JIRET Vol.: 01 ll Issue II ll Pages 01-13 ll July 2017

Investigation Of 3D Bio-Composite Structures Using Vacuum Infusion Method Via Chicken Feathers Fibers

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ISSN - 2456-7841 http://ijirem.com/

Abstract: Chicken feather as a natural fiber reinforcement from non-commercial natural-based materials can be transformed into economic value by obtaining the eco-friendly and bio-composite products. Using the chicken feathers as composite construction, which demonstrated a positive effect on the mechanical properties of the epoxy composite material. Target application of this high performance and durable bio-composite material can be used in the construction industry, interior panels for automotive and especially in transportation vehicles. One of the most important aspect of the research, all composite materials that currently be used is bringing a new dimension of understanding. This study will conduct to create high-performance 3D knitted bio-composite structures with low price that can be substitute for expensive and low performance counterparts in many areas. As a result, effect of Polyester and epoxy resins and chicken feather on the mechanical properties of the resulted composites materials investigated and tensile testing conducted to examine the performance of 3D bio-composite materials.

Keywords: Vacuum infusion, Bio-composite, Chicken feather, Polyester, Epoxy, Green composite

ISSN - 2456-7841 http://sijiret.com/

1 INTRODUCTION

Recent years due to environmental concerns, numerous studies related to bio-composite materials have carried out. Bio-composite materials generally reinforced by using herbal flax, hemp or animal feathers. In potential applications, it has concluded to be available. The cost of composites materials will be reduce by using the chicken feathers. For destruction of feathers a solution that is harmless to the environment. In study of Zhang et al the electrical properties of composites were improved by adding various materials [1]. Mechanical and thermal properties of polylactic acid and green composites/ chicken feather fibers have been studied by S. Cheng et al. Thermogravimetric analysis of materials indicate that increasing the thermal stability of the composite materials by adding the chicken feather fibers [2]. Thermochemical behavior of chicken feather fibers investigated in study of Tuna and her colleagues. Characterization of composite materials investigated by using XRD, SEM, FTIR, DSC and TGA. Furthermore, the specific surface area of poultry chicken feather fibers was found by utilizing the BET equation [2]. Especially brown chicken feather fibers that contain small amounts lipid are extremely rich in terms of the keratin content. Chicken feathers has great potential in the synthesis of natural and renewable fiber. Two-stage pyrolysis method used in production of the fibers. Recycling of chicken feathers provided by the conversion of low-quality food for animals. Furthermore, wastes destroyed with burying method. Lately chicken feathers was accepted as industrial waste and suitable alternatives have been sought to convert them into valuable products [3]. In study of Martinez-Hernandez and his colleague's mechanical analysis and thermal analysis were performed reinforced polymeric composites with chicken feathers and in this research polymethylmethacrylate used as a supplementary source of chicken feather keratin fibers. Composites formed has a high transition temperature and thermal stability. Obtained results are positive with low cost composites [4]. Chicken feathers that are harmful to the environment are trying to destroy them by several methods. Burning of

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waste, burying, conversion to fertilizer give damage to the environment and use of polymer matrix composites are important solution method. Burning method causes air pollution. Burying method improves soil pollution. Using the fertilization of waste leads to excess nitrogen emissions. Nitrogen emissions pollute groundwater. In addition, some companies to leave the waste to the landfill damage to human health. Damages given to environment are aimed to reduce by evaluating of the chicken feathers as waste. Also high added value products are intended to be obtained. As organic materials for this study, chicken feathers are used. The high rate of chicken feather keratin allows the occurrence of crosslinking when heated. Further chicken feather fibers are 6-8 times more robust than cellulosic fibers. This material is extremely important to reduce the running cost. Chicken feather that is provided easy, is cheap and is supplied in excess is waste material. Figure 1a shows chicken feather, which we used in our study. We measured diameter and length of barbs part of chicken feather under microscope. Barbs had averagely 0.02 mm diameter and length of between 4 and 38 mm. Natural doped bio-composite materials have quickly begun to be preferred due to the superior properties they own. Chicken feathers were used in this study for natural fiber reinforcement. Creation of composite structures was aimed. With the use of chicken feathers as the fiber material will be provided the low commercial value of fiber recovery. By evaluating the construction of composite of chicken feathers waste problem will be solved, it will also contribute to the national economy.

