Portland, Oregon
NOISE-CON 2011
2011 July 25-27

"PAINT" WITH POWDERED CORK WITH OPTIMIZED ACOUSTICAL BEHAVIOR

António P. O. Carvalho[a)]
Daniela J. D. Maio[b)]
Francisco J. C. X. Carvalho[c)]

Laboratory of Acoustics, College of Engineering, University of Porto (FEUP)
R. Dr. Roberto Frias
4200-465 Porto
Portugal

This paper presents the analysis of a new product ("paint") with the incorporation of powdered cork to optimize its acoustic performance. Tests were performed in a reverberation room to measure the variation on the sound absorption coefficient values of an existing standard aqueous paint by the introduction of different amounts of powdered cork and also to compare these results with a named "acoustic paint" already available in the market. The "paint" tests were performed on two different base supports (wood and metal) and analyzed with different percentages of added powdered cork and different thicknesses.

1 INTRODUCTION

This study examines the possible use for a by-product of the cork industry, cork dust (or powdered cork), now almost worthless. Several samples of "paint" with cork dust were made to be tested in a reverberant chamber and to determine the values of sound absorption coefficient (α). A comparative analysis was carried out among different bases where the new product was applied, to check the influence of the type of paint used, the different rates of mass built obtained from cork dust and significance of the number of coats applied[1].

2 DEVELOPMENT PROCESS OF 'PAINT' WITH INCORPORATED POWDERED CORK

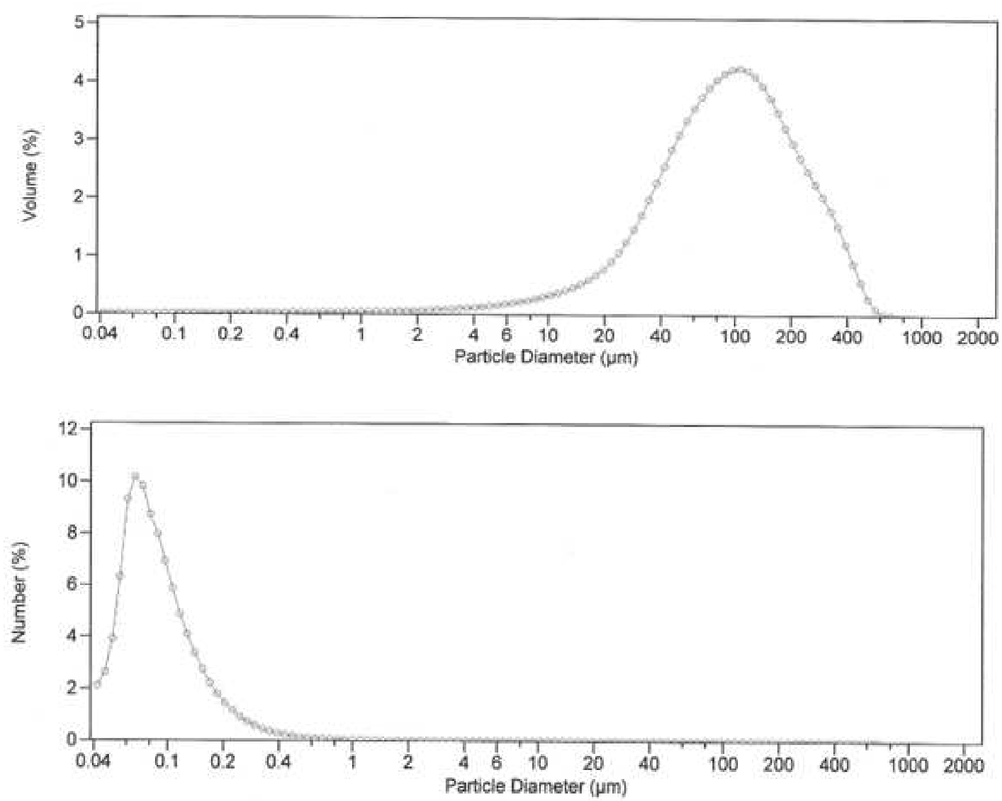
The particle size characterization of the cork dust allowed to analyze that cork dust particles have an average diameter of 121 μm in volume and 0.104 μm in number which means that there is a small number of particles with a high volume (Figs. 1 and 2, and Table 1).

