



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 1, January 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

9940 572 462

6381 907 438

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Evaluation of Mechanical Properties of Corncob Fiber Reinforced Composites with Polyester Resin

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ABSTRACT: Particulate filled polymeric composites with enhanced mechanical properties are highly in demand in engineering applications. So, this research work dealt with an experimental investigation on the mechanical properties enhancement of corncob powder/kora fiber reinforced polymer composites. corncob powder and kora fiber were reinforced in polyester resin in different weight percentages to fabricate composite using compression molding machine. The efficiency of the prepared composites was evaluated by determining the mechanical properties like tensile strength, impact strength and flexural strength as per ASTM standards. The prepared composites were subjected showed a tensile strength of 21.7 MPa, maximum flexural of 78.22 MPa, and impact strength of 12.21 kJ/m².

KEYWORDS: Composites, Polyester, Kora fiber, Mechanical.

I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions [1-4].

In other words, the composites maybe defined as the combination of matrix and reinforcements [5]. Matrix is the continuous phase and surrounds the reinforcements [6]. Matrix generally made from metal polymer or ceramics. Reinforcements is the dispersed phase, which normally bears the majority of stress [7]. A reinforcement is the strong, stiff integral component which is incorporated into the matrix to achieve desired properties [8]. There are many situations in engineering where no single material will be suitable to meet a particular design requirement [9-10]

In such situations two or more materials in combination may possess the desired properties and provide a feasible solution to the materials selection problem. These materials are referred as a composites [11-13]. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

It is evident that growth of human population demands more and more materials, products which in turn leads to several environmental problems. Nowadays more concern has been given towards the ecological problems. From the material perspective, researchers are trying to invent new environmental friendly materials. One such approach recommended by the researchers is to replace the glass/carbon fibers with natural fiber composite materials. The natural fiber composites possess many advantages inclines towards the environment like renewable resources, biodegradable, less pollution during the production process, lower energy requirement than glass fibersetc [4,5,8-10].

Hand lay-up is the most widely used method to fabricate the composite plates. It involves the sequence of manual fiber placement on the mold, and addition of resin matrix. Then with the help of hand rollers, the wet mixture is then rolled to obtain required thickness along with the uniform distribution of resin and also to ensure proper reinforcement-matrix interaction [9,10,12,13]. This prepared composite plate is then cured.

In this work, the polyester composite reinforced with kora fiber and corncob fillers were prepared and investigated for their mechanical properties. In addition to the filler and reinforcement, the accelerator and catalyst was also used and studied.

II. METHODOLOGY

The methodology followed in this investigation is shown in Figure 1. Based on the thorough literature study, cyperusrotundus (kora fiber), corncob powder and polyester resin was considered to make the composite plate. The methyl ethyl keptone peroxide and cobalt octate was used as the accelerator and catalyst respectively.

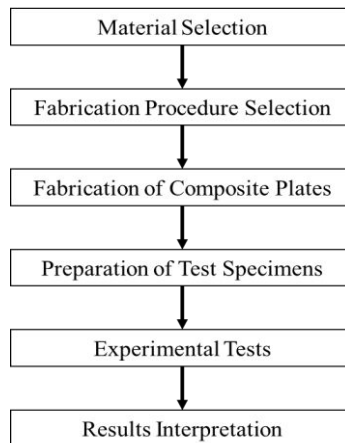


Fig. 1. Flowchart of methodology followed in this work

Kora fiber (cyperusrotundus)

The kora fibers were collected from local supplier and kept in the sunlight to eliminate the moisture. Then by using the power tool, the fiber was cut into small pieces of 3 cm in length.

