ISSN: 2641-192X

DOI: 10.33552/JTSFT.2019.04.000580

Journal of
Textile Science & Fashion Technology

Iris Publishers

Mini Review

Brief Overview of Developments in BC-Based Biosynthesized Nano-Fabrics Production: Challenges and Future Perspectives

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Received Date: November 08, 2019

Published Date: November 14, 2019

Abstract

Apparel industry is infamous for causing water pollution, carbon dioxide emissions, soil erosion and huge waste generation. There is a need to find novel, sustainable and green manufacturing methods, which are cost effective and production efficient. In this regard, this mini-review discusses the recently reported techniques to biosynthesize BC and BC-based hybrid fabrics which can ecologically affect the textiles industry and the environment.

Keywords: Bacterial cellulose; Nano-fabrics; In-situ fermentation; Biosynthesis

Abbreviations: BC: Bacterial Cellulose; H-Bonding: Hydrogen Bonding

Introduction

Fashion trends are rapidly changing and consumers' demand for affordable apparel is rising. Traditional textiles production process involves several stages and growing production has raised various environmental concerns, including the enormous amounts of harmful processing wastes produced, landfill consumption, carbon dioxide emissions, air/water pollution and so on [1-5]. Hence eco-friendly biomaterials [6-8] and green production techniques are being actively sought after [9-12]. Nature has the best sustainability model as it creates no harmful wastes and natural biomaterials like polysaccharides, cellulose, chitosan etc. [13-16], are sustainable resources which have biocompatible, biodegradable, and hazard-free features. Bacterial cellulose (BC) is a promising biodegradable natural polymer, possessing high modulus and strength [17,18], secreted by Acetobacterxylinum through a hierarchical cell-directed self-assembly process [19]. BC is harmless to humans and the environment and free of impurities, such as lignin and hemicellulose. Its unique physical characteristics and cultivation properties have demonstrated a great potential to achieve zero-waste design for apparels (20). BC based fabrics are highly porous, biocompatible, with exceptional environmental biodegradability and can be easily customized for size, shape, and thickness [21-23].

Recent research works have reported innovative ways to produce BC-based fabrics by using natural renewable resources and techniques, instead of using conventional manufacturing methods. Hence apparel production can be redefined for cost effectiveness, labor friendliness, low environmental impact, and biodegradability [12]. Shape and dimensions of cultivation containers are the factors which limit the customized growth of BC at air-liquid interface. Genetically modified bacteria have been successfully grown on three dimensional templates to produce seamless fabrics. Such biological fabrication technique will eradicate a considerable amount of material wastage at various production stages and enhance the overall process efficiency [24]. Cultivation of bacterial cellulose in form of sheets has also been reported, in order to make clothing through traditional cut-and-sewn method. Production of self-grown seamless 3D BC fabrics was also realized, to prepare tailor-shaped clothing based on zero-waste design [20]. Other studies analyzed the bleaching and dyeing of BC with help of direct and reactive dyes, by using in-situ and ex-situ approaches [25,26].

However, BC alone lacks the durability required for everyday use, considering sustainable apparel applications [27-30]. Hybrid fabrics can be produced by incorporating other materials of interest (natural fibers, polymers, nano-fillers etc.) during BC fermentation. Numerous hydroxyl groups present on the surfaces of hydrophilic substrates and BC result into strong interaction (H-bonding) between the components combined [31-34]. Several recent studies report the localized growth of BC nanofibers on electrospun membrane support, to form a nano-fabric structure [35-39]. Seamless tubular hybrid fabrics were prepared by using controlled bioreactors which consisted of rectangular containers, equipped with micro-fluidics system to inject additional nutrients as needed. Cellulose acetate (CA) electrospun membrane was used as support material for BC growth. A conveyer-roller arrangement used to expose pristine membrane on air-liquid interface enabled the formation of seamless tubular fabrication. Another recent study has reported the formation of functional fabrics to be used for biomedical application [37]. The characterization results for water holding, vertical wicking, contact angle and mechanical analyses suggested the use of biologically prepared hybrid fabrics for wound dressing application. Future research works can help to investigate the possibility of incorporating biodegradable hydrophobic medicine-loaded nanofibrous membranes (e.g. polylactic acid/ poly glycolic acid) to achieve specific clinical objectives. With aforementioned self-synthesizing and tailor-shaped characteristics, the biosynthesized BC-based fabrics have great potential to be new sustainable textile materials for the apparel industry. However, the cost and pace of production; handling, laundering and aesthetics related issue still remain a challenge to be addressed.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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