The studies carried out mainly consists of three main steps. The first step is preparation of mixture polyester and epoxy. The second stage is to obtain composites with vacuum infusion method. In addition to the resin and reinforcing material used, production method also is significant in determining the final properties of the composite structure. In vacuum infusion fiber-resin ratio is equal everywhere of composite parts and the mechanical values are higher than other applications. Mechanical properties of the hand lay-up and the vacuum infusion method were evaluated in the study by S.-Y. Kim et al about hybrid composite material. Examined the mechanical properties is tensile, compression and sliding plane. In this study, vacuum infusion was determined to be a useful method in production. The mechanical properties of composites prepared by both methods were compared. The samples processed with vacuum infusion both has greater shear strength and a high fiber volume fraction. Composite formed by hand lay-up method has greater porosity. Hybrid composite obtained by vacuum infusion device tensile and compression test results is higher. Composite showing the best mechanical properties are obtained with vacuum infusion method [5]. Composite structures were created with the desired properties by means of vacuum infusion device. The last step includes studies of characterization composite. We already investigated on spacer fabric using carbon fiber as reinforcement material to make a composite by had lay-up method [6].

In this study, Investigation of mechanical properties of polyester and epoxy resin composite was aimed prepared by vacuum infusion method. Comparing the mechanical properties of polyester and epoxy resin composite, it was observed that gave the best result of the epoxy resin polyester composite. Tensile test results showed that addition of chicken feather fibers improved the mechanical properties of the epoxy composite.

2 EXPERIMENTAL

3D composites were prepared using vacuum infusion method. Firstly, samples were prepared for tensile test. 3D fabrics were weighed by placing two times in a row (Figure 2a). In the method of this study chicken feathers were used according to the weight of the fabric 5%, 10% and 15% ratio (Figure 2b). Properties of the produced composite by were determined tensile test. Two types of resin with epoxy and polyester were prepared. Resins provide uniform

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and homogeneous distribution charge transfer to the fibers in the compound and more importantly, the protection position of the fibers in the composite. Resin was prepared by adding 100 ml casting machine type's polyester, 1ml cobalt octoate and 1ml Butanox-M60 Methyl ethyl ketone peroxide for polyester. As curing Butanox-M60 Methyl ethyl ketone peroxide and as promoter cobalt octoate were added. After that resin was prepared by adding 70 ml epoxy and 24 ml hardener for epoxy. Created resin was made homogeneous with stirring.

Figure 1: Chickn fethear and computer control electronic universal test machine setup

Later surface of the production carried out by vacuum infusion device was cleared. Wax was applied to avoid sticking to the surface of the vacuum resin infusion device. 3D fabric, release film, resin flow mesh was cut to desired size. After 3d fabric, release film and resin flow mesh lay down and pinned properly to the wax plowed areas. Then double-sided sealing strip pasted to the rim portion. Also double-sided tape pasted to the resin hose and the edges of the vacuum hose, sealing was controlled. Also double-sided tape was pasted to the resin hose and the edges of the vacuum hose, sealing was controlled. This step was performed carefully. Resin hose was placed to ensure the flow of the resin from the resin container. Vacuum hose was placed for vacuum athwart. The other end of vacuum hose was connected to overflow vacuum tank. Top of the system was closed very carefully with vacuum bagging film. Vacuum pump was run after mixing resin and the vacuum bagging film pasted then empty air on the 3d fabric was evacuated (Figure 2c). Before applying resin whether or not the air leakage was checked. Then to the system under vacuum resin was given. Applying vacuum to the presence of air leakage was checked. After resin was absorbed together with the vacuum, resin progress speed was checked. Resin proceeded due to the negative pressure. When each side of the 3D fabric wetted with resin, the system was closed. After coating, the entire volume of the 3d fabric with resin, end of the hoses was closed hermetically sealed. Curing resin was waited 24 hours for polyester applications. Vacuum infusion device was held to cure the epoxy by setting the particular temperature program at 50 ° C for 18 hours. Generated samples were removed from the surface of vacuum infusion device (Figure 2d). Vacuum infusion device surface was cleaned with ethanol. Tensile test was made to examine the performance values of the 3D bio-composite materials. Tensile test was made to bend the sample under a tensile loading of sudden by the method of determining the necessary energy.

