Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 03, March-2021

Analysis of Composite Materials (Polypropylene-Wood) with Optical and Scanning Electron Microscopy

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Abstract— **Microscopic analysis in composite materials has become a fundamental tool for the development of composites, offering a range of physical, chemical, and mechanical characteristics, which are part of engineering interpretation to achieve direct conceptualization in favor of composite material for tangible applications in the engineering branches. It is important to consider that this analysis is applied in composite materials generated with recycled raw material from a wood-reinforced plastic material, which is in the form of sawdust, on the other hand, no mating element is used for both materials, the basis is based on improving manufacturing technologies for these materials. The results obtained by microscopy offer great opportunities to continue with the line of composites, as they show areas where the reinforcement material is mechanically joined homogeneously.**

Keywords—Sawdust, composites, microscopy, plastic, composition.

I. INTRODUCTION

Microscopy is a fundamental tool in the study of materials, regardless of their classification, as interpretation depends on it to generate considerations in a material to be studied.

In the last sixty years the most diversified materials with the highest volumes of consumption worldwide have been plastics reinforced with synthetic fibers: thermoplastics and thermosets reinforced with carbon fibers, aramid (Kevlar), glass fibers, etc. Because of increases in commodity prices and the generalization of environmental awareness in recent years, so-called "green materials", many of which are of the type reinforced by plant-based fibers, have been gaining ground [1].

One of the difficulties presented by these materials when designing the parts is the need to design the material itself to achieve the required properties [2,3]. This shows that not all composite developments are successfully determined, but there is much to work on in this line of materials, to constantly improve in the analysis of compounds and thus obtain tangible applications [4].

With the above mentioned so far it is possible to perceive the importance in the study of composite materials reinforced with recycled raw material and natural fiber reinforcements, which is shown at the time of analyzing the impact that has arisen when improving the mechanical properties of such compounds [5].

Therefore, this work shows the results obtained by microscopic observation of the composite material in its interface to understand and analyze the structure of composite materials based on polypropylene and sawdust reinforcement in the form of fiber, without the use of coupler agents for the homogeneous bonding of fibers with PP (polypropylene).

In addition, the scanning optical and electronic microscope methodology is used, finally, relevant points are given in the analysis of results that offer fields of opportunity for the development of research in this line and improve the conditions of compounds reinforced with natural fibers generating new evaluation alternatives with materials that perform that function.

II. DEVELOPMENT

This section will describe in a general and graphical way the microscopy process of the composite material, initiating in the preparation of specimens and ending with the obtaining of corresponding images for optical microscope and scanning electron.

First, the selection of specimens to be evaluated is carried out, of which the following base material compositions are available with the reinforcement material, this is described in Table 1.

TABLE 1 PERCENTAGES OF COMPOSITE MATERIAL TO BE EVALUATED BY MICROSCOPY

Material Base	Percentage[%]	Reinforcement material	Percentage [%]
Polypropylene	90	sawdust	10
Polypropylene	80	sawdust	20
Polypropylene	70	sawdust	30
Polypropylene	60	sawdust	40

The table mentions the two materials to be used in the evaluation, the two materials are recycled, polypropylene and the unique pine sawdust. The compositions considered correspond to a previous selection with respect to the size of the reinforcement material, which is obtained from a screening process where mesh 40 is used, since previous works in this field show that the best use of sawdust is with that type of mesh.

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The test specimen result is shown in figure 1, impact test specimens, used for microscope observation.

Fig. 1. Impact specimens for evaluation.

The selection of the specimens for evaluation under the microscope was considered for the parts of the impact test, in which are presented critical areas of fracture that offers the opportunity in the corresponding analysis and imaging with various points to be evaluated [6, 7].

Another stage is the preparation of microscopy specimens, which consists of: a) placing the part in a base material for support in clamping, b) roughdressing fine with sandpapers from 220 to 1000, c) finely polished with cloth, d) optical microscope observation, this sequence is seen in the diagram in figure 2.

