FUTURE OF FASHION-TECH ALLIANCE

edited by
Daria Casciani, Chiara Colombi

FTalliance

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EDITORS

Daria Casciani, Assistant Professor, Politecnico di Milano - Design Department
Chiara Colombi, Associate Professor, Politecnico di Milano - Design Department

CONTRIBUTORS

Patrizia Bolzan, Assistant Professor, Politecnico di Milano - Design Department
Daria Casciani, Assistant Professor, Politecnico di Milano - Design Department
Chiara Colombi, Associate Professor, Politecnico di Milano - Design Department
Erminia D'Itria, Assistant Professor, Politecnico di Milano - Design Department
Arianna Regaglia, intern, Politecnico di Milano - Design Department
Jérémy Legardeur, Full Professor, University Bordeaux, ESTIA Institute of Technology
Nicole Sofia Rohsig Lopez, PhD student, University Bordeaux, ESTIA Institute of Technology
Amanda M. Bernar, PhD Student, University of Bordeaux, Bordeaux, France
Christophe Prevot, Petit Bateau, France
Hélène Chanal, Associate Professor, Université Clermont Auvergne, Clermont Auvergne INP, CNRS, Institut Pascal, France

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FTALLIANCE
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to Co-create Fashion-Tech Future Talents

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THE CONSORTIUM FTalliance

PROJECT COORDINATOR

Politecnico di Milano, Dipartimento di Design, Milan, Italy

FULL PARTNERS

ESTIA École Supérieure Des Technologies Industrielles Avancées, Bidart, France

Högskolan i Borås, Borås, Sweden

University of the Arts London - London College of Fashion, London, United Kingdom

Technische Universiteit Delft, Delft, The Netherlands

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Fashion-tech and growing materials: challenges and opportunities facing bacterial cellulose

AUTHOR: Patrizia Bolzan and Arianna Regaglia
AFFILIATION: Politecnico di Milano, Department of Design, Milan, Italy

KEYWORDS
Fashion-Tech, growing materials, bacterial cellulose, technological integration

Abstract

The technological integration in the fashion industry is an issue that is gaining increasing relevance driven by the renewed demands for sustainability, transparency and ethical worthiness of consumers. Fabric is the raw material that has the priority role in the environmental impact of the textile sector, and in this context, growing materials - in particular bacterial cellulose - can act as substitutes to enable the achievement of sustainability, both in terms of resources and methodological approach to fashion production, with a holistic circularity perspective. Therefore, this contribution aims to investigate the possibilities of integration and contamination between technology and bacterial cellulose by mapping the opportunities arising from application in the fashion industry. Following an analysis of the reference context and the most relevant examples of biomaterial application in relation to both fashion and technological inclusion, the research focused on experimentation regarding the integration of the technology as much in the production phase as in the final product output. The contribution presents the development path and outcomes of three applications of bacterial cellulose for the creation of an accessory for the fashion world following an optimization approach to resources and production processes. Starting from the evidence gathered, the conclusions outline development strategies for the realization of other effective and functional demonstrators.

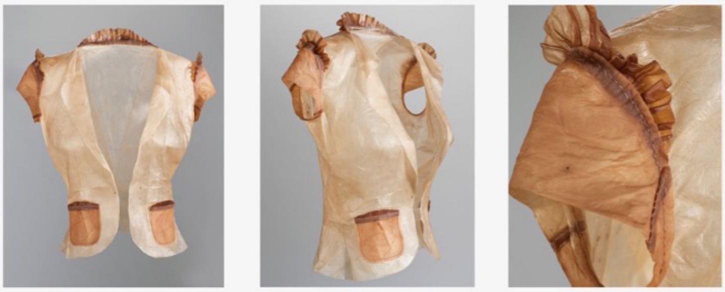
1. Introduction

The fashion industry represents one of the most influential sectors globally, its business alone contributes to the creation of value chains that are crucial to the global economy (Jacometti, 2019). In recent years, fashion companies, increasingly driven by consumers' growing search for business models characterized by transparency (Bertola & Teunissen, 2018), ethics and sustainability (Pine & Gilmore, 2007), have shown a tendency to integrate digital technologies within their business models, products, services and processes (Kozlowski et al., 2016). This is with the aim of maintaining competitiveness in the sector, even renewing themselves through

