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A Review on Genetically Modified Fibres: A Biosystem Perspective

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ABSTRACT

The technological advancements that are predicted for the 21st century will be expensive and have a significant impact on the world of fibres, fabrics, and textiles. In the twenty-first century, textiles won't just offer the best functional qualities of both natural and synthetic fibres; they'll also be highly engineered systems designed to offer complex functionalities for technical applications. Fibre engineering and materials science will be the two key technologies guiding the development of these next-generation textile systems.To create new varieties of textile fibres, genetic engineering techniques are being researched. Genetic engineering is used in contemporary science to directly alter DNA molecule strength.This review paper discusses a review of the application of genetic engineering to textiles with reference to improvements in natural fibres, novel new biodegradable fibres and polymers, new industrial processes, and renewable raw materials.Most techniques are not yet commercialised, but progress has been swift when there is a clear economic justification and market for a particular product or process.Thus, it is anticipated that in the future, several genetic engineering techniques will contribute to resolving the environmental issues brought on by the textile sector.

Keywords: Genetic engineering, DNA, Textiles, Contemporary science,

INTRODUCTION

Synthetic Biology is where science and engineering are entwined.It applies an engineering and computing mindset to biology and it is the creation or modification of a subject's DNA in order to enhance/create more of its abilities and characteristics. Synthetic biologists generally design a portion of DNA and combine it with an existing cell or organismso that the new cell or organism behaves according to design specifications.One characteristic that distinguishes the synthetic biology of today from the molecular biology of years past is the significant role played by standardized parts, computers, and automation, accelerating a trend prevalent throughout biotechnology(**Baldwin*et al.,* 2016).**The Synthetic Biologist tries to make an artificial biologic element (enzyme, piece of DNA etc.) in his lab. Whereas the Biotechnologist tries to isolate the biological element in its natural form without modifying it**(Benyus, 2017)**.

Areas of Synthetic Biology

Scientists working on synthetic biology projects use approaches from disciplines such asBiotechnology (a broad area of biology involving living systems and organisms to develop or make products), Molecular biology(a branch of biology that deals with the structure and function of the macromolecules(e.g., proteins and nucleic acids) essential to life), Chemical engineering (a branch of engineering that uses principles of chemistry, physics, mathematics, biology, etc. to design materials) and Genetic engineering(Direct manipulation of DNA to alter an organism's characteristics in a particular way).

Dreams comes true with Genetic engineering in textile

Genetic engineering simply entails copying a portion of DNA from one organism and fusing it with the DNA of another. In the second part of the 20th century, we discovered how to extract genes from nearly any living thing and use them to modify organisms like plants, animals, and even humans.A gene is a section of DNA or deoxyribonucleic acid, that is involved in the synthesis of a polypeptide chain. It includes sections before and after the coding region as well as in-between-coding-segment intervening sequences.In contrast to the transfer of several genes by conventional breeding, genetic modification (or GM) only allows the transfer of a restricted number of genes whose function is typically known. the animal. The term "transgenic organism" refers to a plant or other organism that has had genes added using GM technology.

Contrary to traditional breeding, genetic modification (GM) enables the introduction of novel features into major crops like cotton or animals like sheep and goats. These novel genes can give natural fibres desirable properties like colouration, obviating the requirement for dyeing. They can increase resistance to particular insect pests and herbicides and lower the need for fertilisers.In addition, GM provides a chance for the commercial manufacture of entirely new fibres or fibres that have never before been suited to large-scale production (e.g., spider silk). This review discusses how genetic engineering can be used to improve natural fibres, create novel biodegradable fibres and polymers, develop new industrial processes, and use renewable raw materials in the textile industry.

New developments

There are already a vast number of raw materials and processes known to the textile trade. Some of the new developments mentioned in this section deal with modifications to existing materials but others are completely new and may only be at the pilot stage.

Genetic engineering-based fibre modification

Cotton is still the most common fibre with up to 20 million tonnes used each year, or 46% of all fibre used globally, it would be ideal to be able to grow high-quality cotton without having to deal with pest control issues and climatic changes, without having to bleach and scour the cotton to achieve a base colour suitable for dyeing, and without having to create fabrics with improved thermal properties and reduced shrinkage after washing**(Apodaca,1993)**. Because cotton consumes 10% of the world's pesticides, 22% of its insecticides, and 7.5% of its chemical fertilisers despite only growing on 3% of the world's agricultural acreage.

