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Mechanical Characterization of Nanocellulose/Jute Fiber Based Composites

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ABSTRACT :- The present work aims at fabrication and characterization of hybrid nano composites that could negate ecological problems and replace synthetic materials. Several material scientists around the world are focusing on materials that can be fabricated with low material cost and superior properties. However, natural fibre based composites do not exhibit excellent properties in mechanical perspective when compared with synthetic materials. Hence, in order to enhance the mechanical properties of natural fibre based composites, fillers can be added. For this reason in the present work Nano cellulose powder is added as filler to Glass fibre based composites and Jute fibre based composites.The matrix material used for composite preparation is polyester resin. Hand-layup technique is used for fabrication of composites as per ASTM Standards. Prior to sample fabrication, calculated amount of Nano Cellulose powder is mixed with polyester resin through ultra sonicator. As a part of mechanical characterization, tensile strength, flexural strength and impact strength are tested. Tensile strength increased with respect to weight percent of Nano Cellulose powder up to certain weight percent and then showed downward trend. When compared to Glass and Jute fibre based composites, the tensile strength is enhanced by 32% and 27% by the addition of Nano cellulose powder of 3% weight percent. However, tensile strength is decreased with further addition of nano powder. Flexural strength also showed similar trend as tensile strength while impact strength is increased continuously with every weight percent of nano powder. On the other hand, thermal conductivity of both the composites decreased with weight percent of nano powder and increased with increase in temperature.

Keywords:- *Flexural Strength, Impact Strength., Jute Fiber, Nano Cellulose, Tensile Strength.*

I. INTRODUCTION

There have been many rules and regulations imposed on manufacturing industries to minimise the solid and non-recyclable waste by many countriesso as to protect the environment.In the past few years, the energy consumption has been very high so is the cost of the products. Several materialscientists and researchers across the globe are focussing on devices which run on low energy and operating costs.

The use of natural fibers in place of petroleum based synthetic fibres is the new exemplar in the preparation of fibre reinforced composites.The glass fiber reinforced composites have good mechanical properties but they are more dense have less machinability,and cannot be recycled. When compared to synthetic fibers like glass,natural fibers have virtue of availability at low price,less power consumption,less density,non-abrasive and possess higher specific mechanical properties.Production of low-cost and non-polluting, environmental friendly compositematerials is a subject of greater significance.

The evolution and utilisation of many natural fiber polymer composites have been thoroughly analysed.Various procedures have been chosen to bring out the fiber from elephant grass and found that in case of retting the yield of fibre was higher compared to the manual and chemical processes.MC Symington et al studied the effect of moisture content on tensile properties of natural fibers: jute,kenaf,flax,abaca,sisal and it was concluded that jute fibers exhibited better mechanical properties than other fibres. Considering the effect of moisture, jute fibers had better mechanical properties [4]. Similarly, Wambua et al. studied sisal, hemp, coir, kenaf and jute fiberreinforced polypropylene composites. Comparing these composites, hemp composite showed higher tensile and flexural strengths and sisal composite showed higher impact strength [5]. The investigation of mechanical and thermal properties of waste grass broom reinforced polyester composites was carried out by Ramanaiah et al. Results revealed that thermal conductivity increased with increase in temperature and decreased with fiber content. As well tensile and impact strengths increased with increase in fiber content. Most of the fibers were reinforced together in different combinations, to fabricate hybrid composites. Hybridization influenced certain physical parameters, for which mechanical properties were enhanced [6]. Sansevieria cylindrical fiber has low densityand high porosity fraction which is favourable for light weight applications and acoustic and thermal insulation. For cost effectiveness and high volume applications fibre extracted from waste water bamboo husk and disposable chopsticks has been used as reinforcements for making the composites.For producing binder less particle board composite panels, oil palm biomass waste is the best suitable material.Tensile modulus and impact strength of rice straw-reinforced composites are about 1.66and 1.8 times to that of pure polyester resin, respectively. The tensile strength of jute, kenaf, and coir reinforced composites have been increased with the increase of fiber volume fraction.The composites were tested and characterized to evaluate the tensile flexural and impact properties.

This work concentrates on fabrication, characterization and most importantly on the comparison of distinguishable polyester composites. Next, to the fabrication of cellulose based polyester composites, the composites are characterized by testing tensile strength, flexural strength, impact strength. Later the results obtained for the composites were compared with each other.