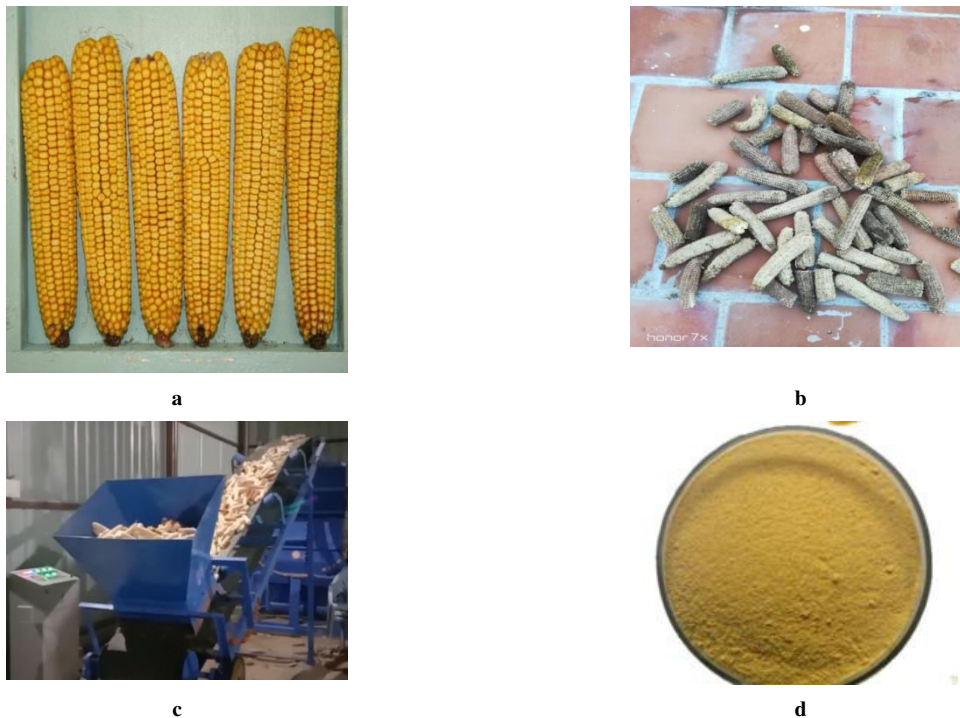


Fig. 2. Processing of corncob (a) procured zea maize from local farm (b) dried corncob (c) grinding of dried corncob (d) prepared corncob powder for further use.

Corncob

Corncob is a popular food source for both humans and animals, providing the required calories to the body. The required corncob (CC) was obtained from a local farm (Figure 2). In order to remove the moisture, the CC was dried in the sunlight. After drying in sunlight the CC was kept inside the oven at 35°C for 8 hrs prior to milling. The dried CC was ground to fine powder and kept in the desiccator.

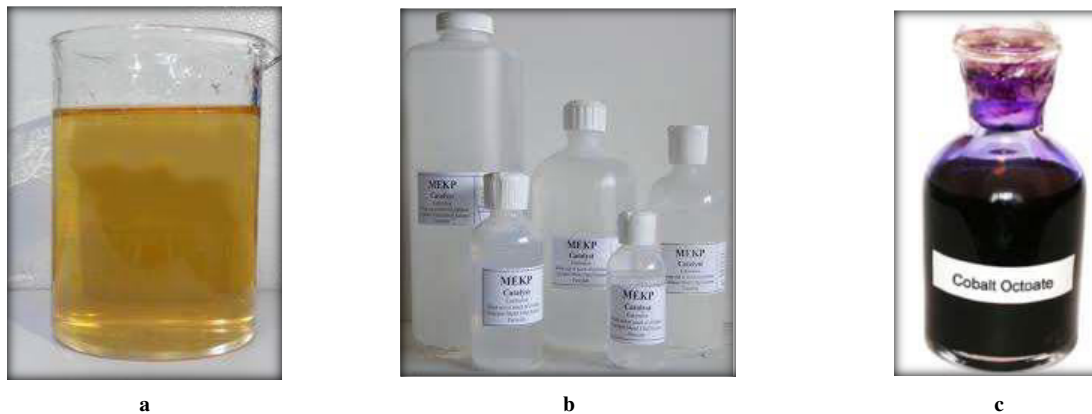


Fig. 3. Chemicals used in the plate fabrication (a) polyester resin (b) methyl ethyl ketone peroxide (c) cobalt octoate accelerator.

Polyester resin

The polyester resin (Figure 3a) is comprising of repeating ester units and are the primary resin matrix in the sheet and bulk molding compounds. Along with the polyester resin, the Methyl ethyl ketone peroxide accelerator (Figure 3b), and the cobalt octoate as catalyst (Figure 3c) was used during the fabrication procedure.

Plate Fabrication

With the hand layup process, by using the kora fibers, polyester resin, the composite plates were prepared in different formulations as given in Table 1. The catalyst and the accelerator were also used as given in Table 1.

Table 1. Different percentages considered in this investigate to fabricate the composite plates

Material	Sample-A	Sample-B	Sample-C
Corncob powder	40%	35%	20%
Polyester resin	60%	65%	70%
Kora fiber	-	-	10%
Catalyst	Methyl ethyl ketone peroxide (1.5% by weight)		
Accelerator	Cobalt octoate (1.5% by weight)		

Hand lay-up process was considered in this investigation to fabricate the kora fiber impregnated polyester composites (Figure 4). For this purpose, the mixture of corncob powder and kora fiber was first arranged on the mould plate. Then the unsaturated polyester resin, methyl ethyl ketone peroxide, and cobalt octoate was sprayed on the mixture followed by hand rolling process and cured.

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Fig. 4. Hand layup process of kora fiber impregnated in the polyester resin.

