

Case Study

Fashion's Race for New Materials

By Rachel Deeley

Brands are pursuing a raft of initiatives to adopt recycled textiles, regeneratively farmed cotton and mushroom-based leather, but giving fashion's major materials a sustainability makeover still requires billions of dollars worth of investments and deeper, longer-term commitments to scale. BoF breaks down some of the key innovations, the companies leading the charge and the barriers to change.



Executive Summary

Hermès is a luxury brand that prides itself on being steeped in heritage and traditional craftsmanship. So when it emerged in 2021 that the maker of the iconic Birkin bag was working on an experiment with MycoWorks, a Californian start-up that manufactures a new mushroom-based alternative to leather, it sent a powerful signal to the rest of the industry: change is coming.

Fashion joins countless other industries to play a role in global sustainability efforts, racing towards targets to slash greenhouse gas emissions within this decade and grappling with waste, water usage and the negative social outcomes of poorly traced supply chains. While estimates of fashion's contribution to the climate crisis vary, industry body Global Fashion Agenda (GFA) and consultancy McKinsey & Company place it at roughly 4 percent of total global emissions. Raw material production alone accounts for 38 percent of the fashion industry's total emissions, their analysis found. In 2018, that amounted to some 800 million tonnes of carbon dioxide equivalent.

For some companies, the materials shakeup that Hermès is signalling has the potential to be radical. After all, fashion has long relied on largely the same roster of materials — notably polyester, wool, cotton and leather — to produce clothes, footwear and accessories. Entire companies' design, supply chain and manufacturing strategies have been built around these materials.

While Hermès is breaking with tradition on just one bag for now, other fashion brands are pushing further ahead to transform how they manufacture and use materials that are more environmentally and socially sustainable.

Some companies, including German sportswear brand Adidas, have vowed to eliminate virgin polyester, using recycled resources for the fabric instead. Others like US outdoor wear company Timberland have committed to source cotton, leather, wool and rubber from regenerative farms, focusing on responsible land management and positive ecological outcomes. Others are turning to alternatives to

virgin animal leather, with Danish brand Ganni phasing out the material altogether in an effort to cut its overall carbon footprint.

The race to develop new materials and processes is gaining momentum thanks to fast-maturing technology and more substantial, profound partnerships between brands and innovators, which often used to be “slow on the action front,” said Georgia Parker, innovation manager at sustainable project accelerator Fashion for Good.

However, there are significant challenges to overcome, including competing with incumbents to achieving sufficient scale. Material innovators — from textile recyclers to mycelium growers — need upfront capital to build capacity. Brands can help support this growth through minority equity investments or by making long-term buying commitments.

While the buzz around new materials is helping them gain traction, billions of dollars worth of additional capital and further innovation are needed to achieve the industrial scale that would enable alternative materials to compete in a system designed to maximise business growth and profit, rather than minimise negative environmental impact.

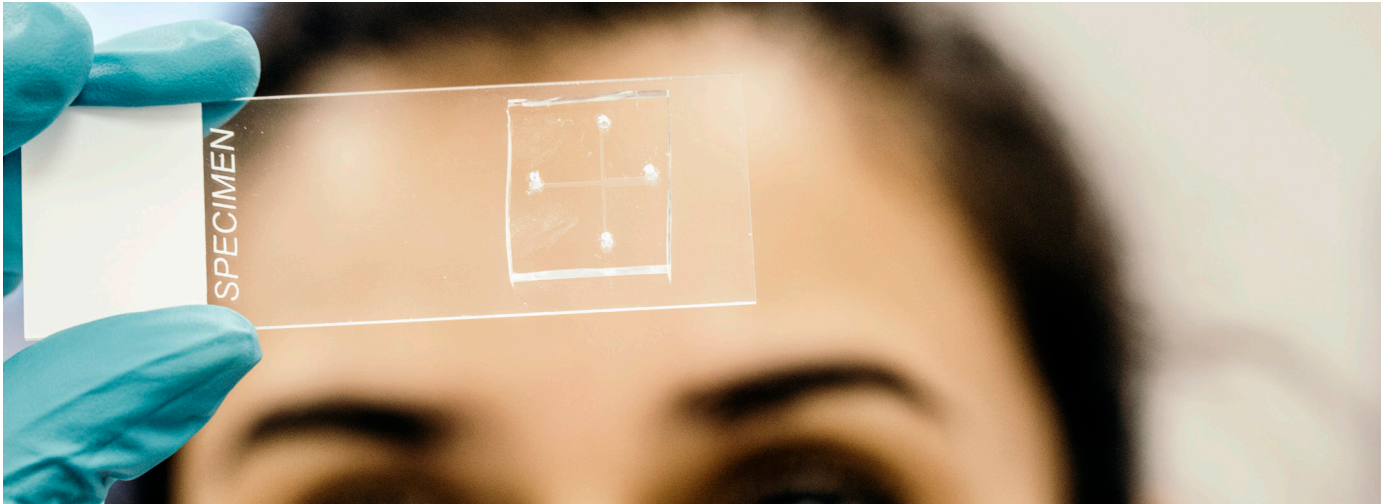
Understanding which, if any, of these sustainable materials will spur a paradigm shift to generate widespread adoption of sustainable materials is not straightforward.

This case study examines three innovations in raw materials production that are gaining some traction and offer opportunities for the fashion industry to reinvent the destructive materials and practises on which it has long relied.

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Context

Materials Innovation: What's at Stake?



