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Mechanical behaviour of chicken quills and chicken feather fibres reinforced polymeric composites

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ABSTRACT

Purpose: The objective of this study is to utilise and evaluate the mechanical properties of the chicken feather quill and fibre reinforced vinylester and polyester composites.

Design/methodology/approach: Prior to production of the composites, the chicken feather fibres (CFF) were cleaned, tested and analyzed in terms of physical properties; linear density and tensile behaviour. The unidirectional CFF reinforced composites were produced with vinylester and polyester resins with three fibre reinforcement loadings (2.5, 6, 10wt%). Following experiments were conducted to determine physical properties of the control (0%) and CFF reinforced composites; tensile, flexural and Charpy impact testing.

Findings: It was found that the impact properties of the CFF reinforced composites are significantly better than the control composites however both the tensile and the flexural properties of the CFF reinforced composites have poorer values compared to the control composites. For the 10% CFF reinforced vinylester composite, Charpy impact value was 4.42 kgj/mm^2 which was 25% higher than the control vinylester composites (3.31 kgj/mm^2) and also for the 10% CFF reinforced polyester (4.56 kgj/mm^2) composite had three times better impact resistance than the control composite (1.85 kgj/mm^2).

Practical implications: The CFF reinforced composite have potential applications due to its improved impact behaviour.

Originality/value: If the poultry waste can be utilised and used any engineering applications they will be preferred due to low-cost and superior characteristics and the most importantly they will not cause ecological and health problems.

Keywords: Chicken feather; Composites; Mechanical properties; Polyester; Vinylester

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PROPERTIES

1. Introduction

Throughout history, technological innovations have helped humankind improve their standards of living, with the rapidness of development and research is so impressive. However, certain technology also creates a negative environmental impact. Therefore efforts are invested in making use of natural based biodegradable and sustainable material that exist in nature rather than create a new material.

Textile structures reinforced composites, specifically with fibres, have gained importance in engineering and technical applications due to their light weight, higher tenacity, superior elasticity and strength, good thermal resistance, low density, and better rigidity [1-3].

The CFF are commonly described as a waste by-product and they are contributing to environmental pollution due to the disposal problems. There are two main chicken feather disposal methods that exist, a burning and burying. Both of them have negative impact on the environment. Recent studies on the chicken feather waste demonstrated that the waste can be a potential composite reinforcement. The composite reinforcement application of the CFF offers much more effective way to solve environmental concerns compared to the traditional disposal methods. Some of the advantages of the CFF are inexpensive, renewable, and abundantly available. The CFF as a composite reinforcement having certain desirable properties including lightweight, high thermal insulation, excellent acoustic properties, non-abrasive behaviour and excellent hydrophobic properties. The CFF has the lowest density value compared to the all natural and synthetic fibres [4-7]. Castano et al found that the CFF keratin biofibres allows an even distribution within and adherence to polymers due to their hydrophobic nature and they reported that CFF reinforced composites have good thermal stability and low energy dissipation [8].

The main purpose of this study is to manufacture and determine the mechanical properties of the CFF reinforced vinylester and polyester thermoset composites. The chicken feather fibres were tested and analysed to identify the following properties; linear density, breaking elongation and tenacity. The CFF reinforced composites were fabricated by hand layup technique in the laboratory. Vinylester and polyester resin were used as matrixes and the composites were manufactured by using three different fibre loading proportions. The mechanical properties of these composites were determined and compared including tensile, flexural and Charpy impact properties.

2. Experimental

2.1. Materials

The composite matrixes are epoxy vinylester resin (Polives™ 702) and hybrid RTM type polyester resin (Polipol™ 337) manufactured and supplied by Poliya® Polyester Industry and Trade Ltd.Co. (Istanbul, Turkey). The mechanical properties of resins are given in Table 1. The chicken feathers were collected from a commercial poultry in Istanbul, Turkey and they were washed by using a lab dyeing machine with a polar solvent (ethanol). After the washing process the chicken features were rinsed and left to dry for 24 hours under normal room temperatures.

2.2. Methods

Prior to the composite manufacturing, the CFF samples were conditioned for 48 hours at 65% RH and 20°C [9]. The fibre linear density values were determined in accordance with ASTM D1577 [10] and the tensile properties of the fibres were determined in accordance with ASTM D3822 [11].

