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Study and Development of Eco-Composite from Waste Chicken Feather for Partition Board Application

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Abstract

The current work aims to prepare composites from waste chicken feathers and investigate their mechanical properties. For the composite fabrication, chicken feathers were used as reinforcement and Lapox L12 as the matrix. The composites were prepared manually using the hand layup technique. A metal die was used to prepare the composites. Reinforcements with volume fractions of 30%, 40%, and 60% were evaluated for their tensile and flexural strength. The tensile modulus increased as the Vol.% of chicken feather fibre increased. A maximum tensile and flexure modulus of 170 MPa and 480 MPa were obtained during the experiment with 60 Vol.% composites. The improved water resistance, low weight, noise absorption capability, flexibility for tailored qualities, and ease of dust removal make this developed material ideal for the mining industry.

Keywords: Chicken Feather, Chicken Fibre, Eco-composite

1.0 Introduction

Chicken feathers are a waste product of poultry processing. With increased consumption, the disposal of this waste is posing challenges. Burying and burning are the two most common methods for removing chicken feathers. Both of these strategies, however, are harmful to the environment. New research has concluded that chicken feathers can be a potential reinforcement. Poultry feathers are plentiful, low-cost, and renewable wastes that have been investigated as possible raw materials for various applications. Professionals were now processing chicken plumes to remove the feathers and barbs from other poultry feathers. Feathers can be used for a variety of purposes.

The feathers obtained from different parts of the chicken's body are diverse. Two methods were tested for separating the quill material from the fibrous material. The properties resulted in more fibres and fewer feathers and quill fragments[1]. The composite was prepared with 65 per cent plumes, the quill, which has hollow structures[2]. These structures contribute to the material's lightweight and sound absorption capacity. It has a minor increase in yield force, higher force, flexural strength, and a 90% increase in stiffness, while Young's modulus remains unchanged.

Waste chicken plumes were pre-treated for simple solubilization to reveal the polar functional group hidden inside the folded protein structure[3]. Waste chicken plumes were thermo-chemically pre-treated to produce keratin hydrolyzate, which was then used as feedstock in the production of keratin-based bio-adhesives. The hydrolyzate recovered from discarded chicken plumes via

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alkaline hydrolysis before treatment had adequate protein functionality. It is required for both the formulation of bio-adhesives and their subsequent modification. The presence of these protein functions results in the expected interaction of protein hydrolyzates with the citric acid-based polyamide epichlorohydrin cross-linker and, as a result, reaction adherence by the wood particles.

The Chicken Feather Fibre (CFF) reinforcement is compatible with a wide range of matrices and additional reinforcements, including epoxy resin, polypropylene, and various polymers. Chicken feather fibre significantly improves strength per unit weight. In a variety of material developments, CFF may be used to solve livestock disposal issues[4,5]. The strength of the produced composite was increased[6]. The strength began to fall as more feathers were added to the matrix. Because the fibre composition of the 2.0 per cent chicken feathers composites was low in comparison to the other samples, it produced the lowest results when compared to the controlled sample. The strongest composites were those containing 6.0 per cent chicken plumes fibre. Furthermore, packing chicken feathers increased tensile modulus, and when chicken feather fibre was loaded, the percentage elongation at break decreased.

The density decreased as a result of the low density of plumes, which was one of the key factors for using bio-composites with higher concentrations of chicken feathers[7]. When compared to other natural fibres, the density of chicken plume fibres varies. This variation could be attributed to a different plume source. As a result, incorporating chicken plumes into a thermoplastic matrix may reduce biocomposite density when compared to other natural fibre reinforcements. Utilization of organic fibres, like chicken plume fibre, in the reinforcement of polymer matrix can result in interesting thermal and acoustic insulation properties[8]. Heat testing revealed a 37% improvement in temperature resistance when specimens with 60:40 and 80:20 ratios of chicken plume fibre and epoxy resin were compared. These results are corroborated by the morphological characteristics of chicken plumes, which include an open structure that enhances these skills. Furthermore, because chicken plume fibres have a lower density than natural materials, their use in the construction of lighter composites becomes more appealing. Polymer composites reinforced with feathers can serve as components such as doors, and furniture, especially in humid regions. Wooden components swell under a moist environment. The composites consisting of CFF will eliminate this issue and also aid in easier transport as its unit weight would be lower than that of commercial wood. Another issue that would be eliminated when such composites are used is those of termites. Wooden components need periodic varnishing to guard against termite menace. The chemicals used to protect wood from pests are non-eco-friendly. Therefore, by the inherent characteristics of CFF composites, this problem would be eliminated. Apart from these it is well known hard and good quality wood requires decades to grow. In recent times the periodicity of floods and other environmental issues has increased which is an indirect consequence of deforestation. Promoting components that do not endanger and reduce the pace of desertification will bode well for the environment.

