Are Microbes the Future of Fashion?

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Microbiology has played a huge part in the evolution of textiles and is by no means a new phenomenon in the field.

Research published in the Textile Research Journal in the early 20th century revealed the presence of mould fungi and mildew prevalent in sheep fleece which caused deterioration of strength and dyeing properties in the wool fibre. The soil organism, *Actinomyces dermatonomus* caused the condition 'lumpy wool' making the wool fibres impossible to process. Bacteria such as *Pseudomonas fluorescens* were also held responsible for the discolouration of fleeces.

Research on cotton fibre revealed similar findings. Fungi types such as *Alternaria, Cladosporium herbarium* and *Fusarium* were isolated on cotton plants that were deemed 'weathered'. The general conclusions drawn were that the moulds and bacteria found in the fibre were capable of causing discolouration at best, and major structural damage at worst.

In an attempt to counteract this bacterial damage, developments were made not only in chemicals sprayed onto crops and animals during the growth cycles, but also in the additives used in the processing of the fibres after harvest. All of these chemicals had the sole purpose of removing any offending microbial activity to prevent attack and damage and promote higher growth yields.

Even textiles discovered as part of archaeological finds have been exposed to microbial attack in the soil which cause deterioration in terms of discolouration (either due to pigment producing bacteria or changes in the pH which affect the dyes on the fabric), loss of strength and odours. This is despite many of the natural dyes used in these textiles exhibiting antimicrobial properties. Once retrieved from their historical hiding places, textiles preserved as museum pieces need to be stored carefully as airborne microorganisms can continue to attack these delicate pieces given the correct atmospheric conditions.

Whilst in terms of growth and preservation bacteria has been seen as the enemy of the textile industry, some manufacturing processes have found microbes to be beneficial.

Dyeing and finishing has always been an important part of the textile production process, with natural dyes and finishes remaining popular even with the development of their synthetic counterparts. Denim has been the most famous – with a 'true' denim product being that which is 100% cotton and dyed with natural indigo dyes. However, denim products are also famous for their varied finishing effects such as sandblasting and stone washing. Traditional techniques, using sand and stone are deemed extremely hazardous to operatives and are not promoted in the modern textile production environment. However, cellulase enzymes have been used as an acceptable and effective replacement for finishing techniques where an aged look is required.

Sustainability and eco-friendliness are terms that are ever present in modern life. The fact that the textile industry is becoming increasingly under scrutiny is hardly surprising given some of the practices mentioned above. Figures published in 2015 suggest global consumption of apparel fabrics was 400 billion m^2. This production consumed 7.5 trillion litres of water, 1074 billion kWh of electricity and emitted 537 billion kg CO_2 (equivalent) in air pollution. Added to this, 20% of fabric production was deemed waste before ever leaving the manufacturing plant and 75% of manufactured garments will be disposed of in landfill. The industry still relies heavily on oil based fibres such as polyester and nylon and it is difficult to even contemplate life without Lycra®.

Yet all this leads to a dilemma – whilst there is no denying that recent developments in man-made fibres and recycling processes have revolutionised the textile industry, is this rate of production - and of waste - really acceptable or sustainable?

It is therefore interesting that the next phase of the textile story is starting to see the reintroduction of microbes, once seen as the enemy.

In order to recycle waste there have been many reprocessing initiatives involving synthetic fibres. However, researchers at Kyoto university have adopted a completely different approach. They have isolated the bacteria *Ideonella sakaiensis,* a microbe that eats plastic, or more specifically PET (poly(ethylene terephthalate)), a synthetic fibre commonly found in clothing. The suggestion is that this newly discovered bacterial strain has evolved and mutated over time in effluent outlets near the fibre manufacturing plants, enabling it to make use of the polymer food source. This is an exciting discovery as the potential of microbes 'eating' synthetic fibre that would once sit in landfill could solve a growing problem for the textile industry.

