5ème Conférence Internationale des Energies Renouvelables (CIER– 2017)
Proceeding of Engineering and Technology –PET
VoL.28 pp.78-81

Usage of Acrylic Non-woven Waste as Reinforcement in Composite Material

Wafa Baccouch [1*], Adel Ghith[2], Wafa Miled[3], Xavier Legrand[4], Faten Fayala[1]

[1] *LESTE, Laboratory of Thermal and Energetic Systems Studies, National School of Engineering of Monastir, Tunisia*
[2] *LARATSI, Research Laboratory of Automatic, Signal and Image Analysis, University of Monastir, Tunisia.*
[3] *LGTex, Laboratory of textile engineering, Height Institute of Technical Studiesof Ksar Hella, Monastir, Tunisia*
[4]*GEMTEX, Research Laboratory of Textile Materials Engineering, National School of Arts and Textile Industries of Roubaix, Lille University, France*
* Corresponding author's email: wafaabaccouch@gmail.com

***Abstract*— Recycling textile waste gained a great importance in the past decades, and using it as reinforcement of new composite materials is a new research theme that is being studied in these last few years. The use of reprocessed fibers has the primary advantage of being eco-friendly and low cost compared to virgin ones on the expense of lower structural properties. In this study, a needle punched acrylic non-woven waste was used as reinforcement material to epoxy resin. Textile non-woven waste was afforded by a local textile recycling industry and was characterized in a metrological laboratory; chemical identification of the composition of the fabric, width, density and fiber orientation of the nonwoven. The composite material is then realized via resin infusion method. The mechanical properties of the composite were investigated by a tensile testing machine and a bending testing machine. Scanning electron microscopy (SEM) was also used to analyze the fiber/matrix interactions of the composite.**

***Keywords*— recycling, non-woven waste, composite material, textile, epoxy resin.**

I. INTRODUCTION

New fashion trends and designs appear each season and then new items are made, leaving us wondering about the fate of old-fashioned ones. The increase in the annual production of clothing added to the increase in the population explain the large quantities of textile waste generated each year.

Textile waste can be generated inside the industries as production remnants such as fabrics, fibers and filaments wastes, wastes from spinning, weaving or knitting and they can be also discarded clothing that the person doesn't need any more due to any damage of for being out of trend, or that the industry discards before consumer use for not meeting some quality standards.

World fiber production is now exceeding 64 million tons per year [1]. In 2002 global production - in million metric tons - for the key fiber types was: polyester 21.0, olefin 5.9, nylon 3.9, and acrylic 2.7 [2]. This means that millions of tons of textile waste are generated every year. Burying and landfilling present an environmental concern. In fact, certain synthetic fiber products do not decompose, while natural fibers such as wool does decompose but produce methane which contributes to global warming [3]. Recycling textile waste reduces then the need to landfill space, pollution as well as water and energy consumption.

Discarded clothing can be used as a second hand clothes or given to charities in case they are not damaged, fibers, carpet waste and damaged textiles can be recycled into nonwovens and mats. These nonwovens can be used as insulation materials, carpet underlay, shoes insoles or stuffing for toys [4].

Textile waste can be used to produce composite materials as well; they can be used as reinforcement for composites or laminates or as a matrix for recovered polymers by melt processing [1].

Using recycled textile in composite materials is a new theme of research and an attractive subject but there are only few studies in the literature related to this subject. Yet it could be a remedy for the problem of the increasing volume of textile waste.

In this study, we used acrylic waste as reinforcement to epoxy matrix. Composite was made via infusion method and performance tests were evaluated based on the non woven fabrication direction. Scanning electron microscopy (SEM) was used to analyze the fiber/matrix interactions of the composite.

ISSN 2356-5608

II. MATERIAL AND METHODS

A. *Reinforcement and matrix materials*

Needle punched acrylic waste non-woven supplied by a local textile waste recycling company was used as reinforcement material in this study. Epoxy resin (density = 1.175 ± 0.01 g/cm^3 at 20°C) and its hardener (density = 1.01 ± 0.01 g/cm^3 at 20°C) were used as matrix material and they were supplied by Sicomin company under the trade name SR 8200 and SD 7203 [5].

Fig 1 Non woven waste used as reinforcement

B. *Manufacturing method*

Composite panel was prepared by resin infusion method; it is an open mould process that uses vacuum as driving force to infiltrate resin through bagged fiber reinforcement [6].

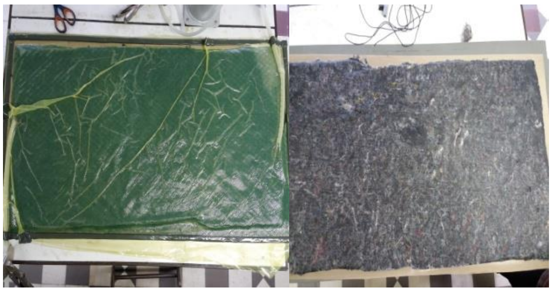

Fig 4 (a) composite realization via resin infusion and (b) demolded composite material

A steel mold covered with release agent is used, the non woven fabric covered with a tear-off tissues from both sides is then placed, then a perforated film to ensure resin circulation. An adhesive silicone tape was placed around the perimeter of the mold to provide a proper seal and to fix the flexible vacuum bag that was placed on top. An inlet tube and an outlet tube were placed inside the vacuum bag. The inlet tube was connected to a pot filled with premixed epoxy resin while the outlet tube was connected to a vacuum pump. The vacuum was applied while the inlet valve was closed in order to compact non woven reinforcement and to remove excess air. The resin was then vacuum infused into the fabric. The material was kept for 24 hours at ambient temperature before demolding it.