Plume barbs have honeycomb fashioned hollow cells in their cross section[9]. These hollow cells serve as temperature and air insulators, which makes them perfect for applications where sound-absorbing materials are needed, such as composites used in cars. The honeycomb structure is also said to be highly compressible. Because of the hollow honeycomb structures, barbs are particularly light in weight. Because of their low weight and heat-insulating capacity, plumes are preferred for applications such as outerwear jackets. Chicken plume Fibres and a thermal bonded non-woven mat were used as reinforcing material[10]. Chicken plumes have a distinct set of characteristics that can assist polymer composite in meeting all of these requirements. According to the findings, a small amount of chicken plume Fibre increased the thermal firmness of the matrix; a negligible change was detected by increasing the quantity of chicken fibres in the matrix. The presence of chicken Fibres improves the mechanical properties of composite

Because of the large number of chicken plumes produced each year and method of disposal is critical to place this poultry dissipate in the application where its qualities can be properly utilized. Polymer composites becoming increasingly popular for a broad variety of appliances, and they are frequently predicted to do better than others in terms of mechanical, thermal, physical and electrical performance criteria. They must also be environmentally sustainable and resource-friendly. Importantly, composite constituents retain their distinct physical and chemical properties, but when combined, they form a set of traits that individual constituents could

not produce on their own. Wood composite boards with excellent strength and lightweight are still ideal choices for construction due to their low cost. However, due to the increasing scarcity of wood, the development of alternative materials is required and it will be well suitable for the mining industries.

2.0 Methodology

2.1 Materials

The composite specimens were prepared via hand layup technique. The metal die (Figure 1) was used in the preparation of the composite, with dimensions of 10*20*0.4 cm (L*W*H). The chicken feathers (Figure 2) were collected from poultry establishments. These feathers contain various foreign materials, like clotted blood and meat. At first, the feathers collected were washed repeatedly with warm water, detergents and sundry. After dehydrated quills were divided by removing from the barb, later the fibres were cleaned in water and sundried. Dehydrated fibres were soaked in a 6 ml Na-OH solution (Figure 3) and distilled water for 3 hrs and later washed under flowing water. Further, the fibres were dehydrated for 10 hrs under natural climate conditions.



Figure 1. Die.



Figure 2. Chicken feather from the poultry industry.



Figure 3. Chemical treatment of feathers.

2.2 Specimen Production

The bottom and the top halves of the mould were carefully cleaned with thinner, and smoothened with wax polish and a releasing agent (Polyvinyl Alcohol solution) was applied. The mould halves were allowed to dry. Epoxy resin L12 and hardener K6 mixture were prepared with a 10:1 ratio. After the mould was dried, chicken feathers were distributed in its cavity with varying volume ratios for different specimens (Figure 4). The resin-hardener mixture is poured on the fibres and thorough compaction was achieved using hand rollers to prevent entrapment of air bubbles.

The mould was completely closed. The arrangement was loaded to compress the workpiece and to attain a thickness of 3mm. The formed specimen was allowed to



Figure 4. Preparing the specimen.



Figure 5. Tensile test specimen.



Figure 6. Flexural test specimen.

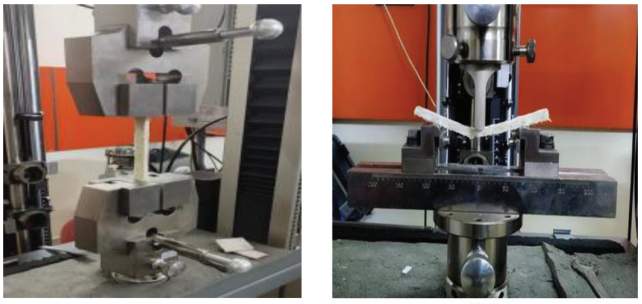


Figure 7. (a) Tensile. and (b) Flexural testing.

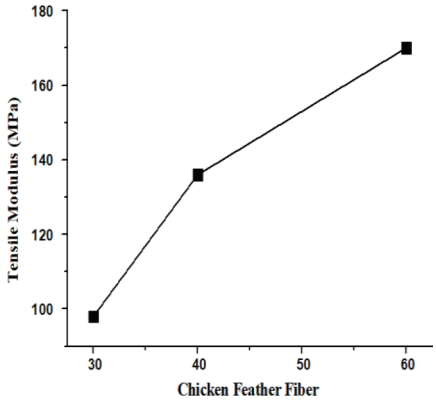


Figure 8. Tensile Modulus vs. CFF.

cure for 24 hours within the mould before it was retrieved from the mould.