the added value of Tech in approaching a new sustainability on an ecological, economic, social and cultural level (Ceschin & Gaziulusoy, 2016).
In this context, it becomes crucial to incorporate the concept of enabling fashion through technology to that of circular economy, aiming at the shift towards a more sustainable and less wasteful fashion industry (Brydges, 2021).
A major factor within the sustainability landscape of the fashion industry is textiles, which have undergone significant growth over the past 50 years, reaching a threefold increase in production volumes (EEA, 2021). This phenomenon, driven by the advent of realities such as fast-fashion, has led to the overproduction of more than 30 million tonnes of textile waste globally each year (Chen & Burns, 2006).
Within this landscape, it is therefore of paramount importance to rethink the fashion system through more sustainable and circular materials and production strategies.
One opportunity in this direction is represented by the fashion-oriented technological integration of new biofabricated materials: in particular, this contribution explores some application potentials of Kombucha-derived Bacterial Cellulose (BC) for the production of fashion-tech accessories. The synergy between experimentation with biofabricated materials and the use of technology, in relation to the BC material, is demonstrated according to two strategies: through the creation of (i) outputs containing technological actuators, and through (ii) artefacts constructed using an advanced supply chain supported by digital technologies. The results of this experimentation, conducted at the Design Department of the Politecnico di Milano, are aimed at empirically defining possible application trajectories in the contamination between the world of growing materials and Fashion-Tech for the development of innovation scenarios aimed at promoting the holistic dimension of sustainability and circularity for fashion.

2. Literature review

In the contemporary landscape, research and design are moving to explore new paths that can overcome the linearity of production, embracing increasingly holistic and circular practices (Moreno et al., 2016). The contamination between the worlds of design and biology, through biofabrication techniques (Fritz et al., 1994), which exploit forms of design hybridisation of nature and its growth processes to incorporate living organisms for the creation of biomaterials and growing materials (Myers, 2012; Camere & Karana, 2017), appears to be an emerging theme on which the interest of researchers and designers is converging.
All the characteristics of growing materials show substantial affinity with sustainable, circular and low environmental impact production logics. In particular, BC deriving from the fermentation of Kombucha tea with Symbiotic Colony of Bacteria and Yeast (SCOBY) additives, is widely applied in the fashion sector, showing itself as a sustainable alternative to traditional production processes and materials.
In particular, the possibility of treating the material both as a fabric layer and as BC tartare (Bolzan et al., 2022) resulting from the chopping and subsequent recompacting of the SCOBY allows complex shapes to be obtained from an initial piece size and the reuse of biomaterial waste and/or layers with production defects, placing the material in a circularity-oriented zero-waste production model.
The application potential of this material in



