WTiN

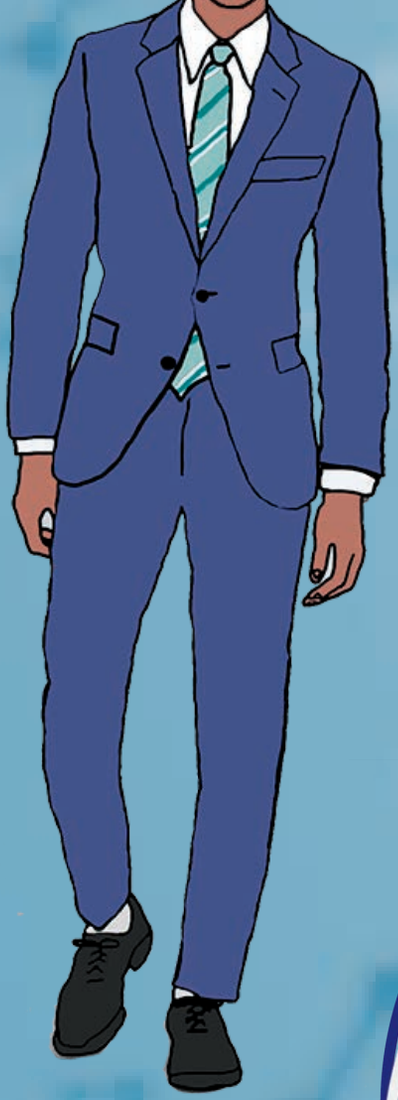
2023

Material Innovation

Analysis of material innovation developments and trends in the textile & apparel sector

brrr°

PROVEN TO KEEP YOU COOLER



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Significant transformation

The needs of the textile & apparel industry when it comes to materials are undergoing significant transformation. This is due to a confluence of factors, not least mounting environmental concerns, advancements in technology, research and development, changing consumer preferences and challenging economic conditions.

As mentioned in WTiN's virtual conference, Innovate Materials (see pp. 10-15), environmental concerns are driving a paradigm shift in textile material choices and development. The apparel industry is among the most resource-intensive industries, and its impact on the environment is substantial. This has led to a growing demand (and legislation) for sustainable textiles that reduce water consumption, land consumption, energy usage and harmful chemical pollution.

Alternatives across the value chain are being developed by innovators across the globe. For example, on pp. 12-19 we look at more environmentally friendly polyester alternatives and on pp. 20-27 we assess developments in alternative leather materials. Other fibres, such as plant-based fibres cork and eucalyptus are also assessed (see pp. 28-31) and those that offer superior functions, such as carbon capture (pp. 36-39).

Technological advancements are also playing a pivotal role in shaping the future of textile materials. Innovations in material science have led to the development of high-performance fabrics that offer enhanced functionality, durability and comfort. For example, material technology company brrr° discussing advancing cooling performance in fabrics (pp. 6-9).

With all this and more, there is little doubt that a shift towards sustainable, high-performance and ethically sourced materials is shaping the future of the industry and redefining our value chains.

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Material Innovation: Contents

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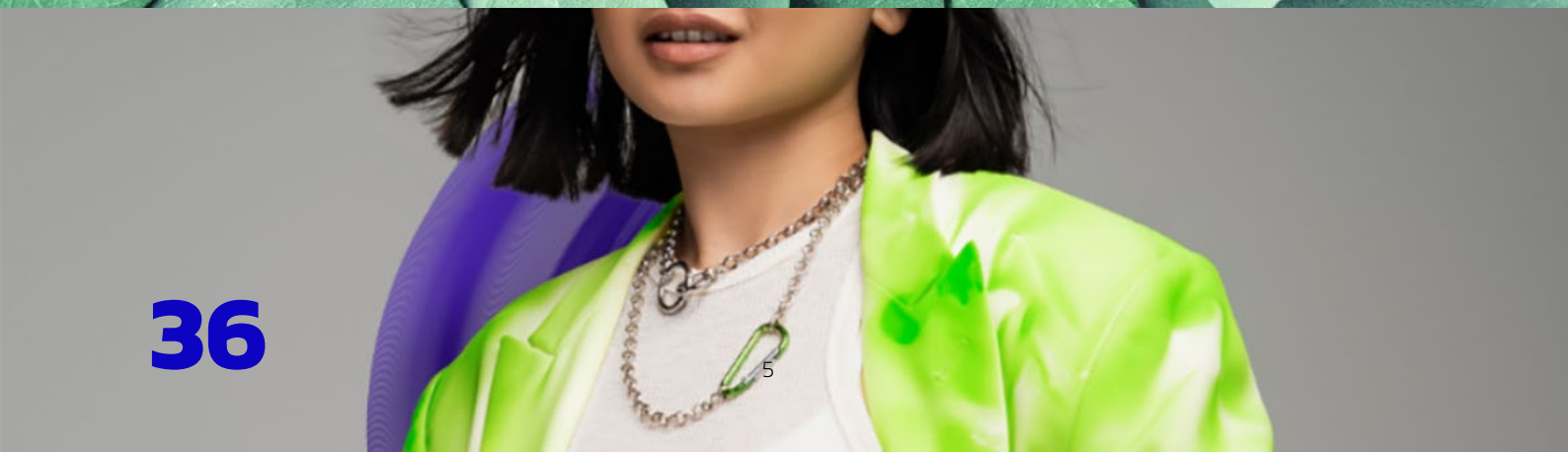
Material Innovation: Contents



Advancing performance cooling

By **Mary Jane Credeur**

It's been several decades since a major athletic brand introduced clothing that had better wicking capabilities for improved moisture management.

Although they were widely marketed as "cooling," those garments were really just good at one thing: wicking.

That development set the stage for other advances like wet "snap" towels that use the principles of evaporative cooling but they only work when they are wet — which is fine if you're mowing the lawn or out for a run, but isn't very practical for office attire, casual wear or most activities in daily life.

Some products achieve a cooling sensation with chemical sprays or coatings that wash out and diminish over time, which is also harmful to the environment.

However, cooling fabric innovator brrr° is advancing the category by using natural cooling minerals, active wicking and rapid drying technologies that create a "Triple Chill Effect" that instantly and continuously draws heat and moisture away from the skin.

Every brrr° fabric is independently lab tested and scientifically proven to outperform other products.

Mary-Cathryn Kolb, founder and CEO of brrr°, says: "We stand behind the science and brrr° is proven to help keep you cooler and more comfortable wherever life takes you — work, working out, hanging out with your family, or meeting friends for dinner."

A more sustainable choice

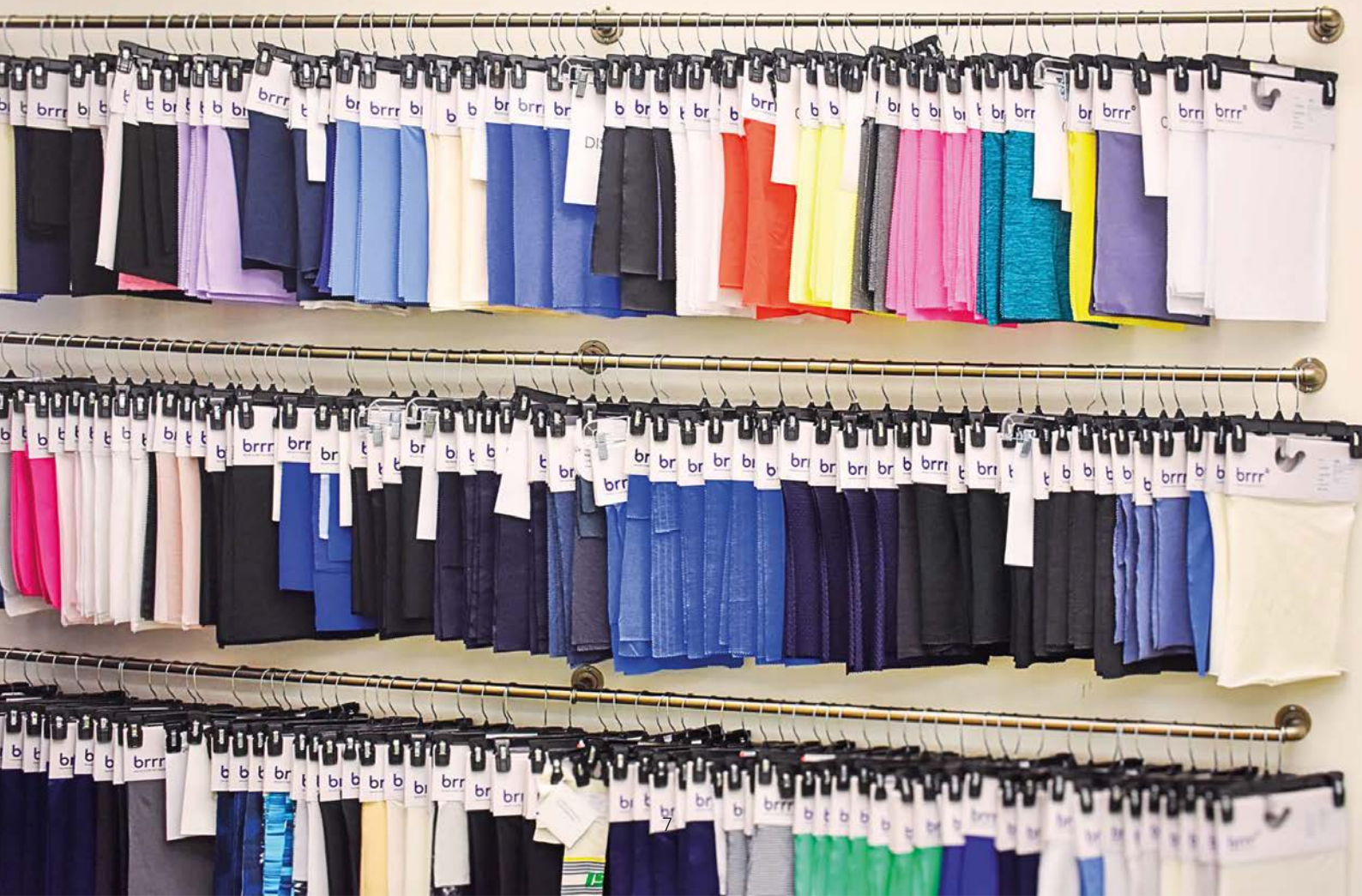
As brrr° technology is permanently embedded in the structure of the yarn, it won't ever fade or wash out like the chemical sprays and coatings used by some other companies.