The composites were fabricated with different fibre loadings (0%, 2.5%, 6% and 10%). Initially, vinlyester resin was mixed in hardener using a mixer in a bowl after the vinlyester polyester, resin was also prepared separately. The matrix materials were prepared in a portion of 73% of resin matrix and 23% of hardener by volume. Then, the fibres were spread into mould and covered with the matrix. The composites were manufactured by using a hand lay up technique with size mould of 300 mm length x 300 mm width x 20 mm thickness. The composites were kept for 24 hours at room temperature and subsequently put in an oven for 8 hours at 80°C for curing.

The control and the CFF reinforced composites were evaluated in accordance with ASTM D3039/D3039M (Tensile Properties of Polymer Matrix Composite Materials), EN ISO 14125 (Fibre-reinforced plastic composites- Determination of flexural properties), and EN ISO 179-1 (Determination of Charpy impact properties).

Table 1.
Mechanical properties of the cured resins

	Flexural strength, MPa	Flexural modulus, MPa	Elongation at break, %	Tensile strength, MPa	Elongation at break, %	Izod impact strength, kj/m^2
Vinylester	155	3500	6	76	5	16
Polyester	107	3263	4.3	58	2.6	8

Table 2.
Mechanical properties of chicken feature fibre (CFF)

	CFF
Linear density, Tex	40-90
Fibre length, cm	1-4
Elongation, %	10.85
Breaking tensile, kg	0.75

3. Results and discussion

The chicken feather fibre properties are given in Table 2. It was found that the chicken feather fibre does not have constant linear density. From quilt to fibre end the diameter decreases due to this linear and density was ranged from 90 Tex to 40 Tex. The breaking tensile of the CFF is better than most of the natural based fibres, especially biodegradable composite reinforcement fibres kenaf bast and jute.

The composites thicknesses were 4.5 mm, and the mass per square meter of the composites ranged from 3000 g/m^2 to 3500 g/m^2. The mechanical properties of the vinylester and polyester composites are shown in Table 3 and Table 4, respectively. The results were discussed in Figures 1-5.

Table 3.
Mechanical properties of vinylester composites

	0%	2.5%	6%	10%
Tensile strength, N	4785	1891	1525	1384
Elongation at break, mm	8.71	2.71	1.92	2.31
Flexural strength, N	201.1	94.88	85.73	67.99
Flexural breaking point, mm	12.1	3.74	4.53	4.55
Charpy impact, Kgj/mm^2	3.31	4.07	4.21	4.42

Table 4.
Mechanical properties of polyester composites

	0%	2.5%	6%	10%
Tensile strength, N	3268	1127	883	705
Elongation at break, mm	6.56	1.21	1.09	0.98
Flexural strength, N	159.6	69.5	59.1	49.7
Flexural breaking point, mm	8.24	3.24	2.85	3.04
Charpy impact, Kgj/mm^2	1.85	2.27	2.47	4.56

The tensile strength results of control (0%) and different fibre loaded composites were demonstrated and compared in Fig. 1. These results show that the control composites tensile properties were significantly higher when compared to the CFF reinforced composites. In all cases, the vinylester matrix based composites had better tensile properties than the polyester matrix based composites. It was expected that when the fibre loading percentage increases some of the mechanical properties decreases due to the random short fibre distribution inside the composite matrix and also lack of adhesion between matrix and fibre. The main concerns with short fibre reinforced composite is the difficulty in controlling the random fibres within the composite structure and therefore the physical properties of the composites can be dramatically reduce.

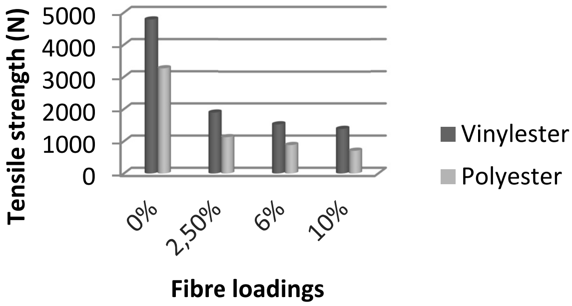

Fig. 1. Tensile strength results of composites

The breaking elongation results of the composites are given in Fig. 2. The breaking elongation results were found to be similar to the tensile results, when fibre loadings increased the breaking elongation decreased. Elongation at break for vinylester is just above 8mm at 0% fibre loading compared to just above 6% for polyester. The lowest breaking elongation occurred at the 10% CFF reinforced polyester composite which was 0.98 mm.

