QUICK TAKE

INNOVATIONS IN FABRIC MATERIALS

KEY TAKEAWAYS

In this report, which continues our coverage on innovations in fabric materials, we focus on bio-based synthetic fibers and synthetic spider silk. We look at the companies developing products in these categories and the potential applications of these innovations.

1) Lenzing AG estimates global fiber consumption at 95.6 million tons in 2015. Petroleum-based synthetic fibers comprise the largest share at 62.1%, however, leave a significant carbon footprint during the production process.

2) **Bio-based synthetics**, on the other hand, are made from renewable resources which offer a lower carbon footprint alternative to conventional synthetics, as well as satisfy the growing trend for more sustainable products.

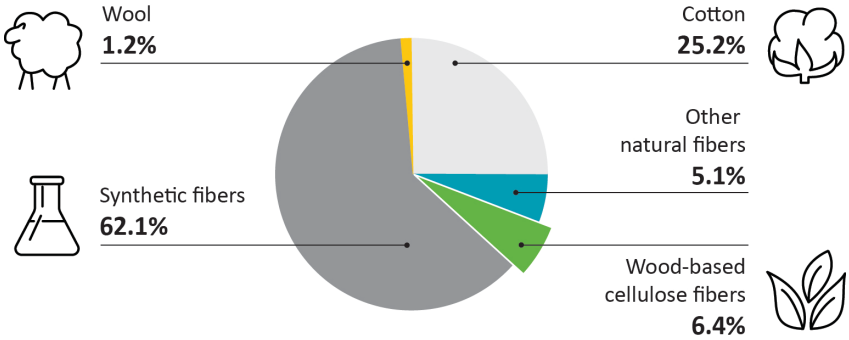
3) **Spider silk** possesses extraordinary mechanical properties. Some innovative companies have successfully mimicked this wonder material. **Synthetic spider silk** has already seen potential use in military and outdoor performance apparel.

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016

ONGOING INNOVATIONS IN FABRIC MATERIALS

Fabrics are typically made of natural or man-made fibers. Global fiber consumption globally was estimated at 95.6 million tons in 2015, according to Lenzing AG. Synthetic fibers – the majority of which are polyester fibers – comprise the largest share at 62.1%, followed by cotton with a 25.2% share, according to a report by Lenzing AG, a leading manufacturer of synthetic fiber.

Figure 1. Global Fiber Consumption in 2015

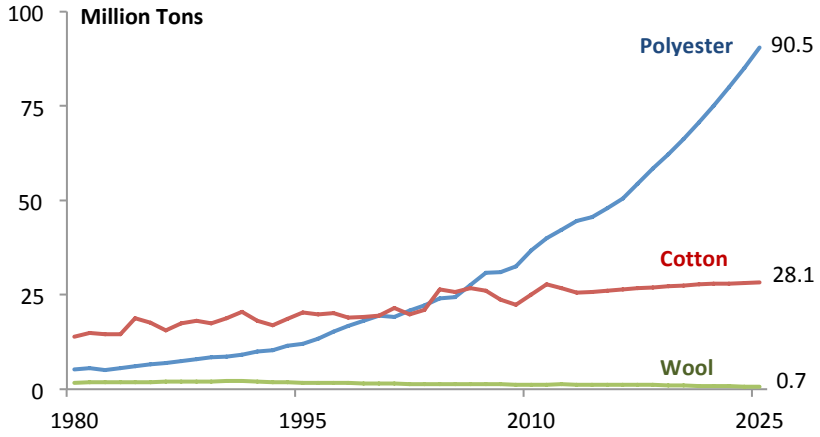


Source: Lenzing AG

The fabric material landscape has been transformed over the past couple of decades with ongoing innovations in new or enhanced fabric materials.

One of the key innovations in fabric materials in the 20th century was polyester. Since then, polyester fabric has gradually proliferated the textile industry. It overtook cotton as the most-produced fabric material in 2002, with 20.8 million tons manufactured worldwide. Polyester fiber production has continued to grow, more than doubling to reach an estimated 48 million tons in 2015. By 2025, it is expected to reach 90.5 million tons, a four-fold increase from 2002.

Figure 2. Global Production of Cotton, Polyester and Wool Fiber



Source: Tecnon Orbichem

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016

Many other innovations in fabric materials have emerged over the past couple of decades as well, from heat insulating to water-proof fabrics, creating new possibilities in apparel design and production.

In this report, we look bio-based synthetics and synthetic spider silk.

