THE USE OF LOCAL AND RENEWABLE PRODUCT IN THERMAL INSULATION.

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Abstract

This work aims to develop a new eco-composite construction that is good thermal insulation with a simple and inexpensive method. The prepared material is Portland cement and date palm fibers. This was characterized by: Raman spectroscopy to study the impact of fibers on the chemical behavior of the matrix, the hot wire method for measuring thermal conductivity and Scanning Electron Microscopy (SEM) for porosity measurement. The comparison of the results with those of Portland cement reveals that the inclusion of date palm fibers has no impact on the chemical behavior of the matrix and that the addition of these fibers increases the porosity and decreases the thermal conductivity cement.

***Keywords**: DPF, RAMAN, SEM thermal conductivity.*

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INTRODUCTION

The overconsumption of energy in the heating and cooling of buildings has led researchers to think of sustainable construction. In the context of sustainable construction, the new regulations on thermal insulation in the field of construction encourage the development of new materials based on plant fibers to build energy-efficient buildings while ensuring the comfort of habitat [1].

Although Algeria is among the countries that have a multitude of plant materials (the date palm, cork, ...), the recovery of these materials remains insufficient mainly in the building sector [2].

In this study, we will discover the insulating power of the date palm (Figure.1) to enhance the local product while saving energy.

In Algeria, the number of date palm is more than 10 million trees [3]. This material contains several renewable parts, the estimated global production being greater than 1 200 000 tonnes of petioles, 410 000 leaves and 300 000 clusters per year [4]. Several studies have been done with natural materials and have shown that they are comparable to standard building materials [5].

Figure 1. image of a date palm

Kriker *et al* [6] developed a new material containing concrete and date palm fiber to evaluate the mechanical properties of this material. Benmansour *et al* [7] found that the use of DPF in the mortar provides a composite with good thermal resistance and mechanical properties that can be used in building construction as new insulating materials. Chikhi *et al* [8] found that gypsum reinforcement with 5% Date Palm Fiber (DPF) gives a composite with good thermal and mechanical properties making it a good candidate for the development of effective insulation materials safe. Recently, Chennouf *et al* [9] Confirmed that the introduction of (DPF) in reinforced concrete gives excellent hygrothermal properties.

In this work the characterization of the developed material will be done with the following methods: Raman spectroscopy to determine the chemical composition of the DPF and the new prepared material, the hot wire method to measure the thermo physical properties and the Scanning Electron Microscopy (SEM) to study the porosity of the material.
The results obtained showed the insulating power of cement based on date palm fiber.

II. EXPERIMENTAL

A. Materials:

A.1. Portland cement (PC) :

Portland cement **(CIMENT PORTLAND A LA POUZZOLANE CEM II/A-P 42,5 N)** is mainly composed of four different mineral phases: Tricalcium silicate (Alite) C_3S, Dicalcium silicate (Belite) C_2S, Tricalcium aluminate (Celite) C_3A and Tetracalcium alumino ferrite (Ferrite) C_4AF. This matrix was provided by the cement company "SCHB" of Hamma Bouziane-Constantine, a subsidiary of the industrial group of Ciments d'Algerie **"Groupe GICA**".

A.2. Date palm fiber (DPF):

The renewable part of the date palm used in this study is the cluster that was collected at Biskra (Algeria), the choice of this part of the date palm was made for its thermophysical properties from the literature [2]. The cluster was dried at 60 ° C in the laboratory's Memmert oven for 24 hours and milled with an electric grinder until the fiber was obtained.

B. Sample preparation:

The prepared composite (BM5) is obtained by mixing Portland cement with a 5% concentration of date palm fiber. the prepared powder is analyzed with the methods: RAMAN and SEM and compared with pure portland cement (PC).

To measure the thermal conductivity of these samples with the hot wire method, two samples (BM5 and PC) of the same mass composed of Portland cement mixed with two mass fractions (0 and 5%) of DPF with progressive water addition corresponding to the weight of the added fibers. The mixtures are poured into molds of (10 cm × 10 cm × 10 cm). The samples were extracted from the molds after 72 hours and allowed to cure for 28 days in the laboratory under ambient conditions.

II. Characterization techniques

Horiba Raman spectrometer was used to characterize the molecular composition and external structure of the samples.