[a)] Email: carvalho@fe.up.pt
[b)] Email: danieladolgner@hotmail.com
[c)] Email: xavierc@fe.up.pt

Progress was made to perform embodiments of cork dust, through the post-addition, in two separate base paints with high PVC (*Pigment Volume Concentration*) and low PVC, to try to understand whether this difference established some considerable divergence in sound absorption characteristics. In these mixtures the aqueous paint *Contrato*[3] (high PVC) was used, with the addition of 2% of cork dust and also the aqueous paint *Vinylsilk*[3] (low PVC), with the incorporation of 3% of cork powder[3].

The cork powder presents a great difficulty in handling related to its dispersion and suspension. This powder is very light and has high static electricity, which complicates enormously the process of dispersion and reproducibility[2].

After production, through the manual cork dust dispersion, the application of the paint was done on a wood paneling *Platex*[4] (density 1000 kg/m^3, 3.2 mm thickness, dimensions 2.75x1.25 m^2 and with a smooth surface and a rough underface which results from the pressing of wood fibers) and galvanized metal plates *Zincor*[5] (2x1 m^2 and 0.6 mm thickness).



Figs. 1 and 2 - Particle size of cork dust in volume and number, respectively

Table 1 - Results of cork dust granulometric

Particle Diameter	Minimum Value	Median	Mean	Maximum Value
In Volume (µm)	25.3	92.4	121.3	265.1
In Number (µm)	0.054	0.082	0.104	0.169

3 TESTS AND RESULTS

3.1 Tests

The sound absorption coefficient (α) measurements were made in the 200 m^3 reverberation room of the Laboratory of Acoustics, College of Engineering, University of Porto (using a B&K multi-channel *Pulse* system and the EN ISO 354[6]) with the test samples applied on the pavement. Twelve samples were used, named:

Ch	Metal Plate (Ch);
Ch_1d_C	Metal plate (Ch) with one application (1d) of paint *Contrato* (C);
Ch_1d_C_2%	Metal plate (Ch) with one application (1d) of paint *Contrato* with 2% of powder cork;
M	Wood paneling (M);
M_1d_V	Wood paneling (M) with one application (1d) of paint *Vinylsilk* (V);
M_1d_V_3%	Wood paneling (M) with one application (1d) of paint *Vinylsilk* (V) with 3% of powder cork;
M_2d_V_3%	Wood paneling (M) with two applications (2d) of paint *Vinylsilk* (V) with 3% of powder cork;
M_1d_C_2%	Wood paneling (M) with one application (1d) of paint *Contrato* (C) with 2% of powder cork;
M_1d_V_5%	Wood paneling (M) with application of paint *Vinylsilk* (V) with 5% of powder cork;
M_1d_K	Wood paneling (M) with one application (1d) of a commercially available aqueous paint (using "hollow ceramic particles") that announces acoustical qualities (here named as K);
M_2d_K	Wood paneling (M) with two applications (2d) of the above paint (K);
M_PC	Wood paneling (M) with application of powder cork (PC) in emulsion.

