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INVESTIGATING THE MECHANICAL BEHAVIOUR OF COCONUT SHELL AND GROUNDNUT SHELL REINFORCED POLYMER COMPOSITE

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ABSTRACT

This paper investigates about developing polymer matrix composite using coconut shell powder (CSP) and groundnut shell powder (GSP) in different volume and evaluating its tensile strength, impact strength and flexural property and hydrophilic behavior along with engineering application of resulting composites. Then the plate specimens are examined using the scanning electron microscope (SEM). The resulting composites are more environmental friendly and are used in transportation (automobile, railway coach), military applications and civil applications.

Keywords: Coconut shell powder (CSP), Groundnut shell powder (GSP), Polymer matrix Composite, Mechanical properties, Scanning Electron Microscopy (SEM).

I. INTRODUCTION

Most of the developing countries are very rich in agricultural fiber and a large part of agricultural waste is being used as a fuel. India alone produces more than 400 million tons of agricultural waste annually. It has got a very large percentage of total world production of rice husk, jute, stalk, baggase, groundnut shell and coconut fiber, etc. In the composites industry, natural fibers refer to wood fiber and agro based bast, leaf, seed, and stem fibers. These fibers often contribute greatly to the structural performance of the plant and when used in plastic composites, can provide significant reinforcement. Natural fibers are complex and three-dimensional polymer composites, which are made up of cellulose, pectin, hemicellulose and lignin. Recent advances in the use of natural fibers in composites have been reviewed by several authors [1-4]. Currently natural fibers form an alternative for glass fiber, the most widely applied fiber in the composite technology.

The advantage of the natural fibers over synthetic fibers like aramid, carbon or glass fiber are low densities, nonabrasive, non-toxic, high filling levels possible resulting in high stiffness and specific properties, biodegradable, low cost, good thermal and acoustic properties, good calorific value and enhanced energy recovery [5-6]. The environmental impact is smaller since the natural fiber can be thermally recycled and fibers come from a renewable resource. The natural fibers also offer a possibility in developing countries to use their own natural resources in their composite processing industries.

Many authors have reviewed the latest developments in the application of natural fibers [1-4]. The widespread investigations on the preparation and properties of thermoset and thermoplastic composites with the application of natural fibers such As kenaf [5-6], jute [7-8], sisal [9], bagasse [1-4], bamboo [2-5], pineapple [7], rice husk [4] and groundnut shell[1] have been carried out. The natural fibers are used for variety of appliances such as packaging, low cost housing and structures. Growing attention is nowadays being paid to coconut fiber and groundnut shell husk. The incorporation of filler such as coconut shell powder (CocosNucifera) and groundnut shell husk into thermosetting materials is used to reduce the production costs of the molded products [4]. Coconut shell powder (CocosNucifera) is widely available at very low cost, so it is an ideal filler material in this regard [5]. Coconut shellpowder is made from the most versatile part of the coconut which is from the shell where this shell is organic in nature. High filler content, however many adversely affect the processability, ductility and strength of the composites. Groundnut shell powder (Arachis hypogeae) is the largest oilseed interms of production. Groundnut shells are chemically treated with NaOH solution and sieved through 600µm BS sieve. Brian George et.al investigated the groundnut shell fiber characterization.

II. EXPERIMENTAL PROCEDURE

Materials used in this experimental work are Epoxy resin, Hardener and Coconut shell powder, groundnut shell powder. Epoxy resin (Grade-VBR8912) is a thermosetting epoxy resin of medium viscosity supplied by GVR Enterprise, Madurai, Tamil Nadu and India having outstanding properties as the matrix material, like excellent adhesion to different materials, high resistance to chemical and atmospheric attack, high dimensional stability, excellent mechanical properties, nontoxic nature and negligible shrinkage.

Hardener VBR-1209 is used to harden matrix material. The chemical composition of coconut shell powder consists of Lignin (29.4%), Pentosans (27.7%), Cellulose (26.6%), Moisture (8%), Solvent Extractives (4.2%), Uronic Anhydrides (3.5%) and Ash (0.6%).The cleaned coconut shells were crushed into small pieces by using hammer. These small pieces then converted into powder by using hammer.\

The chemical composition of groundnut shell powder consists of Lignin (30.2%), Cellulose (35.7%), Hemicellulose (18.7%) and Ash (5.9%). The cleaned groundnut shells were crushed into powder by crusher.

2.1 Preparation of Composites

A mould with the dimension of 300 mm × 300mm × 3mm was used to prepare the composite specimen. A layer of wax was applied to the mould so that the specimen can be easily taken out of the mould. Measured quantities of groundnut shell particles and resin were taken in a plastic container and stirred thoroughly to get homogeneous mixture. After adding the suitable quantity of epoxy resin and hardener (10:1), the mixture was again stirred for 10 minutes and thoroughly mixed mixture was placed in the mould and compressed uniformly. This set up allowed for curing and then the composite specimen was taken out from the mould. Curing time was 80ºC - 120ºC Coconut shell particles and Groundnut shell particles reinforced polymer composite (C&GSPC) specimens were prepared by varying weight percentage of reinforcement material (i.e. 30, 40, 50, 60, 70 weight %) and matrix material.