II. MATERIALS AND METHODS

A. Materials and Chemicals

Unsaturated polyester resin (ECMALON 4412), methyl ethyl ketone peroxide (catalyst) and cobalt naphthenate (accelerator) are provided by Ecmas Resin Private Limited. Nanocellulose is supplied by CIRCOT, Mumbai.

B. Preparation of Composites

Composites are fabricated by initially mixing nano cellulose with polyester resin in a sonicator. Once the mixing is successfully done jute fibers are reinforced into the resin-cellulose mixture using hand layup technique and proper focus on the orientation is required as it is the long fiber reinforced nano-composite. Samples poured into the moulds are allowed to cure for 24 hours. After which the samples are carefully taken out and tested. ASTM standards are followed while fabricating the samples. A similar technique is used in the fabrication of other sorts of composites [7].

C. Tensile Strength

The standard opted to test the tensile strength of the sample is ASTM D-638. The dimensions of the sample are 160mm x 12.5mm x 3mm according to the standard. With accuracy in achieving these dimensions, specimens having different weight fractions of cellulose nanofiber are prepared. The specimens are glued with Aluminium strips which are meant for perfect gripping during testing. With the help of Electronic Tensometer at a crosshead speed of 2mm/min, testing is performed.

D. Flexural Strength

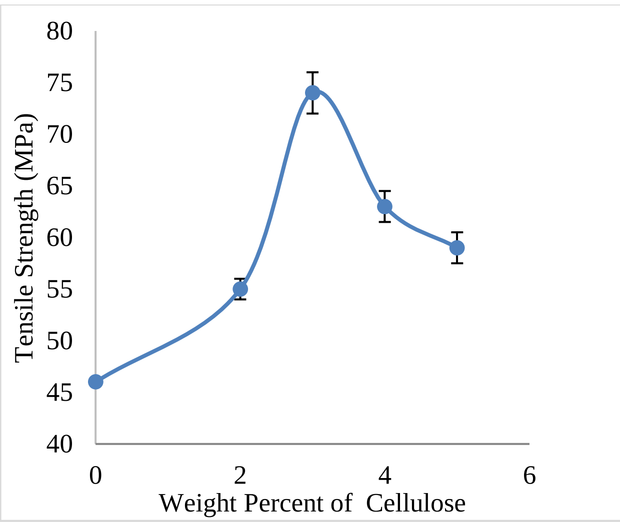
By 3- point bend or 4- point bend testing, Bend or flexural strength is tested. 3- point and 4- point bending differ in the number of loading points while the supporting points are same. In this work, 3- point bend test is done as it eliminates the need to determine center point deflection. Bending test is performed with the help of Electronic tensometer with flexural test fixtures. Samples are prepared using ASTM D790M standard with 100mm x 25mm x 3mm as dimensions. Samples are tested with same crosshead feed as tensile strength.

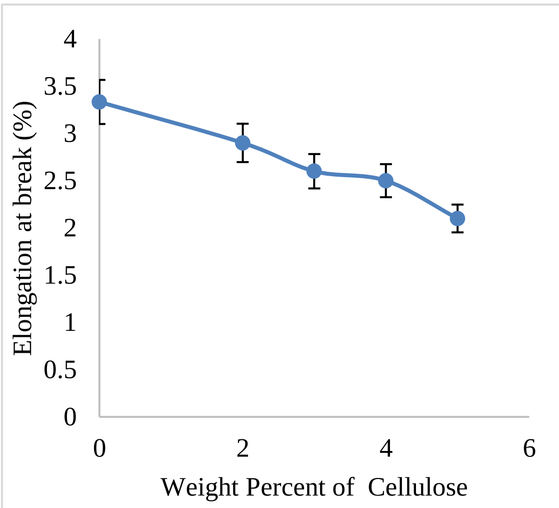
E. Impact Strength

Bio-composites which do not undergo plastic deformation after the impact are fabricated as per ASTM D256M. For this standard, the sample is 63.5mm long, 12.7mm deep, 10mm wide. The notch of width 0.25 ±0.04 mm and included angle of 45° is a stress concentrated zone. 8 ±0.1 mm is the width remained under notch to stimulate the condition.

