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Effect of fibers surface modification on the thermal properties of a new Eco-composite

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Abstract

This paper presents a study of the feasibility of adding natural and treaded date palm fibbers, to cement to produce a new Eco-composite. Raw dates palm fibers underwent different surface modification methods such as the alkali and the bleaching treatments. Untreated fibers and extracted bio-polymeres were characterized by attenuated total reflection infrared spectroscopy (ATR-FTIR), and scanning electron microscopy (SEM).Moreover, the thermal conductivity and the water absorption were experimentally quantified .

Keywords : Natural palm Fibers,Treated Fibers, Eco composite, Thermal properties **.**

I. INTRODUCTION

In the past few years, there have been a lot of research efforts to use natural fibres and biopolymers to produce a new low cost composite with high insulating properties. In this context, the aim of this work is to develop a new composite based on vegetable fibers like the natural or the treated fibers to reinforce the cement matrix in order to improve the thermal and acoustic insulation. Tunisia is a North African country with large amounts of dates palms planted but unfortunately they are poorly exploited. The objective of this work is to contribute to the development of local resources and integrate them in a rational way in the field of the construction materials.
However, natural fibers present some disadvantages, such as the addition between fiber and matrix . In this context there are interesting reports on the treatment of fibers in order to modify their surface [1] and improve fiber adhesion to the cement matrix.

II –EXPERIMENTAL

The composites used are formed of sand,cement, and dates palm fibers, which were obtained from the local oasis of Gabes Tunisia. After being dried under normal conditions, the petiole rods are cut into small pieces.

A. Surface modification of palm fiber

1) *Pre-treated fibers*

The palm fibers (DPP) were treated with an alcoholic solution for 5h at 80°C, then washed with distilled water.

2) Bleached fibers

The palm fibers (DPB) were treated with an alcoholic solution. After being washed the residue was treated with 5% of NaOH solution for 3h at 80°C, then the fibers were washed with distilled water to remove any trace of alkali. Finally, the fibers were bleached with 5% of NaClO solution for 2h, washed several times with distilled water, and dried in an oven at 60°C.

B. Composites preparation

The cement used in mortar mixtures was an ordinary Portland cement II 32.5 N. For each mix the fiber length were <0.2mm.The mass percentage of natural and bleached fibers was between 0 and 30%. Finally the mixture of (fibers-cement-sand) was placed in molds (44mm * 44mm * 10 mm) and moist-cured for 28 days at 20±2 and 98% relative humidity both before and after demolding.

Three types of composites were obtained.

DPN = Sand + cement + Natural fibers
DPP = Sand + cement + Pre-treated fibers
DPB = Sand + cement + Bleached fiber

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C. Technical characterization

1) Scanning electron microscopy

The morphology and the surface of the fibers were observed by scanning electron microscope of the treated and the untreated vegetable fibers.The device used for observing the microstructure is a scanning electron microscope JEOL 6301 F.

2) *Fourier transform infrared spectroscopy*

The FTIR-ATR spectra of raw surface of natural and treated fibers were recorded in a Perkin-Elmer spectrum.

3) Water absorption

The water sorption measurements were performed by a balance placed over a water bath in which a sample is immersed. The weight of the initial dried sample was then recorded over time. The water absorption coefficient, sorption and permeability were then calculated.

4) Thermal properties

The thermal conductivity “k” and the thermal diffusivity “a” were measured using the measurement device DICO.This technique was developed in the laboratory CERTES. The measuring principle is based on the periodic thermal excitation of a block comprising a sample between two metal plates. A measurement of temperature is performed on the front and rear plates using thermocouples. From these two measurements, the thermal transfer function of the material is calculated. To find the thermo-physical parameters of the sample, we proceed with the simultaneous identification of the thermal diffusivity and conductivity from the minimization of the squared difference between the two heat transfer functions (experimental and theoretical) using Levenberg-Marquardt.This device is described in detail in reference [2].

III. RESULTS AND DISCUSSION

A. Chemical structure

Various chemical treatments are suggested to improve surface finishing and adhesion proprieties of fibers .

SEM images of the treated and untreated elementary petiole fibers are shown in the Fig1.The surface of the natural fiber is cylindrical, rough and full of impurities [1] it is a typical surface of a natural fiber. The cuticle around the fibers is rich in pectin and waxes that make the surface completely hydrophobic. Fig 2(b) shows the surface morphology of the fiber after the alcoholic washing. The pre-treatment cleans the surface of the fibers by removing waxes. It modifies the composition, roughness and surface hydrophobicity of the fibers. Fig 2(c) shows the morphology of the bleached fibers, the bleaching helped to remove most of lignin present in petiole fibers. Indeed the diameter of the bleached fibers is much smaller than that of the untreated and alcoholic treatment[3].

