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Experimental Investigation on Mechanical Properties of Chicken Keratin Fiber Reinforced Isophthalic Polymer Matrix Composite

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Abstract

Natural fibers such as hemp, flax, sisal, coir, hyacinth, kapok, feathers, kenaf etc. have been used as reinforcement material with polymer composite. Feathers are waste products and generated every year by poultry industry when birds are handled in dressing plants and the disposal of these feathers create environmental pollution. Chicken feather fibers were initially subjected to alkaline treatment in order to kill the micro organisms and clean before extracting the fibers. The fibers were then classified and segregated into two types namely barb and wool. The chicken feather fiber reinforced isophthalic polymer matrix composite was fabricated using hand layup technique by varying the fiber content of 5, 10 and 15 wt%. The samples of composite materials were then subjected to testing of mechanical properties such as tensile, compression, flexural, impact and hardness as per ASTM standards. An increase in mechanical properties were found up to the fiber content of 10 wt% in the chicken fiber reinforced polymer matrix composite material and the addition of fiber decreased the strength due to weaker bonding between resin and fiber content. The barb feather fiber reinforced polymer composite have better mechanical property due to presence of central core compared with wool and non treated fiber composites.

Keywords: Barb; Biodegradable; Flexural strength; Hardness; Isophthalic resin; Keratin fiber

1. INTRODUCTION

From the past many years, research and development work was shifting from traditional materials to fiber reinforced polymer matrix materials due to non corrosive property, high strength to weight ratio and high fracture toughness. The materials such as aramid, carbon, glass etc mainly have high strength and can be dominated for aerospace, construction, automotive and sporting industries. These synthetic fibers have severe drawbacks of non-renewable, high energy consumption in manufacturing process, non-biodegradable, health issues, high cost and non-recyclable. In many countries, manufacturers were considered three processes to avoid severe drawbacks is to reduce the amount and toxicity, reuse the product and recycle as much as it is possible. Now days, the bio-fibers such as sisal, wool, feathers, flax, hemp etc. are reinforced with biodegradable polymers to form environmental friendly composite materials. These types of composites have good mechanical properties, low cost, ease of separation, less density, moderate thermal stability and must be biodegradable after being used.

Chicken feather fibers are mainly consists of 91% of keratin (protein), 8% of water and 1 % of lipids. The keratin composed of cysteine, lysine, proline and serine contents are soft, strong, lightweight, eco-friendly, non-abrasive, insoluble in organic components and biodegradable have better mechanical and insulating properties. Zhan et.al, fabricated chicken feather fiber reinforced epoxy composite which have better insulation effect and dielectric constant decreased with the increase of fiber content and frequency. Martinez et.al, collected fibers from processing plant and washed with water and ethanol and dried in order to clean, remove odour and sanitize. The processed chicken feather fiber was reinforced with methylmethacrylate monomer and heated up to 70 °C for 24 hours. From the fabricated specimen, the composite have good thermal stability at both generated and decomposition temperature. Uzun et.al, the fibers were collected from commercial poultry industry and then subjected to washed with water and ethanol, then dried in room temperature. The composite was fabricated by reinforcing chicken feather fibers with both vinyl ester and polyester based polymers. The mechanical property of composite materials was determined and there is a decrease in tensile and flexural properties due to increase in fiber content.

The present study is to fabricate the chicken keratin fiber polymer composite using isophthalic resin and evaluate the mechanical properties such as compression, flexural, tensile, impact and hardness for three different fibers like barb, wool and non-treated fibers.