III. RESULTS & DISCUSSION

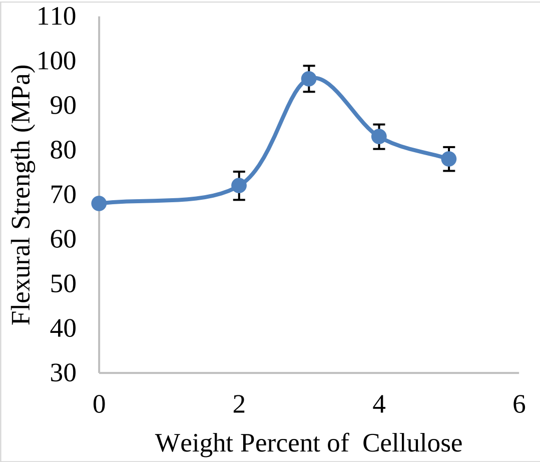
A. Tensile Strength

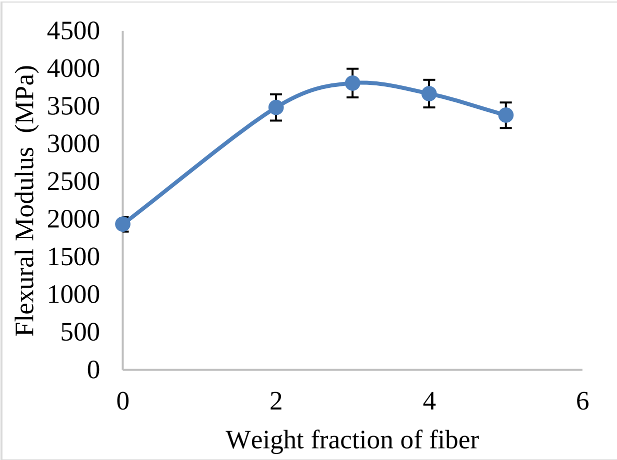




Cellulose of 2, 3, 4, 5 weight percents is incorporated in 2weight percent jute fiber reinforced polyester composite. The tensile strength of composites increased with respect to weight percent of cellulose upto 3 wt% and decreased with further increase in cellulose percent, further. The decline in tensile strength is due to agglomeration of nanocellulose and jute fibers in the composite. However, peak tensile modulus of 1128MPa is observed at 4 weight percent of nanocellulose and elongation at break declined at with increase in weight percent of nanocellulose.

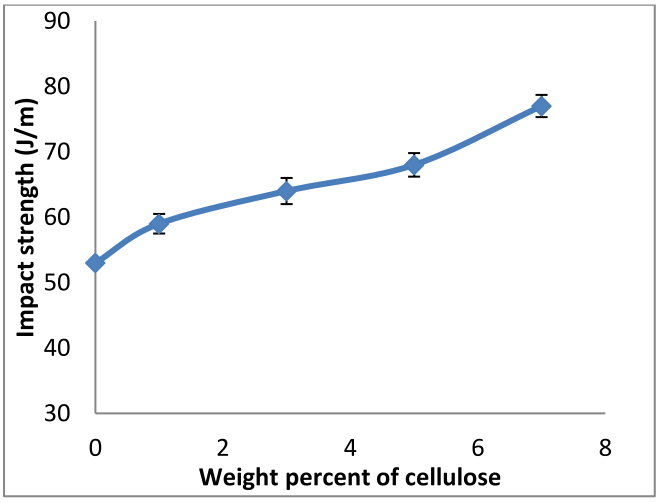
B. Flexural Strength





Flexural strength and flexural modulus 2weight percent of jute fiber based composite increased with increase in nanocellulose. The trend variation of flexural strength and flexural modulus is same. Highest flexural strength of 96MPa and flexural modulus of 3807MPa is observed at 3 weight percent of nanocellulose, which is due to good interference and adherence.

C. Impact Strength



Impact strength of jute fiber based composite increased with increase in weight percent of nanocellulose that is from 2 to 5 weight percent. At 5 weight percent of nanocellulose 77J/m is recorded.

IV. CONCLUSION

In the present work,

- Characterisation of nanocellulose/ jute fibers based polyester composites was done successfully.
- Tensile strength of jute/nanocellulose composite showed promising value at 3 weight percent of nanocellulose.
- Flexural strength and Tensile strength showed similar trends due to good inference and adherence
- Impact strength showed consistent increase with increase in nanocellulose weight percent.

The results of the study indicate jute/ nanocellulose based composites are having competing mechanical. Hence these composites find their applications in various fields such as automobile, aerospace etc.

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