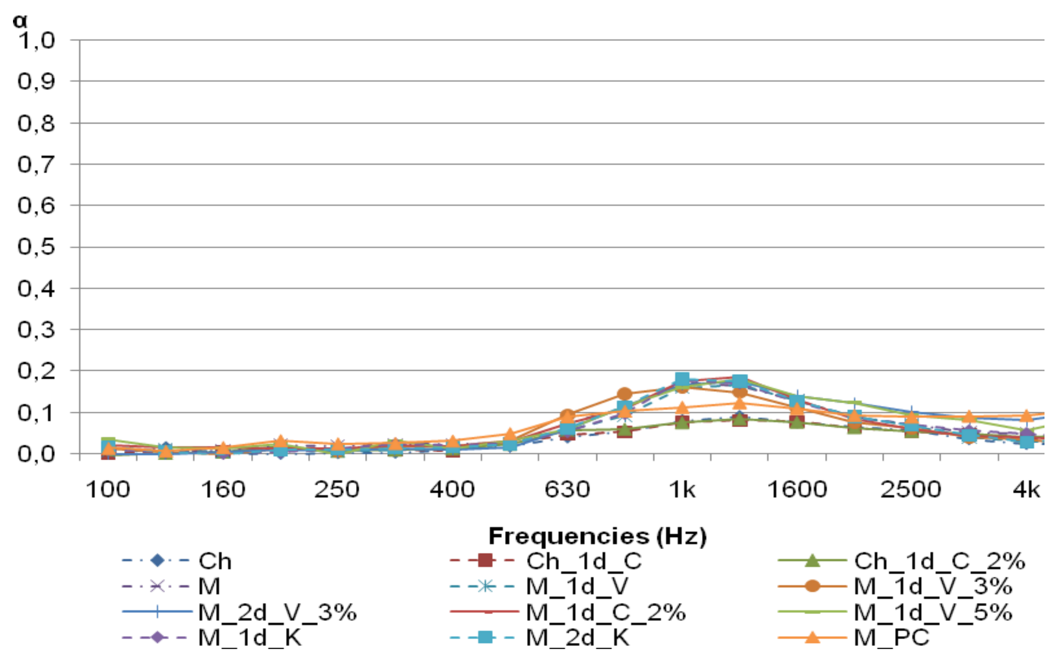


Fig. 3 - Values of the sound absorption coefficients (α) of the 12 samples tested

For low frequency bands (< 500 Hz) none of the samples displayed measurable values of the sound absorption coefficient (α values up to 0.02 can be justified by the possible uncertainty of the method) (Fig. 3). The influence of various parameters and the comparison in relation to the type of sub layer, type of paint, the percentage of incorporation and the number of paint coats applied, was analyzed through the differences between the samples tested and its base layer.

To perform these analyses and comparisons, only the values above the 800 Hz frequency band are presented, but the only really relevant are at high frequency bands (≥ 2 kHz) although differences in the sound absorption coefficients values (Δα) are also important.

3.2 Comparison of Results

3.2.1 Influence of the Sublayer

Using as reference the application of paint with 2% powdered cork made with the *Contrato* paint (applied to the wood paneling and metal plates: M/Ch_1d_C_2%), the influence of the material used as a sub layer is analyzed. It appears (Fig. 4) that the increase shown by the differences in the sound absorption coefficient values in both cases are lower than the maximum uncertainty value of the method, so it was not possible to say in which of sub layer is that use more acoustically profitable. Moreover, it is shown that the increments can be comparable either on the wood paneling or the metal plate as it does not appear that there is a great influence on the type of material used as a sub layer.

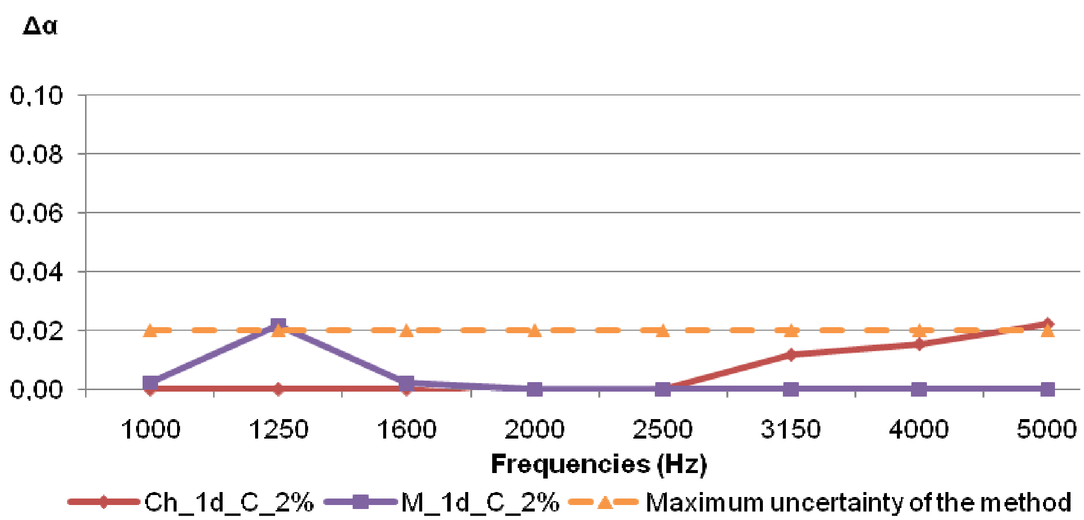


Fig. 4 - Differences in the sound absorption coefficients values (Δα) between the metal plate with application of Contrato paint with 2% powdered cork and the metal plate (base), and between the wood paneling with Contrato paint with 2% powdered cork and the wood paneling (base)

