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Enhancement of Rigidity and Thermal Performances of Fabrics Through the Addition of Nanoadditifs

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Abstract: In this study, the nanocomposites have been synthesized with the natural Tunisian clay which has the advantage of being cheap. In fact, it is composed of many kinds of clay (Kaolinite, Dolomite, calcite, Illite and Quartz). This clay has been cleaned, purified, dried and mixed with different resins currently used in many textile applications such as comfort, elasticity, impermeability … etc. The samples have been examined under MEB in order to identify them and ensure the formation of nanocomposites. The mixture resin/clay has been deposit on a 100% cotton fabric (400 g/m^2) and tested on adiathermic power (AP%) measuring equipment. The parameter of thermal isolation of coated fabrics has been calculated through the difference in temperature between the interior and the exterior of the fabric in focus. It has been noticed that the increase in clay quantity improves significantly the thermal characteristics of the coated fabrics. The rigidity of the fabrics has also increased in terms of clay quantity, this proves that this new kind of fabric must be used in specific domains that compile their isolating characteristics and their increasing rigidity with the rate of clay inserted.

Keywords: Nanocomposites, Clay, Coating, Thermal Isolation, Rigidity

1. Introduction

The nanotechnology has participated in the scientific progress in different fields such as the textile, the electronic and the optical. The nanostructured materials like the late films owe their characteristics to two parameters: the size and the surface effect.

The manufacture of nanocomposites applied in this study is very delicate, since the used resins are hydrophilic, so they have an affinity for clay. In addition, the analysis requires a lot of attention because the multitude of overlapping peaks due to clay can't be well interpreted. Many researchers have tried to give the fabrics new characteristics through the addition of nanoadditifs, for example, in the domain of mass spectrometry (1), thermal isolation (2,3), ignifugation (4), lubricants and aerospatial applications (5), flexibility and resistance to organic solvents(6), moisture sensors (7,8) and the fictionalization of surface(9); however, their works were only accomplished when using the Montmorillonite which is characterized for its simple composition (10, 11, 12 and 13).

The aim of this study is to show how the coating of nanocomposites is carried, and how this method of thermal isolation takes place in terms of the percentage of clay, the resin used and the deposit quantity.

2. Experimentation

In order to be able to use clay as a reinforcement element in the nanocomposite, we have purified it, crushed it then dried it during 24 h in a stove at 100°C in order to get rid of intertitial water. Then, we have prepared the nanocomposite through a method adapted to that of Kim and Choi (10):

5g of clay added to 100 ml of chloroform are well dispersed in an ultrasonic mixer (freq= 28 KHz) equipped with a controller of temperature during 2 hours (the formation of nanocomposite is tightly related to the good dispersion of the nanoparticules of clay). The mixture with the resin is done after that during 48 h in a magnetic blender at 25°C by adding small quantities of clay during at least 30 min in order to get an homogeneous mixture which will be then dried during 30 min at 100°C, and at last polymerized in a stove during 30 min at 150°C.

Four resins have been used: modified DMDHEU, Vinyl-Polyacelate (PVAc), Polyacrylate (PAC) and Polyurethane (PU2).

All tests have been done on a 100% cotton samples with a surface mass of almost 400g /m^2 (Jeans fabric), the addition has been done in a discontinued manner thanks to regulated pressure device (the quantity put has been the same for all the samples, and which equals 540g/m^2) (figure 1).

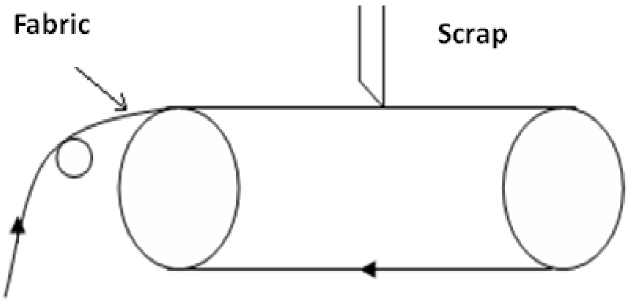

Fig. 1. *Fabric coating using a regulated pressure device*

The formation of nanocomposites has been affirmed by DRX and MEB in previous work (14). Therefore the thermal characteristics have been studied through measuring the adiathermic power (AP%) using the device PASOD of the enterprise SODEMAT.

3. Results

3.1. Identification of Obtained Nanocomposites

For all the resins employed, we have seen on the MEB photos (figure 2) the mingling of the clay grains with the basic structure of the obtained material and this, on some nanometer decades.