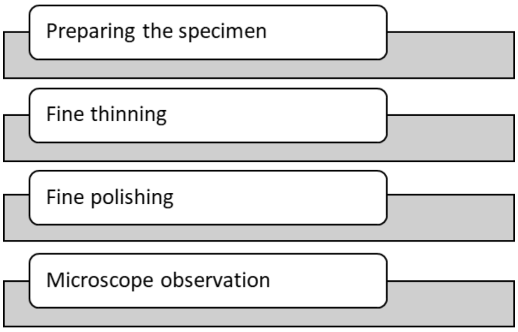

Fig. 2. Sequence in the preparation of specimens for microscope observation

Figure 3 shows the specimens for observation under an optical microscope, in three compositions of the composite material. It is intended to show how the impact parts were worked, after the fracture, for their respective analysis under microscopes.

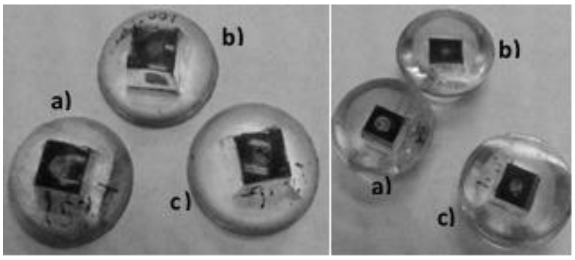

Fig. 3. Test specimens ready for evaluation

The figure above shows the specimens prepared for evaluation, the compositions identified are a)90-10 %, b)80-20%, c)70-30%, polypropylene-sawdust respectively. Considering that the specimens should have similar characteristics for the corresponding evaluation.

At the end of the process, the specimens are ready and the process of both optical and scanning electron microscopy is carried out, which is described and exemplified in the following paragraphs and images.

After the preparation of the specimens is observed by means of optical microscope, figure 4, Nikon model EPIPHOT, with increases from 5X to 100X.

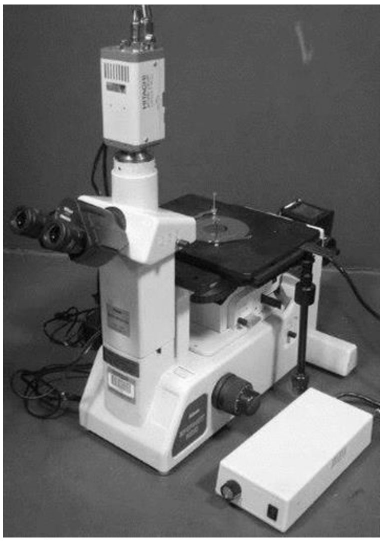

Fig. 4. Nikon optical microscope

Subsequently, the Philips XL20 TMP scanning electron microscope, figure 5, is used to obtain the corresponding images and achieve the evaluation of the composite material, observing in a timely manner the gaps between the base material and the reinforcement material.

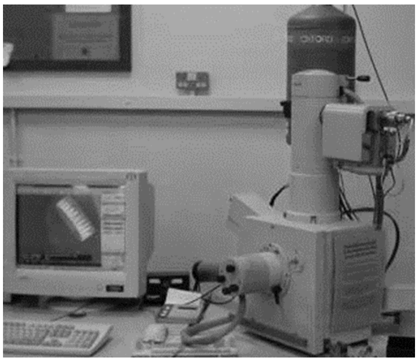

Fig. 5. Scanning electron microscope

The characteristic of the electron microscope is the number of increases,10 to 10000, which allows to observe in general the composite material and its adhesion between them.

The images obtained in each of the microscopes are shown in figure 6.

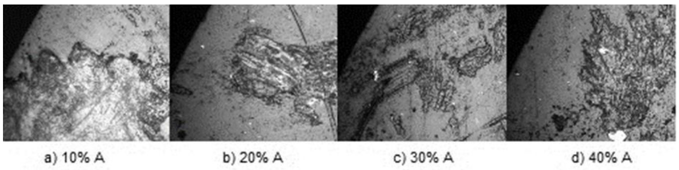

Fig. 6. Optical microscope images

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 03, March-2021

Figure 6 shows four sequences of the specimens in compositions 90-10, 80-20, 70-30 and 60-40 of PP-A, where it is observed that there are dark areas between the base material and the reinforcement material, which gives indication to the separation between the materials.

