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A STUDY ON MECHANICAL BEHAVIORS OF ALKALI TREATED COIR FIBER REINFORCED PARTICLES IMPREGNATED POLYESTER COMPOSITES

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ABSTRACT

The global demand for a building material is gradually growing, while the availability of manmade synthetic resource is diminishing. This current trend has led to the development of alternative materials. There were a various synthetic materials that have been explored and advocated. Polymer composites claim a major participation as building materials and other all applications. In general the natural fiber composites are low cost, no health hazard and good mechanical properties etc. Studies on the use of natural fibers as replacement to man-made fiber in fiber-reinforced composites have increased and opened up further industrial possibilities. Natural fibers have the advantages of low density, low cost, and biodegradability. However, the main disadvantages of natural fibers in composites are the poor compatibility between fiber and matrix and the relative high moisture absorption. Therefore, chemical treatments are considered in modifying the fiber surface properties. The main objectives of this present work, to investigate the mechanical properties of alkali treated coir fiber and particles such as chitosan, eggshell and red mud reinforced polyester composites. Initially the coir fibers were treated with NaOH solution to improve the interfacial bonding between fiber, particle and matrix. The composite plates were fabricated using coir fiber particles by compression molding techniques. The mechanical properties such as tensile, flexural, impact and compressive strength were evaluated as per ASTM standards. The SEM images and XRD studies were also carried out for the above combination of coir fiber reinforced particles impregnated polyester composites.

Keywords – *Chitosen, Egg shell,* *Red mud, Coir fiber, Polyester resin, Compression molding, Alkali solution, SEM and XRD.*

1. Introduction

Composite materials are being widely used in recent period for day to day applications and at the same time they possess a vital role in manufacturing of highly sophisticated machines and equipment also. Composites consists of two phases one is called discrete phase and other phase called reinforcing phase, which may be fiber, particulate or flakes and the other is a continuous phase which termed as matrix material which possess the major share of composite material [1]. Composite shows advantages like low weight, low density, low cost and good specific properties like tensile, flexural and impact strengths. It may possess applications in area where weight of the total equipment is a major problem. The objective of using the composite material is for its high strength to weight ratio and to meet the applications with predefined properties [2]. Many composite materials comprised just two phases; one termed the "matrix", which is spread throughout and surrounds the other phase, often referred as the "reinforcement". The properties of composites are mostly dependent on the type of reinforcement; their ratios, orientation, and the geometry of the reinforcement. There are two classification systems of composite materials [3]. One of them is based on the matrix material (metal, ceramic, and polymer) and the second is based on the reinforcement material structure. Agricultural residues are excellent and versatile alternatives to chuck wood and some synthetic fibers away [4]. Their abundant and

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plentiful availability, renewability, being eco-friendly, ease of fabrication and being low CO_2 emitters are among the few reasons that make the agro residues a preferred choice [5].Although there are useful several literatures on agricultural residues and fibers in the polymer composites, but there is only a meager research work done on agro residues and hybridization of agro particles, which must be encouraged in order to stimulate commercial production of these novel materials and will produce good economic returns to farmers [6].

2. Experimental Procedure

2.1 Materials and methods

Huge rise in environmental awareness has led to utilization of natural fibers and bio particles in polymer composite applications. The coir fiber is available abundantly in India. The coir fibers are non-toxic, biodegradable and can be easily extracted from green husks using dehusking machine. The fibers instead of going as waste dumping, it has been used as reinforcement in polyester composites. Initially the coir fibers are treated with NaOH solution for the removal of wax and impurities on the fiber surface. The physical properties of coir fiber are given in Table 1.

