BANANA AND ABACA REINFORCED POLYETHYLENE COMPOSITES MICROTENSILE VIDEO TESTS

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Abstract
This research focus on the characterization of banana and abaca reinforced composites obtained by rotomoulding. These composites were characterized by mechanical tests (tensile, flexural, impact and DMA), DSC and optical microscopy. This paper shows the results obtained when testing these composites with a microtensile tester, observing the failures method. Differences between both types of fiber have been observed, showing different compatibility of these fibers with the polymeric matrix; chemical treatments also influence the behavior observed at failure. Banana and treated abaca fibers break in the PE matrix, while pull-out effect was observed for abaca fiber.

1. Introduction

Rotational molding process is a procedure to get hollow parts, with high mechanical properties, good superficial quality and good thickness distribution; on the other hand, this process has a long cycle time, low energy efficient and low number of materials available, being most of them PE and PVC.

In this context, the use of new formulations of plastic materials, environmentally more friendly, has being studied, by the use of natural fibers within this process. In particular this paper shows the results obtained when banana and abaca fibers are used as reinforcement of polyethylene matrixes, producing standardized test samples made by rotational molding.

An important number of research works have been carried out to introduce different vegetal fibers into polymeric matrixes, although just a few have been reported for the rotational molding process. The use of natural fibers can improve the mechanical properties of the virgin polymer, mainly the elastic tensile modulus [1, 2], showing a reduction in impact properties [1-3].

This study was made by producing thin sheets of polyethylene with virgin abaca or banana fibers, and also with NaOH treated abaca fiber. Microtensile video tests were performed with sheets obtained from these composites, getting series of pictures during the breakage of the material.

Failure of a composite made with fiber can basically happen in two manners: with fiber breakage inside the polymeric matrix or with fiber pull – out [4]. Fiber breaking inside the composites implies a good adhesion between the fiber and the matrix, leading thus to increased mechanical properties; on the other hand, pull – out of fibers means that matrix does not transfer mechanical stress to the fiber, being displaced into the matrix.

2. Materials and testing methods

Metallocene polyethylene (mPE3583UV) from Total Petrochemicals was used as polymer matrix (density: 0.934 g/cm^3, melt flow index: 8.0 g/10min). Abaca fiber was kindly supplied by Celesa, while banana fibers extracted at ULPGC. Fibers were treated by soaking them in a 1N NaOH for 1 hour at boiling temperature (Panreac NaOH pellets, with a 98 % purity, product code 215-185-5) to improve its thermal stability and reduce the odor of the composite.

2.1. Preparation of samples

Films were prepared in a Gibitre instruments press, by placing the rotomoulded samples between two teflon papers and putting them at 140 ºC for a few minutes; once the material was molten, the pressure cycle started: 200 bar for 2 seconds and 250 bar for 1,5 second. After cooling, films made with PE and fibers, as shown in figure 1 (left), were obtained; these films were cut by means of a die with the shape of a standardized test sample (as shown in figure 1, right).

Figure 1. Films obtained from the rotomoulded parts (left); die used to obtain the test bars (right)

2.2. Test of samples

Test bars were then tested in the experimental microtensile video tester, developed at ENSAM, and shown in figure 2. This device includes a microscope, with 5x magnification objective, allowing to observe during the entire tensile test the changes happened in the material and the breakage mode, and allows testing at rates between 50 to 20000 μm/min. These tests were carried out at a rate of 1000 μm/min.

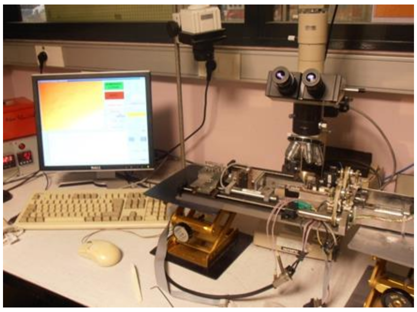

Figure 2.Experimental microtensile video tester used in the tests

Different behaviors of the film have been observed, depending on the orientation of the fiber (cross or longitudinal) related to the stress applied, and also depending on the type of fiber in the film. In order to ensure that results obtained are significant, at least 5 test samples were tested for each type of film produced and for both orientations of fibers. Although the equipment also records values of tensile-strain, they have not been taken into account, as they are not considered as representative (and the mechanical behavior of the composites was already found out in a universal testing machine).

3. Results

3.1. Fiber placed perpendicular to test direction

In any test sample with the fiber placed perpendicular to test direction, breakage happens in the edge of the fiber, as observed in figure 3. No differences have been found in this case due to the type of fiber.