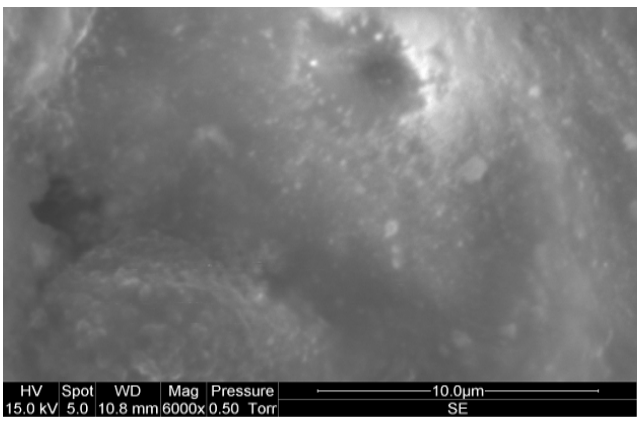

Fig. 2. *SEM image of nanocomposite PAC/clay.*

When comparing those photos with those done on the pure matrix, we have deduced that the white points are no other than the clay grains, « the clouds » observed accompanied generally with dark lines can be but some oriented parts of macromolecules there where we found the maximal density of reinforcement of clay (15). The DRX analyzed samples allowed us to understand the spectral difference between the pure resin and the produced nanocomposite with (16, 17, 18 and 19).

3.2. Thermal Characteristics of Coated Fabrics

The application of clay in the nanaocomposites proves to be of major importance, since the characteristics of thermal isolation have been abviously enhanced in terms of the amount of clay (figure 3). The average of this enhancement is between 20 and 30 percent and this always remains in terms of resin (conductivity and viscosity) and the percentage of clay.

The resin PVAc proves to be the best in terms of its recovery of thermal characteristics of fabrics after a decline when using the resins without clay since the adiathermic power becomes so close to that of the reference seen inferior. Its worth mentioning that 5 percent of clay added to PU2 makes the mixture more isolating thermically; this characteristic becomes less significant when the quantity of clay decreases. This is due to many reasons, mainly when we speak about the optimal quantity which replaces almost the major part of the interfibers and intrafibers air quantity in the fabric since the conductivity of air is so low to that of the fabric.

The resins DMDHEU and PAC present relatively the lowest AP% and this for diverse reasons such as:

- The chemical reactions emerging between the resin and the cellulose which give products of secondary reactions holding different degrees of conductivity and capable of generating decrease in PA percent.

- The viscosity and the contact angle (cellulose- resin) relatively low which engender a good penetration of the former in the fibers and consequently replaces the holes which have been occupied with air so having very low conductivity, and this will generate decline of PA percent (20%). In fact, we noticed that if the viscosity of resin increases, the thickness « e » of the latter increases, so there is less penetration of resin in the fabric, and the PA percent will be enhanced.

The resin PVAc shows the best percentages of AP and especially as the quantity of clay is increasing.

The application of clay as a fundamental component of nanocomposite can be a solution to remedy the fall of AP percent due to the application of resin only.

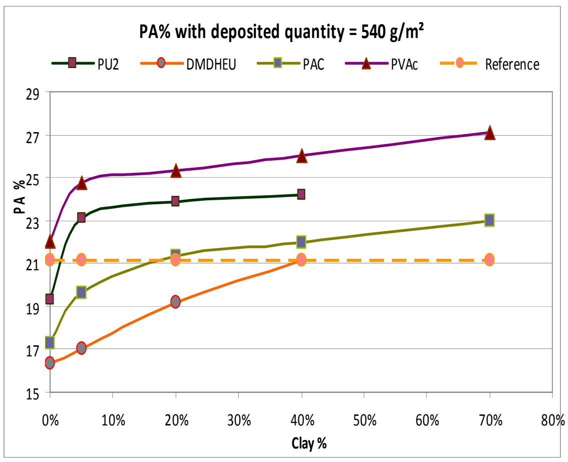

Fig. 3. *AP % of coated fabric through resin/clay in terms of the clay rate.*

3.3. Flexure Rigidity of Coated Fabrics

After having applied the coating, we have noticed that the samples have become more rigid and that's why, we have opted to do the tests of rigidity in order to compare it to the reference sample, so that we can precise to what extent can we limit the use of those articles, and for, each domain of use.

The samples have been divided into 2 x 25cm rectangles, and then examined on a cantilever tester according to standard BS 3356 : 1990. The method consists of making the sample slip on a horizontal plane until that its extremity touchs an inclined plane of 41,5° relative to a horizontal support, and we take the length of flexure on a scale of the rule S.