3.2.2 Influence of type of paint

This subchapter explains the differences in the sound absorption coefficient values due to the use of different paints. Figure 5 presents the results obtained using the samples of wood (M) and with one coat of paint for the case of *Contrato* with 2% of cork dust (M_1d_C_2%) as well as applying a coat of *Vinylsilk* paint with 3% powdered cork (M_1d_V_3%). This comparison is done with different percentages of cork dust incorporation (2% and 3%). However, as seen on

Fig. 5, the differences are practically zero, so it can be concluded that the type of paint used does not influence the sound absorption coefficient results.

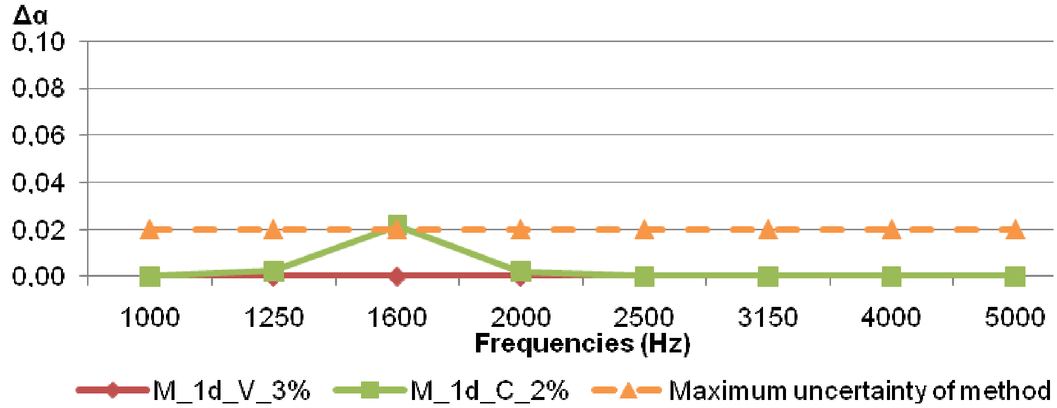


Fig. 5 - Differences in the values of sound absorption coefficient (Δα) between the wood paneling (base) and the wood paneling with application of Contrato paint with 2% powdered cork and Vinylsilk paint with 3% powdered cork

3.2.3 Influence of Incorporation rate of Cork Powder

In this section the effect of the incorporation of the cork dust based on the *Vinylsilk* paint is analyzed, to understand whether the increased rate of incorporation of cork dust is reflected in increased values of sound absorption coefficient.

It appears that the differences obtained (≥ 2 kHz) already exceed the maximum uncertainty of the method allowing to conclude that indeed the increasing incorporation of cork dust produces an increase in the sound absorption coefficient values (Fig. 6). Although this does not seem enough to be commercially attractive, it shows that the cork dust is responsible for the differences on the values of sound absorption coefficient.

