

та хімічні методи переробки текстильних відходів, оскільки вони найбільш поширені, найбільш досліджені та найменш затратні.

Література

1. Tang, K.H.D. State of the Art in Textile Waste Management: A Review. *Textiles* 2023, 3, 454–467. <https://doi.org/10.3390/textiles3040027>
2. Islam MM, Yin R, West A. A Brief Review of Mechanical Recycling of Textile Waste. *Textiles*. 2025, 5 (4), 41. <https://doi.org/10.3390/textiles5040041>
3. Erha Andini, Pooja Bhalode, Evan Gantert, Sunitha Sadula, Dionisios G Vlachos. Chemical recycling of mixed textile waste. *Sci Adv* 2024, Jul 3,10 (27) <https://doi.org/10.1126/sciadv.ado6827>
4. Dissanayake, D.G.K.; Weerasinghe, D.U. Fabric Waste Recycling: A Systematic Review of Methods, Applications, and Challenges. *Mater. Circ. Econ.* 2021, 3, 24. <https://doi.org/10.1007/s42824-021-00042-2>
5. Liu, T.; Miao, P.; Shi, Y.; Tang, K.H.D.; Yap, P.-S. Recent advances, current issues and future prospects of bioenergy production: A review. *Sci. Total Environ.* 2022, 810, 152181. <https://doi.org/10.1016/j.scitotenv.2021.152181>

УДК
677.057.3

TETIANA MALIY, ALINA TOKARIEVA
Kharkiv State Academy of Design and Arts, Ukraine

LIVING TEXTILE MATERIALS WITH MICROALGAE: PERSPECTIVES FOR CREATING THE PHOTOSYNTHETIC FABRICS OF THE FUTURE

Purpose. *The aim of this study is to explore the potential of integrating microalgae into textile materials to create living, photosynthetic fabrics capable of performing biological functions such as carbon dioxide absorption, oxygen release, and air purification. The research seeks to assess both the technological feasibility and the design implications of such materials, emphasizing their role in the transition toward sustainable, bioactive textile systems.*

Keywords: *photosynthetic textiles; microalgae; biodesign; hydrogel matrices; sustainable materials; biofabrication; living materials; biocouture.*

Problem Statement. Traditional textiles are passive materials that serve primarily aesthetic or protective functions. However, growing environmental concerns and the search for sustainable solutions in design have prompted interest in biologically active fabrics. The challenge lies in

developing textile systems that maintain microalgal viability, stability, and aesthetic value while ensuring practicality and biosafety for use in fashion, architecture, and product design.

Research Methods. The study is based on an interdisciplinary analysis of existing experimental and design research on microalgae-based textiles. It synthesizes findings from materials science, biotechnology, and fashion design, focusing on hydrogel immobilization techniques, light and nutrient management, and case studies such as AlgalTextile, Living Mushtari, and Iris van Herpen's bioluminescent couture. The research also employs comparative evaluation to identify technological barriers and prospective engineering solutions for sustainable application.

Research Results. The development of living textile materials incorporating microalgae represents one of the most innovative directions in contemporary material science and sustainable design. Such materials, capable of photosynthesis, challenge the traditional perception of textiles as passive structures, reimagining them instead as active, biologically functional systems. Microalgae, due to their high growth rate, photosynthetic efficiency, and ecological adaptability, have become a promising component for bioreactive fabrics that can absorb carbon dioxide, release oxygen, and even purify air or generate aesthetic visual effects. Recent studies have demonstrated the feasibility of immobilizing microalgal cells within hydrogel matrices such as sodium alginate and carrageenan, both of which are derived from marine algae and fully biocompatible. These gels serve as transparent, nutrient-permeable matrices that maintain cell viability while allowing efficient light penetration. Melnikova et al. (2022) [2] proposed the AlgalTextile material, where *Chlorella* cells were immobilized in a calcium-crosslinked alginate gel and applied onto cotton fabric. The composite exhibited high nutrient absorption and maintained photosynthetic activity, combining wastewater treatment functionality with the potential for reusable biomass recovery. Similarly, In-na et al. (2022) [1] coated cotton and polyester textiles with *Chlorella vulgaris* embedded in carrageenan gel, achieving a CO₂ fixation rate of approximately 1.8 g CO₂ per g biomass per day – significantly higher than traditional suspension cultures. These findings indicate that hydrogel-coated textiles can serve as efficient microalgal carriers, enabling scalable development of photosynthetic fabrics.

Beyond experimental research, the integration of living organisms into textiles has also entered the domain of design and biocouture. A notable example is Iris van Herpen's 2025 haute couture creation in collaboration with biophysicist Chris Bellamy, featuring a "living dress" containing about 125 million *Pyrocystis lunula* cells immobilized in a

nutrient gel. The garment glowed with bioluminescent light in response to the wearer's movement, demonstrating that living algae can function as both aesthetic and metabolic agents within fashion design.

This experiment follows earlier pioneering work at the MIT Media Lab, particularly the Living Mushtari project (2017), where 3D-printed microfluidic channels were populated with photosynthetic microorganisms to form wearable photobioreactors. Such systems illustrate how microbial photosynthesis can be harnessed directly within textile-based structures for light generation, air regeneration, and even energy production.



Fig. 1. Photos from the Iris van Herpen Haute Couture Autumn-Winter 2025/2026 collection are featured in VOGUA.UA magazine [5]

However, several challenges remain before living textiles can be widely applied. Maintaining the viability of algal cells over long periods requires strict control of moisture, light intensity, and nutrient availability.