There are also versions of brrr° made with recycled material that divert post-consumer products from landfills and reduce the need for virgin material and brrr° fabrics made with sustainably grown materials such as hemp and bamboo. The company has a library of hundreds of fabrics and can create custom blends or fabrics for clients to meet their specifications.

Caption

brrr°

brrr° fabrics



brrr° holds GRS certification in accordance with Global Recycled Standards, which shows customers and consumers that companies are committed to meeting internationally recognised sustainability standards and practices. brrr° also follows OEKO-TEX standards for sustainability and safety.

In addition to its appeal during the hot months of the year, brrr° is gaining popularity in base layer clothing and activewear for year-round comfort and dryness because it supports the body's natural thermoregulation, such as hoodies by Duck Camp and Strafe and a featherweight performance pullover by Criquet.

Kolb continues: "brrr° can help keep you more comfortable all year long. And when your body can regulate its own temperature more effectively, you don't need to use as much air conditioning and heating."

Comfort is king

In our post-pandemic world, the number one thing consumers want in their clothing is comfort and 70% say they plan to dress more casually from now on, according to a survey by NPD and research by The Wall Street Journal.

Numerous retailers have made repeat purchases of brrr° as they expand the cooling fabric to more of their products.

brrr° is now used in a wide variety of garments made by major brands including BRADY by Tom Brady, Adidas, Greyson, Southern Tide, Vineyard Vines, and numerous brands in Europe such as Jack Wolfskin, Triumph, and Martini.

Beyond apparel, brrr° is also used in bedding by Sheex, baseball hats by 47 Brand, compression sleeves for people who have lymphedema, sports medicine support boots for horses and more.

A leader in cooling fabric innovation

In the decade since brrr° was founded, the Atlanta, US-based company has become a leader in cooling textile technology innovation. brrr° holds several patents and is constantly investing in R&D to develop the next generation of cooling textiles.

The company recently created a performance cooling product called brrr° Pro that uses micro cooling minerals to amplify the cooling sensation, plus hyper wicking and performance drying.

In independent lab testing, brrr° Pro Polyester scored 0.194 in Q-MAX cool-touch testing, which was 81% better than another brand of cooling fabric and 53% better than a comparable performance polyester. It also outperformed in wicking and drying tests.

"brrr° Pro intensifies the cooling sensation because there is more surface area for our micro cooling minerals to scavenge heat and draw moisture away from the skin," Kolb adds.

Why isn't there a cooling standard?

As consumers seek better performance from their clothing, there is a pressing need for a universal standard to define the "cooling" category and move toward common testing methods to support cooling fabric claims — similarly to the way UPF sun protection is measured.

brrr° relies on scientific independent lab tests by globally respected third party labs to prove the cooling, wicking and drying properties of each of its fabrics using widely recognised standards by FTTS and the American Association of Textile Chemists and Colorists (AATCC).

Adopting universal standards to measure the coolness of fabric would also reduce confusion among consumers and entice people to try new products. This could encourage more retailers to offer apparel made with cooling fabrics and propel new growth in the category.

To learn more about innovative brrr° cooling fabric technology, please visit brrr.com.

Investigating innovation in materials

By **Madelaine Thomas**

As the textile & apparel (T&A) value chain continues to search for ways to gain ground in efficiencies and use more green processes and materials, the market for alternative and more sustainable resources and materials is booming.

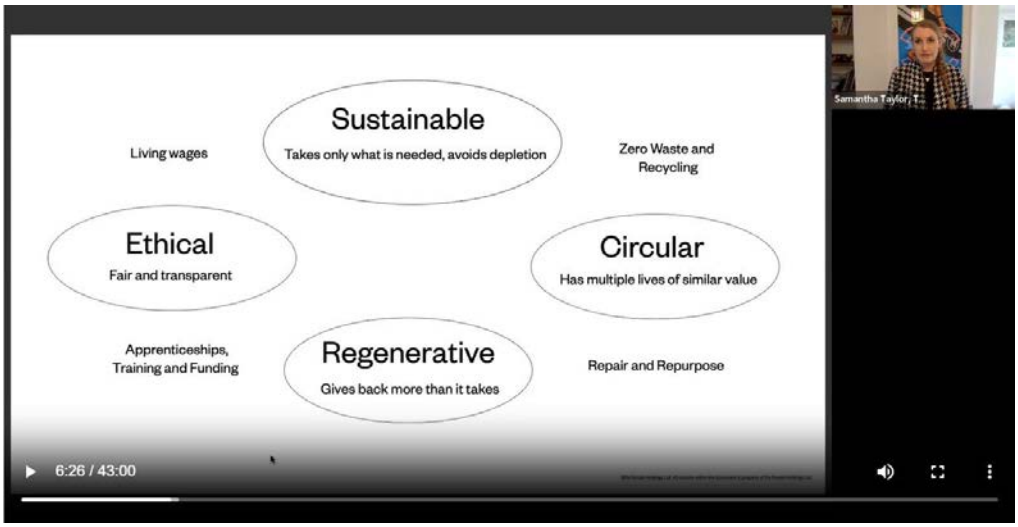
Investigating this burgeoning market, World Textile Information Network (WTiN) hosted a virtual conference, Innovate Materials, from 19-20 September 2023. The first day of the conference evaluated how we can better use or improve the existing materials in the supply chain. The second day covered new and alternative materials entering the industry and the realistic time frames, legislation and best practice involved when implanting them.

Samantha Taylor, founder of sustainable manufacturing consultancy The Good Factory kicked off the event with a keynote presentation on how the T&A industry can enhance the efficiency and impact of traditional materials and work towards circular and sustainable processes. Taylor explored strategies and initiatives that can unleash the potential of existing materials in a much more sustainable way than current practices. “We must transform the way we produce, source and utilise existing materials,” she said. She offered key objectives to help propel the industry forward: taking only what is needed, zero waste and recycling, regeneration, circularity and transparency, to name but a few. Some of her recommended strategies are detailed in the image below.

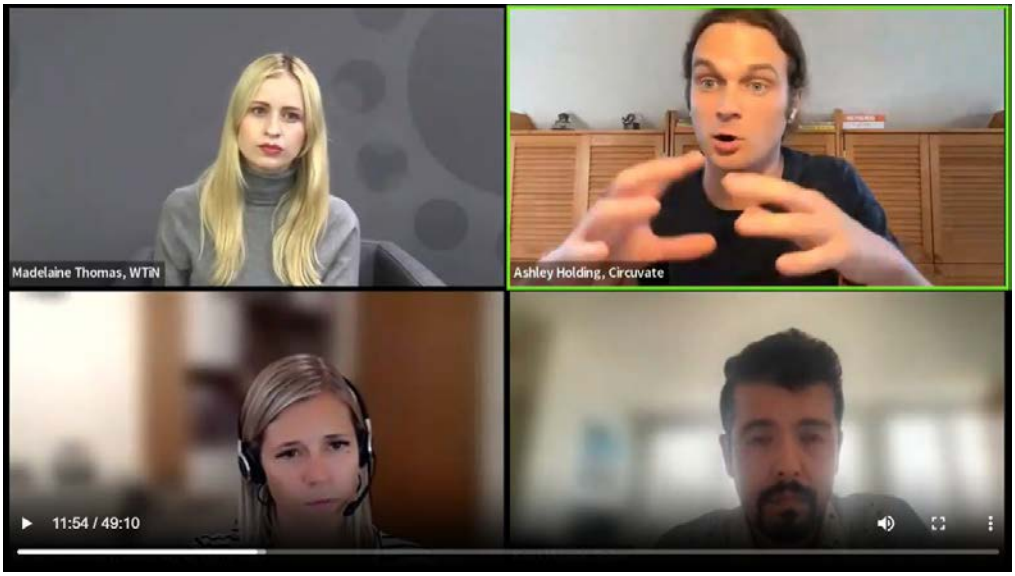
Taylor noted that bio-based alternatives to polyester are becoming much more prevalent in the market. This was a sentiment shared in a panel discussion on developments in polyester. The session speakers included: Benoit Illy, co-founder and CEO of CO2-based polyester developer, Fairbrics; Carmen Danner, business development director, HeiQ, who is replacing polyester with cellulosic yarn; Dr Sebastian Funtan, laboratory manager, R&D, UPM Biochemicals, who has created a wood-based polyester, Billy McCall, founder and CEO of Kintra Fibers, a material company that has developed a biodegradable polyester.