A- BIOCOTURE JACKET

Designer:
Suzanne Lee

Year:
2012

Output:
Product oriented

Level of development:
Prototypal

B- INTEGRATED THREADS

Designer:
Iaac

Year:
2018

Output:
Materic & Product oriented

Level of development:
Prototypal

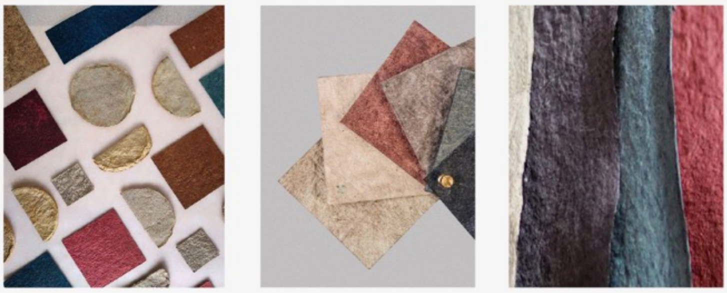
C- SCOBY-COMPO

Designer:
Riina Õun

Year:
2019

Output:
Materic & Product oriented

Level of development:
Ready-to-market



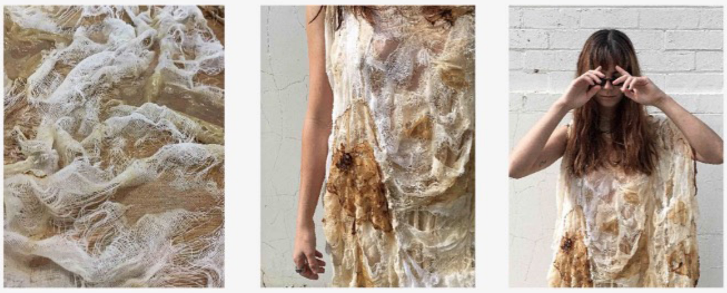
D- MALAI

Designer:
Zuzana Gombosova

Year:
2019

Output:
Materic

Level of development:
Prototypal



E- BIO BORO

Designer:
Kate Hall

Year:
n.d.

Output:
Materic & Product oriented

Level of development:
Prototypal

Fig.1 BioCoture jacket (A), Integrated threads (B), SCOBY-compo (C), Malai (D), Bio Boro (E).

the fashion field is expressed in the selection of seven explanatory case studies (Blatter & Haverland, 2012), the first five, shown in the first image below (fig. 1), where BC was used for the production of garments and accessories, and two others in fig. 2, where electronic circuits and actuators were integrated into the material.
In detail, the BioCouture Jacket (Fig. 1, row A) represents one of the first examples in which BC was used to construct an entire garment. The BC layer, after drying, was cut into the pieces necessary to construct the jacket, which was subsequently assembled using traditional tailoring techniques (Lee, 2012).
In the second case study (fig.1, row B), the Institute of Advanced Architecture of Catalonia (IAAC) investigated textile integration within the BC by using a yarn support structure that was inserted into the growing culture (IAAC, 2018).
Designer Riina Õun explores the potential of waste from the kombucha industry by using discarded SCOBY to produce a new material (fig.1, row C) that is sustainable, vegan and leather-like. The fabric developed by combining chopped waste material, natural oils, waxes and organic compounds is water-resistant and flexible and can be produced on a large scale, providing a viable alternative to the materials traditionally used within the fashion industry (Õun, 2020).
Another case study focused on the construction of a material is Malai (Fig. 1, row D). It is a material created from BC grown in substrates using agricultural waste from the coconut industry in southern India (Malai, 2021).
In the last row of the image (fig.1, row E), Kate Hall exploits the growth of BC to join, mend or patch together broken fabrics, drawing inspiration from the traditional Japanese Boro technique (Li, 2021).
As introduced earlier, there are also experiments on the integration of BC in electronics. Among these, it is possible to distinguish two different types of approach to contamination: a strongly engineering orientation and a more experimental and laboratory orientation.
In the former case, electrically conductive filler materials are usually added to BC nanocomposites to enable the fabrication of modern electrical and electronic equipment, such as biosensors, flexible electronics, electromagnetic interference (EMI) shielding and energy storage (Poddar & Dikshit, 2021).
On the other hand, within the second approach, the experimental and artisanal dimension for the integration of electronic components into the material is more present. This dimension, which is also the focus of the experimentation conducted by the authors of the contribution, in which the designers have the role of approaching and devoting themselves to a production process (Bolzan et al., 2022) intended to understand and verify the possibilities offered by the union of the world of growing materials with that of digital fabrication.
Existing application experiments are mainly unstructured, and are at an embryonic stage in which most outputs do not go beyond the laboratory/academic dimension. Among the most significant applications are those of Reinout Van der Hauwert (fig. 2, row A), in which the integration of electronic components into the BC occurs in the growth phase (Van der Hauwert, 2019).
In contrast, the Biker Vest (fig.2, row B) is a garment made of bacterial nano-cellulose (ScobyTec BNC) and equipped with LED lighting, powered by Teensy micro-computers (Giebichenstein, 2014). The electronic components are in this product inserted between different layers during the

drying process.