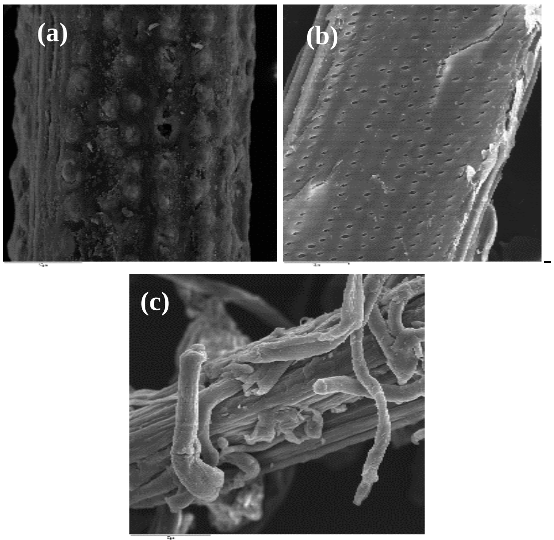

Fig 1. Scanning electron microscopy images of palm date fibers: (a) raw fibers, (b) pre-treated fibers ,(c) bleached fibers

The results of the spectra presented in Fig 2 show the changes in the chemical composition of the raw fibers .

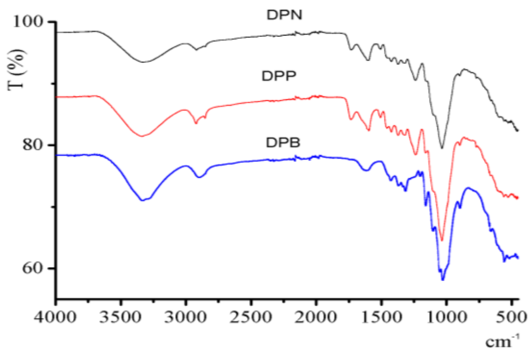

Fig 2. FTIR spectra of palm date fibers: Natural fibers (DPN), pre-treated fibers (DPP), bleached fibers (DPB).

Vegetable or cellulose fibers are mainly composed of cellulose, with varying amounts of lignin and hemicelluloses and other minority componements , such as water and inorganic compounds [10].

The peaks in the 3400-3300 cm-1 and 1640 cm-1 region is attributed to the stretching and bending vibrations, respectively of the OH groups of cellulose. [3] On the other hand the vibration of the aromatic rings can be seen at 1606 and 1515cm-1 (aromatic rings vibrations) which can be associated to lignin [4].

Finally, the absorbance peaks observed at 1028-1161 cm-1 range was attributed to C-O stretching and C-H rocking vibrations of the pyranose ring skeleton [3].

B. Water effect

Water resistance of composite was an important parameter for the composite reinforced with fibers.

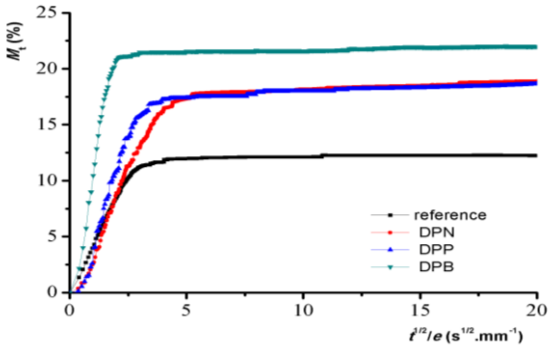

Fig 3 . Water absorption of treated and untreated palm fibers with 2.5% mass fraction.

It is clear that the composites reinforced by fibers absorb more water than the concrete one.the introduction of cellulosic fibersnin cement increases the water demand of composites [6].The velocity of the water absorption in composites is related to the water filing time of the voids present in the date palm fibers (DPF) .This behaviour is mostly noted for composites reinforced with natural fiber [5]

This can be explained, partly, by the hydrophilic nature of plant fibers and secondly, the high rate of pore structure and distribution in the composite. [6] It is also observed that the composites made with the raw fibers absorb more water than the composites made with treated fibers.Thus, after each treatment the surface topology of fiber varies and the fiber becomes more hydrophilic in nature leading to good fiber/matrix interaction [1].