Polyester is the most widely used fibre in the world, accounting for more than 50% of the global market share. However, the production of virgin polyester involves the use of non-renewable fossil fuels, harmful production processes and the synthetic fibres persist in the environment at end-of-life. In recent years, polyester has undergone a significant transformation to attempt to align it with the principles of a circular economy. This includes advancements in sustainable polyester production, including the use of recycled materials, bio-based alternatives and innovative manufacturing processes.

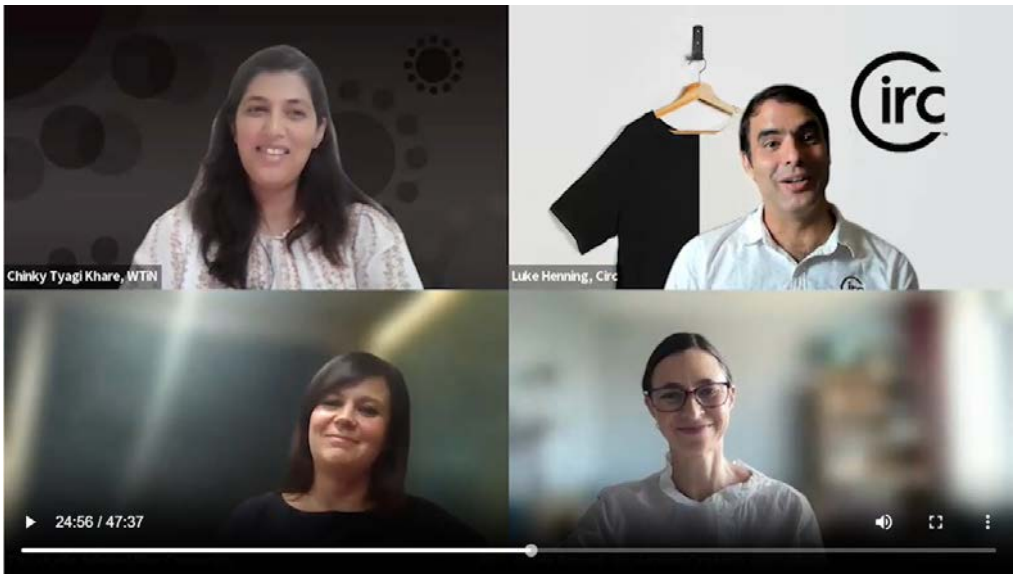
Review: Innovate Materials



Samantha Taylor, founder of The Good Factory, discusses strategies for moving the textile & apparel industry forward



From L-R, Madelaine Thomas, head of content, WTiN, Dr Ashley Holding, principal consultant, Circuvate, Dr Fiona Charnley, co-director at the Centre for the Circular Economy and co-director of the UKRI National Interdisciplinary Circular Economy Hub within the University of Exeter Business School and Kenji Higashi, executive vice president of Business Development, Spiber.



From L-R, Chinky Tyagi Khare, head of business development, WTiN, Luke Henning, chief business officer, Circ, Tanja Karila, CMO at Infinited Fiber Company and Angela Boswell, US project director, Accelerating Circularity

Circularity

Elsewhere, panellists Kenji Higashi, executive vice president of business development, Spiber, Dr Fiona Charnley, co-director at the Centre for the Circular Economy and co-director of the UKRI National Interdisciplinary Circular Economy Hub within the University of Exeter Business School and Dr Ashley Holding, principal consultant, Circuvate discussed whether biodegradability is truly circular. There is a growing interest in the T&A industry in fibres and fabrics that have been formulated and designed to be biodegradable. Biodegradability refers to the ability of a material to be broken down by natural processes, such as microbial action, into simpler compounds.

The concept of biodegradability is often associated with the idea of circularity, which emphasises reducing waste and creating closed-loop systems in which materials can be reused or returned to the environment without causing harm. However, the question of whether biodegradable textiles are part of the circular economy raises important considerations. There is an argument in the industry that biodegradable fibres and materials are not part of the circular economy as they are not reused to produce another product, but go back into the environment instead.

Textile-to-textile recyclability – a process that converts pre- and post-consumer textiles into new textile products – is also in need of development if it can be used on a real industrial scale. However, according to Luke Henning – chief business officer, Circ and panellist at Innovate Materials – investment into textile-to-textile recyclability has exploded over the last five years. Other panellists in the textile-to-textile recyclability session were Angela Boswell, US project director, Accelerating Circularity, and Tanja Karila, CMO at Infinited Fiber Company.

There has been a surge in recycling technologies – from well-established mechanical methods to emerging chemical and enzymatic solutions. The aim is to create a closed-loop system in the fashion and T&A industries, reducing the reliance on virgin resources and minimising textile waste by diverting textiles from landfills. Along with scalability, though, there are still many challenges ahead. For example, the panellists recommended better labelling so consumers are better informed, as well as designing with recyclability in mind, from the get-go. Henning said: “Recyclability needs to start with design so things can be more seamlessly designed.” Specific attention also needs to be paid to whether finishes can be recycled or how they can safely be removed before recycling, such as durable water repellents (DWR) or event prints.

Another important note was that the newness of the innovative materials that were discussed on day two of the event could set recycling back. For example, we are now recycling polyester after 80 years of working with the fibre. “We have been shaving inefficiencies off polyester for 80 years,” said Henning. However, it is hoped the new materials’ starting point will be stronger than polyester when it comes to recyclability and sustainability.

Legislation

The keynote presentation on the second day of the event (20 September 2023), presented by Lutz Walter, secretary general, European Technology Platform for the Future of Textiles and Clothing, discussed how new legislation is shaping the future of materials.

The session highlighted how recent legislative measures have and will impact the T&A industry by encouraging the adoption of eco-friendly materials. These regulations promote the use of recycled fibres and bio-based alternatives, amongst others, fostering a shift towards a circular economy. It emphasised the positive impact of such legislation in terms of reducing environmental pollution, improving worker safety and promoting consumer awareness but also the challenges it raises. By embracing these changes though, the textile industry is poised to revolutionise its approach to materials, shaping a greener and more sustainable future.

For example, Walter discussed four key strategic innovation themes for the industry and its legislation:
1. Smart, high-performance materials for new growth markets
2. Digitised materials, products, manufacturing, value chains and business models
3. Durable, circular and bio-based materials and processes
4. Safe, low footprint productsprocesses and responsible supply chains

In-line with this, the three big sustainability challenges Walter highlighted for the industry are:
1. The exclusion of fossil-based primary materials (defossilise, bio-based)
2. The exclusion of fossil energy from production (electric and renewable)
3. The requirement to produce locally and on demand through automation and digitalisation

The incoming legislation will have a number of impacts on material innovation. According to Walter, these include a strong push towards fibre-to-fibre recycling (as previously discussed); potential targets for recycled content under new ecodesign rules (and durability and repairability); a push to replace fossil with bio-based feedstocks; substitution of hazardous chemicals in textile processing and finishing; reduced fibre shedding to minimise microparticle release and new processes for lower water and energy consumption, as well as reduced waste.

Keeping legislation in mind, the first panel session of day two assessed realistic time frames and considerations for incorporating new materials. In this session, panellists Sydney Gladman, chief scientific officer, Material Innovation Initiative, Richard Wielechowski, senior analyst, Planet Tracker, Brett Cotton, co-founder of Arda Biomaterials and Christine Goulay, founder of Sustainabelle Advisory Services discussed the challenges and opportunities associated with integrating novel materials into various areas within the T&A value chain. It is important to have realistic time frames for the implementation of new materials, as building new supply chains or transforming existing ones can be time consuming.

The panellists discussed strategies for managing potential risks and disruptions during the transition phase to new materials and how, by adopting a realistic and systematic approach, businesses can effectively incorporate new materials into their operations, driving innovation and gaining a competitive edge.

New materials

It was important, therefore, that the event looked at the potential new materials that could replace conventional ones. A panel session entitled: 'What can we replace conventional materials with?' explored the vast array of innovative alternatives.

