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Investigation on Mechanical and Physical Properties of GFRP-Egg Shell Powder Hybrid Composites

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Abstract

Objectives: In this paper, various physical and mechanical properties of egg shell powder filled hybrid composites have been found. **Methods/Analysis:** Different types of composites have been fabricated using 5 wt% egg shell powder and 10 wt% egg shell powder with 50 wt% fiber, rest matrix material. The composites were fabricated by hand-layup process. Specimens were cut and tested according to ASTM standards. **Findings:** All composite with filler material exhibited better tensile strength than unfilled composites. Adding filler material might have resulted in restriction of propagation of crack and delamination. The shape and size of egg shell powder was the fine-tuning factor. The rate of burning of the composites at any given filler particle size decreased with increase in filler contents. **Novelty/Improvement:** The cost of egg shell powder fillers is less than that of the polyester matrix. The use of egg shell powder as fillers for the plastic industry will not only provide a renewable source of filler for the plastic industry but also generate a non – food source of economic development for the famers in the rural areas.

Keywords: Egg Shell Powder, Hybrid Campsites, Mechanical Properties, Physical Properties

1. Introduction

A composite material is a materials structure made of a mixture or combination of two or more macro constituents viz., reinforcement, resin and filler material. Filler materials play a vital role in polymer industry. Filler materials mixed polymer matrix composites have the potential to swap orthodox materials[1]. The main advantage of use of fillers is, it might cut the overall cost of the composites by reducing the requirement of resin[2]. Some fillers also help in improving, mechanical properties. The production and worldwide use of chicken eggs on an industrial or domestic level leads to a considerable quantity of shell residue, which is considered as a waste or is used as a complement in agriculture[3]. Use of biowaste materials in polymer matrix composites is on the rise mainly due to environmental and economic apprehensions[4].

2. Materials and Methods

The composite is prepared on a flat metal or granite surface and cleaned with a Nictro Cellulose (NC) thinner. Later the required dimensional area is marked to prepare the composite. First releasing agent (PVA) is sprayed on the surface. Second E glass fibers (300 gsm & 450 gsm) cut into plies as per the required dimension (300X300mm^2) and same amount of resin mixture by its weight is taken[5]. Third polyester resin prepared by add curing agent in the ratio of 1 ml per 70 ml of resin. The composite is prepared by the hand layup process, by applying resin on the glass fiber plies one above the other (by stacking till 3 mm thickness). A hand roller is used to make sure that the resin and glass fiber are properly pressed and all the air bubbles are removed[6]. For the laminates with egg shell powder by 5 wt% and 10 wt%, as filler material as shown in Table 1, is added to the resin and it is mixed accordingly by weight equivalent to the weight of the fiber plies.

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Table 1. Details of constituents (wt%) of composites used in the study t

Constituents (wt%)	C I	C II	C III
Polyester Resin Matrix	50	45	40
Glass Fiber Reinforcement	50	50	50
Egg Shell Powder Filler	0	5	10

3. Preparation of Samples for Testing

After preparation of the composite materials, the specimens will be cut according to ASTM standards as shown in Table 2. Three samples of each type were cut and prepared for the test.

Table 2. Sizes of specimens as per standards

SL No	Testing	Standard	Length X Width X Height (mm)
1	Tensile Strength	ASTM D 3039	250 X 25 X 3
2	Water Absorption Test	ASTM D5229	25 X 25 X 3
3	Flammability Test	FMVSS	152 X 5 X 3

4. Testing

4.1 Tensile Strength Test

Tensile testing is performed on 9 separate specimens, 3 each for C I, C II, C III. The test is conducted using Universal Testing Machine at crosshead speed of 1.0 mm/min. The ultimate strength of the material is determined from the maximum force carried before failure[7].

4.2 Water Absorption Test

The specimens are immersed in the normal water and salt water for the period of 20 days. The weight of the specimen is measured once in 5 days. The specimen are taken out of water, wiped and dried before measuring the weight. The variation of the weight of the specimens is noted. The weight is measured in electronic balance and the thickness is measured using Vernier caliper[8].

