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Investigating the potential of mycelium textile composites

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INTRODUCTION & AIM

Sustainable and renewable resources such as mushrooms offer a wide range of application possibilities in different areas. In particular, the combination of mycelium and textiles shows promising approaches for the filtration of waste water in the textile industry, air purification, the use in protective clothing, medical applications such as blood purification or the use in packaging and even in building construction [1-3]. Mycelium, the vegetative network of fungi, is an alternative and renewable material that is easy to cultivate. In addition, many organic wastes from the agricultural industry can be used as nutrients for mycelium cultivation, further increasing sustainability. In addition, mycelium has anti-inflammatory, immunomodulatory, antibacterial, antifungal, antitumor, antioxidant, antidiabetic and lipid-lowering properties that can be exploited for specific applications [4-6]. Despite several studies conducted in the last few years, the use of mycelium and textiles as a textile alternative has been little explored. In the present study, mycelium of the fungus *Pleurotus ostreatus* was used to produce mycelium textile composites. The aim of the study is to evaluate the potential of mycelium in the textile industry and give an overview of the mechanical properties of these composites.

MATERIALS AND METHODS

Cotton fabric samples (100% cotton) were cut and placed on malt agar extract and inoculated with sterile liquid mycelium (Liquid Pure Culture *Pleurotus ostreatus* var. columbinus MG1010, MycoGenetics Pilz-Shop, Everswinkel, Germany). The mycelium was cultured for 21 days in the dark at 21–22°C, dried at 60°C in the oven, and analyzed. The schematic overview of the preparation of mycelium textile composites is depicted in the Fig. 1. The confocal laser scaning microscop (CLSM) image showing the mycelium of *Pleurotus ostreatus* in the Fig. 2.