To measure the thermo-physical properties (conductivity, diffusivity and volume heat capacity) of the samples (CP and BM5) the transient hot wire method was used. The measurements are based on the analysis of the temperature response of the material analyzed at the heat flux pulses. The heat flow is excited by the electrical heating of the resistance inserted in the probe, which is in direct thermal contact with the test sample. The evaluation of thermal conductivity and volume heat capacity is based on periodically sampled temperature records, if the propagation of heat occurs in an unlimited medium [10].

Using Scanning Electron Microscopy (SEM), we observed pore geometry in order to study the impact of the addition of DPF fibers on the porosity of the matrix. The SEM analysis was conducted NeoScope JCM-5000.

III. RESULTS AND DISCUSSION :

A. RAMAN analysis :

The development of new bio-based materials requires prior knowledge of the chemical composition of the fibers used, which is why the Raman spectroscopy of DPF was done.

Figure 2 shows the Raman spectrum of DPF. The bands at 1115 and 814 cm^{-1} were respectively due to cellulose and pectin [11, 12, 13]. The lignin contribution was present at 1660 cm^{-1} [11, 12].

The Raman results of the two samples (PC and BM5) are shown in Figure 3. The phases of the samples were identified by the literature [14]. It can be seen in Figure 1 that the peaks in the two Ramanshift samples of 836, 885 and 1088 cm^{-1} correspond respectively to C_3S, C_2S and gypsum. Peak C_3A can be easily identified in both samples with a Raman shift of 551 cm^{-1}.

In the BM5 sample we notice a development of a broad characteristic peak of the cellulose which extends from 1110 cm-1 to 1190 cm-1. This explains that the DPF are well incorporated into the matrix.

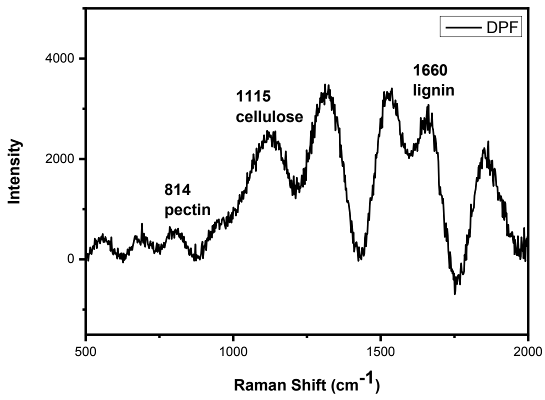

Figure 3. The Raman spectra of DPF.

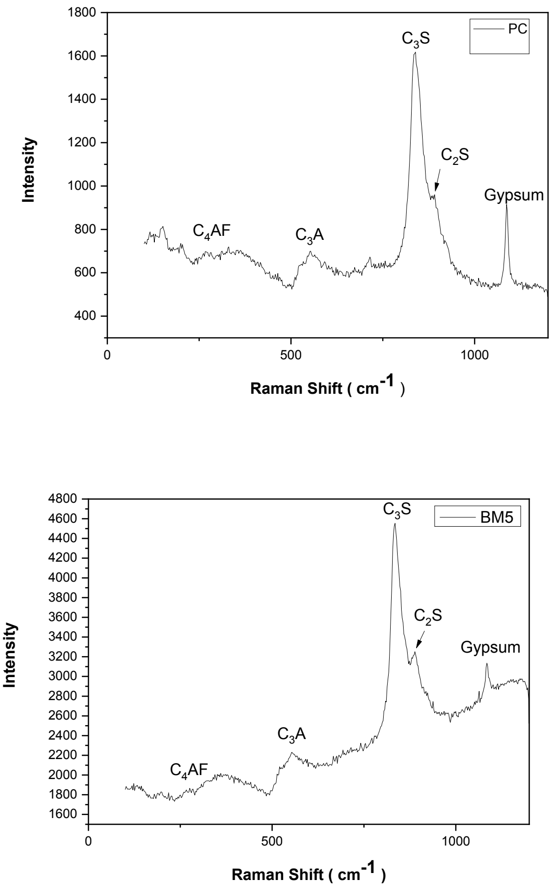

Figure 3. The Raman spectra of samples PC and BM5.