Something important when viewing the images in figure 6, it is perceived that the particles of the reinforcement material have the same dimensional and distribution characteristics, considering that the magnifications are 20X.

Next, you have the result of the images obtained with the scanning electron microscope, figure 7, in different increases established with the preparation of the specimens, one of the characteristics is that the material is not conductive and therefore the difficulty in obtaining the photographs in this type of microscopes.

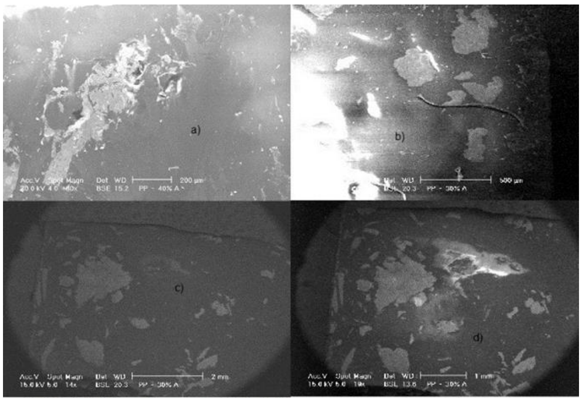

Fig. 7. Scanning electron microscopy images

Figure 7 shows 4 photographs of the result in the evaluation with scanning electron microscope, managing to identify the existence of wood fibers, sawdust, embedded in the base material of polypropylene, unlike in the optical microscope in these figures have white areas that reflect the separation between the materials with which the recycled raw material compound is obtained.

Image a) is at an increase of 80X, while the b) is at 14X, c) 50X and d) back to 80x. The difference between the increases is visible and the separation of the materials is observed, the white areas show as part of the effect when not using the mating material, in these two materials, that the separation between them is normal as part of the production process of the specimens for the corresponding evaluation [8, 9].

In the preceding paragraphs, each of the figures in which the composite material is analyzed through the graphic and visual elements of microscopy has been briefly described. In applied engineering we have materials with uncommon characteristics and properties, when made with recycled raw material, from which it is possible to determine that the results differ in relation to those materials that are generated with virgin products and with couplers for improvement in mechanical properties, however, it is very clear to see that the transformation process in the compound materials with coupler increases the cost of manufacture.

In terms of the mechanical properties of this material manufactured with recyclable products and virgin properties vary between 10 and 12 %, so this work is presented to achieve comparisons and mechanically improve each of the properties of the material after microscope observation, this achieves representative data regarding the separation that exists between the materials.

III. ANALYSIS OF RESULTS

In relation to the analysis of results it is described from the parameter of separation of plastic material and reinforcement with wood fibers.

The microscopic aspects are figure 8, which dimensionally shows the separation of the base material with the reinforcement material.

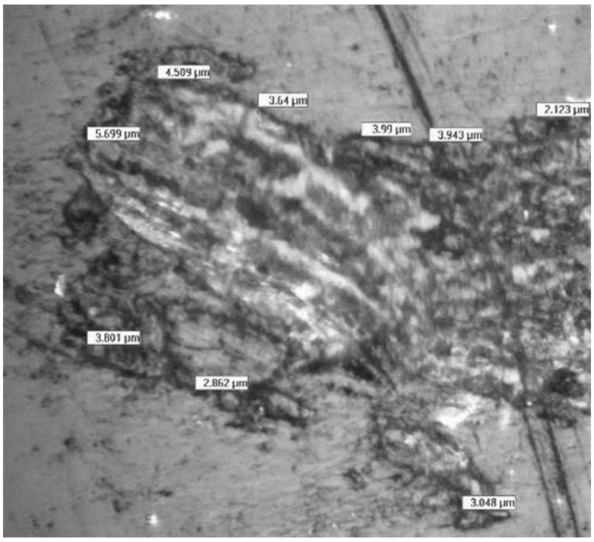

Fig. 8. Dimensions of the separation of the interface from the composite material.