BIO-BASED SYNTHETICS

The main difference between bio-based synthetics and conventional synthetics lies in the raw materials used. Bio-based synthetics, as the name suggests, are made from bio-based raw materials such as sugar cane, corn sugars and agricultural waste. Conventional synthetics such as polyester, nylon and acrylic use raw materials derived from fossil fuels such as petroleum, natural gas and coal.

Bio-based Polyester: Virent

Virent, a US bio-based chemical company, showcased the world's first 100% bio-based polyester shirt this year at the Textile Exchange Sustainability Conference. Bio-based polyester's performance is similar to regular polyester, and it can be processed using the same equipment, according to Ralph Lerner, the company's business development director.

The production process begins with Virent's BioFormPX paraxylene, a compound produced from plant sugars that resembles the chemical components of petroleum. The bio-based paraxylene is then converted into bio-polyester fabric. Virent works with **Far Eastern New Century (FENC)**, a leading Taiwanese polyester manufacturer. To date, they have yet to enter mass production.

Source: Stylourbano

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016

SYNTHETIC SPIDER SILK

Spider silk is regarded as one of nature's wonder materials because of its extraordinary mechanical properties. It is tougher than Kevlar – a high-strength synthetic fiber used in racing tires and body armor – and has a comparable tensile strength to high-grade alloy steel, but is much lighter.

Figure 4. Physical Properties of Spider Silk, Kevlar and Steel

Material	Material Toughness	Tensile Strength	Weight
Spider Silk	120,000–160,000 J/kg	1,100–2,900 MPa	1.18–1.36 g/cm^3
Kevlar	30,000–50,000 J/kg	2,600–4,100 MPa	1.44 g/cm^3
Steel	2,000–6,000 J/kg	300–2,000 MPa	7.84 g/cm^3

Source: Kraig Biocraft

The first reference to the use of spider silk dates back to the early 18th century in France, where attempts were made to use it to make stockings and gloves. Mass production for commercial applications, however, was an obstacle for centuries. Spiders are cannibals and tend to eat each other when enclosed in a small area, making it impossible to farm them like silkworms. This has made spider silk the object of research for many years, with significant research papers dating back as early as the 1960s.

Various attempts have been made to produce spider silk. One such attempt was made in 2009. It took one million golden orb spiders to produce 80 feet of silk, or put another way, it took 14,000 spiders to spin one ounce of silk.

Another attempt used genetically modified goats to produce milk containing protein similar to that of the golden orb spider. However, it was not successful, as the quality of the silk produced was far below the quality of natural spider silk.

Since then, several companies have been racing to commercialize spider silk fiber, also using techniques based on genetic engineering, but with a different approach. We discuss three of these – Kraig Biocraft, Bolt Threads and Spiber Inc.

Kraig Biocraft Laboratories

Kraig Biocraft – Transgenic Silkworms

This Michigan-based company has inserted modified spider genes into silkworms to produce spider silk. Unlike spiders, silkworms can be domesticated and have been used to mass produce silk fiber for centuries. This allows the company to produce a large amount of spider silk efficiently and cost effectively.

Kraig Biocraft has created approximately 20 different genetically engineered spider silk fibers based on genetic designs. Dragon Silk is the company's lead product, with a very high tensile strength and elasticity, making it one of the toughest fibers and an ideal material for many applications, according to company COO Jon Rice.

Its synthetic spider silk has already seen potential application in military apparel – the company received a contract of close to US$1 million from the

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016

US military in July this year. Kraig Biocraft will deliver Dragon Silk-based ballistic shoot packs for performance testing. The armed forces have been relying on nylon for its strength, but nylon is dangerous for soldiers because at high temperatures it melts rather than burns, according to Steve Arcidiacono, a microbiologist at the US Army's Natick Solider Systems Center.

Source: Kraig Biocraft

Bolt Threads and Spiber Inc. – Transgenic Microorganisms

These two startups take a different approach to producing spider silk. Instead of modifying the genes of silkworms to produce the material, they have harnessed genetically engineered microorganisms to produce the protein through fermentation, which serves as the raw material to make the synthetic spider silk. The main difference between the two startups is in the microorganisms they use – Bolt Threads uses genetically modified yeast, while Spiber uses genetically modified E. coli bacteria.

Bolt Threads

Bolt Threads is a California-based startup founded in 2009 with the aim of producing affordable synthetic spider silk. The startup claims to have a lower raw material cost by using significantly less expensive yeast rather than E. coli, according to Sue Levin, its chief marketing officer. Bolt Threads expects to produce the spider silk yarn at a price of US$100 per kg, comparable and competitive with high-end natural fibers such as cashmere, silk and mohair at a similar price range.

