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Bioengineering Textiles at All Scales for Circular Economy that is Sustainable

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Introduction

Flow material creation and handling rehearses furnish materials with positive execution properties, like stretch and dampness the executives, yet these cycles are driving supporters of worldwide ozone harming substance discharges, microplastic contamination, and poisonous wastewater. Fortunately, there are green alternatives to the current textile fibers that can help us move toward a sustainable, circular materials economy. At the nano, micro, and macroscales, bioengineering of fibers opens up numerous opportunities to enhance the technical performance and impact on the environment of textile materials. From biopolymer components to biofabrication strategies, we discuss recent efforts to bioengineer textiles and fibers. Green manufacturing methods, green chemistry processing of raw materials, and genetic engineering of microorganisms for biofabrication are among these. A discussion of the prospects for sustainable biotextile production in the future is informed by this overview, which focuses on the utilization of waste streams to enhance the processes' circularity and commercial viability. Material biofabrication will be crucial in facilitating the switch from a linear economy that is harmful to the environment to a cradle-to-cradle circular economy [1].

Description

The central premise of a circular economy is that infinitely reusing our materials can make industrialization compatible with sustainable development and climate stability. It uses ecologically benign processes to close and minimize material and energy loops. Adopting circular economy strategies, such as closed-loop chemical recycling of synthetic polymers to monomers and programmed biodegradation, for instance, can lessen plastic's significant environmental impact. Currently, new polymeric materials are being developed with appropriate mechanical properties that can be easily degraded in the environment, repurposed for new uses, or completely recycled back to monomer. Since the production of both synthetic and natural textiles has a significant impact on the environment and climate, bio-based strategies for designing biodegradable materials with low carbon footprints are becoming increasingly popular in the textile industry [2].

A variety of nonrenewable and nonrecyclable resources as well as petrochemicals are used to create synthetic textile fibers like nylon and elastane.In parallel, non-sustainable industrial agricultural practices are used to produce natural fibers like cotton and degradable polymer fibers like polylactic acid, which is made from ethanol derived from corn. The tanning, dyeing, and finishing agents used to produce the aesthetic and performance properties of textiles create a linear process that is chemical, water, and energy intensive in addition to the production of raw fiber. For instance, the current textile industry accounts for 20% of global waste water and 10% of global carbon emissions. Importantly, the production of some synthetic fibers results in the formation of microplastics, and it is estimated that the textile industry is responsible for 35% of marine microplastic pollution. Because microplastics have been shown to disrupt endocrine signaling, accumulate throughout the food web, and have been found in the intestinal tracts of marine mammals, humans, and most recently, human placentas, this microplastic pollution is especially harmful. In addition, indigenous communities, people of color, the elderly, women, and children are disproportionately affected by the linear economy's climate effects, which include significant disruptions or decreases in biodiversity and access to fresh water. Human rights and social justice are severely impacted by these effects, as is access to education, which is essential to global sustainable development. The United Nations' Sustainable Development Goals (SDGs) include access to clean water and sanitation (SDG 6), responsible consumption and production (SDG 12), and climate action (SDG 13) if the textile industry's climate impacts are addressed [3].

The dominant cradle-to-grave linear economy dumps the equivalent of a truckload of clothing every second, leaching toxic dyes, plasticizers, and finishing agents into groundwater and releasing potent greenhouse gases into the atmosphere despite the significant manufacturing impacts of textiles. A circular economy, on the other hand, integrates industrial production with end-of-life reintegration of materials through complete recycling or natural biodegradation. As a result, healthy soil is produced, which acts as an important climate regulator, and it has the potential to mitigate 23.8 Gt of CO2-equivalent per year worldwide. As a result, new manufacturing techniques that not only produce high-performance textiles with the necessary strength, ductility, and moisture management but are also biodegradable and non-toxic to the environment's microorganisms are urgently needed. Through custom-designed organisms and bio inspired processes, synthetic biology and biofabrication have the potential to directly transform industrial by products and side streams into high-value materials with numerous applications. Bio-utilization of rapidly renewable biopolymers, like fungal mycelium, can be used to create alternative leathers and fabrics, and genetically modified microbes can produce collagen fibers for leather biofabrication [4,5].

Conclusion

In addition, numerous biofabrication technologies, such as green electrospinning and 3D printing, in conjunction with microbial fermentation present significant opportunities for biotextiles with a closed-loop life cycle and minimal waste during production. Importantly, it is anticipated that biofabrication processes and biomaterial products will be able to reduce greenhouse gas emissions by 1 to 2.5 billion tons annually by 2030. If bioengineering is used to disrupt conventional textile manufacturing, which currently accounts for 25% of the global carbon budget by 2050, greater climate change offsets may be achieved. Research into more environmentally friendly, bio-based textiles has been sparked by the enormous environmental impact of conventional textile manufacturing and the potential to engineer a variety of materials through biofabrication with the potential to accelerate a paradigm shift to a circular materials economy, we present nano, micro, and macroscale bioengineering strategies for the sustainable production of textile fibers. These strategies have broad application across sectors, including fashion, biomedical, and industrial applications.

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