Mycelium-Based Leather: a focus on Post-Processing Treatments

Beatrice Benetti[1] , Fosca Conti[2] and Piet Dimitriadis[3]

1 Department of Biology, University of Padova, Via U. Bassi 58/B, 35131 Padova, Italy

2 Department of Chemical Sciences, University of Padova, via Marzolo 1, 35131 Padova, Italy

3 Department of Bioengineering Sciences, Vrije Universiteit Brussel, Bd de la Plaine 2, 1050, Brussels, Belgium

Dip. Biology

Dip. Chemical Sciences

Contact information:

Prof.Dr. Fosca Conti
Via Marzolo 1, 35131
Padova, Italy
+39 049 8275226
Fosca.conti@unipd.it

Introduction

Textile and fashion industry is one of the most polluting sectors in the world.

Leather tanning is a resource-intensive process, consuming large amounts of water and energy while potentially releasing toxic chemicals.

Conventional synthetic alternatives, such as polyurethane (PU) or polyvinyl chloride (PVC), also pose sustainability challenges due to their fossil fuel origins, non-biodegradability and microplastic pollution.

Mycelium-based biomaterials offer an innovative and eco-friendly alternative, with rapid growth, low resource consumption, and customizable properties.

Key Aspects	Real Leather	Synthetic Leather	Mycelium - Leather Like
Sustainability	⚠️ medium	❌ low	✔️ good
Biodegradability	⚠️ medium	❌ low	✔️ good
Production Impact	❌ high	❌ high	✔️ low
Life Cycle	✔️ good	⚠️ medium	?

Mycelium mat

Mycelium, the vegetative part of filamentous fungi, consists of microscopically interconnected tubular cells rich in **chitin**, **glucans** and **proteins**. [1], [2]

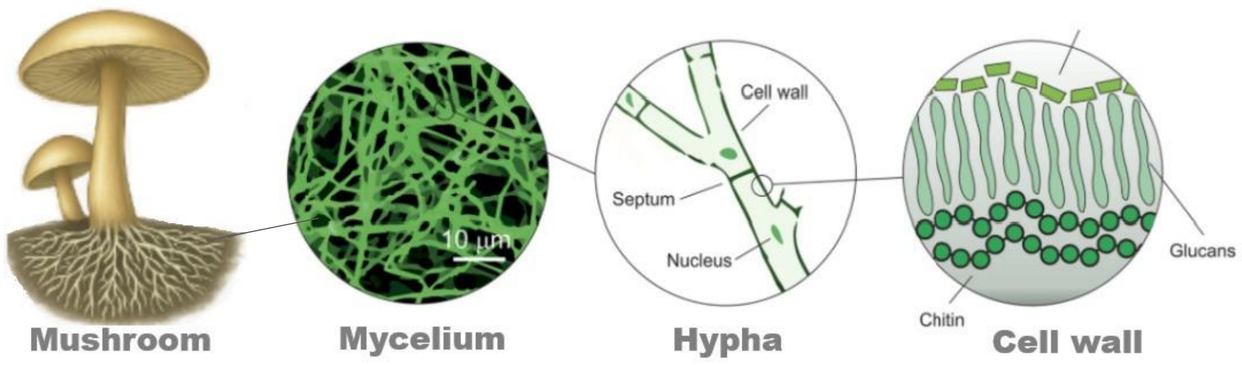
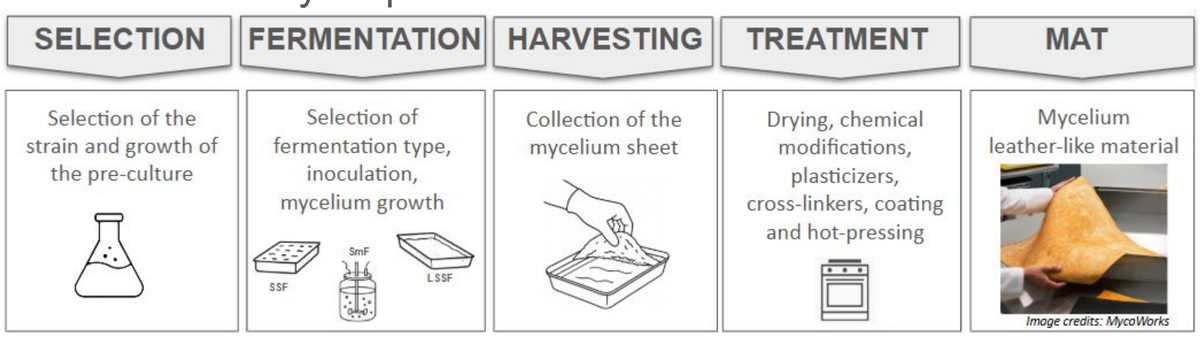