Reinforcement and matrix proportions were then determined and the composite was made of 20,49% non woven waste and 79,51% epoxy resin.

C. *Test methods*

Chemical identification test was conducted to investigate the composition of the non woven waste. We used Heated NaOH for the identification of wool fibers, heated acetic acid for the identification of polyamide fibers and heated DMF for identification of acrylic fibers.

Width and density were also measured. Ten samples were tested for each identification test.

The non woven waste was observed under a microscope with a magnification of x20 and images are presented in fig 4.

The mechanical properties of the composite were investigated by a tensile testing machine. Tensile testing was done using INSTRON test machine with a tensile speed of 10 mm / min and using a load cell of 250Kn, according to ISO 537 – 4. Three-point-bending test was carried out with the same machine but configured for this purpose with a bending speed of 2 mm / min, according to ISO 14125. Tensile strength and bending strength tests were performed on the specimens that were cut both in the non woven fabrication direction (0°) and perpendicular to the production direction (90°) (Fig3). Five samples were tested for each direction.

Scanning electron microscopy (SEM) was used to analyze the fiber/matrix interactions of the composite.

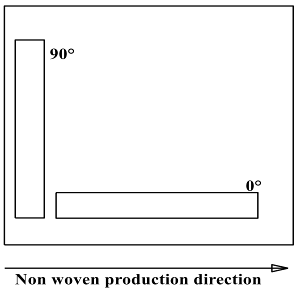

Fig 3 Testing directions of specimens for tensile and bending tests

III. Results

Chemical identification test results showed that the waste is composed of approximately 80% acrylic fibers, 10% wool fibers and 10% polyamide fibers. Density of 800 g/m^2 and width of 8,4 mm.

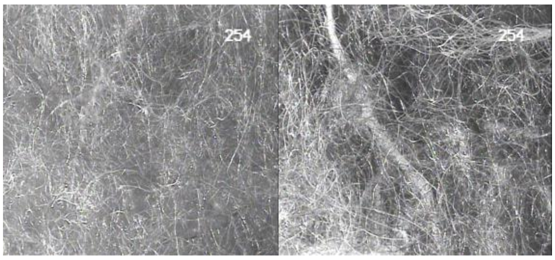

Fig 4 Microscopy images of the non woven waste

TABLE 1
Tensile strength test results

Direction	Direction 0°	Direction 90°
Tensile strenght (MPa)	8.14	6.62
Elongation(%)	1.43	1.75
Young Modulus E (GPa)	0.564	0.393

TABLE 2
Bending test results

Direction	Direction 0°	Direction 90°
Bending strenght (MPa)	29.18	23.7
Elongation (%)	3.46	3.8
Bending Modulus (GPa)	0.3	0.59

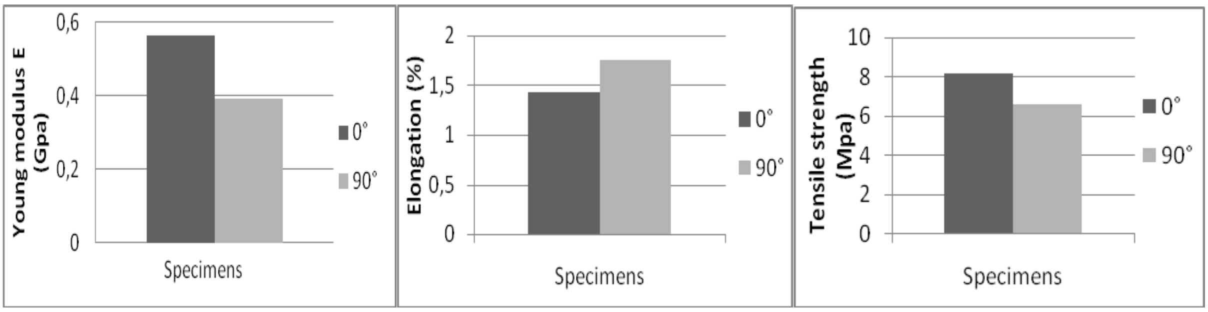

Fig 5 Diagrams of tensile test results for both directions (0° and 90°)