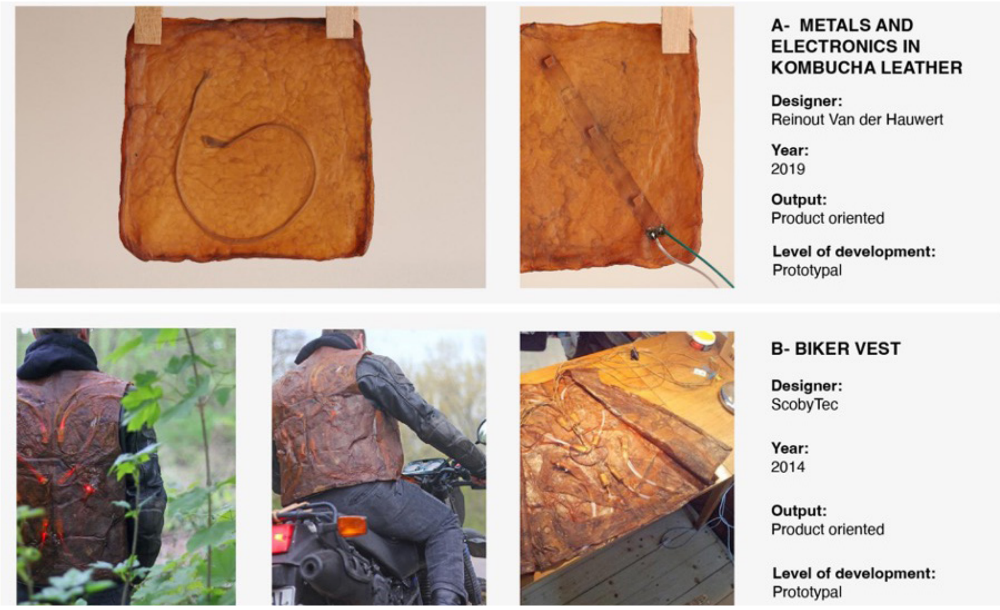


Fig. 2 Metals and electronics in kombucha leather (A), Biker vest (B).

3. Methodology

Aware of the existing experiments on BC-based materials and the possible integration of electronic components in them, this contribution aims to explore the potential of such technological synergy when addressed to the fashion design panorama. To this purpose are presented three possible applicative interpretations of the same fashion accessory, the collar, in which the technology is used in the production phases thanks to digital fabrication and/or becomes explicit in the final output, through the insertion of basic electronic circuits and actuators.

These experiments materialise from the authors' in-depth knowledge of BC as a material (Bolzan et al., 2022; D'Itria et al., 2021) with respect to production and cultivation management processes, as well as raw material treatment. The investigation was conducted as part of the De_Forma (Design Explorations on bio- Fabricated ORganic MAterials) project financed by the basic research fund of the Department of Design of the Politecnico di Milano, and took place in the laboratory spaces of Polifactory, an interdepartmental makerspace and Fab Lab. Following the acquisition of an accurate knowledge of the bacterial material, as well as the definition of the optimal growth conditions and replicability of the cultures (Bolzan et al., 2022), the phase of the De_Forma project described herein focused on the perimeter of the possibilities and ways of combining materials and technologies for the generation of added value in fashion field applications.

With this objective in mind, three possible declinations of the same type of accessory were identified in order to investigate the following opportunities:

1. The creation of a shape in BC material characterised by variable thicknesses and reliefs obtainable through the use of ad hoc moulds, created with digital

fabrication technologies; this approach requires that the technological dimension plays a decisive role in the preparation and production phases of the artefact, but that the final result does not contain any visible trace of its use.

2. The realisation of an output in which the BC acts as a base for the integration of electronic components in order to facilitate the subsequent wiring of the electronics, without the need for stitching or complex electronic circuits to which the actuators can be attached; the final output of this type of production involves an object with a visible technological part.