Image adapted from Stone, 2023 (Medium.com)

These natural polymers make it a promising material for biodegradable and sustainable alternatives to traditional leather for their:

- ✔️ **low carbon footprint**
- ✔️ **rapid growth rate**
- ✔️ **low production costs**

Production's key steps:



Various fungi species (e.g., *Ganoderma, Trametes, Fomes*) are used, with production methods including solid-state fermentation (SSSF), liquid-state surface fermentation (LSSF), and submerged fermentation (SubF). [3]

Challenges

- 🔴 Mechanical properties, water resistance, and consistency
- 🔴 Scalability, and standardization

Treatments

Treatments	Types	Advantages ✔️	Disadvantages ❌
CHEMICAL MODIFICATIONS	• Deacetylation • Oxidation	• Flexibility, strength • Hydrophilicity, reactivity	• High Temp, alkaline conditions • Complex agents
CHEMICAL CROSS- LINKING	• Chromium • Zinc	• Tensile strength • Non toxic, flexibility	• Toxicity • Lower strength
ORGANIC & SYNTHETIC CROSS- LINKING	• Glutaraldehyde • Organic Acids • Genipin	• Covalent bonds • Biobased, stiffness • Sustainable	• Toxicity • Brittleness • Yellowing/blue discoloration
ENZYMATIC CROSS- LINKING	• Tyrosinases, Laccases e.g.	• Natural, low energy	• Limited data on strength/flexibility
PLASTICIZERS	• Glycerol • Sorbitol • EG / PEG • Oils	• Flexibility, elasticity • Reduce brittleness • Tensile strength • Hydrophobicity	• Can decrease tensile strength • Faster degradation • Durability • High variability
COATINGS	• Corn zein • Waxes & Oils • Shellac • PLA	• Water resistance • Hydrophobicity • Color & gloss • Mechanical strength	• Wash durability • High variability • Animal derived • Industrial settings for degradation
COMPOSITE	• Natural fibers • Biopolymers • Chitin nanowhiskers	• Tensile strength • Reinforcement • Fill microgaps	• Risk of fungal degradation • Industrial settings for degradation • Costly, difficult
HEAT TREATMENTS	• Hot pressing	• Homogeneity, smoothness	• Energy consumes

Conclusions

Mycelium-based materials represent a promising sustainable alternative to conventional leather. Despite challenges related to scalability and mechanical properties, their potential for industrial application continues to grow

References

[1] Amobonye A., Lalung J., Awasthi M. K., Pillai S., Fungal mycelium as leather alternative: A sustainable biogenic material for the fashion industry, Sustain. Mater. Technol., 2023:38:e00724.

[2] Elsacker, E., Vandelook S., Peeters E., Recent technological innovations in mycelium materials as leather substitutes: a patent review, Front. Bioeng. Biotechnol., 2023:11:1204861.

[3] Haneef, M., Ceseracciu, L., Canale, C. et al. Advanced Materials From Fungal Mycelium: Fabrication and Tuning of Physical Properties. Sci Rep 7, 41292 (2017).

[4] Stone, V. (2023). When mushrooms go in the lab: growing design. Retrieved from: Medium Article