Table 1 Physical properties of coir fiber

Properties	Value
Fiber diameter (mm)	0.26
Fiber Length (mm)	150
Density (g/cc)	1.4
Extension break (%)	29.13

Particles or fillers added to fiber reinforced polymer composites increases modulus, reduce mold shrinkage, control viscosity and produce smoother surface with improved stiffness, dimensional stability and better thermal properties. From the list of terephthalic, isophthalic and orthophthalic unsaturated polyester resin types, the orthophthalic type is selected because of its availability, low weight and good compatibility with fibers. The resin system consists of unsaturated orthophthalic polyester, Methyl Ethyl Ketone Peroxide (MEKP) catalyst and Cobalt Octoateaccelerator supplied by Sri Vinayaka Enterprises, Chennai, Tamilnadu, India were used. The mechanical properties of polyester resin are listed in Table 2.

Table 2 Mechanical properties ofpolyester resin

Mechanical properties	Value
Density	1350 Kg/m^3
Poisson’s Ratio	0.33
Young’s Modulus	1 GPa
Thermal conductivity	0.21 W/mC

The additive particles were used to improve the static mechanical strength of the composites. In this study, Natural calcium materials such as chitosan and egg shell were used. The red mud is an industrial waste which is being used effectively in polymer composites in recent years. The size of the particles used is 50 µm. The EDAX graphs were obtained using FEI quanta FEG 250 HR SEM-EDAX Spectrum for the investigation of crystalline nature of materials. The dots in the graph corresponds to the building blocks of the crystalline material due the crystalline nature, the atoms are arranged periodically. The incident ray beam is scattered at different planes of the materials, thus resulting diffracted X-Rays. The magnitude of this path length only depends on the distance of crystal planes and it indicates the angle of the X-ray beam.

2.2 Composite fabrication

The composites were prepared by the combination of unsaturated polyester resin, Cobalt Octoate Accelerator and Methyl Ethyl Ketone Peroxide Catalyst using the ratio of 1: 0.015.The particles were mixed and blended with resin by mechanical stirring at 20 rpm for 10 minutes at the room temperature. A 30 Ton ACE make compression molding machine was used to fabricate the composite lamina for the dimensions of 300 × 300 × 3 mm. The matrix and reinforcement ratio has got significant influence on the mechanical properties of the composites. Larger weight fraction of reinforcement materials leads to agglomeration of fibers and particles in the composites which declines the mechanical properties of the composites. Based on that, the resin content of 60 % and fiber -particulate content of 40 % in weight were maintained for the fabrication of composites. The specimens were cut from the fabricated composites using saw machine as per ASTM standards for determining tensile, flexural, impact and compressive properties. The specimens were prepared and finished using emery paper before testing of mechanical properties. The photographic image of compression molding machine is shown in Fig. 1.

Figure 1 Photographic image of compression molding machine

2.3 Mechanical testing

2.3.1 Tensile testing

The mechanical testing of specimen requires some standardization. Tensile strength is the ratio between the load at break to the original cross sectional area of the bar. The static tension test samples were cut according to ASTM D 638 standard for the specimen dimensions of 165 mm × 25 mm × 3 mm and the tensile properties of particles reinforced coir-polyester composites were measured using Digital Universal Testing Machine (Make : Tinius Olsen, Model : H10KL). The gauge length of 100 mm was maintained in the tensile testing. The photographic image of UTM-tensile setup is shown in Fig. 2.

Figure 2 Photographic image of UTM-tensile setup

2.3.2 Flexural testing

Flexural strength is the maximum stress developed when a bar shaped test piece acting as a simple beam is subjected to bending force perpendicular to the bar. The three point flexural test samples were cut according to ASTM D-790-10 for the specimen dimensions of 125 mm × 12.5 mm × 3 mm. The flexural test was conducted as per homogeneous beam theory with the span length of 112 mm and span to depth ratio of 34:1 using Digital Universal Testing Machine (Make :Tinius Olsen, Model : H10KL). The gauge length of 112 mm was maintained in the flexural testing. The photographic image of UTM- flexural setup is shown in Fig. 3.