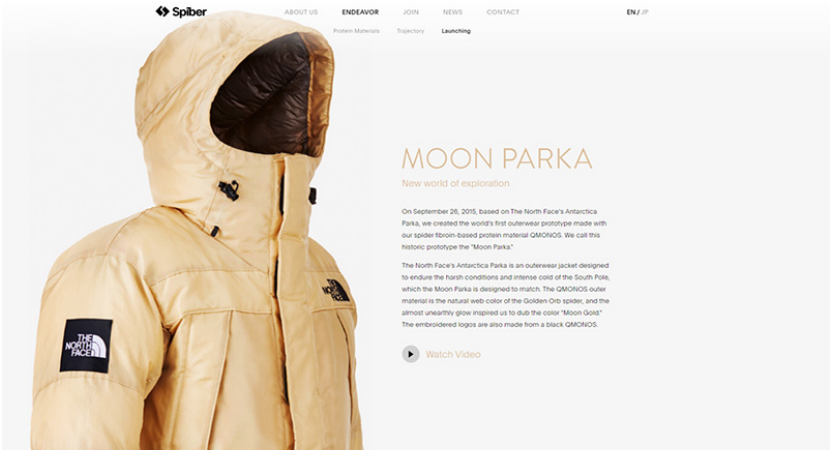
In May 2016, Bolt Threads announced a partnership with outdoor clothing company Patagonia to further develop the fabric, and has already started producing the synthetic spider silk in large scale.

Spiber Inc.

Spiber Inc. is a Japan-based startup founded in 2007 that aims to drastically lower the production cost of spider silk to make it practical for commercial use. Although the absolute production cost has not been disclosed, Spiber claims that productivity has increased by 4,500 times, and its manufacturing cost is only 1/53,000 when compared with eight years ago, when the startup first began to research the fermentation process.

In September 2015, the startup collaborated with The North Face to create the world's first outerwear jacket made with synthetic spider silk, the Moon Parka which retails at US$1,000. The jacket is based on The North Face's Antarctica Parka, which uses conventional material and is sold at $736, about one third cheaper than Moon Parka.

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016



Source: Spiber

IMPLICATIONS FOR THE APPAREL INDUSTRY

Growing Trend in Fiber Innovation

Synthetic fibers, an innovation from the past century, account for over half of global fiber consumption. However, as synthetics are produced from petroleum-based material, the finite supply of petroleum means that the production cost of synthetic fabrics could be subject to market volatility.

More importantly, petroleum-based products leave a significant carbon footprint during the production process. They are also not biodegradable and cause significant damage to the environment. Tiny fibers from synthetic fabrics also have the potential to poison the food chain. According to a study by the University of New South Wales in 2011, microfibers made up 85% of man-made debris found on shorelines around the world.

Consumers have become increasingly aware of a product's sustainability, and this is especially true among millennials. As covered in our Global Retail Trends for 2016 report, millennials place a higher weighting on corporate responsibility and sustainability in their purchasing decisions than do other generations.

Synthetic fabric substitutes include bio-based synthetics and protein-based spider silk, which are based on renewable resources such as plants and microorganisms. Water- and stain-resistant cotton fabrics also help to promote sustainability, as they can reduce the water and energy used in the washing process.

Managing the Cost Barriers

New innovations involve investment in R&D, and, in most cases, a higher manufacturing cost. For example, the production cost of synthetic spider silk is $100/kg while the threshold price for mass adoption is US$20-30/kg, according to estimated figures from Spiber. Even though consumers are willing to pay a premium for sustainable offerings, it is important to strike a balance between price premium and affordability and many fiber innovations are not relevant for the mass apparel market just yet.

DEBORAH WEINSWIG, MANAGING DIRECTOR, FUNG GLOBAL RETAIL & TECHNOLOGY
DEBORAHWEINSWIG@FUNG1937.COM US: 917.655.6790 HK: 852.6119.1779 CN: 86.186.1420.3016

Deborah Weinswig, CPA
Managing Director
Fung Global Retail & Technology
New York: 917.655.6790
Hong Kong: 852.6119.1779
China: 86.186.1420.3016
deborahweinswig@fung1937.com

Eddie Wong
Senior Research Associate

HONG KONG:
8th Floor, LiFung Tower
888 Cheung Sha Wan Road, Kowloon
Hong Kong
Tel: 852 2300 4406

LONDON:
242-246 Marylebone Road
London, NW1 6JQ
United Kingdom
Tel: 44 (0)20 7616 8988

NEW YORK:
1359 Broadway, 9th Floor
New York, NY 10018
Tel: 646 839 7017

FungGlobalRetailTech.com