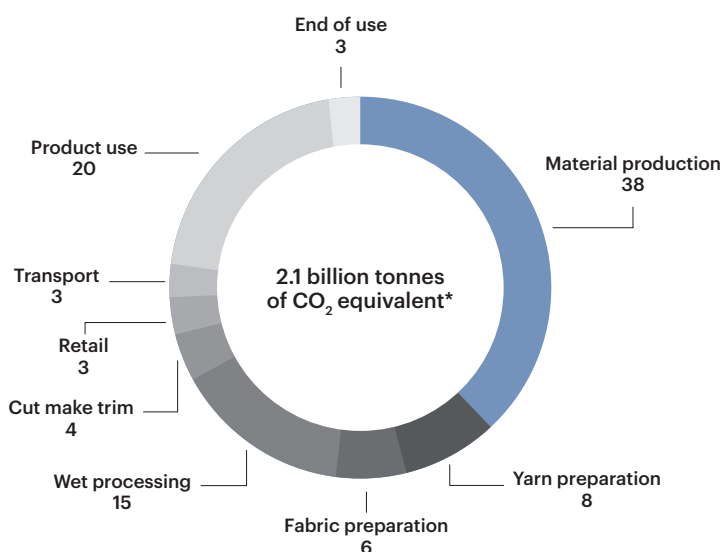
Innovation in raw materials is one way to reduce fashion's carbon footprint. Start-ups from around the world are paving the way forward. Bolt Threads.

Exhibit 1: Material Impact

Material production accounts for the highest proportion of greenhouse gas emissions across the nine stages of the apparel and footwear lifecycle.

Greenhouse gas emissions from apparel and footwear by lifecycle stage (2018)

Percent



Source: Global Fashion Agenda and McKinsey & Company

*CO₂ equivalent is a measure used by the UN's Intergovernmental Panel on Climate Change (IPCC) to compare emissions from various greenhouse gases based on their global warming potential.

The fashion industry is part of the climate change problem, but it also now has an opportunity to become part of the solution, with the help of plant-based leathers, recycled (and recyclable) fibres and other innovative materials and processes.

Amid growing global awareness of the devastating impact of industries on the health of our planet, fashion is having to face up to the role it plays in the environment's degradation, starting upstream with raw materials. Research by GFA and McKinsey found that in 2018 fashion was responsible for 2.1 billion tonnes of greenhouse gas (GHG) emissions, or roughly 4 percent of the global total.

The industry needs to pull as many levers as possible to slash that total emissions number in half by 2030, in line with climate scientists' recommendation to limit global warming to no more than 1.5 degrees Celsius above pre-industrial levels. To contain the climate crisis, many companies and countries alike have set ambitious targets to hit net-zero emissions by 2050, balancing the amount of emissions sent into and taken out of the atmosphere.

In response, fashion players are spearheading a range of measures, from reaching deep into their supply chains to help develop agricultural practises that

avoid GHG-heavy fertilisers to addressing overconsumption and waste by designing more durable or recyclable products.

Whatever the strategy, raw materials need to play a critical role. Their production accounts for 38 percent of total industry emissions – the largest contributor to emissions out of the nine stages of the apparel and footwear lifecycle, according to GFA and McKinsey.

The challenge is formidable. Finding a new, more sustainable path is in many respects like trying to figure out “how [to] get toothpaste back into the tube,” said Edwin Keh, chief executive of The Hong Kong Research Institute of Textiles and Apparel.

The decades-long global expansion of the industry has left complex webs of supply chains, starting with the sourcing of raw materials. Lower-cost but environmentally degrading materials have superseded natural, locally produced textiles, all in a bid to keep up with seemingly insatiable consumer demand for cheaper, instantly available fashion.

The industry is struggling to shake an addiction to environmentally harmful practises. Consider its dependence on

plastic, in the form of polyester. It is now the industry’s most popular fabric, accounting for about 57 percent of global fibre production in 2020, and is forecast to increase its share to 67 percent by 2030, according to advisory company Tecnon Orbichem. Virgin polyester, which is extracted from fossil fuels, is both resource-intensive and non-renewable. It’s also commonly blended with cotton and other natural fibres, making it difficult to recycle.

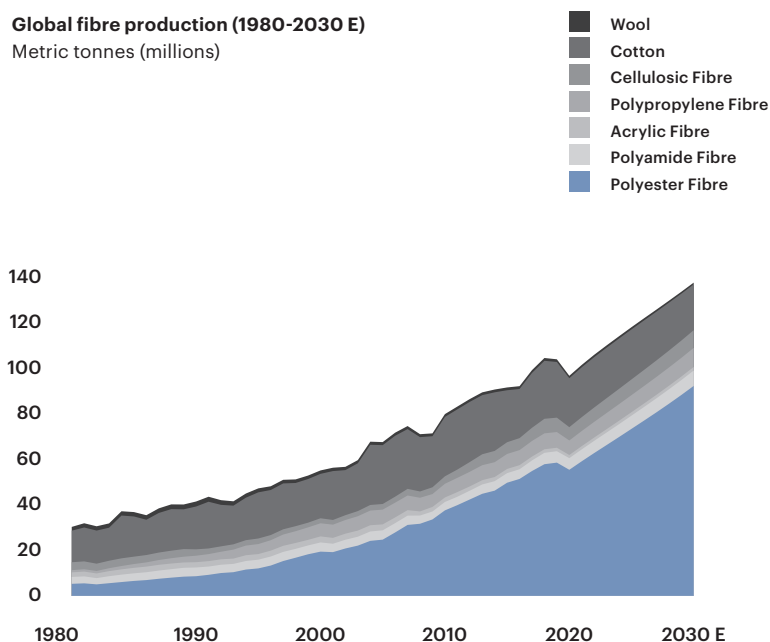
Pressure to take action is mounting on multiple fronts. In the European Union, for example, new regulations have expanded, from requiring labels that identify a product’s environmental footprint to directives for corporates to disclose their climate-related risks. In the United States, meanwhile, a bill known as the Fashion Act is making its way through New York legislature, which, if passed, could require large fashion companies conducting business in the state to show evidence of supply-chain due diligence and emissions targets, among other measures.