The idea that microbes can work harmoniously alongside traditional fabrics is one explored by the bioLogic project. This project examined the idea of microbes working alongside sportswear fabrics to modify properties and enhance wearer comfort. The collaboration between the Royal College of Art, MIT & New Balance uses a bioprinter to deposit a bio-hybrid film containing *Bacillus Subtilis Natto* bacteria. These bacterial cells have been found to expand and contract according atmospheric moisture levels. The printed fabric behaves as a 'second skin' as illustrated by applications showcased in sports garments. The garments have the ability to sense when the body is becoming warmer through increased perspiration production. The behaviour of the bacteria due to this increase in moisture level activates ventilation zones within the garment, engineered at points to be most effective to allow perspiration evaporation. As the body cools, perspiration reduces, moisture levels drop and the bacteria contract, causing the ventilation zones to close allowing the wearer to keep warm. Garments such as these can truly be deemed 'responsive apparel'.

Perhaps the most exciting development is the actual creation of fabric for clothing using bacteria. One of the pioneers in this field is Suzanne Lee, the founder of Biocouture. Suzanne's aim was to look at how microorganisms might grow into suitable textile materials, to move the industry away from the use of petrochemicals and plant materials. Her initial focus was on fashion, but the ultimate goal is to develop fabrics relevant to all aspects of the textile industry.

Her initial interest focused around Kombucha, a symbiotic culture of bacteria and yeasts. Kombucha has traditionally been used to brew tea and as a drink purports health giving and detoxifying effects (the jury is out in terms of research evidencing this). However, using Kombucha as a starter culture, supported in a growth media of green tea and sugar, nano cellulosic fibres are produced through the fermentation process forming a dense layer on the surface of the liquid. This layer, once removed and dried, resembles the texture of fine animal leather – gaining the name ‘vegetable leather’. The active microbe that is attributed to the production of the nanocellulosic mat is *Gluconacetobacter xylinum.* Current research at Manchester Metropolitan University is ongoing to assess the most effective growth mechanisms and conditions that can engineer specific properties of the ‘vegetable leather’ and make this fabric a natural, effective alternative to synthetic technical textiles. The initial experimentation demonstrated a fabric that can be grown to shape (therefore no waste) in completely natural media, is flexible, can be stitched or form self-adhesive seams and can be composted at the end of its useful life. However, one major drawback is high levels of hygroscopicity and unsolicited decay over time.

The application of bacterial species in colouration and finishing of textiles has also been explored. In a project led by Dutch designer Jelte van Abbema alternative printing inks such as those made from soya or natural plant pigments were challenged by using a selection of bacteria to ‘grow’ the prints. Traditional textile printing techniques such as screen and block prints were still used, but various bacterial species (such as *Escherichia coli*) were deposited onto the fabric. The result was a ‘living’ print which developed, changed colour and died over time. This may not currently have a place in clothing, but is been used widely as an art form and has been picked up as a useful marketing tool.

Another project, this time at Central Saint Martins, by Amy Congdon, looked at the concept of bio ink jet printing (also known as rapid cell modelling). In the medical field this idea is being explored as a method of printing replacement organs. However, Amy suggested this idea could be used to ‘grow your own fashion’ through her project the Biological Atelier. This project raised questions regarding the potential impacts of biotechnology in fashion. Could we grow victimless ivory? A cross species fur? A hybrid material for a specialist end use? Do these materials need to have a ‘use’ or could they be grown purely for the aesthetic? This project was truly a case of biotechnology engineering meeting high fashion.

The use of microbes in the textile industry is becoming more widespread and researchers are increasingly adopting novel approaches to their use. Whilst this presents exciting research opportunities, there is some concern being voiced with using microorganisms of which we know relatively little. Is the modification of these microbes to suit our own purposes an area in which we truly understand the potential future impacts on the planet?

Further reading

Myers, W. (2012). *Biodesign: Nature, Science, Creativity*. Thames & Hudson: London.

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