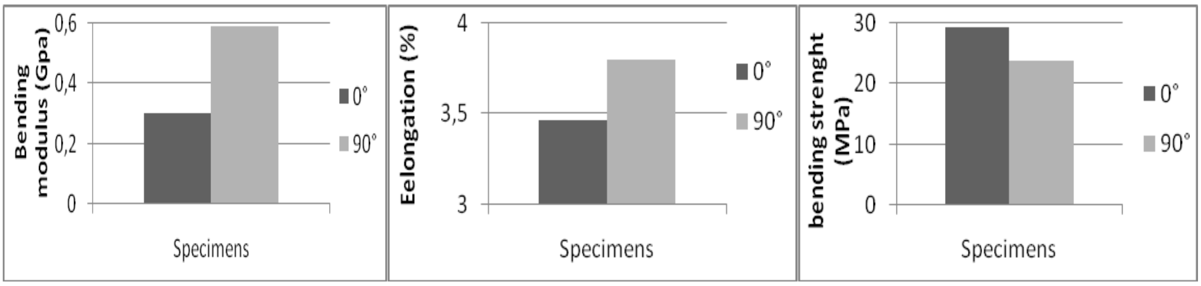

Fig 6 Diagrams of bending test results for both directions (0° and 90°)

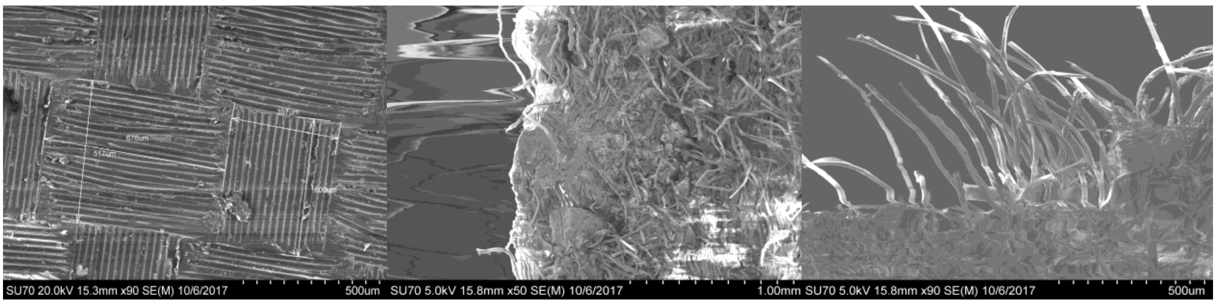

Fig 7 MEB images of acrylic/epoxy composite material (a) at material's surface, (b) and (c) at the breaking surface

TABLE 3
Mechanical characteristics of epoxy resin (tensile test)

Tensile strenght (MPa)	39
Elongation(%)	1.5
Young Modulus E (GPa)	2.9

TABLE 4
Mechanical characteristics of epoxy resin (Bending test)

Bending strenght (MPa)	69
Elongation (%)	2
Bending Modulus (GPa)	3.44

The comparison between the mechanical tests results and the characteristics of epoxy resin show that reinforcement materials decrease the tensile and bending strength of the pure polymer and this can be due to the discontinuity resulting from the reinforcement materials throughout the cross section [7].

The composite has higher tensile strength in the test direction of 0° than the test direction 90°, because of the higher orientation of textile waste fibers along the direction of non woven production. However tensile elongation in the test direction 90° is higher than the test direction 0° and that's due to the matrix's effect, in fact, in the 90° direction, tensile properties are controlled by the matrix rather than the orientation of the reinforcement materials [7].

In 0° direction, the fibers are aligned parallel in the direction of non woven production, when the bending load is exerted in a perpendicular way to the fiber orientation, unlike the 90° where the load is exerted in a parallel way to the fiber orientation which explains the higher values of bending modulus and bending elongation in direction 90° compared to those in direction 0°.

SEM images show a good interaction between the waste and polymer matrix. In fact the material's surface is homogenous (fig 7 (a)) there are no fibers pulling out of the surface and this is due to the infusion method that guarantees a total coverage of the reinforcement by the resin. Besides there are no voids or air bubbles at the shear surface that their existence can cause a non homogeneity of the composite or affect it's mechanical characteristics (Fig 7 (b and c)).

IV. CONCLUSIONS

The above results indicate that the reinforced materials have a lower tensile and bending strength than pure polymer. The composite has higher tensile strength in the test direction of 0° than the test direction 90°, contrarily to the bending strength which is higher in test direction 90°. SEM images show a good interaction between the waste and polymer matrix which can be enhanced by adding some fillers or treating the waste's surface. Many other tests should be performed to characterize the new material in order to asses it's utilization such as acoustic performance test, flammability test, charpy test, water absorption capacity, etc…

REFERENCES

[1] Wang, Y. (2010). Fiber and textile waste utilization. *Waste and Biomass Valorization* , 135-143.

[2] fibersource. [Online]. Available: www.fibersource.com.

[3] Bureau of International Recycling . [Online]. Available: www.bir.org .

[4]Dinesh Bhatia, A. S. (2014). Recycled fibers: An overview . *InternationalJournal of Fiber and Textile Research* , 77-82.

[5] [Online]. Available: *www.sicomin.com.*

[6] Joaquim Vilà, C. G. (2014). A level set approach for the analysis of flow and compaction during resin infusion in composite materials. *Composites: Part A* , 299–307.

[7] Ipek Yalcin, T. G. (2013). Utilization of various non-woven waste forms as reinforcement in polymeric composites . *Textile Research Journal* , 1551–1562.