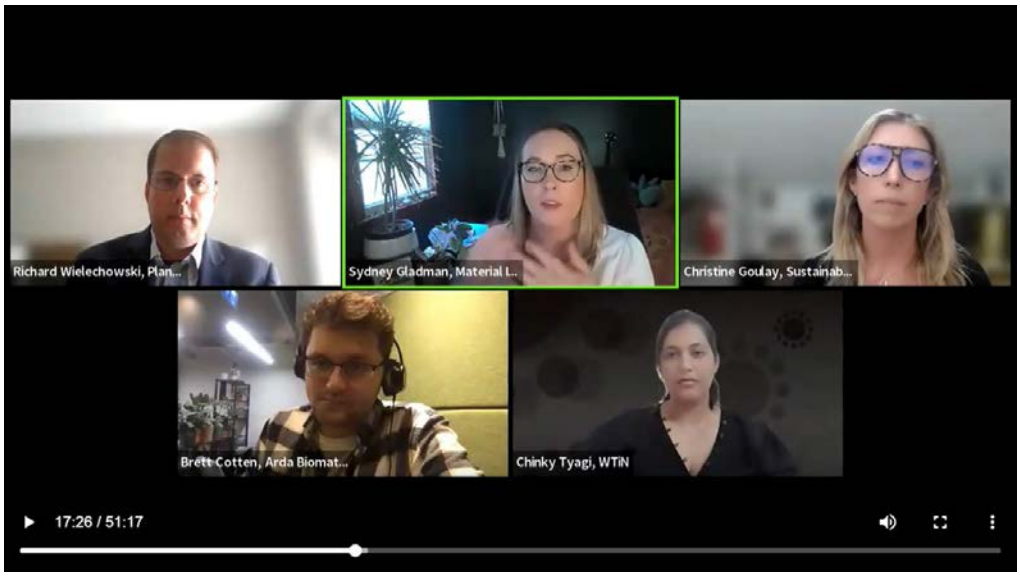
Like many of the previous sessions, the panel highlighted the pressing need to reduce reliance on environmentally harmful materials and showcased sustainable alternatives. The panellists (Dr Reiner Hengstmann, VP additional materials, ISA TanTec, Wayne Best, executive chairman, Nanollose, Julian Ellis-Brown, co-founder & CEO, Saltyco) examined the feasibility and performance characteristics of potential substitutes, many of which they were developing.

By embracing these new materials, businesses can reduce their environmental footprint, enhance resource efficiency and drive revenues. The session encouraged collaboration and innovation to unlock the full potential of alternative materials in diverse applications. The session also assessed how we can keep the characteristics of traditional fibres whilst making new sustainable versions that are kinder to the environment, both during manufacturing and at end-of-life. For this, the panellists noted, collaboration and knowledge-sharing across the value chain, through cross-sector partnerships are essential for accelerating innovation.

The event was rounded off by a PechaKucha session on material innovation and research and development. PechaKucha is a presentation style developed in Tokyo, Japan in 2003 as a way for creatives to present their ideas concisely. The format is based on a simple idea: each presentation consists of 20 slides, each of which is displayed for 20 seconds. This means that each presentation lasts exactly six minutes and 40 seconds.

Presenters were Trisha Andrews, associate professor, University of Massachusetts Amherst in the US and founder of smart textile company Soliyarn; MA student Maca Barrera from the UK University of the Arts, London, presented on harnessing the power of microbes to produce a natural derived sunscreen that shields our bodies from harmful UV radiation; Subhadeep Paul, PhD scholar at the Technical Textiles Research Centre, University of Huddersfield, UK, showcased his investigation of fibre properties to augment British wool. Sticking to the wool and the University of Huddersfield theme, Saikat Ghosh – another PhD scholar – presented his research on amplifying wool's multifunctionality through nanotechnology.

How many EU legislations on sustainability will impact textile and clothing companies?



From L-R, Richard Wielechowski, senior analyst, Planet Tracker, Sydney Gladman, chief scientific officer, Material Innovation Initiative, Christine Goulay, founder at Sustainabelle Advisory Services, Brett Cotton, co-founder at Arda Biomaterials and Chinky Tyagi Khare, head of business development at WTiN

From L-R, Dr Reiner Hengstmann, VP Additional Materials, ISA TanTec, Wayne Best, executive chairman, Nanollose, Julian Ellis-Brown, co-founder & CEO, Saltyco and Madelaine Thomas, head of content, WTiN

Disrupting PET: Bio-based polyester alternatives

With polyester such a critical fibre within the textile industry, WTiN explores emerging, scaling and commercially ready stand-ins. Could growing cellulosic and biosynthetic options one day succeed conventional petrochemical PET? **Lorenzo Costanzo** reports..

Introduction

Polyester fibre, polyethylene terephthalate (PET), has dominated the textile market for decades and is the most widely used fibre in the textile industry, from clothing to furniture, non-woven fabrics to industrial applications[1]. It has seen a significant growth in production over the past few years, mainly thanks to its versatility, durability, ease of care and affordability[2].

But although it offers many advantages, it also has some critical environmental drawbacks: it is a synthetic fibre made from non-renewable sources and it cannot biodegrade, thus contributing to environmental pollution[3].

Microfibre pollution

The production of polyester fabrics requires fossil fuels and their disposal has significant environmental drawbacks. As polyester does not readily biodegrade, it leads to long-lasting microplastic pollution in oceans and soil when released into the environment.

Microfibres and microplastics are minuscule particles shed from fabrics during washing and wear[4]. These enter water bodies from sewage systems and can accumulate in aquatic ecosystems, thus entering the food chain, as well as impacting on terrestrial environments and impacting on soil quality and agricultural systems, posing concerns also for human health.

To address this issue, several approaches need to be taken, from a selection of sustainable materials, improved washing processes and effective wastewater treatments.

Alternatives: polyester

Cleaned post-consumer PET bottles ready for recycling. Source: Indorama

PBS yarns by Kintra Fibers. Source: Kintra Fibers

Hugo Boss is a first mover in adopting HeiQ AeoniQ. Source: Hugo Boss

PLA fibres and yarn from Noosa Fiber. Source: Noosa

With increasing awareness about the environmental consequences of synthetic materials, consumers, manufacturers, and policymakers have prompted efforts to develop more sustainable alternatives. These alternatives aim to retain the advantageous features of polyester while mitigating its adverse effects on the planet, and the players on the market are growing.

One target, different approaches

Considering the size of the polyester fibre market – about 60.5m metric tonnes in 2021 – finding a suitable, more sustainable alternative is a challenging, but possibly rewarding quest[2].

The general, more sustainable replacement is currently recycled PET (rPET), which is created mainly from post-consumer beverage bottles. These rPET fibres are estimated to account for 14% of the market and these values are forecasted to grow. The Textile Exchange in 2021 launched a global initiative – the 2025 Recycled Polyester Challenge – to call on brands, retailers and manufacturers to commit to sourcing a minimum of 45% rPET by 2025.

Indorama Ventures is one of the largest producers and recyclers of PET and since 2011 it has transformed waste bottles into flakes, recycled polyester yarns and rPET resins[5]. Other players producing fibres and yarn from rPET are Toray industries, Teijin, Far Eastern New Century and Repreve by Unifi.

Since distinguishing rPET from virgin PET is quite difficult, even with physical and chemical testing, the fibre REPREVE was developed with a chemical tracer within its structure so that the origin of PET can be confirmed, giving the opportunity to create a fibre-to-fibre circularity.

Until recently, rPET was used mainly to make fibres, but now it is in high demand also from the bottles and food container industry and this has created a potential conflict between textile manufacturers and the food industry, both competing for the same limited supply of rPET.

For this reason, different options are needed and more and more bio-based, biodegradable and/or recyclable alternatives are appearing on the market.

PTT by CovationBio

One of the first bio-based synthetic fibres was PTT, polytrimethylene terephthalate, also known as Sorona®. First invented by DuPont in the 1940s using propanediol (PDO) produced from corn sugars via fermentation, it was the only bio-based polyester fibre to contain 37% of renewable sourced ingredients. DuPont only commercialised it in 2008, due to the initial high cost of the key ingredient[6].

Sorona® is now a product owned by CovationBio, since DuPont biomaterials was acquired by the Huafon group. PTT is reportedly softer, stronger, more durable and more wrinkle-resistant than traditional polyester fibres and it is also recyclable[7].

PEF by Avantium

PEF, or polyethylene furanoate, has a chemical structure and technical characteristics similar to those of PET, which makes it a key competitor for replacing PET fibres. It also has potential for other applications, including packaging and film materials[8].

Avantium, a renewable chemistry Dutch company, developed a fully bio-based PEF, by using its YXY® plant-to-plastics technology to convert plant-based sugars (fructose) into FDCA: the main building block of PEF[9].

In terms of end-of-life management, this polymer can be recycled with existing PET waste streams. It is also said to degrade relatively quickly compared with conventional PET. Accelerated degradation studies have shown that PEF degrades within 240 days when exposed to fungi and bacteria in industrial composting conditions[10].

Avantium is also the leader of a PEF Textile Community comprising five global textile companies and brands, focused on developing textiles for several applications. In 2024, the first large-scale production plant of FDCA is scheduled to be operational in the Netherlands, with a capacity of about 5,000 tons per year, thus making PEF commercially available.

Infinna™ by Infinited Fiber Company

Infinna™ is a premium, circular textile fibre that is regenerated from cellulose-based waste streams, such as cotton-rich textile waste, used cardboard or even agricultural residues like wheat and rice straw via a new cellulose carbamate technology developed by the Finnish Infinited Fiber Company[11].