2.3 Experimentation

Tensile test and flexural test specimens were prepared according to ASTM D628 (Figure 5) and ASTMD-790 standard respectively (Figure 6). The computer-aided UTM was utilized to conduct tensile experiments and the tests were run at a constant crosshead speed of 2mm/min.

Flexure strength was assessed by conducting a point bending test. The tests were carried out at room temperature. Photographs of the test setup for tensile and flexural are shown in Figure 7.

3.0 Results and Discussion

The experiment was conducted for 30%, 40% and 60% Chicken Feather Fibre (CFF) volume fraction fabricated composites. The tensile modulus was increased with the increase of the addition of CFF as shown in Figure 8. A maximum of 170MPa tensile modulus was obtained for the 60% CFF-reinforced composite. Also, a maximum of

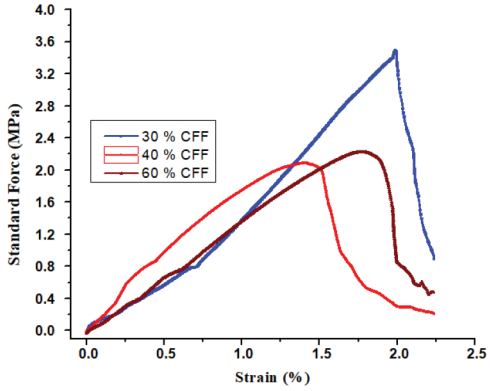


Figure 9. Force vs. Strain.

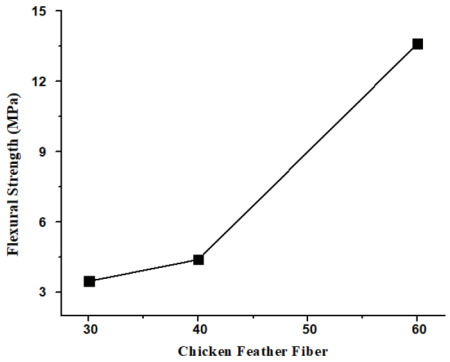


Figure 10. Flexural strength vs. CFF

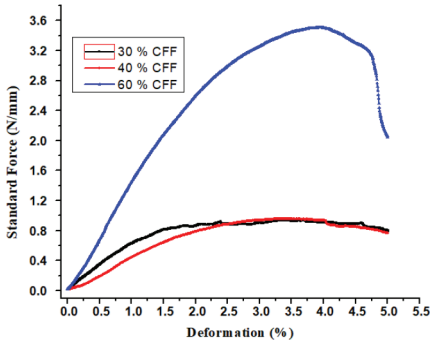


Figure 11. Force vs. deformation

3.50MPa tensile strength was obtained for the produced composite. The highest fracture strength was seen for the 30% CFF composites. However, it failed suddenly during the test due to the insufficient amount of the CFF. Moreover, one can notice the absence of any strain-hardening effect accompanying the deformation in the case of the 30% CFF composite. The 40% and 60% composites underwent shallow stain hardening before attaining maximum load. These also failed gradually past the point of maximum loading in a manner akin to a

typical ductile failure of metal. In other words, the 40% and 60 % CFF failed via crack formation, necking, and crack propagation leading to fracture. Both the 60% and the 40% CFF composite failed at a lower load compared to that of the 30% CFF. The strain at failure was nearly the same for all the prepared composites (Figure 9).

The main components that account for the strength of the composite materials are the strength of the fibre and the bonding strength between fibres and matrix. The fibre's full fracture is represented by the curve's last point. Very little pull-out of the fibres during testing was seen. Thus, it is confirmed that the failure mode was primarily due to the fracture of the fibres.

Figure 10 illustrates the flexural strength vs. composite composition. The flexural strength was increased with the increase of the CFF percentage.

The 60% CFF-reinforced composites showed a higher flexural strength of 13.6 MPa compared to other fabricated composites. The deformation of the composites with the increase of applied load is shown in Figure 11. The 60% CFF reinforced composite showed linearity between the applied load and deformation till the specimen was able to take up a maximum load signifying proportionality behavior between the applied force and the strain hardening experienced. The other two composited exhibited a nature which is typical of polymers having reduced strain hardening during deformation.

4.0 Conclusion

The following conclusions are drawn from the study:

- CFF participate as reinforcement in polymer matrix composites.
- About 70% increase in the tensile modulus occurred on increasing the concentration from 30 to 60 vol.% without much increase in the weight of the composite.
- Ductile mode of failure at higher concentrations between 40 to 60 vol.% is a favourable characteristic feature.
- A fourfold increase in flexure strength was obtained with 60 vol.% compared to that at 30 vol.% with improved delamination features.
- This new material's increased water resistance, low weight, noise absorption capability, flexibility for customized features, reduced environmental impact, and ease of dust removal make it a great fit for the mining industry.

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