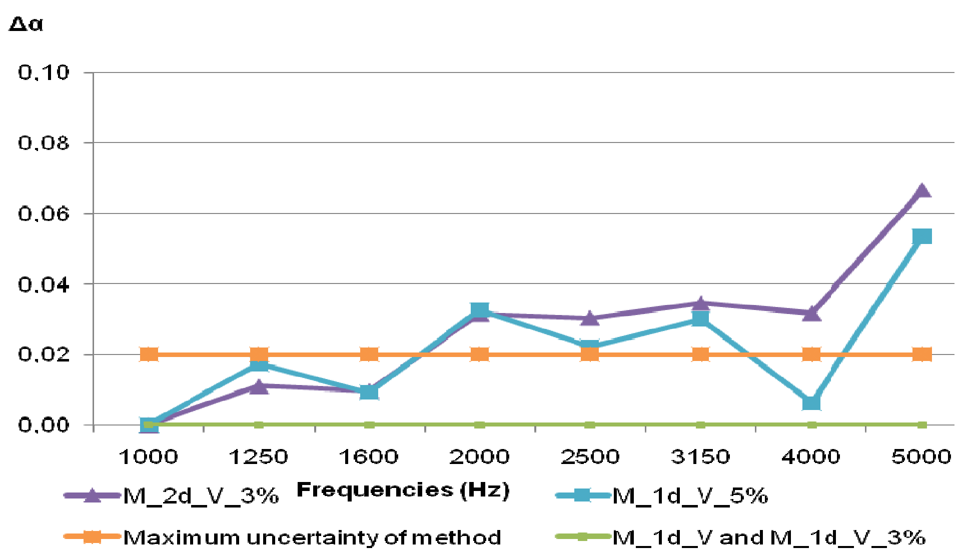


Fig. 6 - Differences in the sound absorption coefficient values (Δα) between the base wood paneling and the wood paneling with: a coat of Vinylsilk paint (1d_V), a coat of Vinylsilk paint with 3% powdered cork (1d_V_3%); two coats of Vinylsilk paint with 3% powdered cork (2d_V_3%); and a coat of a "paint/mass" Vinylsilk with 5% powdered cork (1d_V_5%)

3.2.4 Influence of the number of coats

In this subchapter it is analyzed the influence of the number of coats and the results achieved between the "paint" developed during this study and a paint already present in the Portuguese market.

There is a significant augment between the increases of sound absorption values achieved through the application of one and two coats (1d/2d) of *Vinylsilk* paint with 3% powdered cork, which represents the need for these materials increased thickness for its effectiveness (Fig. 7).

The values of sound absorption coefficients (α) increase from 0.03 to 0.08 (an increase of 18% to 400%), with a second coat of *Vinylsilk* paint with 3% powdered cork.

As for paint K (an "acoustic paint" already marketed in Portugal), there was no significant increase when the second coat was applied. This result disappointed expectations for this product, since its use cannot reflect the properties referred on its technical data. It should however be noted that during the tests, it was expected to get values of sound absorption coefficients above the *Vinylsilk* cork dust paint ones, since this K "acoustic paint" was thicker and rougher for the same level of quantity of application, which are properties that influence the sound absorption coefficient values.