From inside the industry, retailers are increasingly setting sustainability requirements for the products they choose to stock. Berlin-based Zalando,

Exhibit 2: Fashion’s Favourite Fibre

The global production of polyester is booming. By 2030, polyester is projected to account for more than two-thirds of all fibres produced.

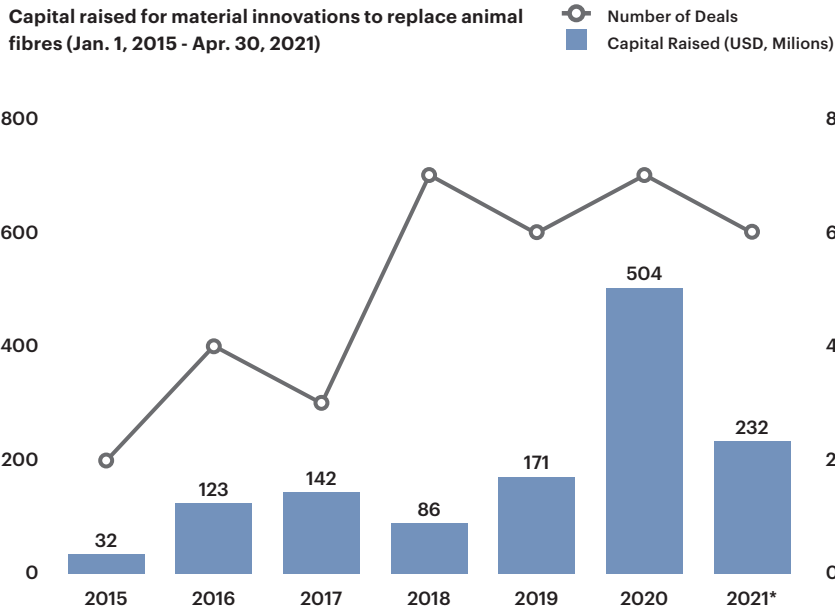
Global fibre production (1980-2030 E)
Metric tonnes (millions)



Source: Tecnon Orbichem

Exhibit 3: Investment Accelerates

Investments in next-generation replacements for animal fibres reached new heights in 2020 and continued to see growth over 2019 levels in early 2021.



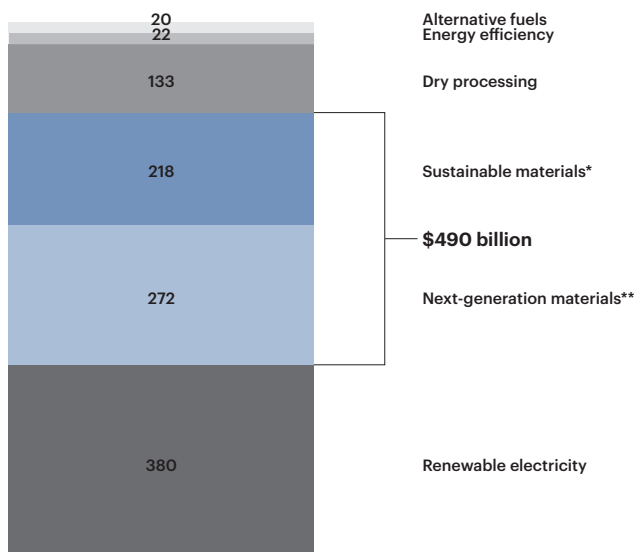
Source: Material Innovation Initiative

*2021 (to end-April)

Exhibit 4: Funding Challenge

An estimated \$490 billion of capital — out of a total \$1.04 trillion — must be invested in sustainable and next-gen materials to meet 2050 net-zero emissions goals.

Capital required to fund solutions to achieve net-zero emissions by 2050
USD (billions)



Source: Apparel Impact Institute and Fashion for Good

*Lower-carbon fibres (e.g. polyester made from recycled plastic)

**Alternative, preferred materials (e.g. recycled textiles, bio-based materials and plant-based leather)

for example, will from 2023 only stock products from the 4,500-plus brands it engages if they agree to report performance metrics in line with the Sustainable Apparel Coalition’s supply-chain tool monitoring environmental and social standards.

It is an unprecedented era for change and innovation, but one that requires a “paradigm shift,” said Keh, who is part of a growing chorus of industry experts advocating for more “thoughtful” sourcing.

Many new sustainable materials are now ready to move out of the lab and into supply chains, after years of investment, research and testing. The demand is certainly there, said Peter Majeranowski, president of Circ, a chemical textile recycling firm whose early financial backers included Patagonia’s venture arm in 2020.

“When word got out [that we were developing fibres using recycled polyester blends], we had some of the world’s biggest brands... reaching out to us,” he recalled. Even though the product wasn’t ready for rollout, “they wanted hundreds of tonnes of material... When you have that kind of response from the market, you know you’re heading in the right direction.”

Barriers to Net Zero

Capital has been flowing into this corner of the industry, primarily through fundraising rounds involving investment firms and fashion brands. And the total overall amount has been steadily rising. According to Material Innovation Initiative, a start-up accelerator and non-profit, capital raised to develop next-generation alternatives to animal fibres like leather, silk, wool and fur reached \$504 million in 2020, nearly as much as the previous four years combined.