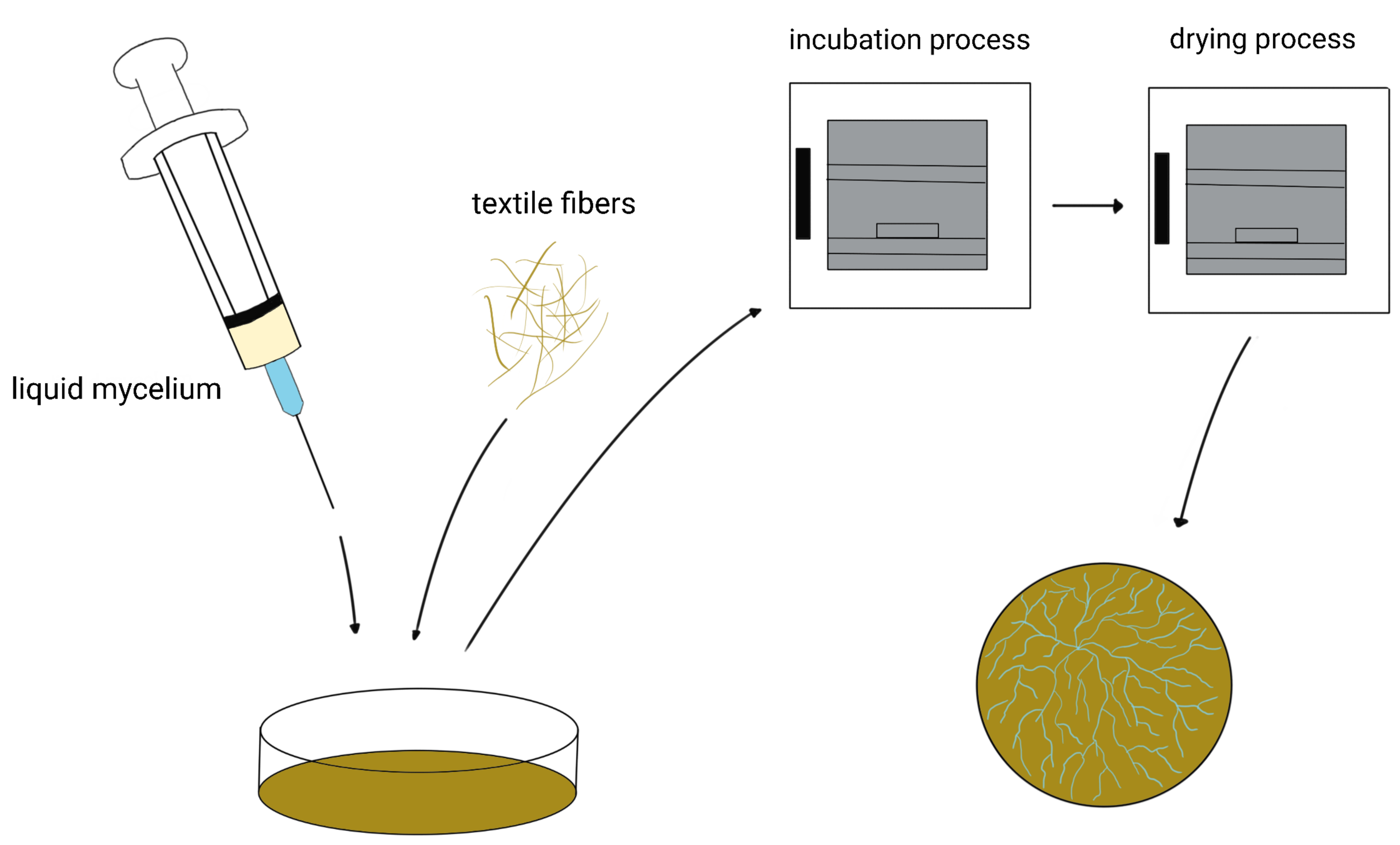

Fig. 1 The schematic overview of the preparation of mycelium textile composites.