4.3 Flammability Test

This test is conducted with the objective for determining the horizontal burning rate the composite and assess its feasibility to be used in the occupant compartment of road vehicles. The specimens are lit from one end and the time required for the specimen to burn fixed length is noted.

The burn rate of the specimen was calculated with the following formula:

$$\boldsymbol{B} = 60\frac{\boldsymbol{L}}{\boldsymbol{T}}$$

Where,

B= Burn rate in mm/min; L= Length of the flame travelled in mm ; T= Time in seconds to travel L mm

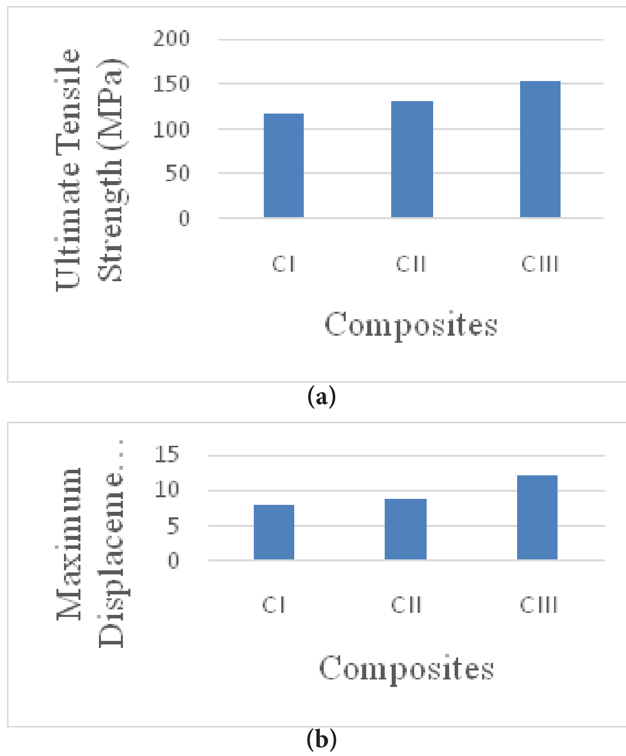


Figure 1. Comparison between the (a) ultimate tensile strength and (b) maximum displacement of different composite specimens.

5. Results and Discussion:

5.1 Tensile Test

5.1.1 Ultimate Tensile Strength

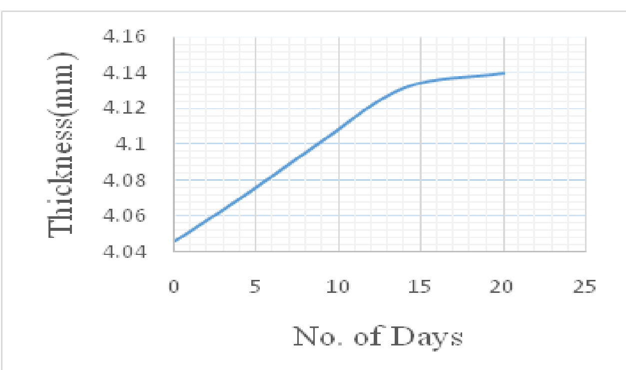
The results revealed that tensile strength for filled composite is higher compared to unfilled composite as shown in

Figure 1. The fracture is due to fiber breakage at the surfaces and delamination of the fibers. The composite with 10 wt % egg shell powder as filler material can withstand a larger tensile stress and undergo go more deflection than those having 0 wt% and 5 wt% egg shell powder as filler material. The ultimate load taken by 10 wt% filler composite and the deflection is more. Adding filler material might have resulted in restriction of propagation of crack and delamination.

5.2 Water Absorption Test

5.2.1 Specimen Immersed in Normal Water

Water absorption is one of the important characteristics of composites that determine their end use applications. The change in thickness of specimen when immersed in normal water showed minute increment as shown in Figure 2. The C I, CII and CIII specimen's thickness is increased by 0.094 mm, 0.475mm and 0.11mm respectively at the end 20 days. The increment might be due to moisture uptake in the specimens and swelling of the specimens. It resulted in adding the eggshell powder as filler lead to more water absorption compared to unfilled.