B. Thermal characterization:

Ten successive measurements were made for each sample to avoid measurement errors. The measurement results are presented in Table 1:

Table1. Thermal conductivity of samples

Samples	Thermal Conductivity (W/m.K)
PC	0,90
BM5	0,24

Table 1 shows the values of the thermal conductivity of the matrix before and after the addition of 5% of fibers. We note that the addition of DPF in the cement matrix considerably reduces the thermal conductivity of the composite. According to the results found, the decrease in thermal conductivity after the addition of 5% of fibers in Portland cement is 73.4%. This decrease was expected and is directly linked to the insulating nature of date palm fibers. Similar behavior was reported by Abani *et al* [15], they studied the impact of adding date palm fibers to the plaster. According to their results for a mass percentage of fiber of 5%, the reduction in thermal conductivity is approximately 36.67%.

From the results obtained in this work it can be concluded that the addition of date palm fibers in a cement matrix could considerably improve the thermal properties of the composites.

C. SEM analysis:

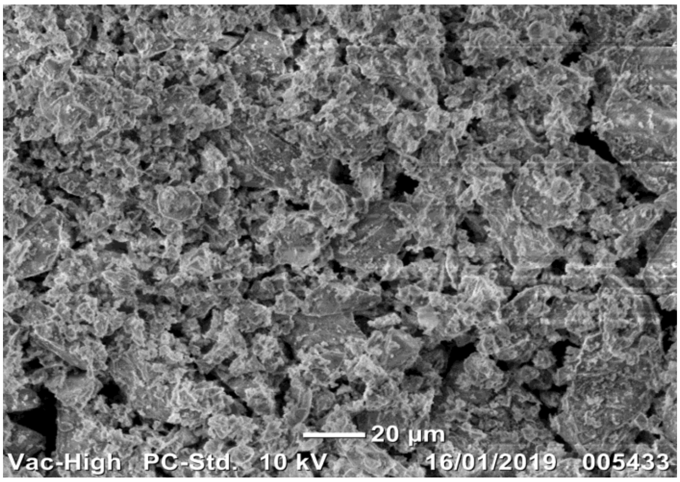

Figure 4. SEM image of the PC sample

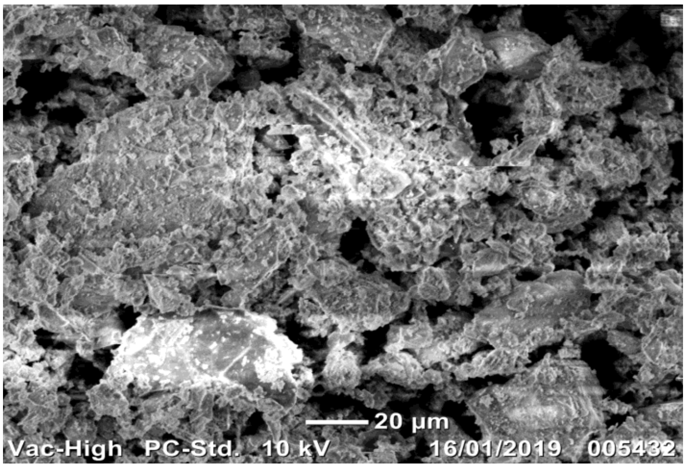

Figure 5. SEM image of the BM5 sample

Characterization by Scanning Electron Microscopy (SEM) of the samples (PC and BM5) allowed the observation of the pores of the samples and the impact of the inclusion of the date palm fibers in Portland cement on the porosity of this matrix.

Figure 4 and 5 show respectively, the images recorded by the

Scanning Electron Microscope (SEM) on samples PC and BM5.

The comparison of the two figures (4 and 5) shows the increase of the pores in the sample BM5 with respect to PC.

SEM analysis shows that strengthening portland cement with 5% date palm fibers (DPF) increases the porosity of the matrix. The increase in porosity includes a reduction in thermal conductivity. This result is in agreement with the thematic results found previously. This explains the insulating capacity of the new prepared material.

IV. CONCLUSION

The objective of this study was to study the impact of the inclusion of date palm fibers in portland cement on the thermal and chemical properties of this matrix.
The characterization results are as follows:

- The RAMAN results have shown that DPF is well incorporated into Portland cement.
- Conductivity results confirmed the insulating power of date palm fibers.
- The inclusion of fibers (PDF) has increased the porosity of the matrix.
- The results of the Scanning Electron Microscope (SEM) reveal that thermal conductivity decreases with increasing porosity.

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