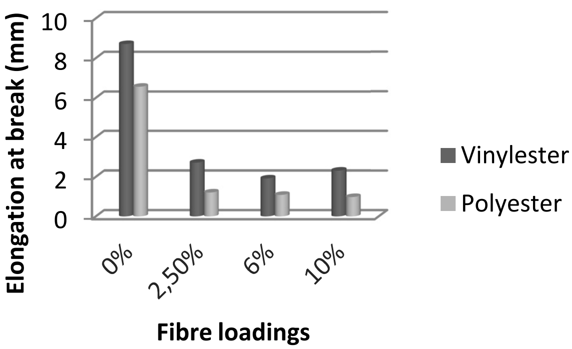

Fig. 2. Elongation at break results of composites

The flexural strength results are demonstrated in Fig. 3. The control composites had considerable higher flexural strength in comparison with the CFF reinforced composites. The flexural strength can be improved by increasing fibre loading more than 30%. In this study, we kept the fibre loadings at maximum 10% due to the composite manufacturing method limitation. The flexural strength values are reduced from 200 N to 50 N which means the reinforcement materials have a positive influence on the composite physical properties.

The flexural breaking point values are illustrated in Fig. 4. For both vinylester and polyester control composites have extensively superior flexural breaking point than the CFF reinforced composites. The flexural breaking point values of vinylester resin composite increase when the fibre loading percentage rises. The differences between 2.5% and 6%-10% are considered to be significant. The difference between 6% and 10% were negligible.

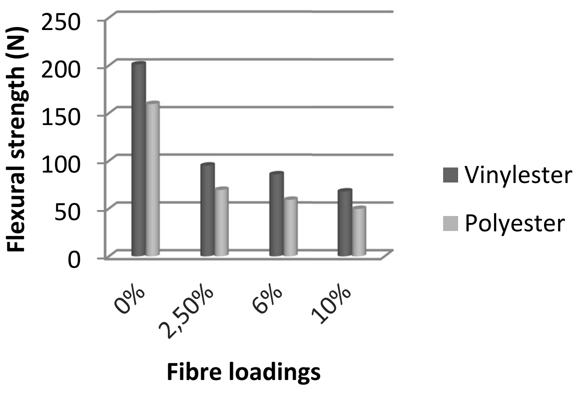

Fig. 3. Flexural strength results of composites

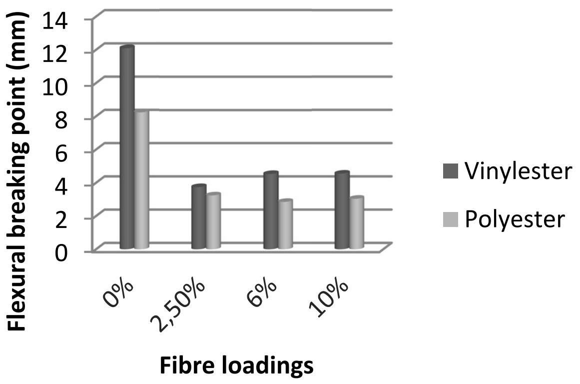

Fig. 4. Flexural breaking point results of composites

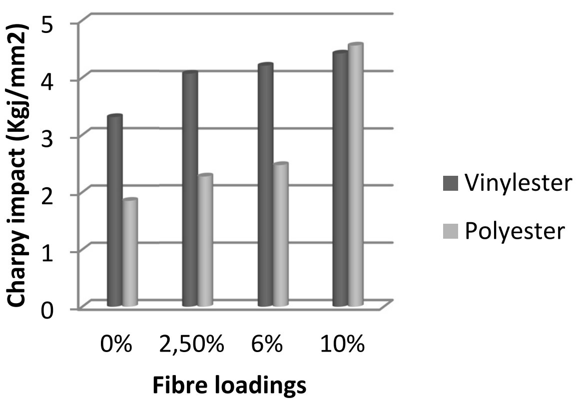

Fig. 5. Charpy impact results of composites

The Charpy impact property is another key importance characteristic of the composite structure, especially due to its significance in many applications such as automotive and architecture applications. The Charpy impact values increases with the fibre loading percentage. The 10% CFF loaded composites have enhanced impact values in comparison with the lower CFF loaded composites. The differences are obvious for polyester resin composites.

