Latest Trends in Textile and Fashion Designing
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Mini Review

Biomaterials and the Textile Industry

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Abstract

Textile manufacturing is currently one of the most polluting industries in the world due to the use of hazardous chemicals, the consumption of energy and water, and the generation of waste. Because of the significant contamination of our ecosystem, research efforts have shifted to environmentally friendly green alternatives. This paper provides an overview of recent literature studies involving the use of biomaterials to improve the sustainability of the textile industry.

Impact of the Textile Industry on our Ecosystem

Textile based materials have numerous applications, involving not only commercial and industrial fields, but also everyday life products. Synthetic fibers account for more than 60% of global consumption of natural and man-made fibers, followed by cotton, cellulosic, and wool [1]. The growing human population, as well as rapid economic growth, continuous urbanization, and lifestyle changes, are thought to be driving up demand for textile products. Textile manufacturing is rapidly expanding in response to fashion, style, and marketing demands, as well as increasingly competitive technical challenges. On the other hand, the prospect of innovation and development stands in stark contrast to the highly polluting impact of this industrial activity on the environment. Because of the involvement of significant amounts of harmful and toxic chemicals, as well as the release of pollutants during the lifecycle of a textile product, the textile industry poses a serious threat to freshwater and the atmosphere. High energy consumption, heavy transportation, and an abundance of packing material are all potential sources of contamination. Finally, as a result of the massive waste generation, the issue of disposing of large solid volumes has arisen [2,3]. The main disadvantage of such large employments of textile products is the difficulty of properly disposing at the end of their life cycle, as well as the resulting accumulation in nature [4]. Another factor to consider is sewage that has been contaminated with synthetic fibers from laundry, which appears to be a significant source of microplastics. Plastic fragments, as small as microns, have recently been identified as a new dangerous source of marine pollution. Microplastics are invisible and not biodegrade in the oceans, posing a problem because they can be consumed by plankton or other marine organisms and potentially enter the food chain [5]. Then, at the end of the life cycle, millions of tons of CO_2 will be emitted into the atmosphere as a result of both the manufacturing processes and final incineration [6]. Massive greenhouse gas emissions, such as CO_2, exacerbated another aspect of global warming by causing dramatic and irreversible weather changes. Based on current trends, it is possible to forecast an increase in CO_2 concentrations from 390 to 450 ppm, as well as 1.5°C increase in ambient temperature over the next 20–40 years [6].

Uses of Biomaterials in Textiles

Bio-based materials, which are composed of organic constituents derived from renewable resources and endowed with specific structural and functional properties such as biodegradability, composability, or biocompatibility [7], may represent a viable alternative to conventional plastics used in fabric and yarn production (primarily polyester (PET), polyamide (PA), and polypropylene (PP)) (Figure 1).They can be divided into three classes:

a) Biodegradable and derived from non-renewable sources, such as fossil-derived monomers (polycaprolactone (PCL), Poly (butylene-adipate-co-terephthalate) (PBAT), Poly(butylene succinate) (PBS), Poly(glycolic acid) (PGA)

b) Durable and derived from renewable sources (Bio-Polypropylene (Bio-PP), Bio-Polyester (Bio-PET), Bio-Polyethylene (Bio-PE), Bio-Polyamide (Bio-PA))

c) Biodegradable and derived from natural sources such as microorganism (Polyhydroxyalkanoates (PHA), Poly(3-hydroxybutyrate-co-3-hydroxyvalerate)(PHBV)), bio-monomers (polylactide acid (PLA)), or biomass (Starch, Chitosan, Lignocellulosic, etc.) [8,9].

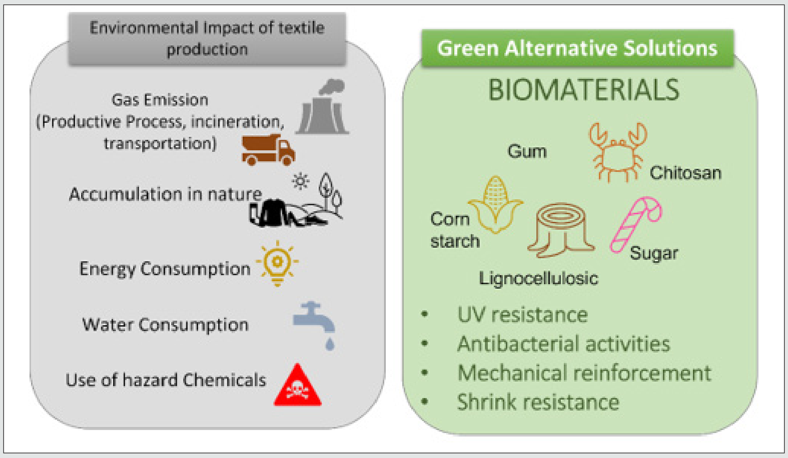

Figure 1: Main environmental issues of textile production and positive perspectives through biomaterials application.

In this framework, eco-friendly bio-based alternatives have been proposed to reduce the environmental impact of textile production. Same examples are reported in following. The antibacterial properties of PHBV filaments have been tested in textile fabrics made from poly (hydroxybutyrate-co-hydroxy valerate)/polylactide acid (PHBV/PLA) blend with natural cotton fibers. The antimicrobial properties of knitted fabrics have been studied in terms of blend yarns, fabric structures, and fiber distributions [10]. Kanakannavar et al. [11] demonstrated the reinforcement effect of 3D braided flax yarns interlaced to create a plain-woven fabric and then combined to PLA polymer to prepare the constituent sheet for laminate composites. The pad-dry-cure technique was used to coat three polysaccharide biopolymers (chitosan, wheat starch, and gum arabic) onto wool fabric after it had been treated with laccase and protease enzymes. Characterization based on microscopy and IR spectroscopy, as well as tensile, frictional, and bending analysis, were performed on the developed samples. The combination of treatments kept the wool fabric white while reducing its yellowness. The result obtained in the presence of chitosan treatment was found to reduce the shrinkage of the wool fabric [12]. The advantages of viscose fibers include biodegradability, excellent air permeability, non-toxicity, low cost, and environmental benefits, with the main disadvantage being their high flammability. Alginate fibers were added to viscose yarns to address this shortcoming. The flame retardancy of developed nonwoven fabrics was improved by lowering flammable gas emissions and smoke release [13]. Silk was made luminescent by chemically coating the surface of natural fibers with luminescent gold nanoclusters (AuNCs). Immersion in an alkaline aqueous solution containing hydrogen tetrachloroaurate (III) hydrate ($HAuCl_4$) resulted in the synthesis via a redox reaction between the protein-based silk and an Au salt precursor. Good optical properties, such as relatively long wavelength emission, high quantum yields, a long fluorescent lifetime and photostability, mechanical properties superior to pristine silk, and low in vitro toxicity, have been demonstrated, making the material suitable for use in the counterfeiting sector in particular [14]. Natural pigments derived from the cooking of commercial white corn kernels were used to improve the UV radiation protection of common textiles. Maceration and microwave oven assisted extraction were used to extract these natural pigments from the samples. Textiles treated with bio-based additives had a higher optical absorption coefficient and a wider optical penetration length band than textiles treated with a chemical anti-UV agent. This demonstrated that natural additives provided adequate UV resistance [15].

Conclusion

In conclusion, different studies have been reported that demonstrated the use of bio-polymers in various areas of the textile industry to impart efficiently specific functional characteristics to final textile products, such as mechanical resistance, antibacterial protection, UV radiation resistance, and shrink resistance.

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