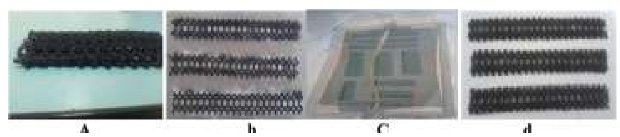

Figure 2: a) 3D fabric b) chicken feather fiber between 3D fabrics layers c) prepared sandwich under vacuum infusion d) specimens after vacuum.

3 RESULTS AND DISCUSSION

Recently, researchers have studied about the effect of chicken feathers fiber in composites for increasing of mechanical properties. One of these researches is Oladele et al. which have studied on chicken feather fiber with 1, 2, 3, 4, and 5 wt % via high density polyethylene matrix to prepare composites. Then they reported that low fiber weight content can show better mechanical properties [7]. Another research, Carillo et al. have studied on manufacture composites with 10, 15, 20, 25, 30 and 35 vol% feather chicken via high density polyethylene, polypropylene and

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polylactic acid. Their results demonstrated tensile strength has slight decreases in composites. Moreover, Young's modulus was increased in all of their specimens and the best improvement belongs to low chicken feather fiber specimen [8]. In this investigation tensile test was used by Computer Control Electronic Universal Test Machine, WDW-5 Model, in order to determine mechanical properties (Figure 1b). The results of the tensile test for the composites, which were reinforced with chicken feather (Ch F) fiber, are shown in Table 1. Tensile strength for control of specimens in epoxy matrix specimens was 18.03 MPa while for polyester matrix specimens was 21.10 MPa. In comparing of tensile strength these two controls show when we use polyester resin, strength is 17% more than epoxy resin. A comparison of tensile strength in the composite specimens is shown in Figure 3a. The results revealed that tensile strength for epoxy resin matrix specimens were 27.45 MPa, 26.01 MPa, and 19.99 MPa for specimens with chicken feather contents of 5%, 10%, and 15% respectively. Thus, we can express that in present of chicken feather strength is increased by 152.25 % at 5wt %, by 144.26 % at 10wt % and then by 110.87 % at 15 wt % compare to epoxy control specimen. However, while chicken feather content is increased, tensile strength is declined in specimens. This is follows the observations of Oladele et al., [7]. Figure 3b shows tensile strength for polyester resin matrix, which strengths were 19.59 MPa, 18.49 MPa, 20.0 MPa for specimens including chicken feather 5%, 10 %, and 15% respectively. The tensile strength at chicken feather content of 5wt % is decreased by 92.84%, 10 wt% by 87.63 %, and 15 wt % by 95.79 % compare to polyester control specimen. Chicken feathers can decrease strength occasionally, as was observed in investigation of Carillo et al. [8].