2.2. Characterization of the Composites

The theoretical density of composite material in terms of weight fraction was found from the following equation as given by Agarwal and Broutman.

$$\rho_{comp} = 1/(w_{csp} / \rho_{csp} + w_{mat} / \rho_{mat}) \qquad (1)$$

- Where, 'W' and 'ρ' represents the weight fraction and density respectively. The subscript comp, csp and mat stands for composite, coconut shell powder and the matrix respectively.

2.3. Testing of Mechanical Properties of Composites

The study of mechanical properties such as tensile strength, flexural strength, impact strength of coconut shell and groundnut shell powder reinforced (randomly distributed in epoxy matrix)composite have been conducted as per ASTM standard.

2.3.1. Tensile Strength

The tensile test was generally performed on flat composite sample. The commonly used shape for sample was the dog-bone. The length of the test specimen was as per ASTM D638.The tensile test was performed in Universal Testing Machine shown in Fig.1. The test was performed with a cross head speed of 2mm/min. for three samples of different CSP&GSP filled volume fraction and average value was taken for analysis.

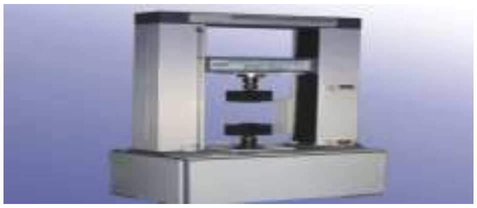

Fig. 1. Universal testing machine

2.3.2. Flexural Testing

Flexural test were performed using Universal Testing Machine according to ASTM D790.The composite samples were tested at a cross head speed of 5 mm/min. In each case, three samples were taken and average value was recorded.

The flexural stress in a Universal Testing Machine was found out by using equation as follows,

$$\sigma_{max} = 3P_{max}L / bh^2 \qquad (2)$$

Where, Pmax is the maximum load at failure (N), L is the span (mm), b and h is the width and thickness of the specimen (mm) respectively. The flexural modulus was calculated from the slope of the initial portion of the load-deflection curve which was found out by using equation as follows,

$$E = mL^3 / 4bh^3 \qquad (3)$$

Where, m is the initial slope of the load deflection curve for each stacking sequence, three specimens were tested and average result was obtained.

2.3.3. Impact Test

The impact tests were performed according to ASTM D256 standard using Impact testing machine. The test method determines the Izod impact strength of groundnut shell particle reinforced polymer composites. An Izod type test in which specimen is held as a cantilever beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp. Five specimens for each sample having size 63.5 mm 10 mm and 3 mm thickness were prepared and tested. The V notch was made at a distance of 31.75 mm from the top at a depth of 2.5mm. Impact strength was calculated by:

Impact strength = J/A (KJ/m$^{2)}$ (4)

Where**,** J=Energy absorbed (KJ) A= Area of cross section of the specimen below the notch (m2).

2.3.4. Scanning Electron Microscopy (SEM)

Studies on the morphology of the tensile fracture surface of the composites were carried out by using a Scanning Electron Microscope (SEM). This test was conducted by using SEM equipment Model HITACHI S3000N at ACCETECH, Karaikudi, and Tamil Nadu. The fractured surfaces of specimens were mounted on aluminum stubs and sputter coated with a thin layer of palladium to avoid electrostatic charging during characterization.

III. EXPERIMENTAL RESULTS

3.1 Tensile strength

Tensile strength of different composite samples is obtained after testing and provide in table.1.

Table.1. Tensile strength of different composite samples

S.No	Composite Samples	TensileStrength(N)
1	30% CSP&GSP Filled	427.79
2	40% CSP&GSP Filled	865.75
3	50% CSP&GSP Filled	309.96
4	60% CSP&GSP Filled	126.94
5	70% CSP&GSP Filled	225.25

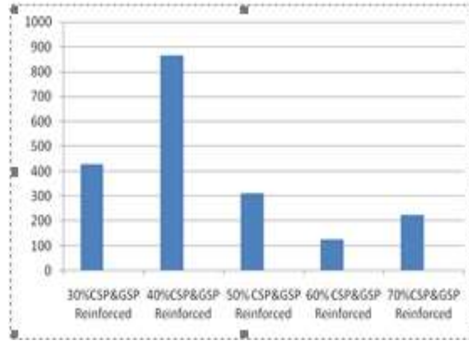

Fig.2. Tensile strength results for different Volume fraction

The tensile strength results in table 1. For various samples which are prepared with CSP & GSP filler with different volume fraction were plotted in Fig .2.TheTensile curve illustrates that, the maximum tensile strength is obtained for the Composite prepared with 40% CSP & GSP volume fraction. It is also observed that an increase of CSP&GSP filler volume the corresponding tensile Strength decreases.