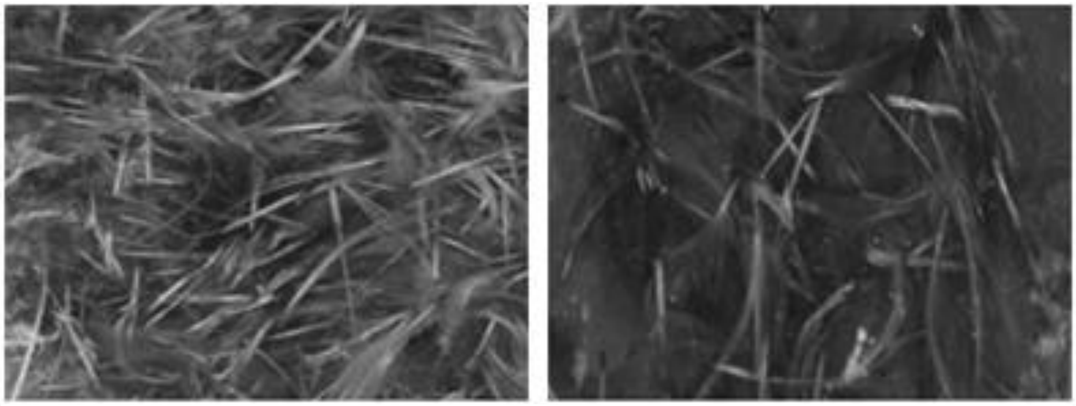
2. MATERIALS AND METHODS

2.1.EXTRACTION OF FIBER

The waste chicken feather fibers were collected from various poultry shops. The feather was cleaned with forced running water to remove the blood particles and dirt. Then it is dried under the ceiling fan for 12 hours. Dried chicken keratins were soaked in ethanol solution for 24 hours in a separate beaker and close with a lid in order to reduce the smell. Finally, the extracted keratin fiber was dried in sunlight to kill the micro-organisms. These treated fibers were then further classified into two types as barb and wool.

2.2.COMPOSITE FABRICATION

The matrix of composite material was isophthalic resin prepared from resin, 2 wt.% of accelerator and catalyst as a separate portion. Four wooden strips were placed on the top of glass surface by using glazed putty at its corner. The internal surface of mould cavity was then rubbed with oil and grease in order to remove the specimen easily. The resin mixture was poured into the mould cavity of size 260 x 130 x 5 mm and fiber content from 5 to 15 wt% was added with the matrix. Cover glass was placed on its surface and a load of 50 N was applied on it. After 15 min, the specimen was removed from the mould cavity and subject to cutting process for testing as per ASTM standard. Fig. 1 shows the fabricated sample of chicken keratin fiber reinforced polymer matrix composite in wool and barb type of fiber.



(a) (b)

Fig. 1 Fabricated chicken feather fiber reinforced polymer matrix composite
(a) wool and (b) barb type

2.3.TESTING

The fabricated chicken keratin fiber reinforced polymer matrix composite was subjected to various testing such as compression, flexural and tensile as per ASTM D 695, ASTM D 790 and ASTM D3039/ D3039M standards respectively. For impact test, the work piece of length 65 mm, breadth 12.5 mm and thickness 5 mm was selected as per ASTM D 256 standard in izod test setup. The hardness test was conducted in Wilson wolpret hardness testing machine with a ball indentor of 1/8”. The material was sputtered using ion sputtering process in order to charge and perform the image analysis in scattered electrons. The lateral surface of composite material was characterized under the secondary electron of 15 kV at 500 X magnification.

3. RESULTS AND DISCUSSION

3.1.EFFECT ON COMPRESSION STRENGTH

The compressive strength for all three types of fibers were evaluated which is shown in Fig. 2. In all the fiber reinforced composite material, the compressive strength increases by varying 5 to 10 wt.% of fiber content and it decreased in 15 wt.% due to weaker adhesive bonding between fibers and resin matrix. The compression strength values for barb chicken feather fiber reinforced composite of fiber content 5, 10 and 15 wt.% have 61, 107 and 82.3 MPa respectively as compared with other two types of fiber due to the presence of central core.

