson in Europe, Steffen Meiler, says is due to "stability issues". Toray also has plans to develop coatings and membranes from castor oil. The quest for new eco-materials is a part of Toray's broad eco-initiative programme. "The entire company is committed to sustainability, and since 2002 has been seeking ways to be less dependent on oil," says Mr Meiler.

In a press release issued in February, Toray announced it had entered into a partnership with Ajinomoto, a Japanese company specialising in amino acids and specialty chemicals, to work on yet another bio-sourced polyamide. This alternative method involves a fermentation process, developed by Ajinomoto, leading to 1.5-PD, a substance that can then be polymerised. Toray has declared that it hopes to produce, via this system, "bio-based nylon products that are competitive in terms of quality, environmental protection and cost".

Meanwhile, RadiciGroup is also investigating new possible markets for its castor-oil polyamide 6-10, currently used in industrial fibres and plastics. The Italian conglomerate has some experience in the matter, since Radici Yarn produced the yarn from the Arkema Rilsan PA 11 polymer chips that Sofila would launch as Greenfil in 2009. Sofila is now testing and texturising Radici's PA 6-10, which is made of 70% PA 6 and 30% biosourced PA 10.

Like Toray, RadiciGroup is also engaged in a vast sustainability programme. Under the heading "Operation Twenty4", Radici is aiming for a 20% decrease in greenhouse gas emissions and energy consumption, and a 20% increase in energy generated from renewable sources and use of recycled materials. As of today, the company claims that the portion of energy generated from renewable sources is 36%, while the use of recycled materials in the nylon production cycle stands at 15%.

'Pure' polyamide 11 vs 'hybrid' polyamide 6-10

Developed in 2009 to cater for the supposed growing demand for eco-fibres, Greenfil by Sofila has not met the success the company expected. The French polyamide specialist invested €1 million in developing the Rilsan



In 2011, The North Face introduced a waterproof membrane, composed of 50% castor oil, in the Venture Jacket. The company claims that this jacket, one of its best-selling products, could reduce 50,000 lbs of petroleum-based materials in 2011.

The North Face

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PA 11 fibre, but has found few brands outside of sock manufacturers (Kindy, Monnet, and Jingo, a brand developed by Sofila itself) ready to take the high-priced fibre to market. "Bio-sourced materials, or organic ones for that matter, are not top priority for consumers these days," says Henri de France, president of the Sofila board.

The company has identified woven fabrics as a new area for possible development, taking advantage of the fibre's reported high resistance to abrasion. This is leading Sofila to new markets, including the automobile and food industries, says Mr de France. Testing done by research organisation the French Textile and Apparel Institute (IFTH) indicates that Greenfil has several inherent properties, including high abrasion resistance, chlorine resistance, bacteria-reduction and quick drying. The IFTH compared Greenfil to ten other fibres (among which PA 6, cotton, silk, PLA, Coolmax and Modal), and found bacteria proliferation to be close to zero (ISO 20743). On a sweating torso, a Rilsan PA 11 fabric dried faster than a micro polyamide 6-6.

Despite these qualities, cost remains the main hurdle for polyamide 11 (as well as polyamide 6-10). "A Greenfil sock may be two to three times more expensive than a conventional nylon sock, but it will be 5 to 10 times more durable," says Mr de France. As the eco-fibre trend currently weathers the economic crisis, Sofila and Arkema tend to emphasise not the bio-sourced origins of polyamide 11, but rather its technical and functional properties.



A ski sock made by Monnet using Sofila Greenfil. The company says it chose the fibre for its high durability, inherent bacteriostatic properties and ability to thermo-regulate.

Monnet/Arkema



A selection of castor seeds, from which castor oil is derived. *Arkema*

The polyamide numbers game

Rilsan, or polyamide 11, was patented in 1944, and its first practical applications were in textiles, though plastics are now the main market for this industrial-grade polymer. In 2009, Arkema, the sole producer of polyamide 11, looked to reintroduce the polymer in textiles for consumer markets. The French chemicals company did so by partnering with Sofila, for apparel end-uses, and Unitika, for non-apparel applications. Rilsan is one of the two ingredients used in Pebax, another Arkema product, which is a blend of castor-oil PA 11 and petrochemical polyether. In the large family of Pebax products, Rilsan can make up anywhere from 20% to 90% of the high-tech plastic.

Toray and Radici are working on polyamide 6-10, in which the PA 10 is derived from castor oil and blended with conventional PA 6. This bicomponent polyamide is commonly used to make industrial monofilaments and plastics. The new developments target textiles and waterproof-breathable membranes for apparel end-uses. In 2001, Japanese fabric manufacturer Toyota Tsusho had presented a castor-oil Gelanots membrane. Toray says it is working on castor-oil membranes, as well.

The numbers used to identify the different types of polyamides refer to their molecular carbon chain. "The longer the carbonic chain, the higher the fibre's resistance, from the smallest (PA 6) to the longest (PA 12)," says Perrine Babin, in charge of the bio-sourced technical polyamide market at Arkema. Arkema's Rilsan is said to be bacteriostatic, lightweight, thermo-regulating, endowed with high mechanical and chemical resistance, and soft to the touch.



Zeal Optic's Penny Lane sunglasses, like all the company's frames, are made in a bio-based polyamide derived from castor oil. The company says that using this novel resin results in reduced carbon dioxide emissions.

Zeal Optics

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