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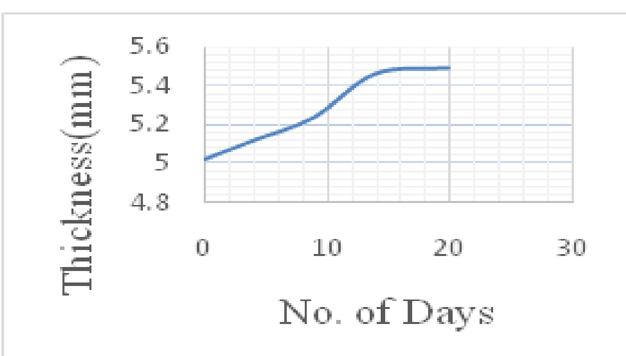

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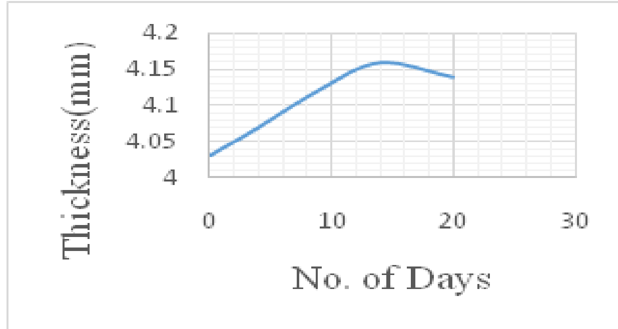
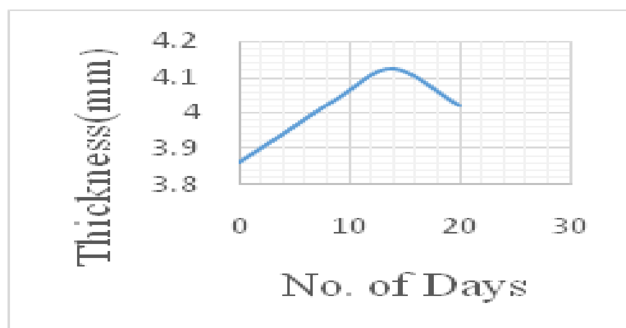


(c)

Figure 2. Thickness variation curve for CI, CII, CIII Specimen.

5.2.2 Specimen Immersed in Salt Water

The change in thickness of specimen when immersed in salt water showed tiny increment s as shown in above Figures 3. The C I, CII and CIII specimen's thickness is increased. The increment might be due to moisture uptake in the specimens by 0.16 mm, 0.12 mm and 0.18 mm respectively at the end 20 days. The increment might be due to moisture uptake in the specimens and swelling of the specimens. It resulted in adding the eggshell powder as filler lead to more water absorption compared to unfilled.



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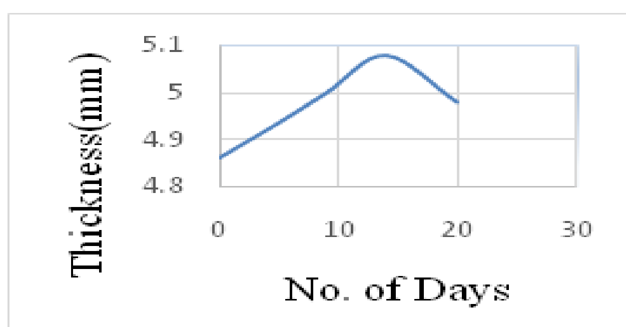

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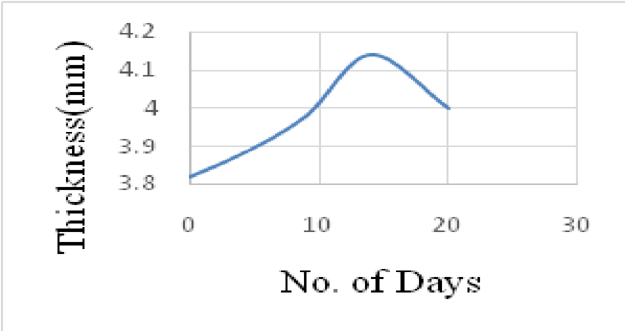