Transport coefficient

The diffusion coefficient "D"can be calculated using the following equation :

$$D = \pi\left(\frac{\theta}{4M_\infty}\right)^2 \quad (1)$$

Where, θ is the slope of the linear portion of the sorption curves, M_∞ the mass fraction of absorbed water at the state of equilibrium. The values of the diffusion coefficient are given in Table 2. The pretreated fibers have a higher value of the diffusion coefficient than the concrete and crude fibers.
The permeability of small molecule into a polymer is dependent on diffusivity as well as the sorption or solubility of a liquid in the polymer [1]. Sorption coefficient S can be calculated using the formula,

$$S = \frac{M_\infty}{m_o} \quad (2)$$

Where m_0 is the initial mass of the sample. The values of sorption coefficients are shown in Table 1. Finally, the permeability P of the composite to water molecules can be regarded as the combined effect of the sorption and diffusion.

$$P = D.S \quad (3)$$

As P is a product of diffusion and sorption coefficient. The values of permeability of various fiber treatments are shown in Table 1.
According to this it is also clear that the surface treatments decrease the permeability which is a good indication of greater fibers_matrix adhesion [1].

Table1. Values of diffusion, sorption and permeability coefficient for treated and untreated palm fibers with 2.5% mass fraction.

	D(m^2/s)	*S(g/g)*	*P(m^2/s)*
reference	3,61E-07	0,122	0,004
DPN	5,98E-07	0,150	0,009
DPP	1,65E-07	0,187	0,003
DPB	6,57E-08	0,220	0,001

C. Thermal conductivity

The measurements of the thermal proprieties have revealed that the values of the thermal conductivity are very interesting. The decrease in the percentage of addition of fibers leads to an increase of the thermal conductivity that reached 0.18 $W.m^{-1}.K^{-1}$ for 30% of fibers.

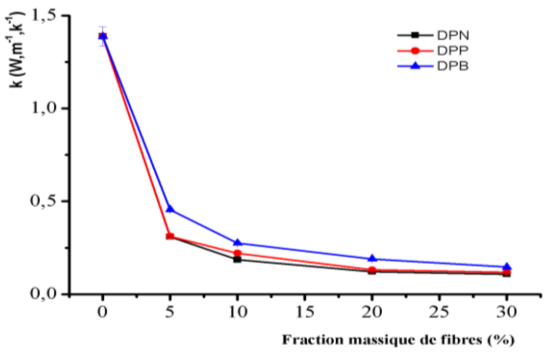

Fig 4. Thermal conductivity as a of concentration of date palm fibers for three compositions

Fig 4 and 5 show the changes in the thermal conductivity and thermal diffusivity as a function of the mass percentage of treated and untreated fibers.It is noted that the addition of these fibers progressively and simultaneously reduces the thermal conductivity and diffusivity of the composites. The pre-treatment of fibers didn't have any influence on the thermal properties.the thermal conductivity of porous materials is governed by the void in the sample [11] The thermal conductivity of the concrete composite decreased from 1.4W.m-1.K-

1 to 0.11W.m-1.K-1 for 30% of fibers. Therefore for an added percentage of more than 5%, Composites become more insulating. The result is that fibers are aligned to be distant from each other.therfore , it creates void and gets low density and low thermal conductivity [6] Taoukil et al [7] studied the effect of adding wood shavings and wood wool on the thermal properties of concrete fibers, and have also concluded that the addition of natural fibers improves the insulation characteristics.

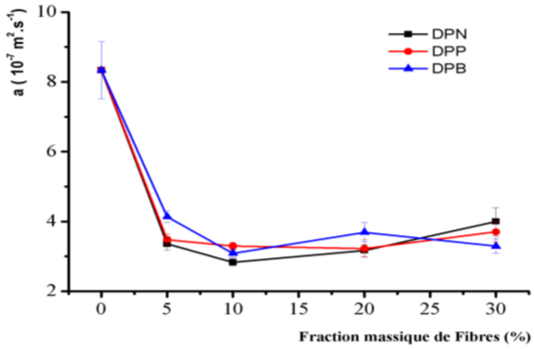

Fig 5. Thermal diffusity as a of concentration of date palm fibers for three composition

Reducing the conductivity was predictable, because of the porous character of the fibers having a lower thermal conductivity than that of the cement has. Also because of the increase of the porosity of the cement when the addition of the fibers. The increase of porosity in the matrix and therefore the reduction of density can be regarded as one of the advantages of using natural fibers mixed with cement; in fact, the cements obtained are much lighter. Aouadja et al. [8] have already noted this effect on the concrete reinforced with wood residues.

IV.CONCLUSION

The exploitation of the agricultural wastes in construction materials has proved to be a very efficient way to create new ecological composite materials and mitigate the economic and environmental constraints on those materials. The results showed that the incorporation of raw dates palm fibers undergoing different surface modification methods with different weight concentrations in the new eco-composite reduces the thermal properties of materials. Indeed, this work showed that the prepared eco-composite has a good thermal insulation propriety.

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