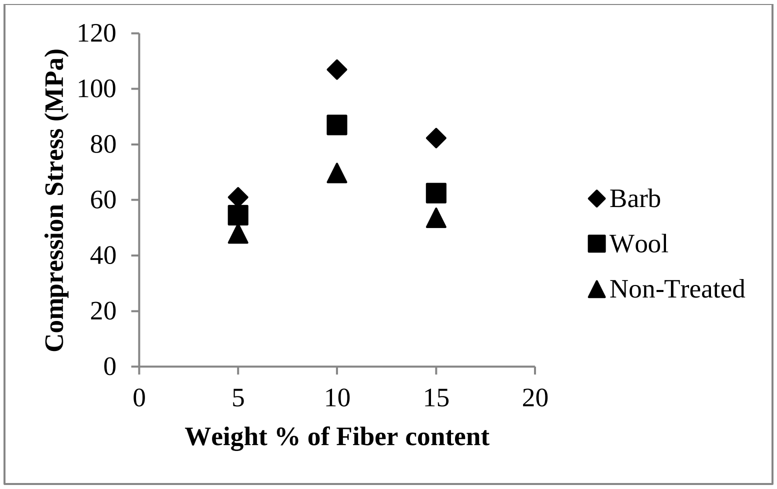


Fig. 2 Effect of fiber reinforcement in compression strength

3.2.EFFECT ON FLEXURAL STRENGTH

The ultimate flexural strength of manufactured composite materials increased after the reinforcement of 5 and 10 wt.% of fiber content due to effective distribution of fibers in matrix and overloading of fiber leads to reduction in flexural strength for the three different types of chicken feather fiber polymer matrix composite. Fig. 3, shows the value of flexural strength for barb fiber composite by varying fiber content of 5, 10 and 15 wt.% have 33.5, 37 and 34.3 MPa which is slightly higher than other type of chicken fiber reinforced composites due to the existence of strong fibril rods.

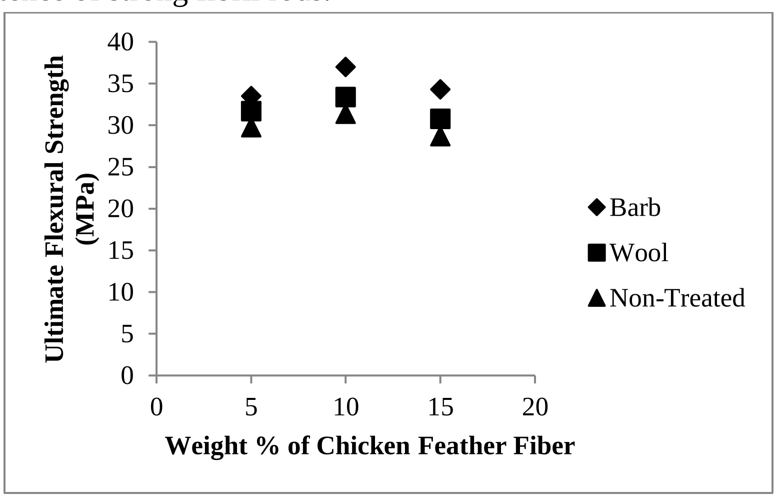


Fig. 3 Effect of fiber reinforcement in flexural strength

3.3.EFFECT ON IMPACT ENERGY

Fig. 4. shows the impact energy for barb, wool and non-treated chicken keratin fiber reinforced polymer matrix composites. The impact energy for all the three different types of isophthalic polymer composite tends to increase after the addition of fiber proportions of 5 and 10 wt.% due to adequate strengthening between the fibers and further addition of fibers

leads to decrease in impact energy due to weaker interfacial bonding between resin and fibers. The composite fabricated from barb type fiber have better impact energy than other two types of fibers, due to presence of skeletal core on its surface.

