



Research Paper

SYNTHESIS AND CHARACTERIZATION OF BIOCOMPOSITES

Swarup Kumar Nayak^{1*}, Purna C Mishra¹, Manoj Ukamanal¹, Durga P Ghosh¹ and Susant K Sahu¹

*Corresponding Author: Swarup Kumar Nayak, ✉ rohanrocks319@gmail.com

The main aim of this work is to prepare a biodegradable biocomposites by extracting cellulose from natural fiber which had extracted from century plant of agavaceae family. Use of synthetic polymers in every segment of our life has increased the plastic waste in large quantities, which forms one of the major environmental problems the world is facing today. In this context thermosetting resin is used for the preparation of laminates prepared by hand layup technique. These are then characterized accordingly by conducting water absorption test and flexural test to study water absorption properties. These properties are evaluated as per American Society for Testing and Materials (ASTM) standards. Intention of this work is to replace a material/metal which are used in many applications by a biodegradable composite that are prepared from natural fibers which is biodegradable, high stiffness, low weight, renewable, non-toxic, ecofriendly to the environment.

Keywords: Cellulose, Natural fiber, Thermosetting resin, Layup technique, Water absorption test, Flexural test

INTRODUCTION

In this century it is believed that aramid, carbon and glass have gained new interest especially as glass fiber substitute mainly to automobile industries. Development of new environmental regulations have been encouraged to search for a new materials and products that are environmentally compactable. Involvement of bio resources to composite materials can further reduce the

dependency on petroleum products. The main disadvantage of present biocomposites are its high cost. Bio composites can supply and can also replace petroleum based composite materials in different fields thereby offering various environmental, agricultural as well as consumer benefits. The main advantage of using renewable materials is that the global CO₂ balance is kept at a stable level. Tobis (1993). Bio composites are now evolving as

¹ School of Mechanical Engineering, KIIT University, Bhubaneswar 24, Odisha, India.

an alternate way to the glass reinforced composites. As bio composites are obtain from renewable resources then the material cost can reduce if they are used in a large scale. The main aim of developing bio composites is to create a new generation fiber reinforced plastic with glass fiber reinforced properties which are environmentally acceptable in terms of production, usage and removal (Hanselka *et al.*, 1995). The general environmental awareness and new rules and regulations will contribute to an increase in the work for more Eco-friendly concept in the automotive industry. Favier *et al.* (1996). The usage of synthetic fiber in polymer composites is fading because these are expensive, non-biodegradable and cause environmental pollution. Using natural fibers with polymers based on renewable resources will allow many environmental issues to be solved. Bledzki *et al.* (1996) and Bledzki *et al.* (1998). By embedding biofibers with renewable resource-based biopolymers such as cellulosic plastics; polylactides; starch plastics; polyhydroxyalkanoates (bacterial polyesters); soy-based plastics, the so-called green biocomposites could soon be the future. Singh *et al.* (2000) and Sinha (2000). Nowadays, biocomposites have been the subject of extensive research, specifically in construction and building industry due to their many advantages such as lower weight, and lower manufacturing costs. Currently, in many different applications the biocomposites became a new revolutionary idea which became ecofriendly to the environment. Rudd (2001).

EXPERIMENTATION

- Fibers were cut to an approximate length of 1 cm. The fibers which are 3-4 cm long

are cut into approximate length of 5 mm-10 mm with the help of scissors as shown in Figure 1.



- Washed with distilled water and dried in oven at 80 °C for 24 hours. The chopped fibers are kept in beaker and washed with distilled water for 20 min-30 min and then these washed fibers are dried in an oven at a temperature of 80 °C for 24 hours
- Dewaxing step-Boiling fibers in a mixture of toluene/ethanol (2:1 vol/vol) in a soxhlet extractor for 6 hours. The washed fibers then proceeded with Dewaxing step. This includes the mixture of toluene/ethanol is poured in flask and the fibers were put in a cloth and placed in the soxhlet extractor. Boiling of these fibers in soxhlet extractor is carried out at a temperature of 70 °C for 6 hours as shown in Figure 2.
- Washed with ethanol for 30 min and dried.
- Pre-treated fiber is then mixed with 0.1 M NaOH in 50% volume of ethanol at 45 °C

Figure 2: Dewaxing Setup



for 3 hours under continuous stirring. The pretreated fibers are mixed with the prepared solution in a beaker and the beaker is placed on magnetic stirrer then it should be heated at 45 °C for 3 hours under continuous agitation as shown in Figure 3.