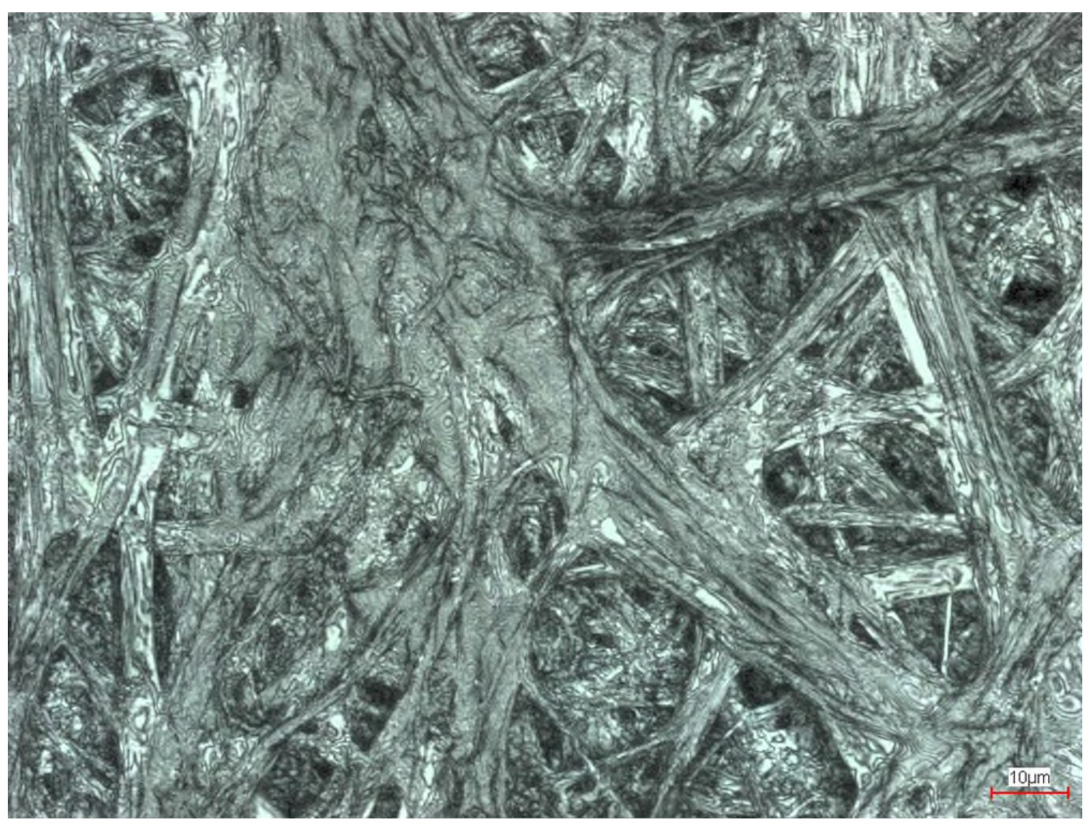

Fig. 2 The confocal laser scaning microscop (CLSM) image showing *Pleurotus ostreatus* on cotton fabric..

The composite is formed by the mycelium bonding with the substrate. After the growth period the composite is dried at high temperatures to inactivate the fungus and stop the growth process and stiffen the composite material [7]. One popular way is hot-pressing because it improves the mechanical properties of the mycelium composite by consolidating and densifying the material increasing tensile and flexural strengths as well as elastic moduli [2].

RESULTS & DISCUSSION

The properties of mycelium composites vary depending on fungus type, substrate, growth conditions, substrate, processing, and additives [7,8]. Substrates with high cellulose content increase tensile strength [7]. Larger substrate particles affect density. Restricted airflow results in growth limitations and low density [9].
For example, the quality of the substrate used greatly impacts the mechanical properties. A study has found that substrates with a high cellulosic content produce composites with high tensile strength [7]. Density is affected by particle size of (larger) substrate. If airflow is impeded within the composite the mycelium cannot grow properly because of oxygen deficiency resulting in a low density product [7,9]. Table 1 shows a limited selection of mechanical properties of mycelium composites with different substrates.

Reference	Fungus	Substrate	Tensile strength (MPa)	Flexural strength (MPa)	Compression strength (KPa)
[11]	*Pleurotus ostreatus*	Wood chips and hemp fibers		347	452
[12]	*Trametes multicolor*	Chopped flax			1180
[13]	*Pleurotus ostreatus*	Rapestraw seed	0.01	2.0	0.06
[13]	*Pleurotus ostreatus*	Cotton fibers	0.03	0.62	35
[14]	*Trametes versicolor*	Hemp			360

Table. 1: Mechanical properties of mycelium composites.

Tensile and flexural strength depend on a variety of factors. For example, hyphal type can influence the properties greatly. *Trametes versicolor*, a trimitic species, exhibits higher tensile (0.04 MPa) and flexural strengths (0.22 MPa) than *Pleurotus ostreatus*, a monomitic species (0.01 MPa tensile strength, 0.06 MPa flexural strength) [1]. Generally, it seems the quantity of mycelium in composites affects mechanical performance. Jones et al. suggest that the insufficient fungal growth density is the most common reason for the limited mechanical performance because failure is more likely to occur within the mycelium [4]. To improve the mechanical properties mycelium composites can be treated a few different ways, such as cold- and hot-pressing. Hot-pressing seems to be even more effective than cold-pressing resulting in product with significantly higher tensile and flexural strength [3]. Pressing generally reduces porosity and thickness and consolidates the composite while increasing material density, reorientating the fibers horizontally in the plane of the panel and creating intimate fiber contact at points of overlap. This is achieved mainly by following mechanisms: phase change (evaporation) of water, compaction and stress relaxation of the material and mass transfer occurring as a result of gaseous and bound water diffusion and hydrodynamic flow of gaseous and liquid water [4]. In summary, enhancing the mechanical properties of mycelium composites involves various strategies, including optimizing fungal growth and employing pressing techniques.

CONCLUSION

The research field of fungus mycelium-based composites remains relatively underexplored, despite a significant increase in publications in recent years. Investigating these sustainable materials is certainly worthwhile, particularly with regard to their mechanical properties. In this study, mycelium-based composites were produced, and an overview on their mechanical properties was compiled.

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