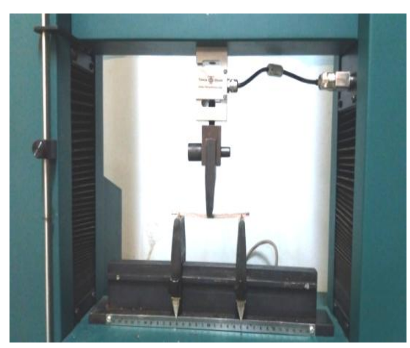


Figure 3 Photographic image of UTM-flexural setup

2.3.3 Impact Testing

The impact properties of a material represent its capacity to absorb and dissipate energies under impact or shock loading. Energy absorbed (σ_{ui}) by the specimen of 62.5 mm × 12.5 mm × 3 mm dimensions was calculated by conducting Izod test with the help of Tinius Olsen Impact tester as per ASTM D 256-10. The photographic image of impact testing machine is shown in Fig. 4.

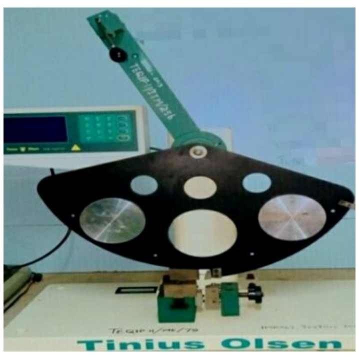


Figure 4 Photographic image of impact testing machine

2.3.4 Compression testing

Compression testing was carried out using a Tinius Olsen compressive tester as per ASTM D 695. The sample was incised into the dimensions of 25 mm x 25 mm x 3 mm. The test specimen was supported in between the two setups; the sample should keep in relative humidity of 55%.The photographic image of compression test set up is shown in Fig. 5.

Figure 5Photographic image of compression testing set up

3. Results and Discussion

The mechanical properties (tensile, flexural, impact and compressive strength) of alkali treated coir fiber reinforced particles impregnated polyester composites were discussed in this section. The SEM images of composites after the mechanical testing were also used to study the interfacial bonding between constituents of composites.

3.1 Comparison of tensile strength

The red mud particles impregnated coir-polyester composites exhibited better value of tensile properties due to the crystalline nature of particles. The fiber reinforcement improved the tensile property of polymer and further the properties can be improved by the addition of particles. The surface to contact area of particles is higher which increases tensile properties of polyester resin where the fibers are short and discontinuous. The comparison of tensile strength of various particles impregnated coir-polyester composites areshown in Fig. 6.

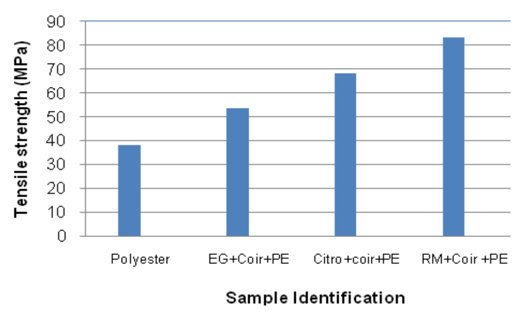


Figure 6Comparison of tensile strength values

3.2 Comparison of flexural strength

The red mud particles impregnated coir-polyester composites exhibited better value of flexural properties. The particle loading of 10 %, correspondingly the fiber loading of 30 % was used in all the cases for the comparison of mechanical properties of coir-polyester composites. The comparison of flexural strength of various particles impregnated coir-polyester composites are shown in Fig. 7.

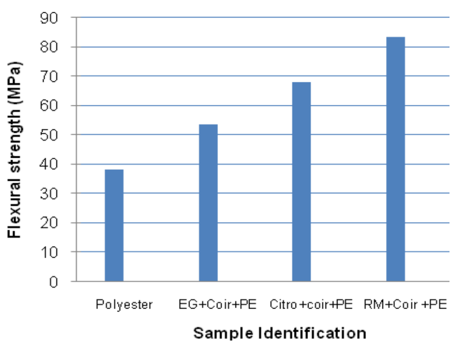


Figure 7 Comparison of flexural Strength values

3.3 Comparison of impact strength

An impact test measures the amount of energy of a material that can absorb before fracturing or breaking into pieces due to the striking of pendulum. The chitosen and eggshell are enriched with calcium oxide particles and provides better mouldability with polyester resin. The comparison of impact strength of various particles impregnated coir-polyester composites are shown in Fig. 8.

