

# Sustainable Bio-based Textiles: Progress and Potential

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## Introduction

The current landscape of sustainable bio-based textiles is undergoing significant review, highlighting their ongoing development and promising future potential [1]. These efforts delve into various types of bio-based fibers, their processing methods, and the notable environmental benefits they offer when compared to conventional synthetic materials [1]. Innovation in material science and textile engineering stands crucial for overcoming challenges in performance and cost, which is key to broader industry adoption [1].

Research also examines diverse bio-based fibers specifically tailored for textile applications, detailing their unique properties, advantages, and limitations [2]. This includes an exploration of natural fibers such as cotton, hemp, and flax, along with regenerated cellulosic fibers and synthetic bio-based polymers [2]. These materials play a vital role in creating more environmentally friendly textiles, pointing towards important future research directions [2].

A comprehensive overview further details bio-based fibers and their specific uses within technical textiles [3]. This involves a deep dive into the wide array of natural fibers and their processing techniques [3]. It shows how these fibers contribute to developing high-performance, sustainable materials suitable for various industrial and specialized applications, ranging from automotive sectors to medical fields [3].

Recent advancements are also bringing sustainable bio-based materials into functional textiles [4]. Innovative approaches are enhancing properties like breathability, antimicrobial activity, and water repellency through the use of natural resources [4]. These materials prove capable of meeting the rigorous demands of advanced textile applications while concurrently reducing environmental impact [4].

Significant work explores the development of bio-based polymer blends and composites for sustainable textile applications [5]. This research encompasses various bio-polymers and their modification techniques [5]. It shows how these are combined with natural fibers to produce materials with improved mechanical, thermal, and barrier properties, presenting a greener alternative to traditional synthetic composites [5].

Emerging plant-based fiber reinforced composites are also being thoroughly reviewed for their potential in sustainable applications, particularly in textiles [6]. This review outlines various natural fibers, matrix materials, and manufacturing processes [6]. It highlights their environmental advantages and performance characteristics, making them suitable for diverse industrial uses [6].

Discussions extend to bio-based and biodegradable polymers as green alternatives for sustainable textile production [7]. The properties and applications of these eco-friendly polymers are examined, underscoring their importance in reducing environmental pollution [7]. They also promote a circular economy within the textile

industry by providing sustainable end-of-life options [7].

The focus also falls on developing novel bio-based and sustainable textile materials through advanced technologies [8]. This area explores innovative techniques for fiber extraction, modification, and fabrication [8]. Such advancements aim to produce textiles with enhanced functionalities and smaller ecological footprints, aligning with principles of green manufacturing [8].

Sustainable bio-based materials designed for advanced textile applications are undergoing comprehensive review [9]. This includes the current state of research and development in natural and regenerated cellulosic fibers, as well as bio-derived synthetic polymers [9]. These materials offer significant potential to replace conventional materials in high-performance textiles and contribute to a more circular economy [9].

Finally, advances in developing environmentally friendly bio-based composites for textile applications are also being explored [10]. Here, natural fibers and bio-derived resins are engineered to create materials that are not only sustainable but also possess enhanced mechanical properties and functionalities [10]. This work addresses the increasing demand for green alternatives within the textile industry [10].

## Description

The shift towards sustainable textile production is a central theme across recent research. A comprehensive review highlights the current landscape of sustainable bio-based textiles, focusing on their development and future potential [1]. This includes a detailed look at various bio-based fiber types, their processing methods, and the crucial environmental benefits they offer compared to traditional synthetic materials [1]. Significantly, innovation in material science and textile engineering is seen as essential for overcoming existing challenges in both performance and cost, which is vital for widespread industrial adoption [1]. The drive for environmentally friendly textiles is pushing for new insights and future research directions [2].

Various studies delve into specific bio-based fibers and their suitability for textile applications, outlining their unique properties, advantages, and limitations [2]. This involves a detailed examination of natural fibers, such as cotton, hemp, and flax, along with regenerated cellulosic fibers and synthetic bio-based polymers [2]. A deeper understanding reveals their contribution to high-performance, sustainable materials for diverse industrial and specialized applications, from automotive to medical sectors [3]. These fibers are not just alternatives; they are engineered components contributing to advanced technical textiles [3]. Furthermore, the exploration of emerging plant-based fiber reinforced composites demonstrates

their potential for sustainable uses, particularly in textile applications [6]. This involves detailing various natural fibers, matrix materials, and manufacturing processes, emphasizing their environmental advantages and performance characteristics suitable for diverse industrial uses [6].

