DOI: 10.61782/fa.2023.0060

forumacusticum 2023

ACOUSTICAL AND PHYSICAL CHARACTERIZATION OF POSIDONIA OCEANICA FIBRES FOR SOUND ABSORBING APPLICATIONS

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ABSTRACT

This article presents an experimental investigation on the acoustical and physical characterization of loose fibers obtained from Aegagropiles of Posidonia Oceanica, more commonly known as Posidonia Balls. These aggregates of fibers are formed near the beaches following the action of the sea waves, which remove the leaves of the marine plant Posidonia Oceanica, typical of the Mediterranean sea. Aegagropiles are very common on beaches, and can be a renewable resource for making sound-absorbing panels with low environmental impact. The aim of this research is to experimentally characterize the acoustic behavior of loose fibers obtained from Aegagropiles; the characteristics have been studied as a function of the apparent density of the fibers, in order to optimize their performance. The five physical parameters of the Johnson-Champoux-Allard model were also evaluated to obtain an analytical model of the acoustic behavior of the Posidonia fiber panels as a function of density and thickness.

Keywords: *Posidonia fibres, natural fibres, sustainable porous material, sound absorption, acoustical modeling.*

1. INTRODUCTION

Posidonia Oceanica is a marine plant, endemic to the Mediterranean Sea with ribbon-shaped leaves. Once dead, the fibrous foliar residues of the Posidonia are entirely processed by the sea, thanks to the action of the water and the waves which free the fibers from the vegetal material, creating ellipsoidal aggregates that end up on the beaches (Figure 1a).
From the acoustic point of view, these materials have been studied in [1] with an in-depth analysis on the physical and acoustic characteristics and on the modeling of regular packets of these spheres as metamaterials.
This research aims to explore the possible acoustic application of loose fibers obtained with a manual process from Posidonia Balls (Figure 1b); experimental tests were conducted by compacting the fibers with different densities, in order to obtain an analytical model capable of calculating the sound absorption coefficient of this material for any combination of thickness and density.

Figure 1. Aegagropiles (a) and Poseidonia Oceanica fibers (b)

2. MATERIALS AND METHODS

Aegagropiles of different sizes were collected on the beaches of southern Sardinia. The collected material was found in dry sand, free from humidity. The woven fibers were manually separated from these Aegagropiles, and the internal sand was removed by sieving.
The following experimental measurements were carried out on loose fibers obtained from Aegagropiles:
- porosity by the air volume compression method [2];

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- airflow resistivity according to ISO 9053-2, as the density of the loose fibers varies (range from 65 to 191 kg/m^3);
- sound absorption at normal incidence according to ISO 10534-2 as the thickness and density of the fibers vary (range from 48 to 210 kg/m^3).

The equivalent dissipative fluid model proposed by Johnson-Champoux-Allard (JCA) [3],[4] was used, which describes complex effective density an bulk modulus as a function of five physical parameters: porosity ϕ, tortuosity α_∞, airflow resistivity σ, and viscous and thermal characteristic length Λ and Λ'. The quantities that have not been directly measured have been calculated through the inversion method [5] from the experimental measurements of sound absorption.

3. EXPERIMENTAL RESULTS

Table 1 shows the values of the five parameters of the JCA analytical model as a function of fiber density. These values can be used to calculate the acoustic performance of panels of any thickness and density. Figure 2 shows a comparison between experimental measurements of sound absorption at normal incidence and results obtained from the JCA analytical model.

Table 1. Physical parameters of the JCA model calculated with the proposed analytical relationships

Thickness [mm]	Density [kg/m^3]	Porosity [-]	Airflow Resistivity [Ns/m^4]	Tortuosity [-]	VCL [µm]	TCL [µm]
40	157	0.90	7867	1.11	52	171
60	105	0.93	3871	1.07	88	232
80	79	0.95	2455	1.05	128	287
120	52	0.97	1356	1.03	217	388

4. CONCLUSIONS

The investigation conducted on the fibers obtained from Aegagropiles of Posidonia Oceanica showed that this sustainable material can be effectively used as a sound-absorbing material in the form of loose fibers. To optimize the acoustic properties, an experimental investigation was conducted as the density of the fibers varied, in order to obtain an analytical model that allows the calculation of the sound absorption curve for different combinations of thickness and density. The analytical model presented, illustrated in more detail in [6], showed a good correlation with the experimental acoustic measurements and constitutes a design tool for acoustic panels made with this sustainable material.

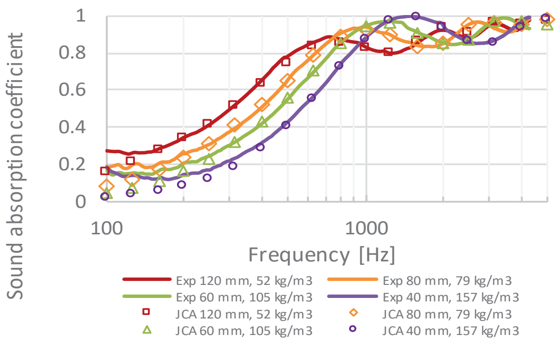

Figure 2. Comparison between experimental and analytical results (JCA model).

ACKNOWLEDGMENTS

This research is funded by the Ministry of University and Research within the PRIN 2017 project, number 2017T8SBH9:"Theoretical modelling and experimental characterization of sustainable porous materials and acoustic metamaterials for noise control".

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