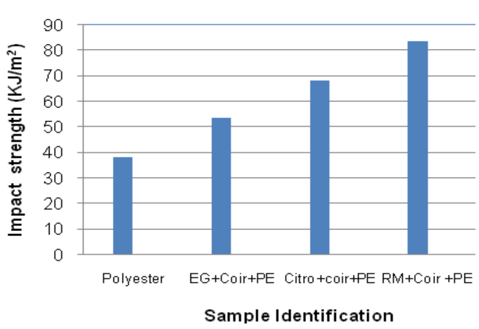


Figure 8 Comparison of impact Strength values

3.4 Comparison of compressive strength

The comparison of compressive properties with various particulates was carried out. The compressive strength of coir-polyester composites was found to be very low among the other composites .The appreciable improvement in compressive strength was obtained with the addition of egg shell particles. The coir fiber impregnated with red mud particles in polyester composites shows positive impact on the compressive strength on comparing with other composites. The comparison of compressive strength of various particles impregnated coir-polyester composites are shown in Fig. 9.

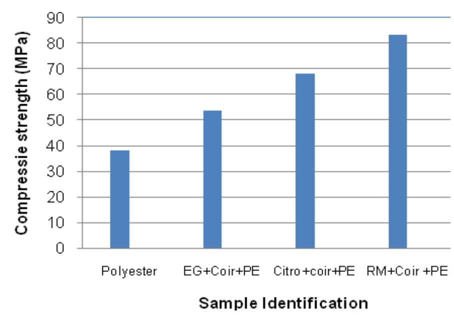
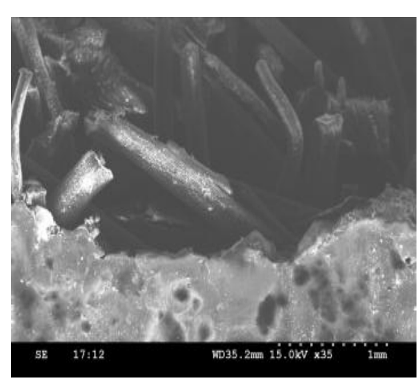


Figure 9 Comparison of compressive Strength values

3.5 Characterization of materials

The SEM images of egg-shell, red mud and chitosan particles impregnated coir-polyester composites are shown in Fig. 10. The inter adhesion between matrix and particles, fiber breakage, uniform distribution of particles and matrix cracking were observed from the SEM images. The better mixing of calcium particles in polyester resin thus improved mouldability of eggshell-coir-polyester composites. The chitosen particles are more enriched with calcium which further improved inter adhesion between reinforcement and resin.

Due to the presence of high iron and alumina content in Red mud-Coir-Polyester composites, the bonding between the particles and fiber is high. Through the XRD image the phase identification of the composite is done. The chemical composition of egg-shell and chitosan additive particles consists of calcium contents of 32.77and 28.76 in weight (%)respectively. The XRD image of egg-shell, red mud and chitosan particles are shown in Fig. 11.