3. The combination of the two strategies illustrated above for the creation of a fashion-tech product through the use of advanced manufacturing; the latter involves an output in which part of the technology is visible and part remains limited to the production stages of the object.

Specifically, the experimentation envisaged the realisation of three collars characterised by: 1) structure made of chopped BC with variable and controlled thickness texture (collar 1); 2) structure made of textile material with the addition of parts made of BC for the containment of back-led (collar 2); 3) structure made of BC foil with the integration of additional elements made of BC chopped for the integration and wiring in position of LEDs and electronic circuits (collar 3). Below is a representation that better summarises the strategy for the use of technology for the realisation of the three collars. The next section describes the experiments and their strengths and weaknesses.

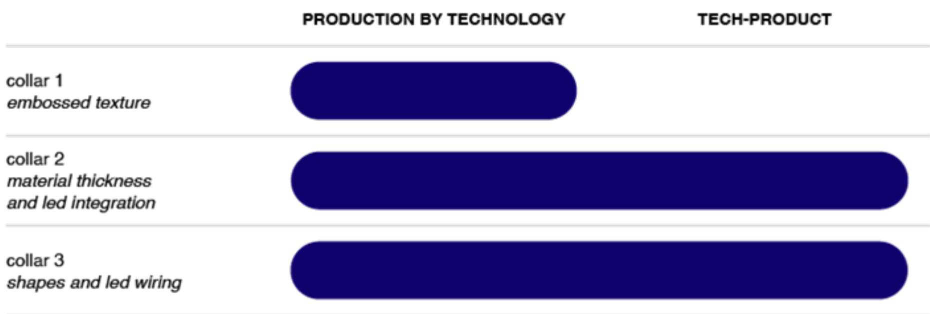


Fig. 3 Strategies employed in the different experiments

4. Results

A. Collar 1 - embossed texture

The first application case involves the use of digital technology to shape material based on BC and textile scraps. Through the use of 3D printing, a mold of variable thickness was produced having the shape of the pattern of a collar. Some finely shredded fabric scraps were combined and amalgamated with a tartare of BC. This material, obtained from scraps of further experimentation, was smeared on top of the 3D printed geometry. During the drying phase, some refills of the deeper areas of the model, in which the material showed a tendency to have more shrinkage, were made to obtain a collar of varying thickness. Once dried, the collar was finished by laser cutting along the edges. Finally, a hook-

and-loop closure was applied to the back of the accessory, via an additional amount of BC tartare, due to the self-fixing property of the material.
The technique used, resulted in a collar with a controlled and highly variable thickness, and with an embossed visual pattern.

B. Collar 2 - material thickness and led integration

The second application proposes a collar with the integration of backled and BC parts in synergy with textile material. Through the use of 3D printing, molds were created that could: a) shape the chopped bacterial cellulose, b) contain high thicknesses of material, and c) hold the pair of backled used in place. The 3D printed molds were filled with a compound formed from chopped BC and inert waste powders to provide more structure to the material. When removed from the molds, the two parts supporting the backleds result solid and at the same time lightweight to provide more stability for the actuators. In addition, the exposed outer surface was aesthetically treated and coated with a thin layer of BC tartare with threads, remaining from previous experimentation.