3.2 Flexural strength

The flexural strength of different composite samples is given in table 2.

Table.2. Flexural strength of different Composite samples

S.No	Composite Samples	FlexuralStrength(MPa)
1	30% CSP&GSP Filled	39.99
2	40% CSP&GSP Filled	59.31
3	50% CSP&GSP Filled	63.21
4	60% CSP&GSP Filled	35.94
5	70% CSP&GSP Filled	37.59

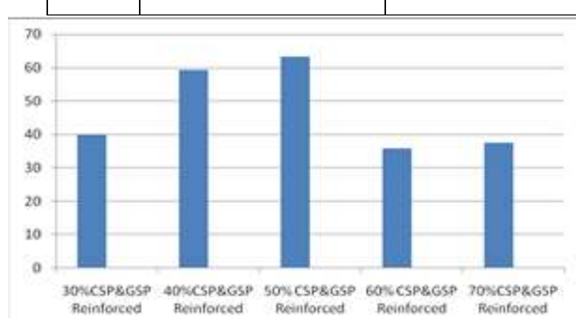

Fig.3. Flexural strength results for different Volume fraction

Fig.3 shows the variation in flexural strength for different volume fraction of CSP & GSP reinforced composites. The flexural strength curve illustrates that the Maximum flexural strength is obtained for the composite 50% both CSP, GSP Filled.

3.3 Impact strength

The Impact strength of different composite samples is given in table 3.

Table.3. Impact strength of different composite Samples

S.No	Composite Samples	Impact Strength(KJ/m^2)
1	30% CSP&GSP Filled	0.20
2	40% CSP&GSP Filled	0.23
3	50% CSP&GSP Filled	0.25
4	60% CSP&GSP Filled	0.21
5	70% CSP&GSP Filled	0.18

Fig.4. Impact strength results for different volume fraction

Fig.4 shows the variation in Impact strength for different volume fraction of CSP & GSP reinforced composites. The Impact strength curve illustrates that, the Maximum Impact strength is obtained for the composite 50% both CSP, GSP Filled.

3.4 Scanning Electron Microscopy (SEM)

The Scanning Electron Microscope was used to examine the tensile fracture surface and flexural fracture surface of polymer matrix/ CSP & GSP filler content as shown in Fig.5. & Fig.6.

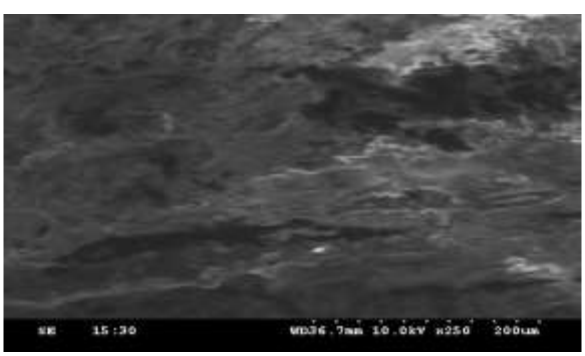

Fig.5. Tensile fracture surface

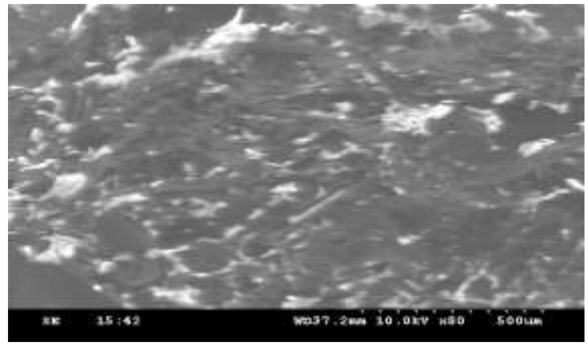

Fig.6. Flexural fracture surface

IV. CONCLUSION

The experimental investigation on mechanical behaviour viz. Tensile strength and flexural strength, Impact strength of CSP&GSP epoxy composite,Material is greatly influenced by the CSP&GSP filled volume fraction.

The maximum tensile strength is obtained for the composite prepared With40%CSP&GSP volume fraction. The tensile strength curve (See Fig -2) shows an increase of filler volume the tensile strength goes on decreasing. Thus, the rate of decrease of tensile strength from 50% to 60% and 60% to 70% CSP& GSP filled epoxy composite is approximately content.

The maximum flexural strength is obtained for the composite prepared with 50% CSP&GSP filled while; the flexural strength is minimum for the composite prepared with 70% CSP&GSP filled.The flexural strength curve (See Fig-3) shows that an increase of filler volume, flexural strength increase from 40% to 50%, while, the flexural strength decreases on increasing filler volume From 50% to 60%.Thus, the rate of decrease of flexural strength from 50% to 60%is greater than the rate of increase from 40% to 50% CSP&GSP filled composite. Consequently, the composite prepared with 40% to 50% CSP&GSP, Filled volume fraction is suitable for the application in the interior part of an Air craft, motor car and automobile where materials with good tensile strength Characteristic are required.

V. REFERENCES

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