In order to realise some of these goals, genetic engineering is currently being employed to transfer genes from sources including bacteria, fungus, and mammals into cotton plants. Through cooperative research, the American Textile Partnership (AMTEX) seeks to increase the competitiveness of the US textile industry. The performance of cotton fibre and plant yield is being improved by cotton genetic modification. Research includes identifying the genes that influence the characteristics of the fibre, establishing molecular markers that may be used to breed cotton, and creating a database to store and organise this data**(Cegarra, 1996)**. They have so far been able to accelerate plant breeding and pinpoint the beginning of cotton fibres (G. Jividen, personal communication).

An enormous amount of interest is being shown worldwide in organic cotton as well. Danish-based Novotex A/S is one business that is currently investing its entire workforce in the production and sale of cotton that is truly eco-friendly. The company claims to be able to prove environmental sensitivity throughout all of its procedures under the brand name "Green Cotton." However, they do choose the processing method that will do the least harm, even though they do not guarantee pollution-free operations.

Green Cotton Organic is made from fibres of certified organic origin, the cotton is hand-picked and free from pesticide residues. Seeds collected from ginning are either resown or converted to oil and feedstuffs. Spinning, weaving/knitting and dyeing are carried out using techniques and chemicals chosen on their environmental merits, and even the waste accumulated during garment cutting is collected and reused. With high durability, Green Cotton suggest that garments should be passed down through generations and when finally worn out, recycled into other products.

One of the leaders in the development of transgenic fibres, notably cotton that has undergone genetic engineering, is Agracetus, a division of W. R. Grace. In order to create a biopolymer-like natural polyester, scientists are currently striving to introduce exogenous genes into the cotton fibre lumen. They've grown cotton satisfactorily with a total of 2% polyester added, but it's obvious that to awaken the interest of, for example, shirt manufacturers, a further 30% or so will have to be successfully introduced.

Lactron is a brand-new type of synthetic fibre made from corn fibre. Ingeo fibre is another name for it. created in Japan by kanebo gohsen. It is a polylactic acid fibre that is made from lactic acid, which is created by fermenting corn starch.

Genetically engineered animals

Genetic research on animal fibres has focused mainly on the ability of animals to survive in poor weather conditions. This is especially important where high added value materials such as cashmere and vicuna are concerned. To make sheep shearing easier, growth-inhibiting hormones are being injected at specific times during the growing season. This interrupts the normal growth of the fleece, and allows it to be almost pulled away from the animal.

The silkworm has not been ignored either. In the East, genetic engineering is being concentrated on developing strains of silkworm that will feed on something other than, the oftenelusive, mulberry leaf. Bast fibres such as flax and jute have been genetically improved to be resistant to herbicide residues in the soil, and with improved retting processes through enzymatic action, flax is likely to become an important home-grown raw material in the future. In 1997 a protocol was signed by all UK flax contractors and processors, who refused to accept flax grown on unsuitable land such as sites of archaeological, scientific or local conservation importance.Some farmers have also been granted licences to grow non-narcotic varieties of hemp in the UK.

Spiders spin a protein fibre known as "spider silk." On the back of a spider's abdomen, in the spinnerets, are glands that secrete the silk. It is an excellent material for various applications due to its biocompatibility and outstanding mechanical qualities**(Hinman, *et al.*, 1992)**. The six different types of silk and one protein-based glue produced by orb-weaving spiders is of great interest (200-350kDa)**(Widhe, 2017)**.A dragline silk's tensile strength is comparable to that of high-grade alloy steel (450–2000 MPa), and each of these silks is distinct in terms of its molecular structure, function, and mechanical characteristics**(Eisoldt, *et al.*, 2013)**.

The use of spider silk, right now, entails the possibility of using it as a remarkably robust and adaptable material. purposes not related to medicine, such as tyre linings, high-performance apparel, parachute ropes replacement ligaments, tissue scaffolds, drug delivery devices, and drug storage materials are examples of medical applications. If spider silk manufacture ever proves to be commercially successful, it will eventually replace Kevlar and be utilised to make a wide variety of products**(Winkler, 2000)**.