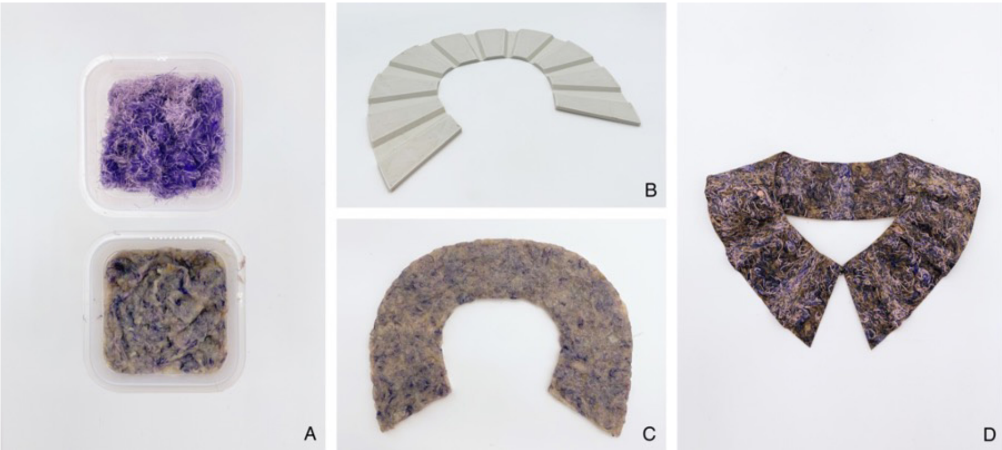


Fig. 4 Chopped bacterial cellulose with textile integration (A), 3D printed stamp (B), material placed over the stamp to dry (C), final output (D).

Fig. 5 Worn end product

The parts were then assembled to the laser-cut textile component by following the shape of the pattern through a layer of chopped BC. Finally, electronic connections were created using a copper tape, and the whole circuit was powered by a button battery placed in battery holder printed with FDM 3D printing technology.
Several tests following the assembly of all components proved the actual functionality of the circuit and consequently of the accessory, which creates a bright accent on the wearer's decolletage.

C. Collar 3 - shapes and led wiring

The latest proposal is that of a collar made from a layer of BC, with parts of BC tartare to hold 6 LEDs for decorative purposes. Through the use of 3D printing and a laser-cut PMMA base, triangular molds were created to shape bacterial cellulose. The molds, with the LEDs inserted inside them, were filled with a mixture of shredded bacterial cellulose and inert waste powders for the purpose of giving more rigidity to the material. When completely dried, it was

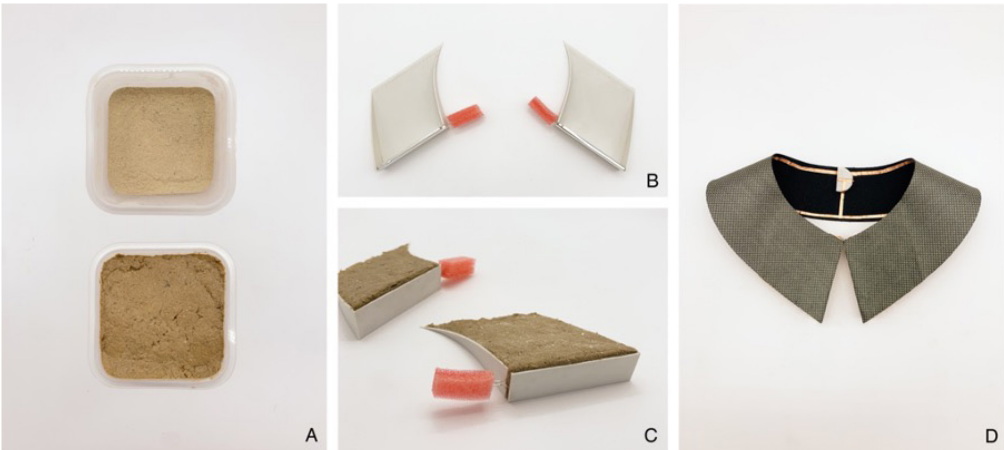


Fig. 6 Chopped bacterial cellulose with dust integration (A), 3D printed stamp (B), filling with the composite material (C), final output (D).

Fig. 7 Lighted worn end product

possible to obtain triangles with material texture having precise shapes.
The main body of the collar consists of a layer of BC, laser cut with the shape of the paper pattern of a collar. The scrap material formed was used to create the BC tartare used in the experiments presented earlier. The electronic components were again connected through a copper tape and powered by a button battery placed in a special housing printed with FDM technology (Fig. 8). Again, a hook-and-loop closure was applied to the back of the accessory, partially rehydrating the affected location and using a bit of chopped BC. Following assembly of the components, the circuit was effective and the accessory functional. The nature of the material emphasizes the presence of the cambage, which itself becomes a decorative element, albeit placed on the back of the piece.