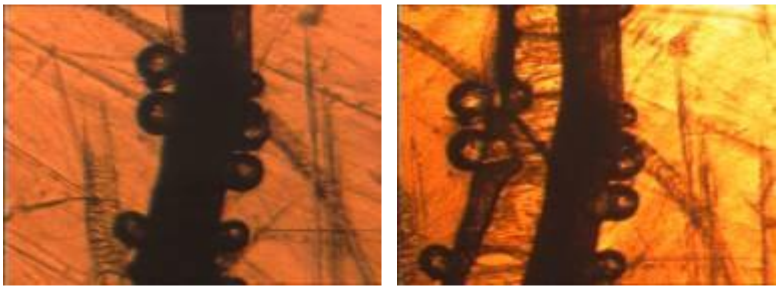

Figure 3. Pictures showing the breakage in the fiber edge, when it is placed perpendicular to test direction

3.2. Fiber placed parallel to test direction

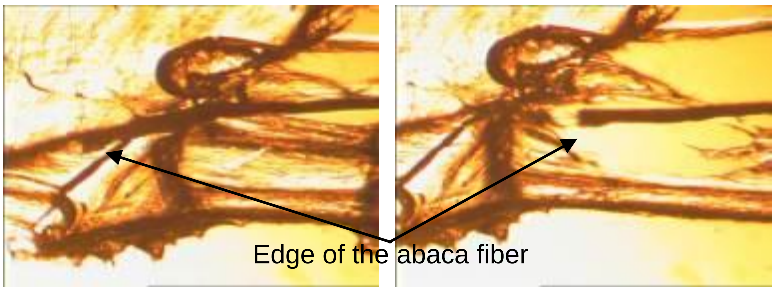

Figure 4. Pictures showing pull – out of abaca fiber in the PE matrix

Virgin abaca fiber shows poor adhesion with the PE matrix, as fiber does not break during the test, but it just slides into the polymeric matrix; so, pull-out effect is observed when the films contain abaca fiber (figure 4).

On the contrary, samples containing banana fiber show fiber breakage inside the PE matrix and, after that, it is observed how fiber starts displacing inside of the polymeric matrix (figure 5).

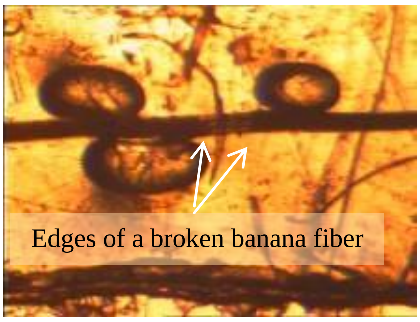

Figure 5. Pictures showing fiber breakage in banana fiber sample

Treated abaca fiber shows a similar performance to this observed for virgin banana fiber; this fact means that the alkali treatment has increased compatibility between the fiber and the polymeric matrix, as this fiber breaks inside the matrix and no pull-out effect is observed (figure 6).

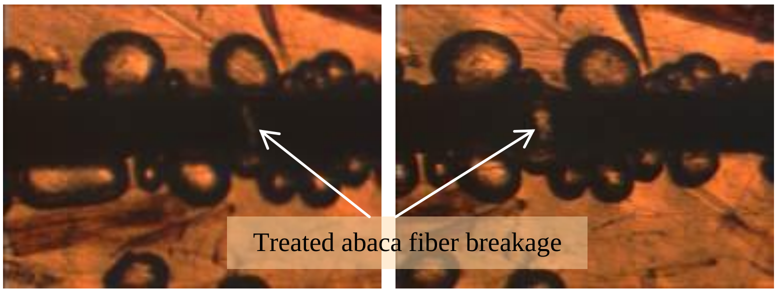

Figure 6. Pictures showing fiber breakage in banana fiber sample

This different behavior is mainly attributed to the change observed in the surface of the fiber because of the chemical treatment; if these fibers are put under an optical microscope a rougher surface with part of detached microfibers is observed, increasing that way the mechanical anchorage of the fiber to the PE. Figure 7 shows, at the same magnification level and scale, two fibers: virgin (on the left) and after being soaked in a NaOH solution (on the right). It is clearly observed how the fiber starts splitting into several microfibers (which form the fiber observed at macro-scale), explaining thus the higher mechanical anchorage to the PE matrix and, thus, the absence of pull – out.

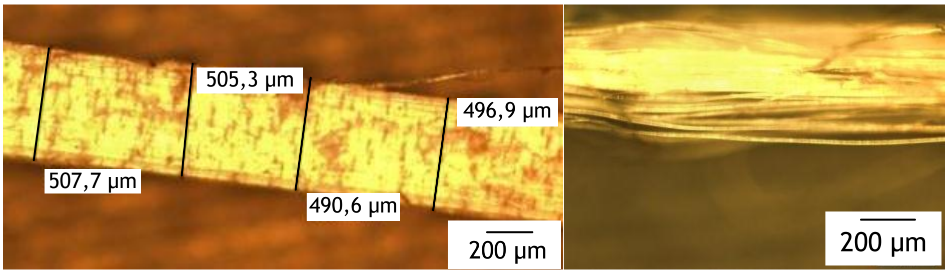

Figure 7. Virgin abaca fiber (left) and NaOH treated abaca fiber (right)

4. Conclusions

Innovative microtensile video tester has been proved to be useful for the determination of breakage modes in composites.

Virgin banana fiber seems having better compatibility than virgin abaca fiber, as banana fiber is broken inside the PE matrix while abaca fiber pulls – out from the matrix.

NaOH treatment dissolves lignin in the fiber and kames it rougher, with detached microfibers, so the mechanical anchorage to the polymeric matrix is higher.

NaOH treatment improves the adhesion of abaca fiber to the PE, because it passes from pull – out in virgin fiber to breaking for treated fiber.

References

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