It is a fibre designed to look and feel soft and natural like cotton. It is said to work well on its own for 100% regenerated fabrics, but also blend well with other fibres such as cotton and viscose. This makes it a versatile and sustainable alternative to polyester. It is also fully biodegradable and can also be recycled again in the same process alongside other textile waste, thus further reducing the amount of textile waste ending in landfills.

The company is aiming to license the technology to enable mass-scale use of Infinna™ fibre and the production can easily be done by converting current cellulose and viscose fibre factories[12]. Early adopters of Infinna™ are Patagonia, Wrangler, Pangaia and Ganni.

PBS by Kintra Fibers

Aiming to eliminate microfibre pollution, New York materials science firm Kintra Fibers developed an innovative bio-based and biodegradable polyester fibre, polybutylene succinate (PBS), made from renewable sources such as corn or sugarcane.

Thanks to the use of renewable raw materials and the elimination of harmful chemicals in the production process, Kintra Fibers claims that the PBS fibre has a 95% reduction in emissions, thus a much lower carbon footprint than traditional petroleum-based polyester.

Its technical characteristics are similar to those of polyester, but with a natural fibre hand-feel. Moreover, it reportedly adds moisture-wicking and wrinkle-resistant properties to the garments.

Kintra Fibers was among the innovations selected for support from Pangaia and Fashion for Good: a global apparel collective committed to creating planet-friendly garments that strongly believes in PBS fibres.

PHA by Mango Materials

Mango Materials uses biogas and methane gas emissions as raw materials to feed polymer-producing methanotrophs bacteria to create polyhydroxyalkanoate (PHA): a biopolymer at the base of the company's YOPP and YOPP+ biodegradable polymer pellets.

These polymers are formulated for the production of fibres as well as rigid goods[13].

At the end of their life, materials produced with YOPP and YOPP+ can be composted in waste facilities that produce methane, which can then be recaptured and converted into PHA, creating a circular closed loop. They can also be completely degraded in nature by microorganisms, without leaving trace of microfibres or microplastics.

Shoe producer Allbirds used Mango Material's biopolymer to produce its net-zero carbon shoe: the M0.0NSHOT[14].

The development of PHA-based fibres is also supported by the Renewable Carbon Textiles Project, launched by Fashion for Good, aiming at reducing carbon emissions in the fashion supply chain. The created consortium includes innovators such as Bio Craft Innovation, Full Cycle Bioplastics and Newlight technologies[15].

Discover more about Mango Materials here:

AeoniQ by Heiq

AeoniQTM is a new cellulosic continuous filament fibre from global textile innovator HeiQ. Made from renewable raw materials, it has a net-zero carbon footprint and was designed to match the properties of synthetic fibres such as polyester and nylon[16].

AeoniQ is made from a combination of plant-based sugars and recycled carbon dioxide with a process said to produce no new carbon emissions.

It can be manufactured from different cellulosic materials, depending on the available sources and it is reportedly biodegradable as well as endlessly recyclable.

It was first adopted by Hugo Boss, which created a garment using 87% HeiQ AeoniQ yarn made from certified wood pulp, demonstrating the potential of AeoniQ in various textile applications[17].

Learn more here.

Alternatives: polyester

M0.ONSHOT: The World's First Net Zero Carbon Shoe by Allbirds. Source: Allbirds

Ingeo by NatureWorks

In the early 2000s, Ingeo was launched as the first polylactic acid (PLA) fibre for textiles. It is made from the fermentation of natural plant sugars, such as dextrose and sucrose from corn or sugarcane, which are turned into a polymer. Given its low melting point, in the textile industry it is mainly used as a binder in non-wovens for apparel thermal insulation.

NatureWorks recently set up a new research facility to develop next-generation fermentation technology for fibre production. This novel production process may be in some ways similar to the one that produces AeoniQ.

PLA by Noosa Fiber

Another PLA-based fibre is the one developed by Noosa Fiber. This promising bio-based fibre is said to be both socially and environmentally responsible, and shifts the textile industry towards circularity[18].

Noosa also developed a closed-loop concept, the NOOCYCLE® technology, which separates the PLA polymer from other compounds and converts it back to fibre form. This project is supported by the firm's intention to collect waste and used clothing made from Noosa fibre. This can be blended with other fibres, but it should reach a minimum of 50% in the final fabric[19].

As Noosa Fiber PLA becomes more widely available, it is likely to become a popular choice for brands that are looking to reduce their environmental impact.

For further information, take a look at this year's (2023) Innovation Outlook: Fibres & Technical Yarns edition: Innovation Outlook: Fibres & Technical Yarns (wtin.com)

Evaluating the real impact of bio-based fibres

In 2021, a Swiss academic group at the Swiss Federal Laboratories for Materials Science and Technology (EMPA) conducted a cradle-to-gate life cycle assessment (LCA) to analyse the environmental pros and cons of replacing polyester with bio-sourced alternatives: bio-polyester, PTT and PLA fibres[20].

When considering that these fibres are generated from first-generation feedstock, ie, crops – predominantly corn and sugarcane – the study found that for certain aspects – global warming potential (GWP), acidification, eutrophication and water consumption – these fibres offer no real environmental advantage over virgin PET. This was due to specific production methods.

Despite this, the authors believe that bio-based polyester fibre substitutes have the potential to be a more sustainable alternative to conventional polyester. Possible paths include: seeking alternative bio-based substitutes, such as polyethylene furanoate; exploring second-generation feedstock (lingo-cellulosic waste); and improving agricultural practices to reduce water use and pollution. Overall, by developing more efficient production methods and introducing circular economy principles, the environmental impacts of bio-based polymers and fibres can be reduced.

Possible paths for less polluting textiles

Thanks to increasing awareness of the environmental impact of textiles, particularly polyester fibres, bio-based alternatives are emerging as innovative solutions.

From bio-polyesters to cellulosic fibres, the possibilities are vast and promising, and they will result in a more sustainable and regenerative future of the textile industry. Although not all of these fibres are biodegradable, they all decrease our reliance on fossil fuels[20].

A possible hurdle in the full substitution of polyester is posed by the high costs of these biosynthetic fibres, but their costs should be compared against the environmental impact of petrochemical fibres. To further push this change, legislation will need to come in place to support and promote the development and use of these novel bio-based fibres.

For a full reference list, click here.

Key takeaways

- China's sportswear market has expanded robustly because of health concerns sparked by the Covid-19 pandemic.
- Chinese brands have strengthened their position in China through better quality and nationalistic marketing.
- Tensions over China's human rights record weakens international brands in China and Chinese brands overseas.

Ones to watch: Leather alternatives

WTiN explores a range of alternative leather technologies, spanning emerging, scaling and commercially ready solutions. By **Lorenzo Costanzo**.

Humans have used leather to make clothing, tools and shelter ever since they started hunting animals.

But nowadays, concerns have been raised about the environmental impact of leather production – the resources needed for rearing animals and the waste produced during the tanning – and the welfare of animals involved in mass production. Consumers are seeking products with better sustainability credentials[1].

This demand has prompted more and more innovators to develop vegan alternatives to traditional leather, from using plant by-products and crafting from fungi to cultivating cow cells in the lab. As well as being more ethical – and in some cases circular – these novel products aim to mimic the typical characteristics of leather.

Mycelium-based leather

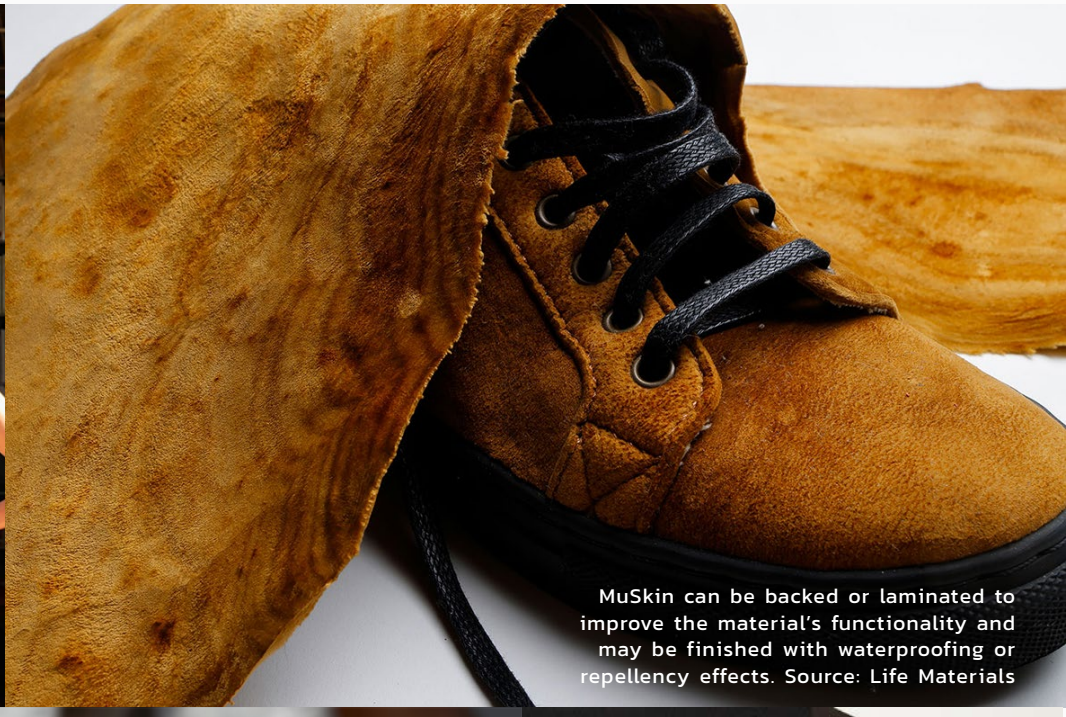
Mycelium is the root-like, fibrous structure of fungi, which is usually hidden below the ground. It can be grown in a lab via fermentation, so it's renewable, and it can be the base for biopolymers, which can be used in a variety of products.