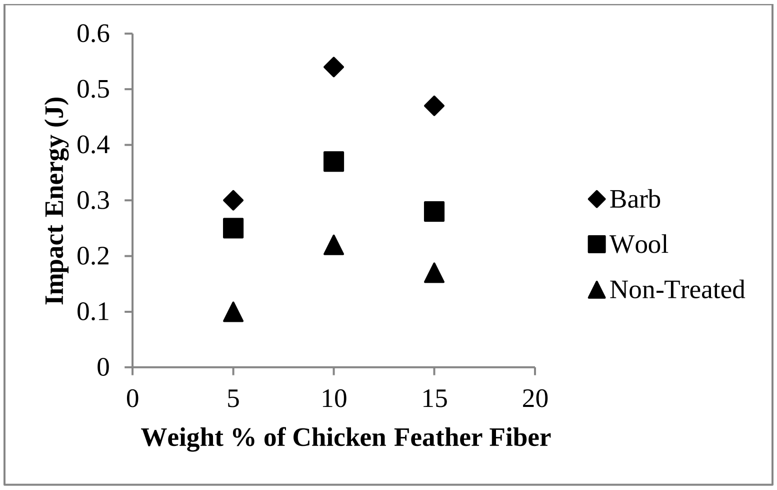


Fig. 4 Effect of fiber reinforcement in impact energy

3.4.EFFECT ON TENSILE STRENGTH

The composite fabricated from barb, wool and non-treated chicken keratin fiber for ultimate tensile strength is shown in Fig. 5. The reinforcement of fibers such as barb, wool and non-treated in isophthalic polymer for 5 and 10 wt.% of fiber content leads to increase in ultimate tensile strength due to the uniform distribution of fiber content. Addition of fibers, tends to decrease in ultimate tensile strength because of weak adhesive bond between fibers and resin. The barb fiber reinforced composite have slightly better than wool and non-treated chicken keratin fiber reinforced composite materials.

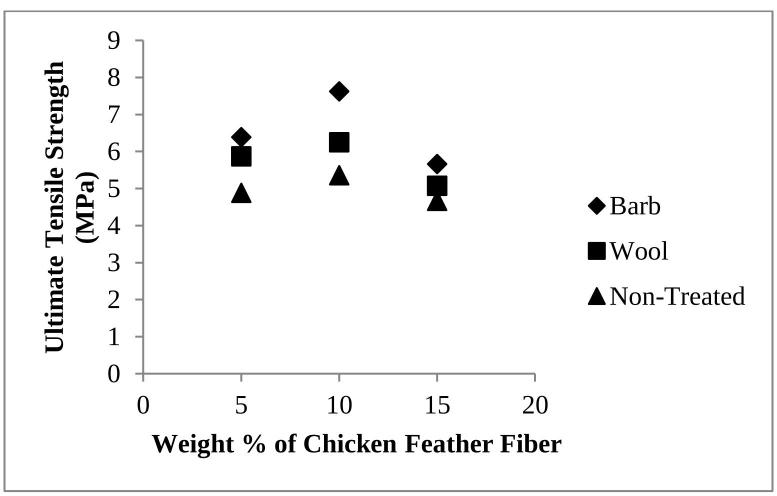


Fig. 5 Effect of fiber reinforcement in tensile strength

3.5.EFFECT ON MICRO-HARDNESS

The micro-hardness was determined using brinell hardness tester under R-scale and results are shown in Fig. 6. After the reinforcement of fibers content of 5 and 10 wt.%, the micro-hardness value increases due to high compatibility between fibers and resin matrix for all the three different types of fiber content. The barb type of keratin fiber polymer matrix composite have better values of micro-hardness as compared with other types of extracted keratin fiber composites, because of strong natural core present in barb fiber.