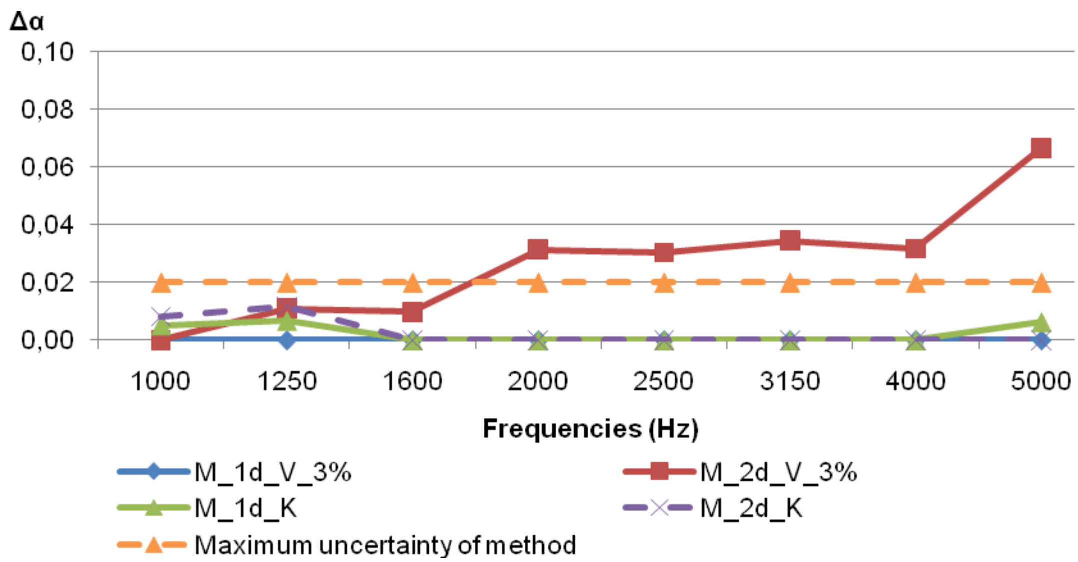


Fig. 7 - Differences of sound absorption coefficient (Δα) between the wood paneling (base) and wood paneling with a coat of Vinylsilk paint with 3% powdered cork, with two coats of Vinylsilk paint with 3% powder cork, with a coat of K "acoustic paint" and two coats of K "acoustic paint"

3.2.5 Sound absorption of cork powder (isolated)

To fully investigate the characteristics that might influence the acoustic performance of this new "paint" is was also determined the sound absorption coefficient values using only the cork dust over a single sub layer of wood (that is, no paint). This sample was called "emulsion" (M_PC) because it is a preparation consisting of a liquid (water) that has very fine particles in suspension (cork powder). The amount of cork powder of this mixture to be tested was about 90% and the test was done only after the water evaporation.

The results were disappointing, since they show that even the isolated cork dust itself did not have the necessary capabilities to become a sound absorbent material, because their α values were very low.

It can be verified (Fig. 8) that above the 2500 Hz frequency band, the increase in the values of the sound absorption coefficient for the sample of wood with two coats of *Vinylsilk* paint with 3% powdered cork (M_2d_V_3%) and for the wood paneling with a *Vinylsilk* "paint/mass" with 5% powdered cork (M_1d_V_5%), approaches the curve of the cork dust emulsion (M_PC). It can be concluded that these two samples reflect the behavior of the wood paneling perhaps through the acoustic phenomenon of *membrane* at the frequency of 1 kHz, starting this effect to dissipate and, above 2500 Hz frequency, accompanying the baseline of the sample of cork dust. So, if more tests were done in which increasing percentages of cork dust were added, it would be expected to get results within these (hypotheses already tested) and the maximum reached by the cork dust.