The material can be grown feeding on a wide selection of agricultural and industrial waste and, for this reason, mycelium seems a very promising bio-based alternative to leather. Several companies have developed their own methods and selected specific fungal species to achieve the optimum leather-like material.

Alternatives: Leather

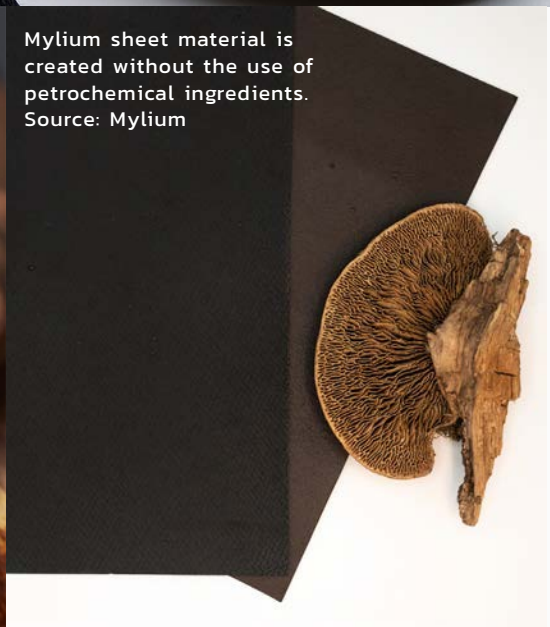
A visual demonstrating Forager's stages of decomposition when discarded in optimal conditions. Source: Ecovative

Another of Mycowork's commercial partners is the designer millinery brand, Nick Fouquet. Source: Mycoworks, Aysia Steib



MuSkin can be backed or laminated to improve the material's functionality and may be finished with waterproofing or repellency effects. Source: Life Materials

Mylea by MYCO is derived from agroforestry by-product. Source: MYCL



Mylium sheet material is created without the use of petrochemical ingredients. Source: Mylium

Since 2019 there has been an explosion in the number of patents on mycelium-based leather-alternatives, as presented by Elsacker et al., and these products are gradually entering the market[2].

ForagerTM – Ecovative

Location: New York, US
Commercial readiness: Scaling
Ecovative is one of the earliest pioneers in mycelium-based materials, having worked on their development since 2006.

ForagerTM is the company's leather-like product based on AirMyceliumTM and it has technical features that match animal leathers[3]. In 2022 Ecovative partnered with ECCO Leather, a part of the Danish footwear brand, to develop and advance new materials by merging their expertise in their respective fields[4].

Reishi – MycoWorks

Location: San Francisco, US
Commercial readiness: Commercially ready
ReishiTM is MycoWorks' mycelium-leather which after harvesting is tanned in a way to make it look and feel like leather[5]. In a collaboration with Hermès, Reishi was used for the Victoria bag and made its debut in high fashion[6].

The material is water-resistant, breathable and biodegradable, as well as resistant to mould and mildew. MycoWorks was also one of the early frontrunners in myco-materials and is now preparing to open its commercial-scale mycelium plant in September 2023.

MuSkin – Life Materials

Location: Montelupo Fiorentino, Italy
Commercial readiness: Commercially ready
MuSkin is a suede-like alternative leather grown from the Phellinus ellipsoideus, a large parasitic fungus that grows in the wild, especially in subtropical forests[7]. MuSkin is very pleasant to the touch and the absence of toxic substances and its breathability make it ideal for use in close-to-skin applications. It can be made waterproof using eco waxes[8].

Although it is quite durable, to make it more robust, it is generally laminated to textiles such as Lyocell fabric.

Others to watch out for

Recently new mycelium-based leathers are appearing on the alternative leather landscape, including names such as Mylea by MYCL-Mycotech Lab and Mylium[9],[10]

Lab-grown

Mycelium-leather needs to be grown in lab-controlled conditions, but some innovators have taken to growing leather alternatives through bio-fabrication, using fermentation or by growing cells.

Bio-Tex – Modern Meadows

Location: Nutley, US
Commercial readiness: Commercially ready
Bio-TexTM is a unique material developed by Modern Meadow and produced by fermenting sugar with a yeast that yields proteins that constitute the leather-like sheets[11]. Its soft handfeel and robustness is said to closely match those of animal leather.

The production process, named Bio-AlloyTM technology, is claimed by Modern Meadow to have an environmental impact that is 90% lower than traditional, chrome-tanned leather in terms of greenhouse gas (GHG) emissions.

Modern Meadow have also utilised Bio-Alloy in the production of another sheet material, Bio-Vera. This variant is engineered to mimic the aesthetic and handle of suede or chamois.

As alternative leathers become more established, the market may expect a wider choice of textures and finishes, with the successful replication of suede benefitting apparel, interiors and automotive applications alike.

VitroLabs Inc

Location: California, US
Commercial readiness: Emerging
VitroLabs Inc has developed a way to create animal hides using a biopsy from a living cow. Cells are harmlessly extracted and cultivated into a bioreactor, which makes them grow, divide and form into tissue. Once this process is complete, the resulting material can undergo the tanning process[12].

This material achieves the same complexity and quality of traditional leather, but without the environmental and ethical aspects of traditional leather manufacturing.

So far, the company has raised at least US$54m in funding. Its latest Series A round reportedly secured eight investors, including designer brand Kering and actor and climate activist, Leonardo DiCapro.

Celium – Polybion

Location: Irapuato, Mexico
Commercial readiness: Scaling
Polybion has genetically engineered select bacteria to make them produce, via fermentation, a

cellulose membrane. The resulting product is Celium: a strong lightweight and breathable material which, after tanning, has characteristics that match those of leather.

In early 2022, the company finished the development of what it claimed to be the "world's first bacterial cellulose biomanufacturing facility", located in Irapuato, Mexico. Once online and optimised, it anticipates an annual Celium production of 1.1m sqft.

In July (2023), Danish fashion brand Ganni unveiled a blazer comprised of Celium as one of several innovation showcases under its Fabrics of the Future R&D initiative. Featuring a lined tailored cut, buttons and a distinct marbled yellow colourway, the piece demonstrates the possibility of consumer-grade, fashion-centric products created with Celium[13].

Leather from plant waste

Other alternative leathers implement plant-based feedstock into their compositions, often as a filler material, to build the basis of a sheet material solution. Agricultural waste and byproduct ingredients are popular, negating the use of edible foodstuffs which may be better reserved for consumption purposes.

GrapeSkin – Vegea

Location: Milan, Italy
Commercial readiness: Commercially ready
Vegea has developed a leather alternative that incorporates grape skins, stalks and seeds discarded during winemaking. These by-products are pulverised and combined with non-toxic chemicals and a bio-oil taken directly from the grape seeds[14].

This product was awarded the Global Change Award by the H&M Foundation in 2017 and can be used across fashion, interiors and automotive applications. Textile and apparel adopters of Vegea's GrapeSkin solution include Geox, Diadora, Calvin Klein and Pangaia.

Malai – Malai Biomaterials

Location: Kochi, India
Commercial readiness: Commercially ready
Malai is a flexible, durable bio-composite material made from bacterial cellulose grown on waste products of the coconut industry[15].

Following fermentation, Malai is collected, refined, air-dried and compounded with natural materials of plant-origin to obtain the final leather-like product. As it does not contain further coatings or synthetic ingredients, it is fully biodegradable.

Furthermore, Malai Biomaterials is currently considering adopting a circular materials model whereby offcuts and unspent material may be bought back from clients. To ensure these materials

Brands such as Tory Burch, Everlane and Senreve have adopted Bio-Tex. Source: Modern Meadows.

Kering and Leonardo DiCaprio are among VitroLabs' investors. Source: VitroLabs Inc

Malai Biomaterials recently paired with Island Apothecary to produce a line of accessories. Source: Malai Biomaterials

Polybion utilises agro-industrial fruit waste as a raw material input for Celium. Source: Polybion

GrapeSkin was utilised in Stella McCartney's Spring 23 collection. Source: Stella McCartney

Desserto has worked on a limited-edition variant of its leather alternative utilising agave fibre – a by-product generated during the production of tequila – which will be released in 2023. Source: Desserto

could be efficiently reincorporated back into the supply system, the company says it is also working on a material formulation that could ensure high yield recyclability.

