

From spider silks to innovative dyeing methods, bacteria are believed to be efficient and sustainable 'micro-factories' that have the potential to manufacture the materials of tomorrow.

Textiles take to bio-manufacturing

Biotechnologies have long been used in the textile industry, and specifically in denims, for finishing processes that call on various forms of living organisms, be they enzymes, yeast or microbes. Also known as synthetic biology, this experimental field of bio-manufacturing is now being harnessed to make materials and dyes.

DuPont's bio-based Sorona-branded PTT yarn, which has been produced using genetically-modified bacteria since 2006, is a forerunner of this burgeoning industry. DuPont Industrial Biosciences, now a division of DowDuPont, officially broke ground this January on a new state-of-the-art, multidisciplinary facility located at the Leiden Bio Science Park in Oegstgeest, the Netherlands, where it will apply its biotechnology to many markets, from improving animal health to lowering environmental impacts in the textile industry. The company that built its success throughout the 20th century on fossil fuels has now turned to using living organisms to convert renewable resources into energy and raw materials.

Thindown, an innovative down material delivered in rolls and developed by an Italian company, is one of the most recent products to feature DuPont's bio-based polyester Sorona. This could add some stretch to the insulation and make it more comfortable to wear. "Sorona has a shape-memory function that infuses fabrics with wrinkle-resistant properties," Renee Henze, global marketing director of Dupont Biomaterials, told *WSA*.

Born as a biodesign research project, Living Colours is a new natural colour palette that Dutch designers Laura Luchtman and Ilfa Siebenhaar have developed both as a sustainable alternative to petrochemical textile dyes and as a new aesthetic.

Laura Luchtman & Ilfa Siebenhaar

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Living dyestuffs

The newest property that biotech companies are seeking to optimise is the ability of bacteria to dye the substrate that they colonise naturally. This is inspiring a series of start-ups in the UK, France and the Netherlands, who are on a mission to offer a sustainable alternative to one of the most polluting stages of textile manufacturing.

Founded in 2016 in Norwich, UK, synthetic biology start-up Colorifix has developed genetically-modified or so-called "engineered" organisms that it believes can be used for industrial textile dyeing. Towards the end of last year, it raised $3 million to scale up its process. The company feeds its organisms with agricultural by-products such as sugar molasses which they turn into colourants suitable for dyeing textiles. These microorganisms transfer the colour onto a fabric or garment, without needing further processing and resulting in water and energy savings. The high-quality results were confirmed by independent and certified quality tests. The company has successfully dyed polyamide-based jersey, polyester and cotton fabrics in two hours, and research is underway to apply the technology to other natural and synthetic fabrics. After dyeing, the fabric is exposed to high temperatures to remove the bacteria and produce a "clean" or sanitised textile.

Dr Orr Yarkoni and Dr James Ajioka, the two synthetic biologists who founded Colorifix, identify the DNA that determines a specific colour found in various lifeforms, be they plants or animals. This DNA is replicated and introduced into the bacteria which are then "programmed to produce the colour," David Nugent, the company's third founder and chief commercial officer, tells *WSA*. As opposed to other "natural" dyestuffs extracted from saffron or madder, the technology developed by the company is said to be able to produce any colour of the spectrum including the most intense cherry pink or deep purple. Not only do the "bugs" produce the dye, they also deposit it and fix it to a textile ground, hence the company's name Colorifix. They are then disposed of during a lysing process, followed by a washing. None of the usual chemicals and solvents of conventional dyeing methods are necessary. The biotech bugs also operate at low temperatures, further reducing the environmental footprint of the process. Polyester can be dyed at 40°C with this method, says Mr Nugent. Swedish eco-brand Philippa K will be one of the first brands to showcase the technique using a Sensitive fabric that will be dyed using the Colorifix process by Eurojersey in Italy.

Laura Luchtman and Ilfa Siebenhaar, the Dutch fashion and textile designers that launched Living Colours in 2016, first started experimenting with bacteria for a biodesign school project. They discovered that "biodyeing" with bacteria generates little run-off, requires limited water and can be conducted at low temperatures without toxic chemicals or fixing agents. In their initial tests, they focused on the natural patterns the bacteria leave on a textile, otherwise known as stains. When they fed the bacteria specific nutriments and applied various sound frequencies, they were able to create geometric patterns and even solid colours. Further research led to a process in which the bacteria could be extracted after dyeing. Not wanting to apply any chemical treatments, the pigments will fade in time, something that the designers do not view as a negative effect but rather as a feature that will evolve with time. The duo is pursuing its research, mostly for their own use as designers, Ms Luchtman told *WSA*. The process has sparked the interest of other designers and textile start-ups, including Pyrates Smart Fabrics. In 2019, they plan to test their microbe-dyeing technique for colour fastness as well as for possible antibacterial properties.

In France, biotech start-up Pili Bio is another company working on a bacteria-powered dyeing method. The company was founded in 2015 at the biohacking maker space known as La Paillasse in Paris, and has since moved to the Toulouse White Biotechnology (TWB)



Munich-based AMSilk is one of the few biotech spider silk companies to produce the material at tonne scale. The fibre produced is said to possess high tear strength, breathability, lightness and elasticity and has been certified biodegradable.

AMSilk

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Bolt Threads continues its research on its biotech spider silk known as Microsilk, which is produced via fermentation processes. The company developed a material that British designer Stella McCartney used to make a dress presented at the Museum of Modern Art in New York last year.