Compression molding

A stainless steel mold of size 300 mm × 300 mm × 3 mm was used to fabricate the composite plate in the compression molding (Figure 5). The operating pressure, temperature and curing time followed was 2.6 MPa, 60 °C and 1 hour respectively. The mold is kept in between the heated platens at 80 °C of the hydraulic press. In the report, suddenly a sentence about the ground nut shell was provided. Thus with the sufficient pressure, the heated plates were closed to minimize the flash at the mold part line. After the curing time, the cured pate was removed and the fresh charge was loaded for next cycle.



Fig. 5. Compression molding equipment used to fabricate the composite plate.

Mechanical Testing

The fabricated plates were investigated with the tensile, flexural and impact tests to evaluate the performance of the composite.

Tensile tests

The tensile tests were performed as per ASTM D638 standard using the Tinius Olsen® universal testing machine (Figure 6a). The tensile specimens cut from the fabricated plates are shown in Figure 6b. The overall length, gauge length, narrow section width, and the overall width followed was 165 mm, 50 mm, 13 mm, and 19 mm respectively. The specimen is held between the lower and upper jaws and the displacement rate of 10 mm/s was applied. The tests were continued until the specimen failure, then the breaking load and tensile strengths were noted.

Flexural tests

Three point flexural tests were performed as per the ASTM D790 standard. The flexural tests were performed on the Tinius Olsen® universal testing machine. The flexural test specimen dimensions followed was 50 mm × 10 mm × 5 mm (Figure 6d). With the application of load, the specimen bends and fracture occurs at the middle of the beam. The breaking load was obtained from the tests along with the load vs deflection curves.

Impact tests

Izod sir, in the report at one place charpy test is mentioned and at other place Izod test is mentioned impact tests were performed using Tinius Olsen® impact tester (Figure 6c) as per the ASTM D256 standard and the pendulum was dropped from an angle of 125° to break the specimen. The dimensions of the specimen used was 50 mm × 10 mm × 5 mm (Figure 6e). The amount of energy absorbed during the breaking of specimen was noted from the impact tests.



Fig. 6. Tensile tests (a) universal testing machine used to perform the tensile tests (b) impact tester (c) tensile specimens (d) flexural test specimens (e) impact test specimens.

III. RESULTS AND DISCUSSION

Tensile tests were performed with the prepared samples. The tests were repeated thrice and the average values were reported in Table 2. In a similar way, the flexural and impact test results are given in Table 3 and 4 respectively.

Table 2. Tensile test results averaged from three repetitions of the experiments

Result	Sample A	Sample B	Sample C
Ultimate tensile Strength (MPa)	21.6	21.7	4.44
Force (N)	800	815	107

Table 3. Flexural test results averaged from three repetitions of the experiments

Result	Sample A	Sample B	Sample C
Flexural Strength (MPa)	61.78	78.22	32.89
Force (N)	46.33	58.67	24.67

Table 4. Impact test results averaged from three repetitions of the experiments

Result	Sample A	Sample B	Sample C
Impact Strength (kJ/m ²)	7.38	9.31	12.21

It was observed that the tensile strength was improved in Sample (B) with the proportion of 65 % Resin and 35% Corncob powder. The tensile strength reaches a maximum value of 21.7 Mpa. Later the tensile strength was found to decrease by a further reinforcement of Cyperusrotundusfiber 10% added to the sample (C) due to improper interaction between the resin and Cyperusrotundusfiber.

Similarly, the flexural strength of Sample (A) was around 21.6 MPa. Whereas the flexural strength reaches maximum value of 78.22 MPa for the sample (B). However, the further increase of Cyperusrotundusfiber, the flexural strength decreases. From the impact strength test is found that the sample (C) is giving better value of 12.231 kJ/m² due to the addition of short length fiber of Kora fiber in the sample. Also, the addition of fiber reinforcement has shown a positive impact in all the samples in the case of impact strength. The predominant reason for this occurrence might be the short fiber length and due to that the increase in addition of the fibers resulted in more reinforcements of smaller length in the matrix. This increases the impact resistance of the prepared composites.

Thus, the prepared fiber reinforced polymer composites resulted in good mechanical properties like tensile, flexural and impact strength. The addition of reinforcements has shown considerable improvement in the properties which made the prepared composites as feasible to implement in certain low-load bearing applications.

IV. CONCLUSION

In this study, the kora fiber reinforced polyester composites were prepared using hand layup process. The prepared composites were subjected to tensile, flexural, and impact tests. Based on the experiments, the maximum tensile strength of 21.7 MPa was witnessed. Also, the maximum flexural and impact strengths were recorded as 78.22 MPa and 12.21 kJ/m². The influence of reinforcement (fiber) was clearly identified from the performed investigation. The addition of short fiber reinforcements increased the strength of composites positively. In future, the authors intend to extend the investigation with the addition of fiber reinforcements with various length to investigate the influence of fiber dimensions in the mechanical properties.

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