Desserto – Adriano Di Marti

Location: Zapopan, Mexico
Commercial readiness: Commercially ready
Cactus-based leather is a novel vegan alternative developed by Mexican company Adriano Di Marti and subsequently handled by ingredient brand subsidiary, Desserto[16]. It is based on the prickly pear cactus, which is abundant in Mexico.

The patented production process uses the organic raw material from the mature leaves, after drying them in the sun. Its versatility allows it to be used in a wide range of products, from accessories to interiors.

Planet of the Grapes

Location: Provence, France
Commercial readiness: Emerging
Planet of the Grape's grape-based leather is made with circularity in focus, by using waste material known in viticulture as grape marc: grape skin, seeds, branches and stems derived from grape pressing[17]. The colour of the grape leather also comes from the grapes, and different colours are obtained with different grape varieties[18].

The business is currently working with around 33 vignerons – those cultivating grapes for wine-making – in the southern region of Aix-en-Provence, with hopes of diversifying and enriching their income streams.

Currently, Planet of the Grapes is making use of polyurethane (PU) to benefit the strength, handle and durability of the material. However, founder Samantha Mureau notes that the business is currently discussing viable alternatives with local partners in France and Italy. While there are hopes to replace the ingredient, a competitive performance will be necessary to secure an alternative, so not to greatly diminish the materials' current properties.

Others to watch out for

Other vegetable-based options have been created, such as using unsold mangoes to create Fruitleather[19]. Elsewhere, lignocellulosic feedstock from urban parks, gardens and inedible agricultural feedstock have been used to create leather-like materials, dubbed Treekind, by UK-based, Biophilica[20]. Discover more about the latter here.

Apple, lemon and barley waste from beverage production have also been upcycled to create leather alternatives by Vegatex, blending them with PU and cellulose-based fabrics as supporting material[21].

Conclusion

These innovative leather substitutes aspire to reduce the environmental impact and the ethical concerns of leather production, while still offering products that possess the qualities and characteristics of genuine leather.

With consumers placing a growing emphasis on sustainability and ethical considerations, these alternatives will play a crucial role in the future of the fashion and materials industries.

Discover more leather alternatives, as well as other bio-based materials, in the Innovation Outlook: Fibres & Technical Yarns Edition.

For a full reference list, click here.

Portugal explores eucalyptus and cork fibre

Portuguese researchers have been exploring the use of fibres from domestic eucalyptus and cork trees in textile applications. The results have exciting possibilities for both innovation and the environment. **Andreia Nogueira** reports.

Portugal is rich in eucalyptus and cork, and research teams have been looking at ways to use the country's natural resources to develop innovative new textiles and garments that comply with Europe's new sustainability and circularity requirements.

António Braz Costa, general director at the Portuguese Technological Centre for Textile and Clothing (Centro Tecnológico Têxtil e Vestuário – CITEVE) and the affiliated Centre for Nanotechnology and Smart Materials (Centro de Nanotecnologia e Materiais Técnicos, Funcionais e Inteligentes – CeNTI), told WTiN that the Portuguese sector is now meeting a 10-year-old goal of boosting its production of textile fibres from wood sources.

This is important on sustainability grounds considering that most artificial fibres produced are of fossil oil origin, and that importing raw materials, such as cotton, from Asia, leads to more CO2 being emitted during shipments, he said. Even where cotton is produced sustainably, the land utilised reduces available fields for food, he added.

Portugal has strong natural wood resources for fibre. It has the largest area planted with eucalyptus in Europe, and the fifth largest area worldwide. It is also the world's largest producer of cork.

Therefore, this June, CITEVE, CeNTI and Portugal-based pulp and forest product manufacturing company Caima finished a three-year project called Fiber4Fiber to develop cellulose pulp, from Eucalyptus globulus wood, to make textile cellulose fibre, namely viscose and lyocell, the consortium told WTiN in a written response.

"Furthermore, functionalised lyocell fibers were developed, specifically antimicrobial, flame retardant and antistatic, intended for the production of technical textiles," the consortium added.

Natural resources

Before this €1.9m (US$2m) project, supported by European Union (EU) regional development funds, European wood pulp had to be sent to Asia for processing into cellulosic fibres, being reexported to Europe for textile manufacturing.

The three entities stressed that although textile cellulosic fibres "currently represent around six per cent of global consumption, there is a growing trend in their consumption." This is due to their sustainable nature since they are biodegradable and "obtained from wood from sustainably managed forest areas." They also offer "unique characteristics in terms of comfort, moisture management and easy-care."

Fiber4Fiber papers said its researchers have been developing traceable elements to add to the pulp, which then can be passed on to processed fibres and textiles, to help prove their ethical sourcing and quality, the consortium added.

For now, the consortium said, "cellulose-based fibres, particularly lyocell, are generally more expensive than fossil-based alternatives on the market" thanks to "the technology involved in the process," but production expansion may bring costs down.

Hence, the consortium and the Portuguese University of Aveiro are now working to commercialise this new production system under a public-private €138m (US$149m) project Bioeconomy at Textiles (Be@t).

But eucalyptus can have other applications. For instance, "active agents" have been extracted from the tree's leaves, which are useful to "provide textile substrates with naturally based antimicrobial or antioxidant properties," the consortium mentioned. Eucalyptus has also "been used to coat textile articles, to obtain aesthetic properties in alternative applications to natural leather," it added. Meanwhile, CITEVE has also been working with another consortium to develop a cork-based yarn. This has led to the creation of a new joint venture, the Guimarães, Portugal-based Cork-a-Tex, uniting efforts from two Portuguese companies, namely Santa Maria da Feira, Portugal-based Sedacor, of the JPS Cork Group, and the Guimarães-based household textiles company Têxteis Penedo.

Albertino Oliveira, marketing director at Sedacor, told WTiN that the company has been trying to industrialise cork for the textile sector. Firstly, by adding laminated natural and recycled cork fibre to a textile substrate, such as cotton, to make it "more resistant to tension and to sewing." The fibre has also been given a water-based coating to make it more resistant "to dirt, abrasion and friction," he added.

Secondly, under this research, cork waste, which used to be burned to produce energy, is now saved to produce a "cork paste that impregnates cotton or another material." This ensures the yarn better meets technical requirements, while offering more resistance to tension and pilling and hypoallergenic properties, Oliveira explained.

It took four years to incorporate the cork yarn in "industrial processes of large textile industries." Now the company is starting to sell it, and the market reaction has been "very positive," although the world's current weak economy is making companies more cautious about investing in new products, Oliveira noted.

"It is a product that is similar to the price of animal skin or even slightly below in some cases," he said, stressing the environmental benefits of cork. He mentioned a University of Aveiro study , under which for every ton of cork produced, a cork forest sequesters more than 73 tonnes of carbon dioxide, which is equivalent to the amount of CO2 released by a car driving around 450,000 km.

The yarn won the best new material award at the 2019 Techtextil Innovation Awards , in Germany. It has also been used to make Dali Azores shoes by Portuguese brand Marita Moreno, receiving an 'Excellent Product Design and Eco Design' award at the 2022 German Design Awards. Marita Ferro – designer and founder of the Marita Moreno brand of accessories, bags, and shoes – told WTiN that nowadays "there is actually a huge focus on cork as a material used in fashion."

She also works with cork mixed with other materials, such as recycled paper, Piñatex, which is a natural textile from pineapple leaf fibres made by Ananas Anam. Looking ahead, Ferro sees "a greater preference for...sustainable brands" and unique pieces, boosting demand for cork shoes, which can last six years. There are health benefits too as with cork shoes, the "spine suffers less than 30% of the impact" when walking, she said.

"From the moment we can make a thin cotton backing, the cork itself is quite moldable and becomes waterproof, that is why we can make umbrellas and trench coats from cork," she mentioned.

Other textile and garment companies in Portugal are developing new products from cork, including a collection of sheets made from cork, launched last year by Têxteis Penedo.

With sustainability reporting and legal requirements intensifying, especially in Europe, the future for Portuguese eucalyptus and cork textile fibres looks bright.

Using AI to enhance carbon capture materials

Singapore-based company, Xinterra, has developed more than 120 new materials to capture carbon in just four months – all thanks to its developed AI technology. **Ruby Penson** speaks to co-founder and technical lead, **Jatin Kumar**.

Based in Singapore, Xinterra has been using the power of artificial intelligence (AI) to radically accelerate the creation of new materials for sustainability through its own AI platform – one that also leverages high-throughput experimentation. Over the span of just four months, as opposed to a process that usually takes a number of years, Xinterra has created 120 new materials – most of which have never been reported before – that can capture carbon dioxide from the air.

From the 120 materials, Xinterra identified a potential for some of them to be applied within the textiles industry. Jatin Kumar, co-founder and technical lead at Xinterra, says: "This is because our vision is to empower every human being walking the surface of our planet to become a CO^2 capture agent.

"In order to attach our carbon capture materials to textiles, we've adapted a finishing process common in the textiles industry to our carbon capture materials in a way that they yield wash-resistant fabrics. We have some recent development that shows this works on wool and polyester, we're just awaiting some results on polyamide as well."