Substantially more is needed across a range of solutions for the industry to scale and meet demand. The Apparel Impact Institute and Fashion for Good estimate that nearly \$500 billion of investment across a breadth of next-generation and sustainable materials is needed between 2021 and 2050 in order to replace virgin materials with lower-impact alternatives, like recycled polyester or organic cotton.

Thus far, it’s been difficult for sustainable materials to take much market share from incumbents. For instance, organic cotton production has been increasing since 2016, but still only accounts for 0.95 percent of the overall market, according to non-profit Textile Exchange.

One big advantage that incumbent materials have over their more-sustainable rivals is price. For some new materials companies, it’s a chicken-and-egg conundrum, where economies of



Overproduction and a reliance on low-cost materials that do not naturally degrade, such as plastic-based polyester, are contributing to fashion's waste problem. Shutterstock.

“It’s a chicken-and-egg conundrum, where economies of scale cannot be reached until a significant number of companies commit to alternative materials, but that is unlikely to happen until these materials become more price-competitive.”

scale cannot be reached until a significant number of companies commit to alternative materials, but that is unlikely to happen until these materials become more price-competitive.

Even if brands are able to bear higher prices, they face other challenges; they need buy-in from stakeholders at different stages of their supply chain to embrace these new materials. That could mean helping farmers transition to alternative livestock and crop maintenance techniques, severing ties with or retraining existing manufacturers, entirely revamping procurement networks or rethinking designs to accommodate different fabric textures and weight — with the least amount of disruption.

As for customers, they must be persuaded that the material is of equal quality to its conventional counterpart, and will demonstrate the same (or better) texture, longevity and performance.

Providing monetary and other incentives upstream might help to address the challenge; passing on costs to customers is another. Both are feasible (albeit risky) options.

But progress continues to be made to test, improve and roll out sustainable materials. As the examples in this case study show, highlighting advances in regenerative farming, fungi-based fabrics and textile-to-textile recycling, lessons are being learned along the way as innovators translate ambition into action.

Strategy

Changing the Game

Fashion's much-needed materials revamp has thus far felt more like a slow evolution than the rapid revolution that hitting climate-change goals requires. However, a convergence of factors is spurring progress at a larger scale, as three innovations involving agriculture, fungi and recycling demonstrate.

01 — Regenerative Agriculture



Allbirds sustainability lead Hana Kajimura (left) and colleague Jad Finck (right) at a regenerative Merino sheep farm in New Zealand. The footwear company has committed to sourcing all its wool from regenerative farms by 2025. Allbirds.

Sustainability-focused footwear company Allbirds has been a hit with Millennial shoppers and Silicon Valley investors alike ever since the arrival of its signature Merino wool sneakers in 2016.

Having earned B-Corp status — a certification for businesses that balance financial performance with social and environmental purpose — the San Francisco-based company in 2020 began to publicly disclose the carbon footprint of its shoes to help better inform shoppers about environmental impacts when making purchasing decisions.

It also worked on a one-year design project with Adidas to create a sneaker with the lowest-possible carbon footprint.

But for all the sustainability work Allbirds has done, it still wasn't enough to hit the targets it had set itself to make a 50-percent reduction in the carbon footprint of its shoes by 2025 and a

95-percent cut by 2030. The brand's raw materials, including Merino wool sourced from New Zealand, were among the biggest factors holding back its progress.

"While wool is a natural, renewable, biodegradable fibre, it also comes with a high carbon footprint," Allbirds sustainability lead Hana Kajimura told BoF in 2021. "The great news is that we think that wool and sheep in these ecosystems can actually be a key part of the solution."

One way some brands are addressing this is through regenerative agriculture, which aims to reduce — or even reverse — greenhouse gas emissions and biodiversity loss, by prioritising outcomes like healthy, nutrient-rich soil that absorbs water and minerals and a proliferation of foliage (which captures carbon dioxide from the atmosphere through photosynthesis). It's an approach that runs counter to typical modern

farming methods, where short-term yields and profitability come at the expense of long-term land degradation.

Kajimura believes regenerative farming presents "a great little solution to climate change." Allbirds has said it will source 100 percent of its wool from regenerative Merino wool farms by 2025, a target it aims to meet by incentivising and investing in farmers to make the switch.

It has also partnered with Merino wool brands Icebreaker and Smartwool and the New Zealand Merino Company to establish a platform for regenerative wool, which aims to facilitate collaboration and knowledge-sharing between farmers, and establish buying commitments from brands.

Each year, some 12.5 million tonnes of animal hide, 26.2 million tonnes of cotton and 1 million tonnes of wool are produced for the textile and apparel industries,

according to Textile Exchange, a global non-profit focusing on sustainable fibre and materials. Every stage of production of these materials and fibres is resource- and labour-intensive, often eroding natural ecosystems, using water and chemicals in an unsustainable manner, and releasing carbon into the atmosphere, particularly when the farming of crops and livestock is done at industrial scale.

While Allbirds and a handful of other companies are starting to make inroads in this area, many others in fashion and beyond have yet to incorporate materials from regenerative farms into their sourcing decisions.

One organisation aiming to change that is grassland regeneration charity Savory Institute, whose Land to Market programme provides brands with a verified, direct sourcing solution for regenerative agriculture. The programme verifies land as regenerative if the farming practises show a trend of net-positive impact on the environment by improving land health, such as by increasing biodiversity, ground foliage and the amount of atmospheric carbon absorbed and captured in the soil.