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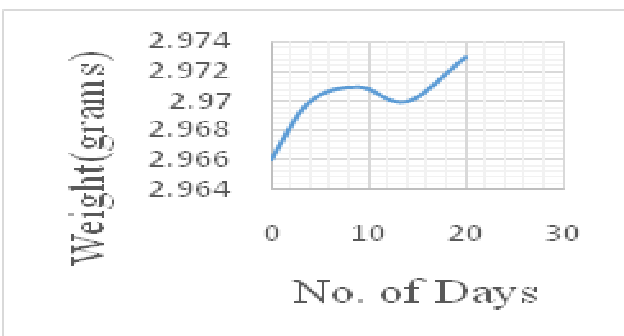
Figure 3. Thickness variation curve for CI, CII, CIII Specimen.

5.2.3 Specimen Immersed in Normal Water

The change in weight of specimen, when immersed in normal water showed little increment as shown in Figures 4. The C I, CII and CIII specimen's weight is increased by 0.007 grams, 0.008 grams and 0.013 grams respectively. The size and shape of the filler materials plays important role in boding. The usage of unshaped and unequal sized egg shell powder as filler might have created the minute voids in the composite. It resulted that adding the eggshell powder as filler lead to more water absorption compared to unfilled.



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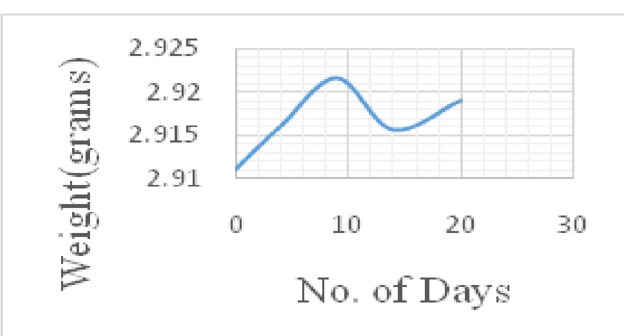

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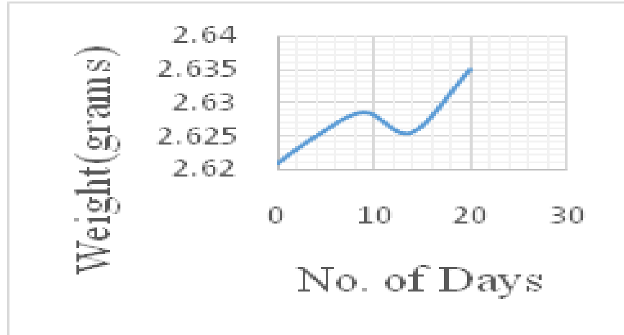

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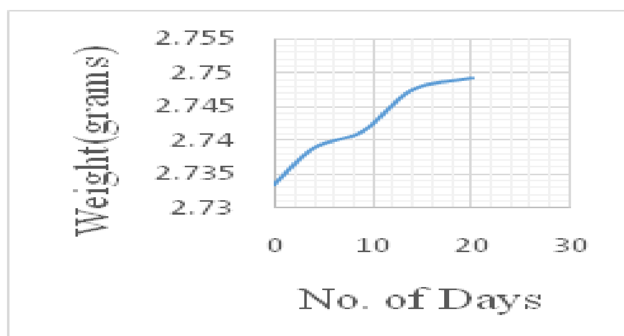
Figure 4. Change in weight curve for CI, CII, CIII Specimen.

5.2.4 Specimen Immersed in Salt Water

The change in weight of specimen, when immersed in salt water showed little increment as shown in Figures5. The C I, CII and CIII specimen's weight is increased by 0.016 grams, 0.019 grams and 0.022 grams respectively. The increment might be due to moisture uptake in the specimens. The size and shape of the filler materials plays important role in boding. The usage of unshaped and unequal sized egg shell powder as filler might have created the minute voids in the composite. It resulted that adding the eggshell powder as filler lead to more water absorption compared to unfilled.



