Sustainable dyes and fabrics created through synthetic biology promise to revolutionize fashion industry

The fashion industry is responsible for 10 percent of global carbon emissions; that is more than air and sea transport combined. When it comes to water usage, the story is bleaker: The production of clothes and footwear accounts for 20 percent of wastewater, while textile dyes-producing factories severely pollute their surroundings. Besides its environmental impact, the industry's practices have been accused to promote aggressive consumerism and work exploitation.

The complex supply chains and the popularity — and low cost — of fast fashion make this enormous issue challenging to tackle, but as consumer awareness is rising there is a demand for more environmentally friendly clothes. And the solution may be coming from the biotech field.

Dyes made out of microorganisms

Since ancient times, textile colors were hard to find and a source of significant revenues for local economies. The examples of crimson (produced in Mediterranean countries and sold around Europe) and indigo (initially produced in Peru, found in China, and through the silk road to the rest of the world) tell an interesting story.

A true revolution in the textile industry came in 1856, when William Perkin accidentally synthesized the color mauve in his lab. More dyes became available – more than 3,500 according to the Swedish Chemical Agency – and the use of petrochemicals as feedstock reduced prices and increased availability. The problem is that (often) the dye production and (almost always) the dyeing of the textiles use harsh conditions, have toxic byproducts, and consume a lot of energy and water. A paradigm shift is needed to make these processes greener, and synthetic biology may have a solution.

The original sources of dyeing pigments were plants and insects. The dyes were costly because the supply is limited and often geographically constrained. But synthetic biology allows the transfer of metabolic pathways and protein production from one organism to another. It is therefore possible to engineer easy-to-grow bacteria and yeasts to produce textile colorants.

Researchers from Joint BioEnergy Institute in Berkeley, CA, demonstrated how modified fungi can produce the pigment indigoidine. And Tinctorium Bio, an American startup, is using bacterially derived indican, a chemical precursor to indigo, to dye jeans in an environmentally friendly manner.

In Europe, there are two promising startups in the field. Pili bio was born in a biohacker space in Paris. The company grew, managed to raise significant funding, and now manufactures dyes and pigments using enzymes. Colorifix is located in Norwich, UK. The company uses microbes to color textiles in a process that takes place in body temperature and wastes minimal water. And as it uses agricultural byproducts to feed the bacteria and fungi, the company avoids consuming valuable agricultural resources and reduces the costs.

Related video: The future of fashion – colors

New materials

Pigments and dying is one part of the problem. The elephant in the room is the textiles themselves. Plant fibers (mostly cotton) used for clothes have a non-negligible carbon footprint. Growing them uses land that could otherwise feed an ever-growing human population and consumes a lot of water. Synthetic fibers derived from fossil fuels and are major contributors to the microplastics problem. We need to find and use a material that is durable, easy to handle, biodegradable, and obtainable in an environmentally friendly

way. Nature has invented such a material, and is used by our eight-legged friends.

Spider silk is a fiber made primarily out of proteins. It has impressive mechanical properties (stronger than steel and tougher than Kevlar), so it has rightfully attracted attention as a potential biomaterial in several industries. As you can imagine, harvesting silk from actual spiders is not a sustainable business. But transferring the spider genes into a microbe and optimizing the strain for silk production can work.

There are two notable players in the field that are close to launching products to the market. Spiber is a Japanese startup that aims to make the use of protein fibers as common as petrochemical-based ones. The company highlights its sustainability focus, and has presented an outdoor jacket made from microbe-derived silk. Their aim is to reduce the cost of producing spider silk to levels similar to synthetic fibers. Bolt Threads produces spider silk in yeast. The company focuses on enhancing currently used material with its fiber, giving new properties and improving quality. Their partnership with Stella McCartney retailer has their material featured in a collection, with more clothes to come.

Related video: The future of fashion – bolt threads

However, designers and researchers try to see beyond spider silk. In a recent exhibition in London, I had the chance to see a display of innovative ideas – including trainers made out of bacterial cellulose! Nature is full of inspiration, and recombining building blocks in new organism can result in novel designs; who would have thought that algae-made fibers can be fire resistant?

Biotech clothing for the future?

If the technology is there and since the sustainability problem is pressing, why can’t we find biotech clothes in our local retailer? The main reason is cost. Synthetic biology-made textiles are currently too expensive, and it is up to the companies to bring the cost down. I am optimistic that we may get there in a few years, especially if consumers push retailers towards that direction.

We should also keep in mind that biotech clothing is not waste-free and carbon neutral. Fermentation uses sugar from plants grown in arable land, sugar that is diverted from the global food supply. And biotech cannot tackle all of fashion industry’s issues on its own, especially the ones touching upon social factors, supply chains and consumer behavior. However, biotech textiles can significantly reduce pollution during production and disposal, while provide more varied consumer choices. Synthetic biology can provide pharmaceuticals, nutrition supplements, healthier food, and even biological data storage. Why not offer us better clothes too?

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