According to the programme's senior vice president of supply chain innovation, Megan Meiklejohn, Land to Market is a "matchmaking service," connecting farmers with proven-regenerative land management with brands.

Kering, Ugg, Timberland and Eileen Fisher were among the programme's founding members in 2018. Others such as Burberry, Tapestry and its subsidiary brand Coach have since joined, granting them access to the supply of regeneratively grown raw materials.

The programme's reach is small but growing. Currently, it has verified that more than 400 farms, covering 2.5 million acres (about 1 million hectares) have a net-positive ecological impact. This is up from 101 farms and 1.5 million acres in 2018. Though increasing, it's still a drop in the ocean. (For comparison, farmland used for agriculture in the European Union alone covered 427 million acres in 2016.)

Growing Engagement

Regenerative farms and land bases account for a minute percentage of overall natural fibre producers. If regenerative practises are to scale, buy-in is required not only from brands but also from farmers, who may see their yields — and therefore revenues — fall over several seasons after adopting regenerative practises. While some positive effects of regenerative land management, such as foliage growth and improved water absorption, can be measured in a matter of months, its carbon-capturing potential can take much longer to realise.

By committing to funding and sourcing from these farms, the benefits for brands could be meaningful, with the potential to establish a more traceable, ethical supply chain that also reduces overall carbon emissions.



Compare and contrast: cattle ranching using today's conventional approaches that prioritise yields and profitability over land preservation (left) vs. regenerative agriculture techniques (right). Timberland.

02 — Mycelium Fabrics



Hermès collaborated with MycoWorks to make a new edition of its classic Victoria bag using Sylvania, a form of mycelium fabric. Hermès.

Of the roughly \$100 billion of sales that Europe's five largest luxury companies recorded in 2020, approximately half came from handbags, footwear and other leather-based products, according to equity analysts at Bernstein. The cost to the environment is steep.

Leather's environmental damage starts at the farm level: cows are responsible for a significant portion of methane emissions, a potent greenhouse gas. Cattle ranching also requires vast swathes of land, sometimes at the expense of crucial ecological conservation.

The hides used for leather are typically a by-product of the beef industry, but have also become a profitable and desirable commodity in their own right. The process to turn raw hides into handbags and other leather goods is also polluting; typical tanning and finishing processes use heavy metals like chromium, which pose potential health risks to workers and, if found in water systems, nearby communities.

Brands wanting to ditch real leather once faced a big tradeoff. For sure, a leather replacement might be more environmentally friendly — a faux leather jacket made from the plastic

polyurethane generates 9.9kg of CO₂ equivalent, compared with 176kg of CO₂ equivalent for a similar jacket made of traditional leather, according to analysis of UN data by animal-free fashion advocacy group Collective Fashion Justice. But, as well as being made from plastics, the chances were high that the end product would have the look and feel of a cheap, low-quality knock-off.

Today, however, there's an emerging alternative that is changing the narrative: plant-based material. A leather-like material made from mycelium — that is, the woven underground root structure of fungi — is gaining ground across fashion companies. Indeed, Material Innovation Initiative estimates the wholesale market for innovative alternatives to animal fibres — such as plant-based leather — to be worth \$2.2 billion by 2026.

Mycelium is grown in the controlled environments of warehouses (sometimes referred to as vertical farming, because the fungi is nurtured in large trays, stacked one on top of another), feeding on agricultural byproducts and waste, sawdust and carbon dioxide. Early prototypes indicate that mycelium materials are more durable than other

plant-based leather alternatives, according to Amy Tsang, UK-based incubation manager at The Mills Fabrica, a platform supporting innovation in textiles and food. The source of mycelium leather (propagated mushroom roots) is also abundant, relatively fast to grow — taking nine days in the case of mycelium grown by materials-science company Ecovative Design — and reliable in terms of yield and production costs.

Still, this material has yet to convince some sceptics of its environmental credibility, with assessments still underway from independent parties to verify the material's carbon footprint, water consumption and other factors affecting its overall sustainability. There's also the fact that while mycelium is biodegradable, a product made with the material may actually contain plastics such as PVC and polyurethane. Inclusion of plastics may be at the discretion of the brand during the finishing process, or can be part of producing the mycelium leather itself; materials-science company Bolt Threads' mycelium material called "Mylo," for example, is predominantly biobased, but uses synthetics to increase performance and ensure consistency.

“If you’re going to make a broad, positive impact on the planet, you have to deliver materials that are both cost- and performance-competitive with the incumbents,” said Gavin McIntyre, co-founder and chief business officer of Ecovative.

A Long Journey

Ecovative has been working with mycelium for more than a decade. Founded in 2007, it first developed the technology to use for packaging and food, and only recently pivoted toward making its own imitation hide.

But more than R&D is needed. Supported by \$100 million from a roster of venture capital investors, including Viking Global Investors and Senator Investment Group, Ecovative’s new vertical farm in upstate New York, which has an annual production capacity of 3 million square feet using just 1 acre (0.4 hectares) of land, is designed to produce large sheets of the material which is free of plastic scrims or petroleum-based coatings.

It has also established a new fashion industry-focused cooperative which is expected to spur further product development, with founding members PVH Corp. and Bestseller receiving direct access to Ecovative’s mycelium hide in

exchange for sharing their design and industry expertise.

While funding new facilities and strengthening industry collaboration are key to growth, so too is addressing outstanding questions about the material’s sustainability worthiness. For that, McIntyre said Ecovative needs more time. “We have not conducted a full lifecycle assessment for our textile product. It’s important for us to do that but we also want to make sure that we do that at the right industrial scale,” he said, adding: “We have done lifecycle assessments for other product lines, however, and we also leverage a lot of equipment that’s used in the mushroom cultivation industry.