Bolt Threads

consortium. The first idea the founding team, designer Marie-Sarah Adenis and synthetic biologist Thomas Landrain, dreamed of was creating a pen that would generate its own ink. Though this concept did not prove to be feasible, it led to the development of the company's current textile applications. It believes microbial fermentation could enable the textile industry to reconnect with its age-old process of using natural pigments to dye materials. Pili's technology is designed to produce colours more efficiently with a tremendous decrease of fossil and polluting inputs, Jeremie Blache, Pili CEO and cofounder stated. Pili Bio has recently raised new funding of €2.5 million from the Fashion For Good accelerator, Wiseed and its existing venture-capital investor SOSV.

Plastic-eating microbes

Commonly used to break down biomass, biotech processes are now being "programmed" to break down PET and PLA bottles by another French biotech company, Carbios, based in Clermont-Ferrand and founded in 2011. The start-up has recently received €7.5 million of new funding from the Investments for the Future Program, operated by French eco-agency ADEME, to scale-up its industrial and commercial PET plastics and fibres biorecycling project. In November of 2018, it signed a Letter of Intent with French chemical company KEM ONE to build an industrial demonstration plant in Saint-Fons.

The process Carbios is working on depolymerises post-consumer PET bottles into its monomer building blocks, potentially opening the way to an infinite recycling loop. It believes it can develop a specific set of enzymes that will degrade the plastic residues not degraded during a first stage and thus reduce wastage. Once the degradation of polyesters is achieved, it intends to develop biotech enzymes to depolymerise polyamides.

Founded by Molly Morse in 2010 and based in the San Francisco Bay Area, Mango Materials has created bacteria that convert methane into a biodegradable plastic. Last year, the company developed a method to spin the substance into polyester-like fibres that may be suitable for clothing.

The bacteria identified by the Mango Materials team transform methane into a plastic polymer that they use to create their own cell walls. The methane source they are fed is considered waste and is supplied by a Bay Area wastewater treatment facility, the company has stated. Up until now it has focused on packaging applications, but it has also pursued possible textile applications, due in part, it says, to high interest from the fashion industry. Clothing made from this polymer would biodegrade naturally in a landfill but could also be recycled to produce new fibres. Founder Molly Morse hopes to be able to manufacture the first garments in a year or two, as she declared to *Anthropocene* magazine.

Biotech spider silks

As reported by *WSA* in 2015 (Beyond biomimicry) and 2017 (Eye on the horizon), several biotech start-ups are developing fermentation processes to produce spider silk proteins that could be used to make fibres. Biosteel, developed by AMSilk, a company based near Munich, is said to be produced in a closed-loop biotechnological process that renders the product highly sustainable, with no petroleum inputs. The biotech material has been used by adidas for shoe uppers, and by

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Puma experimented with biotech sensors that can detect pollution levels in a prototype developed with MIT and presented at Milan Design Week in 2018.

Puma x MIT

Omega for a watch band. The company recently announced a new partnership with Airbus to develop composites suitable for aerospace applications.

Based in Emeryville, California, Bolt Threads has made headlines for limited runs of its Microsilk spider silk fibre generated by biotech microorganisms. The genetically modified yeast is destroyed by heat during production. The sugar they are fed also comes from GM corn, due mostly to its abundant supply the company says.

Bolt Threads is still engaged in the research and development phase for its Microsilk fibre and promises new announcements in the near future. The company has since developed a fungi-based material known as Mylo. A bag made in the material was launched on Kickstarter and had recruited 104 backers and $34,272 of the $40,000 goal within the first seven days of the Kickstarter launch, the company's press manager confirmed.

Another innovative use of microbes has been applied by Puma, in a partnership with the Massachusetts Institute of Technology (MIT). Several prototypes were on display during Milan Design Week in 2018 that featured bio-reactive materials. The biologically-active Breathing Shoe offers personalised ventilation by "growing" its own air passageways to cool feet. Deep Learning Insoles are said to provide real-time biofeedback with organisms that measure chemical phenomena indicating fatigue or well-being. The third item, a microbially-active T-shirt, is said to respond to environmental factors by changing its appearance and informing the user on air quality.

These so-called 'white' biotechnologies appear to be able to provide cleaner manufacturing processes for the textile industry, to biofabricate materials in cell-factories and to introduce novel functions to performance apparel and shoes. What remains to be seen is whether they can be scaled up successfully to industrial levels.

JRC-REFLEX expands its color range

The retroreflective materials specialist has heeded the call of fashion by developing a new range of on-trend colours for the active sportswear and athleisure markets.

French-Italian retroreflective materials manufacturer JRC-REFLEX has recently expanded the range of available colours in a move to address the growing influence of fashion trends on sportswear and the current fascination for sports seen in fashion spheres.

The company has introduced seven new reflective colours that correspond to key trends. "As the use of reflective fabrics and trimming expands, we felt the need to offer more colours for brands that seek to target crossover fashion and sports uses", says company CEO Celine Cugerone. These new references are available in large width rolls as well as tapes and piping.



For active sports end-uses that require higher levels of breathability, JRC-REFLEX has also introduced a new stretch reflective fabric with perforations that will enhance the comfort of users.

For accessories and specifically bags, the company has developed a new mechanical stretch woven reflective fabric that features improved abrasion resistance properties. This reference comes with a 100% recycled polyester backing material.



About JRC-REFLEX: JRC-REFLEX is a manufacturer of high-quality retroreflective fabrics and trimming. Founded in 1988, the company is based in Romans, France.
Its state-of-the-art factory is located in Bergamo, Italy.
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