5. Discussion and conclusions

This paper provides an overview of the potential related to the integration of

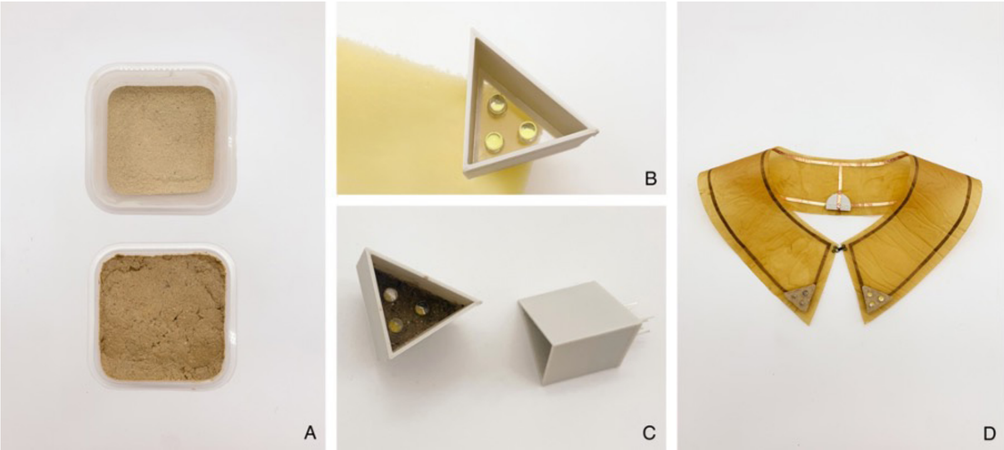


Fig. 8 Chopped bacterial cellulose with dust integration (A), 3D printed stamp and led holder (B), filling with the composite material (C), final output (D).

Fig. 9 Lighted worn end product

the technological component to BC manufacturing, production and processing processes within the fashion field focusing on the application possibilities arising from such synergy.

The possible advantages of using BC in fashion, which had already emerged during the reconnaissance of the case studies, were also further confirmed regarding the encounter between fashion and tech. In fact, the characteristics of sustainability, characterization in the growing phase, reduction of post-production activities as well as waste material, already intrinsic in the bacterial growing material, are successfully transferred into the fashion-tech product output.

In particular, through the three experiments presented, reflections emerge to further refine this encounter between BC and the technological dimension.

From the point of view of technological applications, the use of a BC base makes it possible to anticipate in the design and production phase the possible problems that may arise in the product at the end of its life: the separation of circuits and connective elements from the biofabricated material, in fact, turns out to be particularly efficient and effective, creating new possible supply chains for the disposal of sensorized wearables. Moreover, once the functioning of a prototype has been consolidated and verified, it is already possible to envision the integration of circuits equipped with sensors and actuators into BC's already growing layers, overcoming the limitations and complexities given by the realization of connective traces sewn directly onto garments or accessories.

Equally interesting is the use of this material also from the point of view of the production of artifacts and accessories that are not smart, but take advantage of the use of digital fabrication, as in the first experiment presented. The choice of using BC in all its possible forms allows for the use of alternative assembly systems to stitching, but above all it allows for finished products that have characteristics that are difficult to achieve with other production systems, such as geometries with highly variable thicknesses.

The use of BC in the fashion-tech field, therefore, can be said to be very promising, and the authors plan to continue developing current research to understand the possibilities offered in this area, also checking the possible integration of other technological elements in accessories and finished garments, as well as extending the fleet of digital machines used.

5. References

Bertola, P., & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. Research Journal of Textile and Apparel.

Blatter, J., & Haverland, M. (2012). Designing case studies: Explanatory approaches in small-N research. Springer.

Bolzan, P., Casciani, D., & Regaglia, A. (2022). New perspectives in fashion sustainability through the use of bacterial cellulose. DRS2022: Bilbao, 25.