Figure 3: Heating and Stirring of Fibres

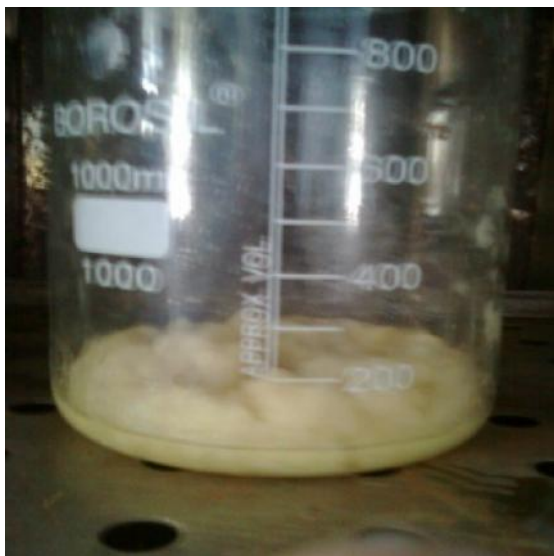


- Then treatment with H_2O_2 at pH = 10.5 (buffer solution) and 45 °C. (a) 0.5% H_2O_2 , (b) 1% H_2O_2 , (c) 2% H_2O_2 , (d) 3% H_2O_2 for 3 hours each under continuous agitation. The fibers now then treated with different concentrations which were prepared. Then each solution is poured in beaker containing fibers and it is kept on a magnetic stirrer and heated at a temperature of 45 °C for 3 hours under continuous agitation. This procedure should be carried out for each solution. A buffer solution of pH = 10.5 is mixed every time with each prepared solution.
- Then mixture is treated with 10% w/v NaOH + 1% w/v $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ at 32 °C for 15 hours under continuous stirring. Now the fibers are again treated with the prepared mixture and it should be poured in beaker containing fibers and kept on magnetic stirrer and it should be heated at a temperature of 32 °C for 15 hours under continuous agitation.
- Finally mixture is treated with HNO_3 , 70%, HAc, 80% (1/10 v/v) at 100 °C for 20 minutes. The fibers finally treated with the mixture prepared and the heating is done at 100 °C for 20 minutes on a heater. Here the cellulose extraction completes. Only cellulose will be left after all the above treatments with different chemical mixtures as shown in Figure 4.
- Then washed with 95% ethanol and then water and dried at 60 °C in oven until constant weight is achieved. Then the obtained cellulose is finally washed with 95% ethanol for 20-30 min and then again washed with water for 20-30 min and finally the washed cellulose is now dried in oven at 60 °C until constant weight is obtained.

Figure 4: Treating of Fibre with HNO_3 

- Finally after drying these fibers were then grind until a powdery form is obtained. The cellulose which was obtained by different treatments is carried out with washing and drying of cellulose. Finally this cellulose is then grinded until a powdery form is obtained which is shown in Figure 5.

Figure 5: Powdered Cellulose



Resin Description

Ecmalon 8811 is isophthalic acid based resin suitable for chemical resistant applications. The resin offers good resistance to corrosion against a wide range of acids and salts of moderate strength. It is not recommended for alkaline conditions. Ecmalon 8811 is of medium viscosity, well suited for wet lay ups. The estimated resin properties are given in Table 1 and cast resin properties are shown in Table 2.

Table 1: Properties of Resin

Appearance	Clear, Light Yellow Liquid
Viscosity @ 25 °C (cps)	550 (Brookfield viscometer)
Specific Gravity (25/25 °C)	1.11
Acid Value (mgKOH/g)	16
Volatiles @ 150 °C (%)	36
Geltime @ 25 °C (mts)	20
Resin	100 g
2% Cobalt Accelerator	1.5 ml
50% MEKP	1.5 ml

Table 2: Cast Resin Properties

Property	Unit	Typical Value	Test Method
Tensile Strength	Mpa	50	ISO 527
Tensile Modulus	Mpa	3000	ISO 527
Elongation at Break	%	2.0	ISO 527
Flexural Strength	Mpa	90	ISO 178
Flexural Modulus	Mpa	3200	ISO 178
Hardness	Barcol	45	IS6746-'94