“We do believe that we will [use] a fraction of the embodied energy in comparison to a conventional animal hide.”

The Tipping Point

Following years of research and development, mycelium leather producers are now preparing themselves for the fashion industry to adopt mycelium at scale. Brands have designed prototypes of mycelium sneakers, handbags and even yoga mats, but 2022 marks the first year consumers will be able to purchase products made from the material.



Ecovative grows sheets of mycelium in shelves in its vertical farm. The mycelium, which is propagated from small cuttings of mushrooms, feeds on agricultural waste in special incubation conditions. Ecovative.



Ecovative originally developed its mycelium technology for packaging and food, and only recently pivoted towards making imitation hide (pictured above). Ecovative.

“If you’re going to make a broad, positive impact on the planet, you have to deliver materials that are both cost- and performance-competitive with the incumbents.”

— Gavin McIntyre

MycoWorks, the Emeryville, California-based biomaterials company founded in 2013 that counts the Hermès mycelium bag among its fashion tie-ups, raised \$125 million in Series C funding in early 2022. This supplemented previous investments from other undisclosed sources, including several fashion houses. The company said the capital will help build a commercial-scale plant in South Carolina.

As it stands, there’s a general supply-demand mismatch in the field. This is potentially stalling some fashion brands from acting on ambitions to experiment with products like MycoWorks’ mycelium, with materials companies favouring brands that can invest in and commit to long-term partnerships.

Other brands have to wait until these materials companies scale their production capacity. Katrina Espiritu, founder of leather goods brand Lupa, told BoF that she has been waiting about two years to develop products made with MycoWorks’ mycelium.

“I’ve put my name down to get samples... and have yet to hear anything,” she said.

MycoWorks chief executive Matt Scullin said the company fields thousands of requests from prospective brands. “We’re unfortunately not able to work with everyone who contacts us,” he said in an email. With the construction of its first commercial-scale plant set for 2022, it will have more material available to expand to additional brand partners, he added.

In the case of Bolt Threads, which was founded in 2009 and launched Mylo in 2018, a new factory set to begin operations end-2022 will span more than 1 million square feet. The likes of Stella McCartney, Lululemon and Ganni have experimented with its mycelium material by creating handbags, gym bags and wallets.

“The tension for us... is always going to be: How many [brands] can we provide high-quality support to in developing the product and the material with them?” said Dan Widmaier, chief executive of Bolt Threads.

But Widmaier’s overarching desire is to grow the business, even if its mycelium material still has sceptics to convince and teething pains — one of which being the use of plastics to create a finished product that competes with traditional leather.

“My take on this is very pragmatic,” said Widmaier. “Sure, nobody’s product is perfect today. We might be waiting, who knows how long, if we just wait for ‘perfect.’ Let’s start putting stuff out there. Let’s find where it works. Let’s improve it. And let’s move with intention.”

03 — Textile-to-Textile Recycling



The infinite hoodie, a collaboration between Evrnu and Adidas by Stella McCartney, is fully recyclable and made from 60 percent NuCycl and 40 percent organic cotton that has been diverted from landfills. Adidas has committed to using only recycled polyester in its products from 2024 onwards. Evrnu.

Tennis fans tuning into 2022’s Australian Open could be forgiven for missing the significance of the launch of a Ralph Lauren cotton polo shirt at the event. Polo shirts are, after all, what the US brand is widely known for. But this shirt was different. Made with recycled cotton, the high-performance sports shirt is the result of the company’s investment in, and partnership with, materials science company Natural Fiber Welding (NFW).

As one of a growing number of textile-to-textile recycling companies, Illinois-based NFW is likely to be more than familiar with the challenges — and opportunities — influencing the way the fashion industry sources and manufactures recycled materials.

Textile-to-textile recycling — the recycling of both post-production and post-consumer textile waste into new textile products — is a crucial solution to fashion’s collective goal of drastically reducing its waste and carbon footprint. This form of recycling marks a break from the industry’s traditional “take-make-waste” model of using virgin raw materials that are grown on farms or extracted from fossil fuels, then turned into finished clothing and accessories through resource-intensive manufacturing, and eventually discarded

— a model responsible for devastating environmental and social outcomes.

At today’s rates of consumption, the outlook is far from rosy. Global fibre production is expected to rise from 109 million tonnes in 2020 to 146 million tonnes in 2030, according to non-profit Textile Exchange.

“In general, we have a lack of thoughtfulness or intention when we develop current materials; they’re not meant to be separated and reused,” said Edwin Keh, chief executive of The Hong Kong Research Institute of Textiles and Apparel, referring to the industry’s widespread use of blended fibres such as polyester and cotton, which are difficult to recycle into new, high-quality fibres.

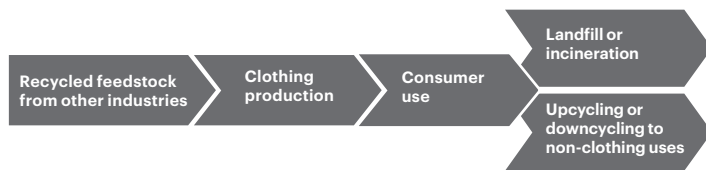
Some well-known brands have begun throwing their support behind textile recycling companies, often taking a stake in them, like Ralph Lauren and Allbirds’ minority investment in NFW, or simply entering into commitments to use their materials. In the case of Keh’s organisation, it has been collaborating for several years with yarn supplier Novetex and the H&M Foundation to develop a commercially viable process for recycling fabric blends using heat, water and green chemistry.