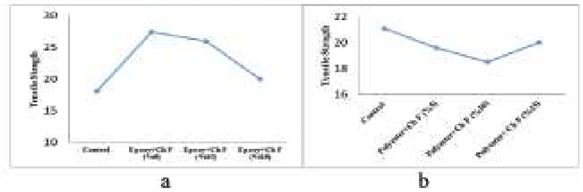

Figure 3: Tensile strength for a) Epoxy resin matrix specimens b) Polyester resin matrix specimens

Figure 4 displays young's modulus for all of our specimens. Young's modulus is the relation between stress and strain when a material is placed under force. Chicken feather improved tensile strength for epoxy resin matrix specimens. While tensile strength is increased in chicken feather specimens in comparison to control specimen, elongation is decreased in chicken feather specimens. Therefore, young's modulus is increased in specimens which including chicken feather. This increase is about 331.90 %, 249.60 % and 262.71 % for specimens with chicken feather contents of 5 %, 10 %, and 15 % respectively. However, there were fluctuations among three specimens. Young's modulus for epoxy resin matrix specimens is seen in Figure 4a. To understand young's modulus results for polyester epoxy resin matrix specimens we can see Figure 4b. Results show that young's modulus in 3D+Polyester + Ch F (10%) and 3D+Polyester + Ch F (15%) is more than control specimen, but in 3D+Polyester + Ch F (5%) specimen is less than control specimen. In the other words, the young's modulus at chicken feather content of 5wt% is decreased by 98.65%, 10 wt%, by 106.41%, and 15 wt% by 286.57% compare to polyester resin matrix control specimen.

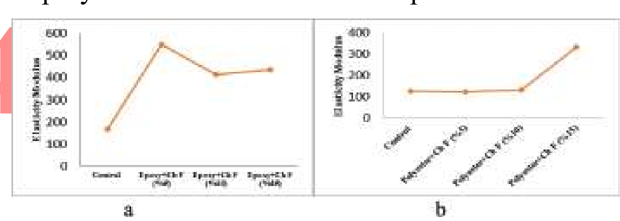

Figure 4: Elasticity Modulus of specimens for a) Epoxy resin Matrix, and b) Polyester resin Matrix

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Morphology of specimens was studied by portable digital USB microscope 1000X 50 X ~ 1000X. In this microscope there are 8 LED light source that adjustable by control wheel. Images of Figure 5 had been taken from composite sub-surface. It demonstrates that chicken feather was fully impregnated with resin. Moreover, homogeneous mixture can be seen into composite. Figure 6 shows 3D fabric and chicken feather in specimen break point after tensile test. In Figure 6 certainly can be seen that by tensile test not also 3D fabric yarn, but also chicken feather participates in stress time. Therefore, both of them pose under strain in stress time. We scrutinized all of the specimens with microscope, but did not see any different in break point. In other word, all the specimens of 3D fabric yarn and chicken feather was alike as in Figure 6.

Figure 5: Images taken of 3D+Epoxy + Ch F (5 %) composite sub-surface

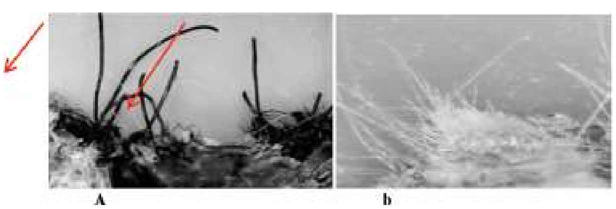

Figure 6: Images of 3D+Epoxy + Ch F (5 %) composite after tensile test a) 3D fabric yarn, b) Chicken feather

4 CONCLUSION

Chicken feather due to lightweight have a lot of advantages to use as reinforcement in composites. Composites which including chicken feather had different behavior for two resins when were applied via 3D fabric. Epoxy specimens showed high tensile strength; however, polyester specimens indicated low tensile strength in comparison to control specimens. On other hand, in epoxy specimen's young's modulus was also better than polyester specimens. The best strength and the best young's modulus was observed in 3D+Epoxy + Ch F (5%) specimen. Therefore, utilization of waste and worthless materials can promise high performance in manufacturing 3D composites.

5 ACKNOWLEDGEMENTS

This study was supported by the Research Projects Commission of Eskisehir Osmangazi University (project code 2015-682). The authors would like to acknowledge Prof. Dr. Nazim Paşayev from Erciyes University for supplying the feather chicken fibers to this work.

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