Figure 8 shows that the maximum value of the separation is 5,983 m and the minimum value of 1,845 mm. The result of optical microscope observation is represented in the graph below in figure 9, which identifies the maximum and minimum measurement values for the existing separation of the plastic material with the reinforcement material.

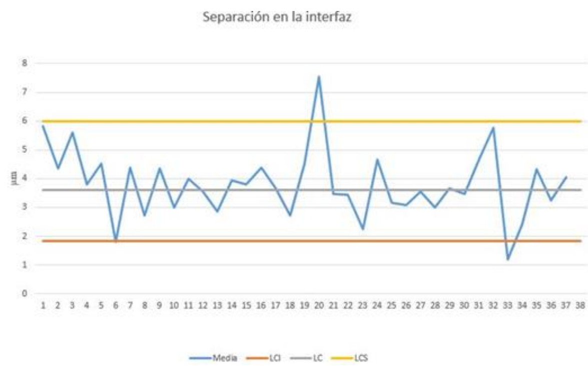

Fig. 9. Separation plot on the interface

The figure shows that as the amount of sawdust in the composite material increases, the separation between polypropylene and sawdust decreases, so it is interpreted that, in this type of compounds with natural fibers, the fibers must be specifically controlled in order to minimize the separation

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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between the materials and follow the development of the materials without the use of external couplers.

On the other hand, the results of microscopy are obtained by means of a scanning electron microscope, where it is possible to observe the separation of the materials already mentioned and evaluated, according to figure 10.

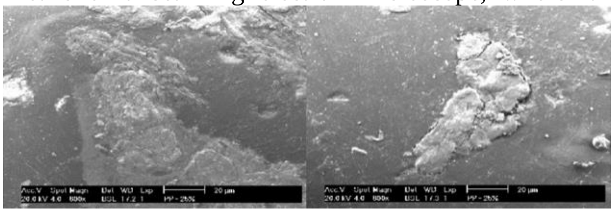

Fig. 10. Scanning electron microscopy in composite material

In this figure you have a view of the composite material with an increase of 800X, where the separation of the reinforcement material with polypropylene is displayed.

The appearance of the particles or fibers of the sawdust is detailed, the morphology shows the orientation and evidence of how the bond between the materials developed with recycled raw material is located.

In general, it is appropriate to reflect on this and the evidence makes it possible to establish that the efforts and flow applied during the development of composite materials have an adhesion between matrix and reinforcement for applications determined under the properties presented by these composite materials.

IV. CONCLUSIONS

An important part in the development of evaluations by means of both optical and scanning electron microscopy in engineering materials, allow to obtain images showing that the material maintains fragile behavior, thus identifying a tendency of a material with rigid characteristics, which will depend on the dimensional conditions of the fiber or particle used of the sawdust.

This is reflected in the mechanical properties of composite materials, which is an important part of the analysis of these compounds, with the photographs determining that the particles become ductile since the matrix absorbs the energy generated during processing and evaluation.

In relation to the results, the dimensions of the wood fiber must be controlled in order to add more of it in a homogeneous way and increase the adhesion of the materials, without forgetting that if the use of natural fiber is exceeded the compound becomes too fragile and affects the properties by decreased, thus affecting the mechanical behavior.

About the analysis, adhesion between plastic and wood is considered appropriate by providing that no substance is used for accession, however, work will continue to improve the conditions of such a bond between raw materials.

From a research point of view, it is an important line to continue working on it and formulate algorithms to generate other analyses for recycled raw material composite materials.

It is well known that the tendency of composites is to achieve consistent properties for the most impactable engineering applications, so we work extensively on the different techniques for the analysis of these materials within engineering and its various areas.

Finally, as a future work there are various assessments regarding the use of microscopy and its use to analyze various dimensions of natural fibers and different types of engineering plastics, achieving satisfactory adhesion in conjunction with mechanical properties and managing to determine tangible and timely applications for each composition of the composite material.

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