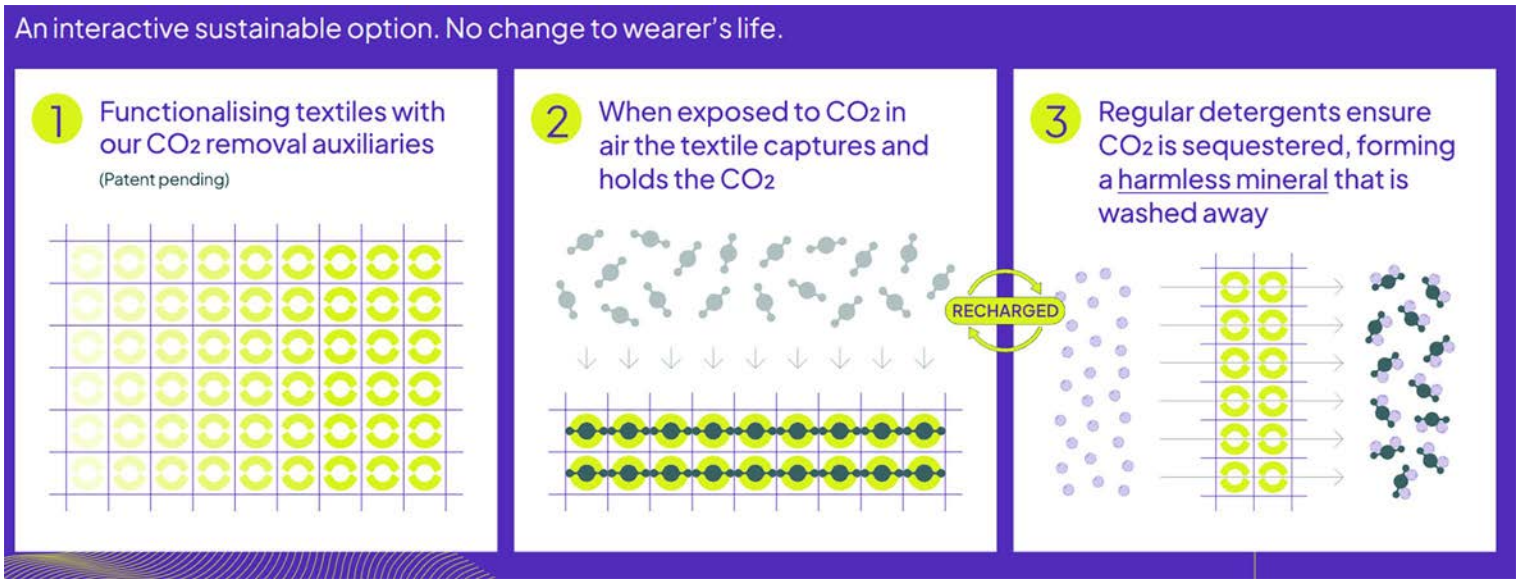
Once a textile has absorbed carbon dioxide over a typical wearing time of a few hours, it can be washed in a normal detergent wash cycle, whereby the detergent neutralises the CO^2 into a harmless mineral that washes away, thereby recharging the fabric for a new cycle of CO^2 capture. The patent for this novel technology has been filed, and we are now actively working on getting this technology to the mills.

In the meantime, Xinterra has launched its brand of CO^2 removing materials, to be applied to textiles, called COzTERRA. Their business model is selling the CO^2 removal product for textile mills. The CO^2 removal auxiliary was designed to be applied in the finishing/padding stage of textile manufacturing

Kim Tham, currently heading up the business development arm of Xinterra, is working to get the product to market. She has an extensive background in fashion design in both lecturing and running a startup, as well as extensive experience working as an incubator for a climate-focused venture capital firm, which is where she first heard of Xinterra.

Kumar is a polymer chemist with around 10 years of training in his history. After getting his PhD, he worked at a national lab in Singapore as a staff scientist developing polymeric materials for a range of different applications, including personal care and nanomedicine batteries. There was always a spin

Functionality: carbon capture



The CoZTERRA process

of sustainability behind the work he was doing – and it was there where the interest in sustainable materials began for Kumar. He says: "What I do for the company is lead the technical direction and serve as the technical interface to our customers. This helps our tightly knitted team to work cohesively and efficiently toward a customer-focused project. I work closely with all the teams, bringing insights and needs from customers to actional technical direction with the R&D teams, thereby acting as a bridge to work towards a product."

The company originally came from SMART, or the Singapore-MIT (Massachusetts Institute of Technology) Alliance for Research and Technology. Within the founding team of Xinterra are professors from MIT, Singapore's largest technology university, the Nanyang Technological University (NTU) and the Agency of Science, Technology and Research (A*STAR) in Singapore, as well as members who are PhD graduates. To complete the founding team, Patrick Teyssonneyre, the CEO of Xinterra, is a veteran from the materials industry, who was the global CTO of a multinational chemical company.

Kumar explains: "AI is at the core of what we do. We're a materials company that uses AI as a tool to design materials in an accelerated way. But this tool requires high-quality data. In order to obtain this high-quality data fast and cheap, we leverage a concept called high-throughput experimentation, which relies on things like parallelisation, miniaturisation and automation."

The company, according to Kumar, approaches problems in a fundamental, scientific way: "We use the foundation that we have, and amongst the founding team we have around a century of experience combined within material sciences."

CO^2 capturing materials

This AI and high-throughput experimentation, combined with their expertise in materials science makes up the platform the company calls the XDF, its Xinterra Design Factory™. Kumar notes the biggest challenge that we are facing as a planet and as a society is climate change. A key contributor to that is carbon dioxide, an issue that will require multiple solutions to solve. It was from this idea that Kumar and the team decided to leverage the Xinterra platform to innovate new materials for carbon dioxide capture as the perfect material doesn't exist. He says: "Everything that exists that performs really well is an academic study that doesn't necessarily translate into something that can be commercialised and industrialised, we decided to tackle that problem."

This brought up a lot of questions for the Xinterra team: How is the company going to innovate new materials? How is it going to get lots of high-quality data fast? How is the company going to do it with very little capital expenditure and operating expenses?

To address the challenge specific to innovating carbon dioxide capturing materials, they needed to be able to first measure how much carbon dioxide a material could capture and, secondly, how quickly it could capture it depending on the environment that it was in – taking into consideration variants in humidity, airflow and other things that can't be controlled. Thus, Xinterra built a high-throughput experimentation system in-house for that purpose, including all of the electronics, mechanics, software and hardware in all of three months – a fraction of the time and cost of buying something "off the shelf".

Once the tool was built, the team then first set about to understand how commercially available carbon capture material behaves. Kumar comments: "With that understanding and data, we then leveraged our AI to formulate and innovate new materials. Within the span of about four months, we went from having no data to having 120 materials that capture CO2, out of which at least two-thirds were unique, never before seen."

"This led to a sequential ready-to-build equipment. From the 120 materials, we selected a couple and now we must target a vertical. It was through a conversation with Tham that we were inspired to talk about textiles with the idea of while you're walking around, you're capturing carbon dioxide."

From identifying the 120 materials, Xinterra then started the second wave of its research: incorporating those materials into textiles. Kumar says that a regular PhD, usually takes around four to five years: "We've been able to shrink that timeline into a staggeringly low number of 11 months from no tools or data to a filed patent, and soon a commercial product. As we know, climate action ideally needed to have been done yesterday. We have a platform that can address these problems."

Moving the needle

Tham explains that in terms of sustainability and global warming, there is a lot riding on the innovation of new materials, saying: "Hopefully with this rapid acceleration, we can move the needle in the fashion industry and in sustainability. For the typical consumer who is looking to support the sustainability movement, they look to buy brands that pledge to be more sustainable by reducing carbon footprints or having greener manufacturing processes.

"Where Xinterra and our product compliments that narrative is that we allow consumers like you and I to be able to be actively involved in the process too. The difference isn't just made upon point-of-purchase, it's constantly interacting, removing carbon dioxide from the atmosphere."

Scalability

As it stands, Xinterra and COzTERRA are in the process of scaling their technology to be rolled out at an industrial scale. Kumar confirmed the company is in talks with several firms to begin trials imminently: "Through using the AI and the material science, we're taking that next step to jump from lab-scale pilot equipment preparing smaller swatches to full-scale equipment in mills to prepare large rolls of fabric." Xinterra is also targeting its verticals with the ultimate vision to enable passive surfaces to actively capture carbon dioxide, such as paints and coatings.

It's a firm belief from Xinterra that everyone has a part to play when it comes to climate change, however small and inconsequential it may be. Kumar says: "There is a lot of pushing of responsibility with the assumption that big corporations will solve it, or the government will solve it – someone else in general will solve it. This isn't the right approach. Everyone must weigh in on this, including all of us as consumers and individuals."

The company is in talks with brands, mills, chemical suppliers and others throughout the value chain to ensure as many people as possible are on board and are looking to validate at commercial scale with their first commercial agreements by the end of the year. Kumar concludes: "Through scaling our technology, we aim to ultimately offer a solution that truly makes an impact."

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