The impact values of composites increases with the fibre loadings due to the test and the random short fibre reinforcement natures. Both the impact test and the short fibre reinforcement have multidirectional (unidirectional) characteristics. Therefore if the unidirectional short fibre percentage increases for the composite structure, the impact values will increase in relation. There is a sudden increase in polyester values at 10% fibre loading due to the test random nature.

4. Conclusions

There are some studies on the poultry wastes, for instance some studies were carried out the use of CFF as provender which is currently found that it is risky for the human health. Most of the poultry wastes have been still destroyed by using traditional methods burning or burying that are one of them pollute the air second one contaminates the ground. If the poultry waste can be utilised and used any engineering applications they will be preferred due to low-cost and superior characteristics and the most importantly they will not cause ecological and health problems anymore. The tensile and flexural properties of the control (0%) composites for the resins, vinylester and polyester, have significantly superior properties to the CFF reinforced composites. The tensile and flexural values decrease when the fibre loading percentage increases. The control (0%) composite tensile strength was found to be 5000 N whilst the CFF reinforced vinylester composite tensile strength was at maximum 1891 N. It is evident that the reinforcement material decreases the tensile property of the composites almost three times. For the flexural property, the reinforced composites indicate around two times lower value than the control composite. Only the Charpy impact values of the CFF reinforced composites are considerable better when compared with the control (0%) composites. Similar results were found in previous works with different fibre loadings and resins.

It can be concluded that the CFF reinforced composite have potential applications due to its improved impact behaviour. The tensile and flexural properties can be enhanced with the increasing percentage of the CFF and also with different resin. Another way to enhance the composite properties is to determine an effective treatment to eliminate lack of adhesion between matrix and CFF fibre.

References

[1] L.T. Drzal, M.J. Rich, P.F. Lloyd, Adhesion of graphite fibers to epoxy matrices. Part 1. The role of fibre surface treatment, Journal of Adhesion 16/1 (1983) 1-30.

[2] M. Hsie, C. Tu, P.S. Song, Mechanical properties of polypropylene hybrid fiber-reinforced concrete, Materials Science and Engineering A 494 (2008) 153-157.

[3] S. Shibata, Y. Cao, I. Fukumoto, Lightweight laminate composites made from kenaf and polypropylene fibres, Polymer Testing 25/2 (2006) 142-148.

[4] J.R. Barone, W.F. Schmidt, F.E. Liebner, Compounding and molding of polyethylene composites reinforced with keratin feather fiber, Composites Science and Technology 65 (2005) 683-692.
[5] T.A. Bullions, D. Hoffman, R.A. Gillespie, J.P. O'Brien, A.C. Loos, Contributions of feather fibres and various cellulose fibres to the mechanical properties of polypropylene matrix composites, Composite Science and Technology 66 (2006) 102-114.
[6] S. Huda, Y. Yang, Composites from ground chicken quill and polypropylene, Composites Science and Technology 68 (2008) 790-798.
[7] N. Reddy, Y. Yang, Structure and properties of chicken feather barbs as natural protein fibres, Journal of Polymers and The Environment 15/2 (2007) 81-87.
[8] A.L. Martinez-Hernandez, C. Velasco-Santos, M. de-Icaza, V.M. Castano, Dynamical-mechanical and thermal analysis of polymeric composites reinforced with keratin biofibers from chicken feathers, Composites B 38/3 (2007) 405-410.
[9] ASTM 1997d Standard practice for conditioning textiles for testing. (D-1776-90). American Society for Testing and Materials, West Conshohocken, PA, 483-446.
[10] ASTM D1577: Linear density of textile fibres, American Society for Testing and Materials.
[11] ASTM D3822: Tensile properties of single textile fibre, American Society for Testing and Materials.