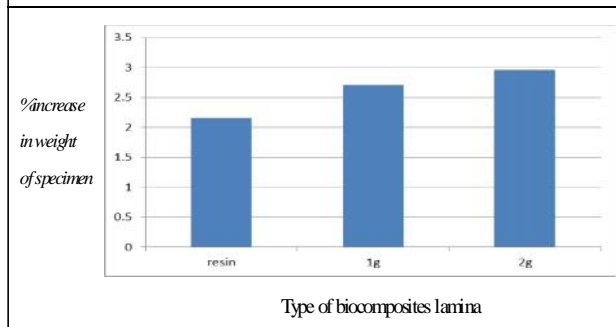
RESULTS AND DISCUSSION

From the comparison of graphs, the following conclusions are quoted below

- From Figure 6 total % Increase in Weight of different biocomposites, it was observed that as water absorption capacity is more

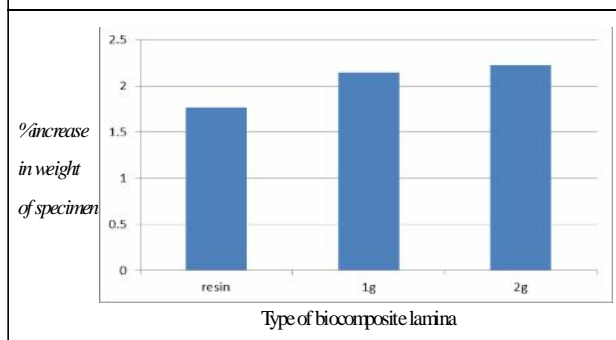
for 2 gm cellulose than that of 1 gm cellulose laminate and resin laminate, percentage increase in weight of different biocomposites will be more.

Figure 6: Total Percentage Increase in Weight of Different Biocomposites



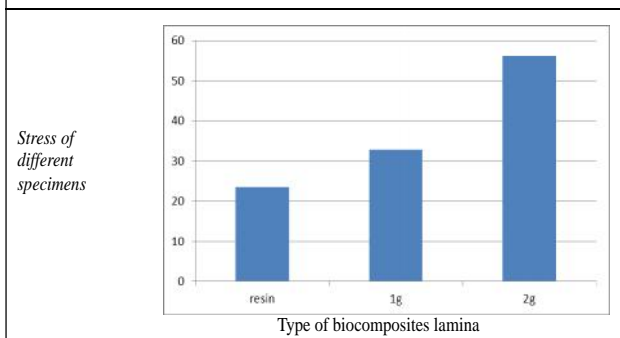
- From Figure 7 soluble matter lost in different biocomposites, it was observed that as water absorption capacity is more for 2 gm cellulose than that of 1 gm cellulose laminate and resin laminate, percentage soluble matter lost in different biocomposites will be more.

Figure 7: Percentage Soluble Matter Lost in Different Biocomposites



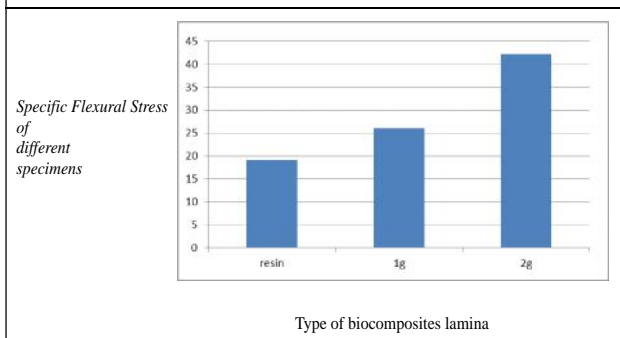
- From Figure 8 stress of different biocomposites laminates, it was observed that stress will be more in 2 gm laminate as cellulose amount is 2 gm so strength will be more for 2 gm when compared with resin laminate and 1 gm cellulose laminate.

Figure 8: Stress of Different Biocomposites Laminates



- From Figure 9 specific flexural stress of different biocomposite laminates, it was observed that as stress is more in 2 gm cellulose laminate specific flexural stress will be more for 2 gm laminate when compared with other laminates.