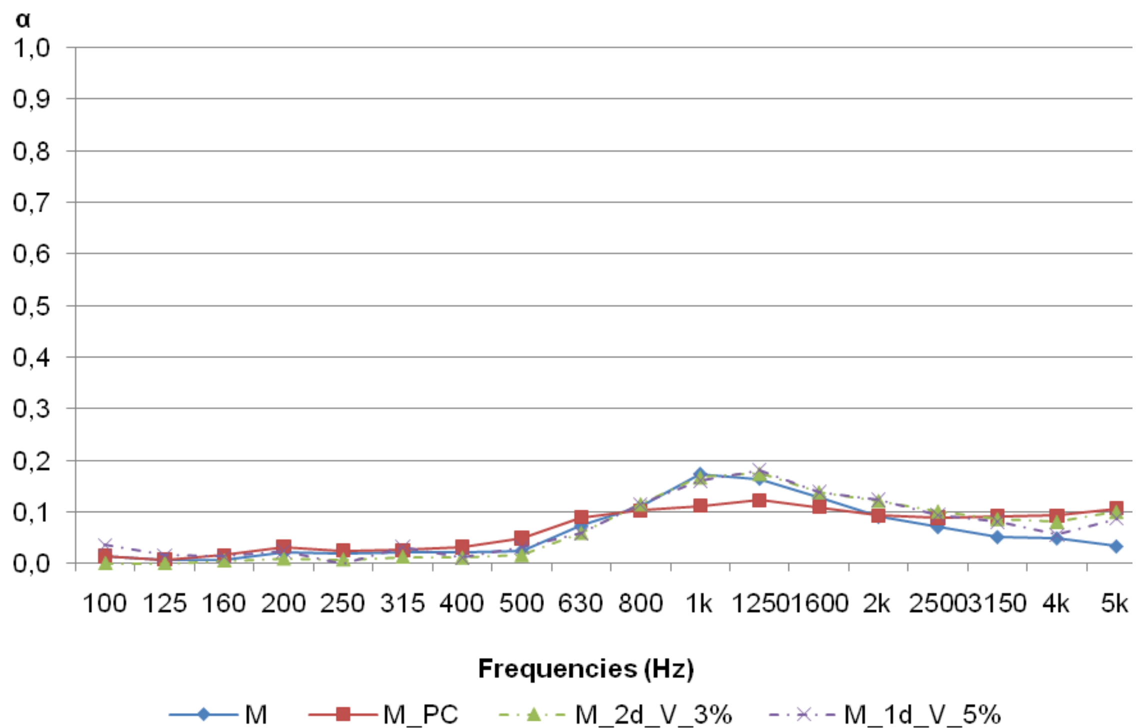


Fig. 8 - Values of sound absorption coefficient (α) for samples of wood paneling, cork powder emulsion, wood with two coats of Vinylsilk paint with 3% powdered cork and wood paneling applying a "paint / mass" Vinylsilk 5% cork dust

4 CONCLUSIONS

This study goal was to develop a new product ("paint") by using cork powder (residue from the cork industry). Several samples were developed in which were determined the values of sound absorption coefficient. Table 2 shows the summary of changes in the values of sound absorption coefficient (Δα) by frequency and percentage.

Comparisons were done to analyze the influence of the type of material used as a sub layer, the influence of the type of paint used as a binder, the influence of the percentage of cork dust incorporation, the influence of the number of coats applied as the comparison between the "paint" developed by this work and one already in the Portuguese market. From the analyses of the influence of material and paint used, it can be concluded that the α values do not differ more than the possible uncertainty of the method. Therefore no measurable effect was visible.

Table 2 - Summary of results

Increment due to the...	Situation Δα = ...		Frequency band (Hz)							
			1k	1250	1.6k	2k	2.5k	3150	4k	5k
% of cork dust	(M_2d_V_3%) - (M)	Δα	0.00	0.01	0.01	0.03	0.03	0.03	0.03	0.07
		%	0	7	8	35	43	67	65	199
	(M_2d_V_3%) - (M_1d_V)	Δα	0.01	0.01	0.01	0.03	0.04	0.05	0.05	0.07
		%	5	5	7	36	53	114	177	208
	(M_1d_V_5%) - (M)	Δα	0.00	0.02	0.01	0.03	0.02	0.03	0.01	0.05
		%	0	11	7	36	31	58	13	160
	(M_1d_V_5%) - (M_1d_V)	Δα	0.00	0.01	0.01	0.03	0.03	0.04	0.03	0.05
		%	1	9	7	38	40	102	90	168
number of coats	(M_2d_V_3%) - (M_1d_V_3%)	Δα	0.01	0.03	0.03	0.05	0.04	0.05	0.05	0.08
		%	4	18	25	62	67	116	141	401

Concerning the percentage of cork powder added, this reveals, as expected, that for increasing values of that use, the sound absorption coefficient values are also increased. However this increase should not exceed the base level that the cork powder shows, when isolated, at high frequencies (> 2 kHz).

It was also shown that the number of coats applied using the "paint" with cork dust influences the outcome and was considered reasonable to expect that the increased number of particles of cork dust is more prominent than the increase in the number of coats applied.

Thus it can be concluded that the incorporation of cork dust in "paint" increases the sound absorption coefficient values but not in significant amounts to an effective and/or commercial use.

5 REFERENCES

1. Daniela D. Maio, *Desenvolvimento de "tinta" com pó de cortiça com desempenho acústico optimizado* (in Portuguese), Thesis, M.Sc. in Civil Engineering, Faculty of Engineering, University of Porto, Portugal, (2010).

2. Rosa M. Pilão, *Estudo da Explosão do Pó de Cortiça* (in Portuguese), Ph.D. dissertation in Sciences of Engineering, Faculty of Engineering, University of Porto, Portugal, (2002).

3. Tintas CIN, www.cin.pt, product data sheets, (accessed on May 10, 2010).

4. Sardinha & Leite, www.sardinha-leite.pt, (accessed on May 19, 2010).

5. JVC Alves, www.jvcalves.pt, (accessed on June 7, 2010).

6. ISO 354, *Acoustics, measurement of sound absorption in a reverberation room*, (2003).