Recent advancements are significantly impacting the creation of sustainable bio-based materials for functional textiles [4]. These innovations prioritize enhancing properties like breathability, antimicrobial activity, and water repellency, all while utilizing natural resources [4]. These materials are designed to meet the demanding requirements of advanced textile applications and reduce environmental impact [4]. The development of bio-based polymer blends and composites is also a key area for sustainable textile applications [5]. This involves exploring various bio-polymers and their modification techniques, combined with natural fibers, to produce materials with improved mechanical, thermal, and barrier properties [5]. These represent greener alternatives to conventional synthetic composites, showing promise for a more sustainable industry [5].

Discussions also center on bio-based and biodegradable polymers as viable green alternatives for sustainable textile production [7]. Researchers examine the properties and applications of these eco-friendly polymers, underscoring their role in reducing environmental pollution and fostering a circular economy within the textile industry through sustainable end-of-life options [7]. Novel bio-based and sustainable textile materials are continuously being developed using advanced technologies [8]. This includes innovative techniques in fiber extraction, modification, and fabrication, all aimed at creating textiles with enhanced functionalities and reduced ecological footprints, aligning perfectly with green manufacturing principles [8]. These efforts contribute to a circular economy by providing sustainable end-of-life options for textiles [7, 9].

The current state of research and development for sustainable bio-based materials specifically for advanced textile applications is robust [9]. This encompasses natural and regenerated cellulosic fibers, as well as bio-derived synthetic polymers, all highlighting their capacity to replace conventional materials in high-performance textiles [9]. Progress in environmentally friendly bio-based composites for textile applications further exemplifies this trend [10]. Natural fibers and bio-derived resins are engineered to create materials that are not only sustainable but also possess enhanced mechanical properties and functionalities, directly addressing the growing demand for green alternatives in the textile industry [10]. The collective research underscores a powerful movement towards more sustainable and functional textiles derived from renewable resources, ensuring a significant positive impact on global environmental efforts.

## Conclusion

The presented research collectively examines the rapidly evolving field of sustainable bio-based textiles and materials. It thoroughly reviews the current landscape, highlighting the development and future potential of various bio-based fibers, materials, and composites [1, 2, 9]. Key discussions revolve around diverse natural fibers like cotton, hemp, and flax, alongside regenerated cellulosic and synthetic bio-based polymers, exploring their properties, processing methods, and environmental benefits over conventional synthetics [1, 2, 3].

Significant advancements are noted in creating functional textiles with enhanced properties such as breathability, antimicrobial activity, and water repellency, utilizing natural resources [4]. The development of bio-based polymer blends and composites, combined with natural fibers, is crucial for achieving improved mechanical, thermal, and barrier properties, offering greener alternatives to traditional synthetic options [5, 6]. Furthermore, the role of bio-based and biodegradable polymers as green alternatives for sustainable textile production is emphasized, promoting a circular economy and reducing environmental pollution through sus-

tainable end-of-life options [7, 9].

Innovation in material science and advanced technologies for fiber extraction, modification, and fabrication are essential for developing novel bio-based textiles with enhanced functionalities and reduced ecological footprints [1, 8]. The collective insights underscore a strong commitment to replacing conventional materials in high-performance and technical textiles, addressing the growing demand for environmentally friendly solutions across various industrial and specialized applications [3, 9, 10]. This body of work points to a future where sustainable materials are at the forefront of textile innovation.

## Acknowledgement

None.

## Conflict of Interest

None.

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**How to cite this article:** Torres, Isabella. "Sustainable Bio-based Textiles: Progress and Potential." *J Textile Sci Eng* 15 (2025):635.

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**Received:** 02-Jan-2025, Manuscript No. jtese-25-172779; **Editor assigned:** 06-Jan-2025, PreQC No. P-172779; **Reviewed:** 20-Jan-2025, QC No. Q-172779; **Revised:** 23-Jan-2025, Manuscript No. R-172779; **Published:** 30-Jan-2025, DOI: 10.37421/2165-8064.2025.15.635

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