Assessment of Acoustic Properties of Mycelium-Based Composites Materials

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1 Introduction

Nowadays, the increasing concern for the environmental impact of plastic or petroleum-based materials has led to a growing interest in biomaterials. Mycelium-based composites are self-grown materials, based on agricultural residue fibers that are inoculated with fungi mycelium. The mycelium forms an interwoven 3-dimensional filamentous network, binding every fiber particle together to create a rigid, lightweight composite material with no additional energy input and no extra waste or residue production [1]. Mycelium-based composites could replace current products in the packaging industry, as well as in construction (e.g., materials for thermal and acoustic insulation) [2]. Many physical properties can be adjusted by controlling the fungal species, the growth conditions and the post-growth processes [3]. To evaluate the sound absorption properties of mycelium-based composites made from residual hemp fiber and Ganoderma lucidum fungi, sound absorption tests were conducted in a small reverberant chamber and in an impedance tube.

2 Materials and experimental procedure

2.1 Materials

The most predominant criterion when working with mycelium-based composite are the selection of fiber residue used for the growth of the fungi species. Thus, hemp fiber, generally used for livestock litter, was chosen as the feeding material for the growth a white-rot fungi, well known by the name of *Ganoderma Lucidum* and its strong filamentous mycelium network (figure 1). Mycelium-based composite fabrication
The fabrication of mycelium-based composite requires first a sterilization of the hemp fiber in a polyethylene bag to ensure no microbial activity other than the one of the fungi mycelium species. This sterilization step is carried out in an autoclave operating at 121°C and 15 psi for about 20 minutes. Subsequently, the fibers are cooled down to approximately 40°C and hydrated with water at about 60% by weight. Then, the resulting substrate is inoculated with the fungi mycelium with a maximum 30% proportion of the total mass. The inoculated substrate is then placed in an incubation chamber for a minimum of 7 days at a temperature between 20 and 30°C and a minimum relative humidity of 60%. During this incubation period, the mycelium develops and colonizes the whole bagged hemp fibers, resulting to firmly joined interwoven 3-dimensional filamentous network. To form mycelium based composite panels, the inoculated substrate is set in a 210 x 210 x 15 mm^3 mold and put back into the incubation chamber for another week. Finally, the square panel is unmolded and placed in an oven at 90°C for, at least, 4 h to stop fungi mycelium growth.

a) Residual hemp fibers b) Ganoderma lucidum mycelium

Figure 1: Mycelium-based composites: a) hemp fiber residues (feeding material) and b) Ganoderma lucidum mycelium.

a) Conventional mineral fiber-based acoustic ceiling tile b) Mycelium-based composite panel

Figure 2: Pictures of tested materials.

2.2 Sound absorption measurements

Reverberant chamber

A small reverberant chamber of 4 m^3 volume was used to perform reverberation tests following ASTM C423 standard. Six mycelium-based composite square panels were assembled to reach a 0,26 m^2 area. An equivalent area of conventional mineral fiber-based acoustic ceiling tiles were used for comparison purpose [4]. The side length of both specimens was not covered for these comparative tests, and not considered in sound absorption calculation which could bring some uncertainties on the estimated sound absorption coefficient.

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Impedance tube

Absorption coefficient was measured by means of a 100 mm diameter impedance tube following the standard method ASTM E1050 using two microphones [5]. All tests were performed on 100 mm diameter mycelium-based composite samples, laser cut from the 15 mm thick panels and compared with same size conventional mineral fiber ceiling tiles. Given the 100 mm diameter, the high frequency limit of analysis is approximately 1900 Hz. The 5 cm spacing of the microphone puts a theoretical low-frequency limit at approximately 70 Hz.

3 Preliminary results

Figures 3 and 4 show the sound absorption coefficient as a function of frequency for the selected materials in an impedance tube and reverberant chamber respectively. As can be seen, mycelium-based composites exhibit similar absorption coefficients to conventional mineral fiber acoustic ceiling tiles over the whole range of frequency. Consequently, one can, reasonably, expect that, if compactness of this material is increased, sound absorption coefficient of this material would be, at least, comparable to that of the conventional acoustic ceiling tile or even better [6].

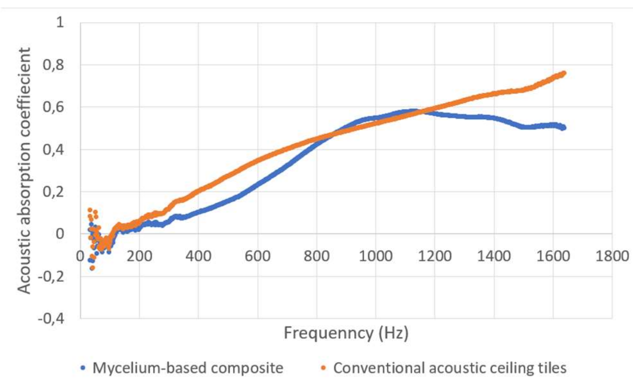

Figure 3: Sound absorption coefficients of mycelium-based composite and conventional acoustic ceiling tiles measured in impedance tube.

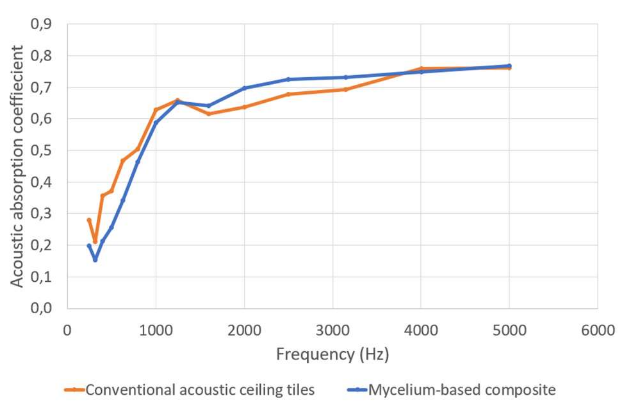

Figure 4: Sound absorption coefficients of mycelium-based composite and conventional mineral fiber acoustic ceiling tiles measured in reverberant chamber.

4 Concluding remarks

In this paper sound absorption efficiency of mycelium-based composite was investigated. It was shown that the selected residual hemp fiber and Ganoderma Lucidum fungi species, created mycelium-based composite panels with comparable sound absorption performance to conventional mineral fiber-based acoustic ceiling tiles. Since the tested mycelium-based panels were preliminary prototypes, the fabrication process requires further optimization to reach improved sound absorption performance.

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