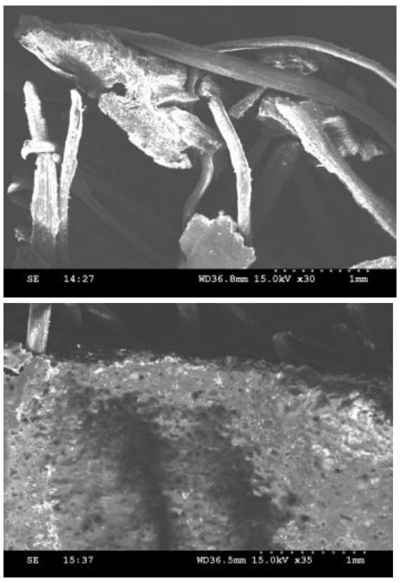
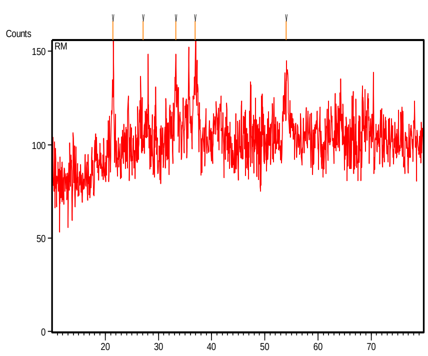
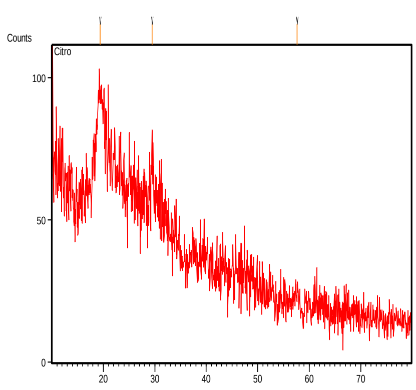


Figure 10 SEM image of eggshell, redmud and chitosan particle impregnated coir-polyester composites





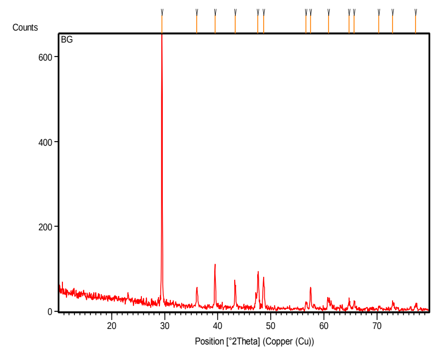


Figure 11 EDAX spectrum of egg-shell, Red mud and chitosan particles

4. Conclusions

The evaluation of mechanical behaviours of red mud, eggshell and chitosan added coir-polyester composites were studied in this investigation. The Red mud-Coir-Polyester composites exhibited better value of tensile strength, flexural strength, impact strength and compressive strength as compared with other two types of composites.The alkali treatment of fibers and particles inclusion in matrix may be carried out in order to improve the mechanical properties coir fiber-polyester composites in this present investigation.

References

1. *Jayabal S, Sathiyamurthy S, Loganathan K T and Kalyanasundaram S (2012), "Effect of soaking time and concentration of NaOH solution on mechanical properties of coir–polyester composites", Bulletin of Materials Science, Vol. 35(4), 567-574.*

2. *Prasad S V, Pavithran C, and Rohatgi P K (1983), "Alkali treatment of coir fibres for coir-polyester composites." Journal of Materials Science, Vol. 18 (5), 1443-1454.*

3. *Sathiyamurthy S, Syed Abu Thaheer A and Jayabal S (2012), "Mechanical behaviours of calcium carbonate-impregnated short coir fibre-reinforced polyester composites." Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, Vol. 226(1), 52-60.*

4. *Singha A S and Vijay Kumar Thakur (2008), "Mechanical properties of natural fibre reinforced polymer composites", Bulletin of Materials Science, Vol. 31(5), 791.*

5. *Rajamuneeswaran S and Jayabal S (2016), "A lexicographic multiobjective genetic algorithm for optimization of mechanical properties of crab carapace impregnated coir–polyester composites" Polymer Composites, Vol. 37(3), 844-853.*

Balaji N S, Jayabal S and Kalyanasundaram S (2015), "A neural network based modelling for machinability characteristics of zea fiber-polyester composites", Transaction of Indian Institute of Metals Accepted for Publication.

6. *Ramprasath R, Jayabal S, Kalyanasundaram S, Bharathiraja G and Yashwant S Munde (2016), "Investigation on impact behavior of rice husk impregnated coir-vinyl ester composites", Macromolecular Symposia, Vol.361(1), 123-128.*

7. *(1999) Thermal properties of environmental friendly green composites made from pineapple leaf fibres and resin", Polymer composites 367-78.*