Exhibit 5: Closing the Loop

Circular fashion requires a transition to textile-to-textile, closed-loop recycling processes.

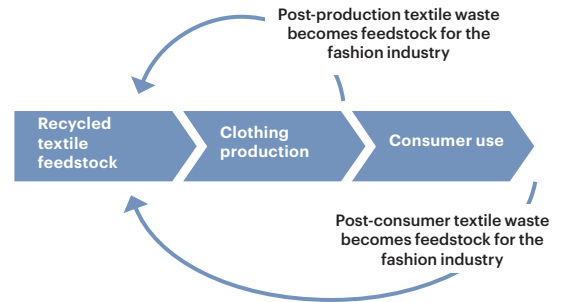
Open-Loop Recycling

One product (e.g. PET bottles) is recycled into a different product (e.g. clothing) but is not recycled into clothing again at end of use.



Closed-Loop Recycling

Textile waste from production and consumer use is recycled into new clothing so that materials can remain in constant circulation.



Source: Ellen MacArthur Foundation and BoF

“Sustainability experts point out that the sophisticated technology used in textile recycling requires energy, water and, in some cases, harsh chemicals with residual chemical waste.”

Yet the barriers to growth remain formidable. Essentially, it’s a “Catch-22” situation, said Stacy Flynn, chief executive of Evrnu, a recycling technology company she helped found in 2014. Attracting partnerships with Stella McCartney and Levi’s, among other brands, the Seattle-based company’s recycling technology breaks down natural and synthetic fibres to the molecular level. The end result is a lyocell yarn made entirely from waste. Called NuCycl, the yarn is tougher than nylon and polyester, with environmentally friendly characteristics, such as its recyclability and ability to efficiently absorb dye.

To create a meaningful impact in their markets, companies like Evrnu need even greater support than they have today from brands and retailers, which are often reluctant to commit to high volumes of these new materials without product testing with consumers and assurance that their suppliers and subcontractors can accommodate them. Financiers, meanwhile, want evidence of commitments from brands and retailers before extending financing. And all the while, these companies are trying to figure out their own supply chains – working out how to operationalise waste collection from factory floors or clothing donation banks in order to produce feedstock requires an entirely new layer of infrastructure and investment.

Ultimately, size matters, without which these companies will continue to struggle to compete with industry incumbents. “It comes down to cost,” said Flynn. “If people are currently paying 80 cents a pound for polyester and cotton, and you ask them to pay \$20 a pound for the recycled version... that equation just doesn’t work.”

The good news for Evrnu is that it hit an important milestone in late 2021, closing a \$15 million Series B fundraising round with plans now to build its first scaled-up facility, which will be able to produce between 10,000 and 20,000 tonnes of recycled pulp per year.

Going Head-to-Head

However, some textile-to-textile companies are finding that even with scale and investment, making inroads in their markets is not a done deal.

Consider Stockholm-based Renewcell, a 10-year-old textile recycling company steadily laying the foundations to take on cellulosic fibre incumbents like viscose. Counting H&M Group’s venture arm as an early investor, it went public in 2020 at a valuation of SEK 2.3 billion (\$245 million), which has since risen to SEK 5.6 billion.

Having now opened an industrial-scale chemical recycling plant – with a capacity of 60,000 tonnes per year –



What are cellulosics?

Cellulosic fibres are derived from cellulose, typically extracted from trees or woody plants such as bamboo, in a chemical-intensive process.

Cellulosic fibres accounted for 6 percent of global fibre production in 2021, according to Tecnon Orbichem. The most common form of cellulose is viscose.

The use of man-made cellulosic fibres has grown over recent decades thanks to the popularity of viscose, which was first marketed as artificial silk.

Modal and lyocell are the most commonly used more sustainable cellulosics, with a lower-impact production process than others like viscose.



What is polyester?

Polyester is a synthetic fibre derived from oil and produced through an energy-intensive chemical reaction involving fossil fuels, air and water.

It is the world's most used fibre, accounting for 58 percent of global fibre production in 2021, according to Tecnon Orbichem. Polyester is light, strong and easily dyed and blended with other fibres.

Since it is an oil-based plastic, polyester does not biodegrade like natural fibres. When washed, polyester fibres shed and enter waterways and oceans as microplastic fibres.

Most polyester currently used in clothing is virgin, with the majority of recycled polyester made primarily from plastic PET bottles.

Renewcell's Circulose, a pulp product made from cotton-rich textile waste, such as old jeans, is competing head-on with man-made cellulosic fibre, selling at "a price in line with organic cotton," according to the company.

And yet Renewcell and other recycled cellulose companies have a way to go before they can replace materials derived from wood pulp like viscose and rayon. Recycled cellulose accounted for just 0.4 percent of the incumbent material's 6 percent market share in 2020. The trajectory of recycled polyester, the majority of which is derived from recycling discarded plastic bottles, has been more promising. The material currently accounts for 15 percent of total polyester production, according to Textile Exchange. However, because a large portion of recycled polyester uses waste from other industries to make the fibre, it is not a fully ideal solution to fashion's overall impact.

Market enthusiasm for closed-loop, textile-to-textile recycled polyester is high, as Circ discovered when the Virginia-based chemical recycling company began casually exploring whether it could apply the hydrothermal technology it was using for its biofuels business to recycle cotton and polyester in clothing. "We laugh now, but we didn't know if it was even a big deal. Does the [fashion] industry need to recycle clothing on a chemical level?" recalled Circ co-founder and president Peter Majeranowski. "We quickly found out that it did."