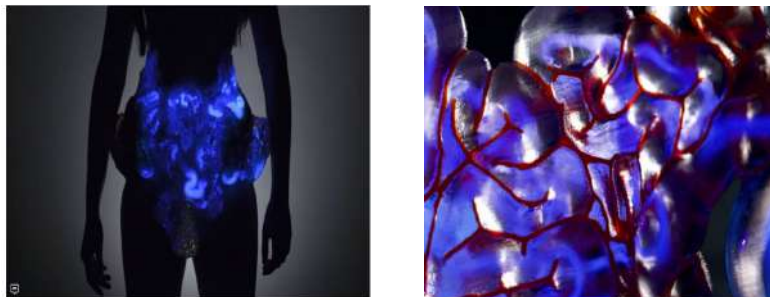


Fig.. 2. Photos of «Mushtari», a project by designer and architect Hepi Okcman, posted on the Arch Daily website [4]

Natural fibers such as cotton are highly compatible with alginate but prone to biodegradation when exposed to moisture, whereas synthetic fibers offer stability but may hinder cell adhesion. Furthermore, contamination control and biosafety protocols are essential for practical deployment in wearable or architectural contexts.

The creation of multilayer textile photobioreactors – structures that allow circulation of nutrient fluids and control of environmental parameters – represents a promising engineering direction to overcome these limitations. The potential applications of photosynthetic textiles are extensive. In architecture, they can be used as façade panels or interior “living membranes” for air purification and CO₂ capture. In fashion and product design, such fabrics may produce color-changing, luminescent, or self-cleaning effects powered by biological activity.

From an environmental standpoint, these materials contribute to carbon-neutral production cycles, integrating biological processes directly into industrial design. As Mancini (2025) [3] has suggested, woven hydrogel-based fabrics could act as microalgal bioreactors for urban air improvement and climate-responsive architecture. Ultimately, living textiles represent a new paradigm in material design – transitioning from inert matter to self-sustaining, biologically active systems. The synergy between textile engineering, biotechnology, and design provides an opportunity to develop materials that not only minimize ecological impact but actively regenerate the environment. Photosynthetic fabrics with embedded microalgae exemplify how future materials may merge the boundaries between biology and technology, nature and culture, forming a foundation for a truly sustainable biofabrication era.

Conclusions. The integration of microalgae into textile materials signifies a pivotal step toward the emergence of living, photosynthetic fabrics that redefine the boundaries between biology and design. By enabling textiles to perform metabolic and ecological functions – such as CO₂ capture, oxygen generation, and air purification – these materials challenge the traditional concept of inert fabric surfaces. The study demonstrates that hydrogel matrices based on alginate and carrageenan provide a viable foundation for maintaining cellular activity within textile structures, offering both functional and aesthetic benefits. Despite notable progress, practical implementation still requires resolving challenges related to long-term stability, controlled environmental conditions, and biosafety regulation. The synergy between textile engineering, biotechnology, and sustainable design provides fertile ground for future innovations in responsive, regenerative materials. Ultimately, photosynthetic textiles embody the next frontier of sustainable fabrication – transforming fashion,

architecture, and material culture through the integration of living systems into everyday environments.

References

1. In-na P., Lee J. G. M., Caldwell G. Living textile biocomposites deliver enhanced carbon dioxide capture. *Journal of Industrial Textiles*. 2022. Vol. 51, No. 4 (suppl). P. 5683S–5707S. DOI: [10.1177/15280837211025725](https://doi.org/10.1177/15280837211025725).
2. Mancini M. *Living Textiles: Exploring Microalgae Growth on 3D Woven Structures in Design*. Delft: Delft University of Technology, 2025. Master's thesis. TU Delft Repository.
3. Melnikova A., Namsaraev Z., Komova A., Meuser I., Roeb M., Ackermann B., Klose H., Kuchendorf C. M. *AlgalTextile – a new biohybrid material for wastewater treatment*. *Biotechnology Reports*. 2022. Vol. 33. Article e00698. DOI: [10.1016/j.btre.2021.e00698](https://doi.org/10.1016/j.btre.2021.e00698).
4. Neri Oxman's "Mushtari" Is a 3D Printed Wearable That Makes Products from Sunlight. *Arch Daily*. <https://www.archdaily.com/769818/neri-oxmans-mushtari-is-a-3d-printed-wearable-that-makes-products-from-sunlight>
5. Містичний океан: нова колекція Iris van Herpen Haute Couture осінь-зима 2025/2026 *Vogue*. <https://vogue.ua/article/fashion/brend/mistichniy-ocean-nova-kolekciya-iris-van-herpen-haute-couture-osin-zima-2025-2026-60046.html>

УДК 685

ОКСАНА МИХАЙЛОВСЬКА, АЛІНА КРАВЧЕНКО,
 СОФІЯ ЛЕВИЦЬКА

Хмельницький національний університет, Україна

ЗМІНА ВОЛОГОСТІ НАТУРАЛЬНИХ ШКІР ДЛЯ ВИГОТОВЛЕННЯ ВЗУТТЯ ЗА РЕЗУЛЬТАТАМИ ЇХ ЗВОЛОЖЕННЯ В ЕМУЛЬСІЙНОМУ ТА ВОДНОМУ СЕРЕДОВИЩАХ

Мета. Дослідження процесу зволоження натуральних шкір для виготовлення взуття із застосуванням емульсій розчинників.

Ключові слова: зволоження, емульсія розчинників, сорбція, вологість.

Постановка завдання. Порівняти зміну вологості натуральних шкір для виготовлення взуття за результатами їх зволоження в емульсійному та водному середовищах.

Методи досліджень. Для виконання поставленого завдання використано метод зволоження зразків натуральних шкір рідкою фазою із зануренням у водне та в емульсійне середовища.