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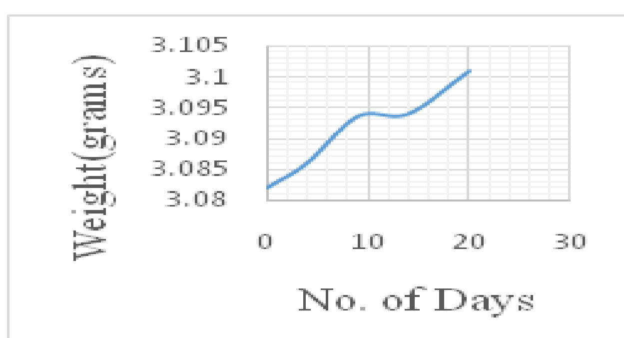

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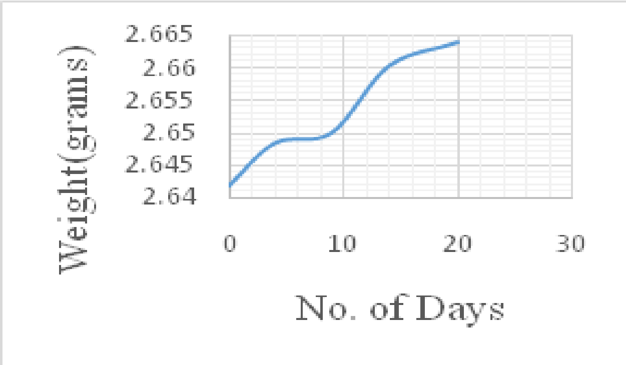

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Figure 5. Change in weight curve for CI, CII, CIII Specimen.

5.3 Flammability Test

Figure 6 shows that the rate of burning of the composites at any given filler particle size decreased with increase in filler contents. Egg shell powder contains calcium carbonate ($CaCO_3$). On the application of flame, calcium carbonate decomposes according to the following equation

$$CaCO_3 \rightarrow CaO + CO_2$$

With the evolution of carbon dioxide (CO_2) which does not support combustion. The more the fillers are incorporated, the more the quantity of $CaCO_3$ in the composites, and the less, the tendency of the composites to burn since CO_2 is a good fire extinguisher. Another possible factor for the observed flame retardant property of the fillers could be the interaction of the fillers with resin and fibers, the possible mechanism which has been described previously.

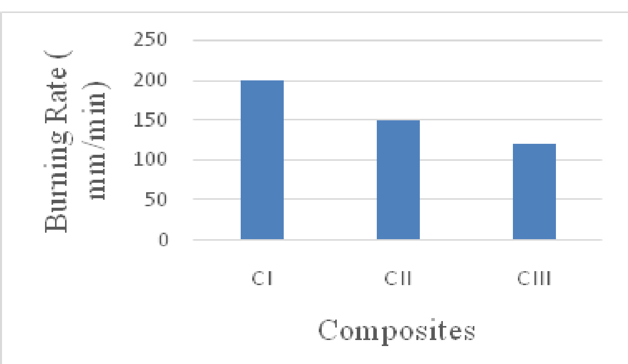

Figure 6. Comparison between burning rate.

6. Conclusion

The work was focused on to analyses the influence of egg shell powder as filler materials on the mechanical behavior of glass fiber, reinforced resin matrix. Different types of composites were fabricated by hand-layup process using different weight percentage of egg shell powder.

All composite with filler material exhibited better tensile strength than unfilled composites. Adding filler material might have resulted in restriction of propagation of crack and delamination. The shape and size of egg shell powder was the fine-tuning factor. The rate of burning of the composites at any given filler particle size decreased with increase in filler contents.

By using egg shell filler material the composite doors can be made stiffer and less economical for domestic applications. Also where, the reduced flame propagation property is required egg shell powder filled hybrid composites could be the best option. But where the water absorption is key factor then this type of hybrid composites could not be the right choice.

7. References

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