Still in demo stage, Circ's technology is aiming to crack some of the tough problems holding back recycling textiles, which need to take into account the vast variety of fibres like cotton that undergo processing in large batches — "it could be cotton bedding sheets, or it can be a T-shirt someone bought at a gas station that they laundered 5,000 times," said Majeranowski. Unlike similar textile recyclers, Circ is "ratio agnostic," meaning it can recycle any ratio or blend of synthetic and natural fibres, he explained. The process is also colour agnostic.

But sustainability experts point out that the sophisticated technology used in textile recycling requires energy, water and, in some cases, harsh chemicals with residual chemical waste. That can lead to a high water, wastewater and carbon footprint, particularly when scaled to cater to industry-wide demand.



Circ's textile-to-textile recycling technology can recycle any blend of synthetic and natural fibres. Circ.

Another critical factor for textile recyclers is establishing deep engagement with brands, enabling companies like Circ to fully understand their supply chains, Majeranowski said, while also underscoring his belief that success in this field hinges on the extent that the fashion industry “has skin in the game.”

Without full visibility into suppliers at all stages of production, integrating recycled materials into the supply chain is “very hard to execute,” said Majeranowski.

The company is bullish. “We have a very bold internal company goal that by 2030, we want to have already recycled 10 billion garments. That’s going to require a lot more than just one factory,” he told BoF.

However, he noted, one big factor working in recycling technology’s favour is that there’s little chance of the waste it needs running low, with brands’ excessive or damaged inventory providing ample supply. “Unfortunately for the planet, there’s so much waste that it’s easy for us to source this,” said Majeranowski.

Exhibit 6: Fashion Companies Getting a Piece of the Start-Up Action

Increasingly, textile-to-textile recycling start-ups have been a magnet for investments and partnerships, be it through equity investments or design collaborations.

Examples of textile-to-textile recycling companies

Company	Year Founded and Headquarters	Material Produced	Notable Brand Collaborations and/or Investments
Renewcell	2012, Stockholm, Sweden	Circulose	H&M Group, Levi’s, Bestseller
Circ (formerly Tyton Biosciences)	2011, Danville, VA, USA	Circ	Patagonia, Marubeni
Evrnu	2014, Seattle, WA, USA	NuCycl	Stella McCartney, Levi’s, Adidas, Target
Ambercycle	2015, Los Angeles, CA, USA	Cycora	H&M Group, Bestseller, Zalando
Natural Fiber Welding	2015, Peoria, IL, USA	Clarus and Mirum	Ralph Lauren, Allbirds, Richemont, Patagonia, Pangaia
Infinited Fiber Company	2016, Espoo, Finland	Infinna	Zalando, H&M Group, Adidas, Patagonia, Bestseller, Ganni, PVH, Wrangler

Looking Ahead

Time isn't on the fashion industry's side. For fashion to hit its net-zero targets by 2050, the pace of innovation and change needs to ramp up significantly in key stages of supply chains. With materials production currently contributing 38 percent of greenhouse gas emissions, materials must play a pivotal role in beating the climate crisis.

Fabric mills, leather tanneries and dyeing facilities are also resource-intensive, creating vast quantities of wastewater, chemical waste and carbon emissions. Cleaning up and decarbonising material processing, the next stage after raw material production in the supply chain, could save 703 million tonnes of annual greenhouse gas emissions, according to modelling by GFA and McKinsey.

However, a number of encouraging technologies and innovations indicate that the foundations have been laid to move towards a less harmful fashion system, step by step. Early-stage investments have already spurred new companies dedicated to environmentally friendly materials, pilot projects are moving more sustainable products into supply chains, and thus into consumers' closets, and with a number of companies now expanding capacity, the choice and availability of sustainable materials is likely to ramp up.

Whether all this is enough to fully replace harmful materials remains to be seen. The need for scale is the running theme across all types of innovation — from vertically farmed mushrooms to regenerative cattle ranching practises. Unlocking this means seizing opportunities to collaborate, including with players outside today's fashion circles that see potential to apply their industries' technologies to help solve brands' sustainability problems, something already demonstrated in this

case study.

Brands must play a proactive role in the solution. Many fashion companies are setting up in-house sustainability and innovation teams and educating the wider organisation on integrating sustainability into every stage of a product's lifecycle.

Gaining access to materials — and adapting products accordingly — boils down to partnering with innovators, not only to share industry expertise and resources but to also fund these ventures beyond pilot projects, ensuring that brands have "skin in the game," as Majeranowski of Circ explained. Without this, brands risk being left behind in the race for fashion's new materials future.

Further Reading

- The Business of Fashion, [The Year Ahead: Paving the Way for Closed-Loop Recycling](#)
- The Business of Fashion, [How Ganni Plans to Eliminate Leather](#)
- Apparel Impact Institute and Fashion for Good, [Unlocking the Trillion-Dollar Fashion Decarbonisation Opportunity: Existing And Innovative Solutions](#)
- The Business of Fashion, [Nature Is Fashion's Next Frontier in Climate Battle](#)
- Textile Exchange, [Preferred Fiber and Materials Market Report 2021](#)
- Material Innovation Initiative, [State of the Industry Report: Next-Gen Materials](#)
- The Business of Fashion, [Luxury's Latest Battleground: Material Science](#)
- The Business of Fashion, [Fashion's New Materials Frontier](#)
- The Business of Fashion, [Why Big Brands Are Investing in Sustainability Start-Ups](#)
- The Business of Fashion, [Chasing The Holy Grail of Circular Fashion](#)
- Global Fashion Agenda and McKinsey & Company, [Fashion on Climate](#)

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