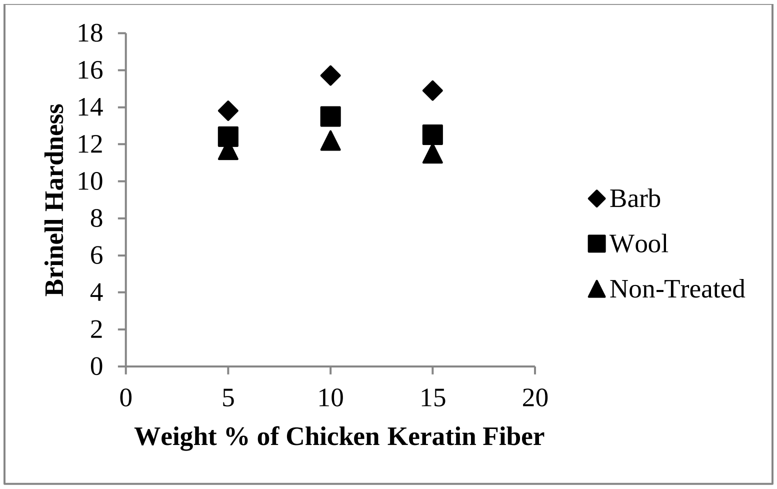
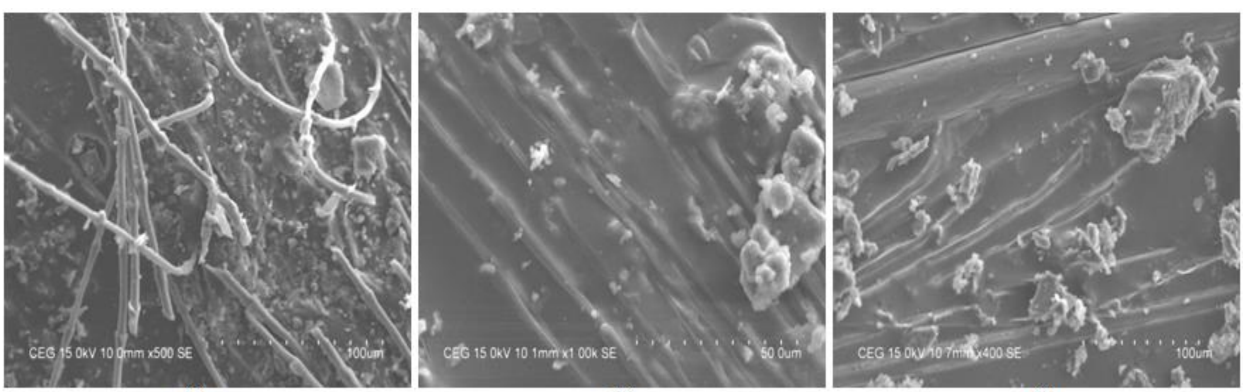


Fig. 6 Effect of fiber reinforcement in hardness

3.6.EFFECT OF MICROSTRUCTURE

The microstructure for chicken keratin fiber reinforced polymer matrix composite for three different types of fiber such as barb, wool and non-treated shown in Fig. 7 (a), (b) and (c) respectively.



(a) (b) (c)

Fig. 7 Microstructure of chicken feather fiber reinforced polymer matrix composite
(a) Barb, (b) Wool and (c) Non-treated

In barb fiber polymer composite, the presence of central fibril core and uniformly distributed with the resin matrix. For wool fiber composite, the particles are densely arranged and small amount of external micro-organisms are present. But, in non-treated fiber composite, fibrils are mixed together, presence of microbes in large quantity and voids in the cross section.

4. CONCLUSION

The chicken feather was extracted using ethanol and classified into three types such as barb, wool and non-treated. Extracted chicken keratin fiber was reinforced with isophthalic polymer resin by varying the keratin fiber content from 5 to 15 wt.%. The fabricated composite was tested for mechanical properties such as compression, flexural, impact and tensile were carried out as per ASTM standard. The compression, flexural, tensile and impact properties tends to increase after the reinforcement of 5 and 10 wt.% of fiber content due to strong adhesive bonding between the fibers and resin matrix materials for all the three different types of fibers. Then, the addition of fiber content leads to decrease in mechanical properties due to the low interfacial bonding between resin and fibrils. The presence of central fibril core, dense arrangement of particles and fibers are uniformly distributed with the resin matrix. The barb fiber reinforced composite have higher value of compression, flexural, tensile strength, impact energy and micro-hardness as compared with other two types fibers. Due to the above features, the chicken keratin fiber reinforced isophthalic polymer matrix composite may an alternate material for HVAC systems and automobile applications.

5. REFERENCES

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