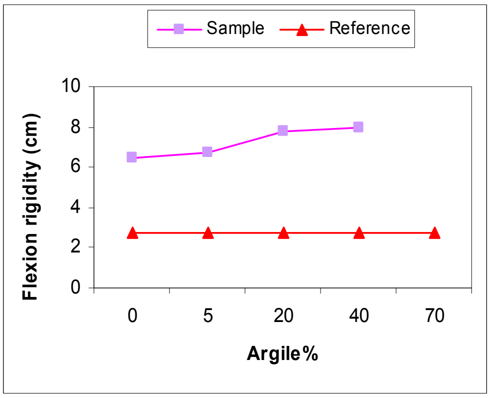

Fig. 4. *Rigidity of the coated fabric with PU2/clay in terms of clay rate.*

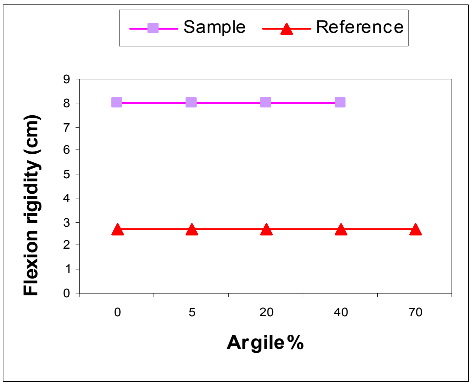

Fig. 5. *Rigidity of the coated fabric with DMDHEU/clay in terms of clay rate.*

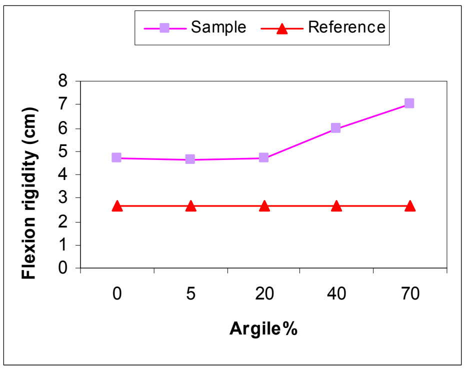

Fig. 6. *Rigidity of the coated fabric with PAC/clay in terms of clay rate.*

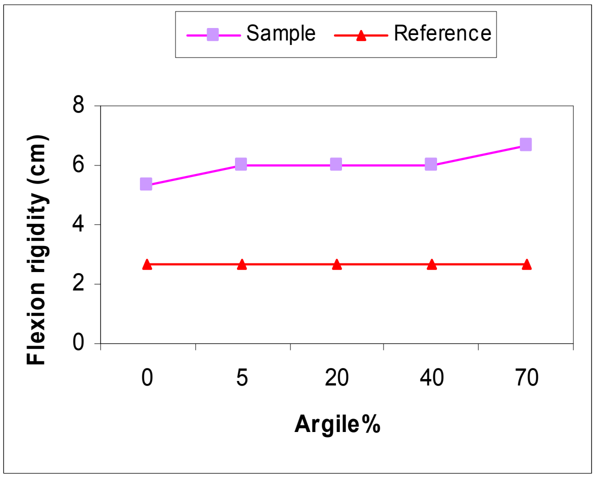

Fig. 7. *Rigidity of the coated fabric with PVAc /clay in terms of clay rate.*

As it is shown in the above figures, all the samples have become more rigid than the reference sample and this is the most important disadvantage of these coated in case of using them for clothing. When those coated fabrics will be used in other applications, such as outdoor articles, tarpaulins etc, the rigidity becomes in this case an advantage.

In addition, if the clay quantity increases, the rigidity increases as well. Sometimes, 5 percent of the clay quantity seems not to influence much the rigidity.

Other tests can be done to better characterize the obtained materials like the toughness (21) which can orient the application of this new class of hybrid materials (5).

4. Conclusion

The application of nanocomposite as coating can in some ways remedy the problems of the fall in thermal resistance caused by the application of crosslinking resins. In fact, we have noticed that each polymer has a very specific characteristic (sticky effect, anti tear… etc). This can explain the use of resin in the textile industry and even in many other domains such as food, aviation, aerospatial … etc.

The application of clay as a fundamental component in the formation of coatings has been very important given that the thermal isolation of the article is enhanced in terms of the reinforcement quantity put inside (from 20 percent to 30 percent). In fact, certain resins, with precise quantities of clay, can be good thermal insulators in case of clothing; and just for this characteristic that we can use those coatings only in specific domains.

Even so, the parameter of viscosity remains always a limiting factor in the handling of the prepared materials. The resin PVAc seems to be the best even for low quantities of clay.

The most important disadvantage of the used clay is its yellow colour, mainly when the treated article has a bright colour, something that can hinder its use.

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