Production of spider silk is not simple due to its inherent problems;Spiders cannot be farmed like silkworms**(Vollrath, 2017)**. Silk produced is very fine so 400 spiders would be needed to produce only one square yard of cloth.Ex: the largest known piece of cloth made of spider silk is an 11-by-4-foot (3.4 by 1.2 m) textile with a golden tint made in Madagascarin 2009**(Lewis, 1996)**. Eighty-two people worked for four years to collect over one million golden orb spiders and extract silk from them**(Copeland, 2015)**.

In an effort to create synthetic spider silk, Dr. Randy Lawis and the Canadian biotechnology company Nexia created transgenic goats in 2000 that manufacture spider silk proteins in their milk. A high amount of protein, 1-2 grammes of silk proteins per litre of milk, was present in the goats' milk**(Richard, 2018)**. Transgenic spider silk proteins are abundantly produced by the offspring of goats. proteins, however, they are smaller than genuine proteins. has made the spinning process better**(Costas *et al.*, 2016)**.

BioSteelwas a trademark for a high-strength fibre-based material.Made by Nexia Biotechnologies in collaboration with Dr. Randy Lawis from recombinant spider silk-like protein isolated from transgenic goat milk. When compared to the same weight, it is 7–10 times stronger than steel and can be stretched up to 20 times its original size without losing its strength**(Richard, 2018)**.

In fluorescent clothing, in today's fashion sector, neon colours are highly sought after. The process of dying luminous fabric uses a lot of harmful chemicals. Japanese researchers genetically modified silkworms to produce luminous skeins, and bridal gown designer Yumi Katsura utilized the silk to make a glow-in-the-dark wedding gown**(Chung, 2012)**.

Developing the next generation of materials

A sustainable textile called microsilk is made from the same protein as a spider's web. At the end of its useful life**(Benyus, 2017)**, sustainability on a big scale has the potential to biodegrade and possesses extraordinary qualities including strong tensile strength, elasticity, durability, and softness.

Bolt thread and synthetic spider silk have attracted a lot of attention: the company has already raised well over $ 200 million in its early stages. It acquired Best made Co. in 2018, a maker of handcrafted outdoor apparel known for its colourful bespoke axes, canvas bags, and sweaters. Bolt Threads has also teamed with outdoor industry titan Patagonia and high-end fashion designer Stella McCartney. In march 2017, it launched its first commercially available product made of spider silk, which sold out almost immediately**(Benyus, 2017)**. They collaborated with (Best Made Co.) to design a limited edition iconic knit hat in February 2018 using a combination of Rambouillet wool and Microsilk fibre as well as the benefits of synthetic spider silk produced by bolt thread, such as durability. Existing products may become lighter thanks to fabrics manufactured from synthetic spider silk. It has natural qualities that increase its adaptability when used as a substitute for conventional fibres like lycra, spandex, nylon, and polyester. Because all that is required for sustainability on a big scale is yeast, sugar, and water, it is fully biodegradable. In the summer of 2017, Best Made Company purchased bolt thread.

Another artificial leather substitute is Mylo, which was created in April 2018. A supple, cosy, leather-like texture is produced by the controlled growth of mycelium, the underground root system of mushrooms. Material can be created in days as opposed to years. less harmful, biodegradable, and less waste-producing during its production process.

CONCLUSIONS

The aim of this paper has been to highlight the use of biotechnology in the textile/clothing industry through the identification of existing genetic engineering processes and consideration of new developments in this field. We are faced with a range of complex issues from depleted resources, to a changing climate, a growing population and key environmental issues. The fashion and textile industry has key problems that need to be addressed now.We cannot keep taking, polluting and wasting as much material as we currently are.Instead, we need to work towards returning this industry to a 'World-Making' one once more. Circular systems need to be adopted and ways to stop or reduce the industry's pollution through less harmful substances and/or new processes.It is clear that genetic engineering one of the areas under synthetic biology has the potential to offer solutions to current energy, healthcare and material issues, but it also brings a range of unknowns and with that fear.On the positive side, it offers the opportunity to produce existing materials more efficiently and completely new materials.On the negative side, there is a danger that engineering biology will just produce more matter with the same production, consumption and linear systems that it does today. It is unclear yet as to whether it can be a more sustainable solution.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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