Figure 9: Specific Flexural Stress of Different Biocomposite Laminates



- From Figure 10 flexural modulus of different biocomposite laminates, it was observed that as flexural modulus depends on stress, so it will be more for 2 gm cellulose laminate than that of 1 gm laminate and resin laminate.
- From Figure 11 specific flexural modulus of different biocomposite laminates, it was observed that specific flexural modulus also depends on stress, so it will be more for 2 gm laminate when compared with other laminates.

Figure 10: Flexural Modulus of Different Biocomposite Laminates

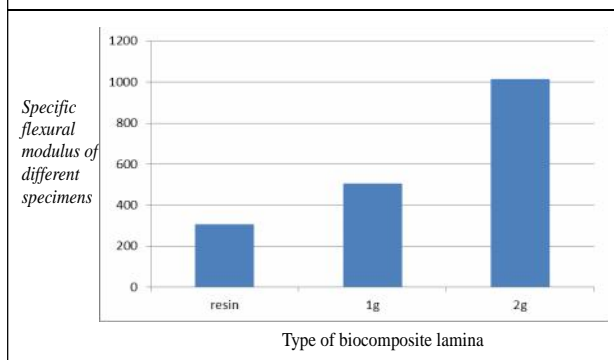
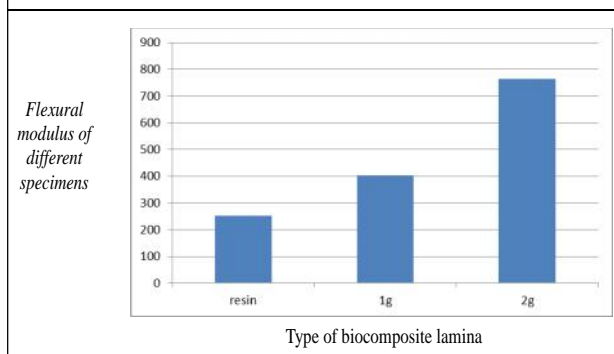


Figure 11: Specific Flexural Modulus of Different Biocomposite Laminates



CONCLUSION

The following conclusions can be drawn from the summary of the results.

- It has been observed that 2 g Cellulose laminate exhibited higher flexural strength compared to other laminates.
- It has been observed that the water absorption capacity is higher for 1 g cellulose laminate compared to resin laminate.
- The flexural modulus exhibited by 2 g Cellulose laminate is higher compared to other laminates.
- The specific water absorption capacity is less for resin laminate compared to 1 g cellulose laminate.

- From the above graphs and results we can conclude that 2 g Cellulose biocomposite laminate gives better results compared with other two laminates. 🌀

REFERENCES

1. Bledzki A K, Reinhmane S and Gassan J (1996), "Properties and Modification Methods for Vegetable Fibers for Natural Fiber Composites", *J. Appl. Polym. Sci.*, Vol. 59, pp. 1329-1336.
2. Bledzki A K, Reinhmane S and Gassan J (1998), "Thermoplastics Reinforced with Wood Fillers", *Polym. Plast. Technol. Eng.*, Vol. 37, pp. 451-468.
3. Favier V, Canova G R, Cavaillé J Y, Chanzy H, Dufresne A and Gauthier C (1995), "Nanocomposite Materials from latex and Cellulose Whiskers", *Polymers for Advanced Technologies*, Vol. 6, No. 5, pp. 351-355.
4. Hanselka H, Herrmann A S and Promper E (1995), "Automobil-Leichtbau Durch den Einsatz Von (Biologisch Abbaubaren) Naturfaser-Verbundwerkstoffen", *VDI Berichte Nr. 1235*.
5. Mohanty A K, Misra H and Drzal H (2001), "Surface Modifications of Natural Fibers and Performance of Resulting Bio-Composites: An Overview", *Composite Interf*, Accepted January.
6. Rudd C (2001), "Composite for Automotive Applications", Rapra Technology Ltd., ISBN 1-85957-265-0.
7. Singh B, Gupta M and Verma A (2000), "The Durability of Jute Fiber-Reinforced Phenolic Composites", *Compos. Sci. Technol.*, Vol. 60, pp. 581-589.

8. Sinha R (2000), "Outlines of Polymer Technology", Prentice-Hall by India Private Ltd., New Delhi 10001.
9. Tobias B C (1993), "Tensile and Impact Behavior of Natural Fiber-Reinforced Composite Materials", Proceedings of the International Conference on Advanced Composite Materials, in T D A K Chandra (Ed.), The Minerals, Metals and Materials Society.