Brydges, T. (2021). Closing the loop on take, make, waste: Investigating circular economy practices in the Swedish fashion industry. Journal of Cleaner Production, 293, 126245.

Camere, S., & Karana, E. (2017). Growing materials for product design. In Alive. Active. Adaptive: Proceedings of International Conference on Experiential Knowledge and Emerging Materials (EKSIG 2017) (pp. 101-115). https://www.researchgate.net/profile/Serena-Camere/publication/319355171_Growing_materials_for_product_design/links/59a6c6fea6fdcc61fcfbbae7/Growing-materials-for-product-design.pdf

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. Design studies, 47, 118-163. https://doi.org/10.1016/j.destud.2016.09.002

Chen, H. L., & Burns, L. D. (2006). Environmental analysis of textile products. Clothing and Textiles Research Journal, 24(3), 248-261. https://doi.org/10.1177/0887302X062930

D'Itria, E., Bolzan, P., & Papile, F. (2021). Growing materials: exploring new design practices towards a sustainable fashion sector. In TEXTEH X international conference proceedings (pp. 155-163).

Ellen MacArthur Foundation. (2017), "A new textiles economy: redesigning fashion's future", available at: http://www.ellenmacarthurfoundation.org/publications.

European Environment Agency (EEA). (2021). Plastic in Textiles: Towards a Circular Economy for Synthetic Textiles in Europe. Brussels: European Commission. https://www.eea.europa.eu/publications/plastic-in-textiles-towards-a

Fritz, M., Belcher, A. M., Radmacher, M., Walters, D. A., Hansma, P. K., Stucky, G. D., Morse, D. E., & Mann, S. (1994). Flat pearls from biofabrication of organized composites on inorganic substrates. Nature, 371, 49-51. https://doi.org/10.1038/371049a0

Giebichenstein, B. (2014). Biker Vest. ScobyTec. http://scobytec.com/portfolio/biker-vest
Jacometti, V. (2019). Circular economy and waste in the fashion industry. Laws, 8(4), 27.

Kozlowski, A., Searcy, C., & Bardecki, M. (2016). Innovation for a sustainable fashion industry: a design focused approach toward the development of new business models. In Green Fashion (pp. 151-169). Springer, Singapore.

Lee, S. (2012). TEDxLondonBusinessSchool - Suzanne Lee - BioCouture. https://www.youtube.com/watch?v=J6lfnX62Pq8&t=392s

Li, L. (2021). Reviving boro: The transcultural reconstruction of Japanese patchwork. Royal College of Art (United Kingdom).

Malai. (2021). Malai Material. https://malai.eco/blogs/news/about-malai-material

Modern Synthesis. (2020). This is GMO. https://modern-synthesis.com/this-is-gmo/

Moreno, M., De los Rios, C., Rowe, Z., & Charnley, F. (2016). A conceptual framework for circular design. Sustainability, 8(9), 937
.
Myers, W. (2012). Biodesign: Nature + Science + Creativity. Museum of Modern Art. https://www.biology-design.com

Õun, R. (2020). Fashion bacteria. Atlas of the Future. https://atlasofthefuture.org/project/riina-o/?fbclid=IwAR1VDCKB0W3TeCwrP00rQ_79j_3afvr--Q2xiV8uAPaOw7ohf6Usk-zbNGA

Pine, B. J., & Gilmore, J. H. (2007). Authenticity: What consumers really want (p. 299). Boston: Harvard Business School Press.

Poddar, M. K., & Dikshit, P. K. (2021). Recent development in bacterial cellulose production and synthesis of cellulose based conductive polymer nanocomposites. Nano Select, 2(9), 1605-1628.

Wu, J. X., & Li, L. (2019). Sustainability initiatives in the fashion industry. In Fashion industry-An itinerary between feelings and technology. IntechOpen.

Zhao, M., Zhou, Y., Meng, J., Zheng, H., Cai, Y., Shan, Y., Guan, D., & Yang, Z. (2021). Virtual carbon and water flows embodied in global fashion trade-a case study of denim products. Journal of Cleaner Production, 303, 127080.

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