iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** III **Month of publication:** March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49388

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Tensile Behaviour of Starch Based Naturally Woven Coconut Leaf Sheath Reinforced Biodegradable Composite

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Abstract: ***Hazardous effects of plastic on human health and environment have accelerated the rate of research in the field of natural fiber composites. Coconut sheath is having potential to be used as a reinforcement to produce biodegradable composite. In this paper naturally woven coconut leaf sheath reinforced corn starch based, potato starch based composites and Low density polyethylene (LDPE) based composites were prepared. Polyvinyl Alcohol was used as blending polymer. Composites with increasing coconut sheath reinforcement layers have been prepared. Further the prepared composites were subjected to tensile testing, Potato starch based coconut sheath reinforced composites were found to exhibit better tensile strength.***
Keywords: Natural fiber composite, biodegradable, starch based, sustainable, rural empowerment

I. INTRODUCTION

Over a few decades use of plastic has been tremendously increased due to its advantages over other materials like low cost, light weight, durability etc. Use of plastic made our life easier but its usage has serious health hazards as it includes chemical Bisphenol A [1]. Though some plastic materials can be recycled it has some limitations as it needs to be collected and sorted in various categories to recycle it properly which requires huge amount of man power and time. Currently the system working on collecting and recycling of plastic waste is incapable of recycling it which leads to the accumulation of the plastic waste into natural resources. Due to this the concept of biodegradable has taken a birth. Several researchers have studied the various alternatives available as reinforcement for the development of natural fiber composite [4-8].

Among the available reinforcement alternatives coconut sheath has tremendous potential but not yet utilized in a organized manner. It has one more advantage over other natural reinforcements is its naturally woven structure which minimizes manufacturing efforts of composite.

Use of coconut sheath as reinforcement with biodegradable matrix will lead to the sustainable development along with rural empowerment. Coconut leaf sheaths need to be treated in order to utilize it as reinforcement. Alkali treatment of coconut sheath with NaOH and acetic acid reported increase in cellulose percentage with decrease in hemicelluloses and lignin which increased the binding between matrix and coconut sheath resulting in increased mechanical properties [4]

Polylactic Acid (PLA) and starch played important role in the development of bioplastic out of which the starch is most popular and cost effective material. Pure starch lacks the strength, moisture resistance and process ability. [3]. In order to improve the properties of starch it is blended with some degradable synthetic polymers like polyvinyl alcohol, polylactic acid. G.M. Glenn [15] demonstrated the use of wheat starch, corn starcch and potato starch to prepare foam by compression/ explosion processing which has potential to replace the single use foam packaging material. Srinivas Shenoy Heckada [14] used the corn starch with water and vinegar as biodegradable matrix with Areca Frond Fibre to produce completely biodegradable composite

Hand Layup and hot pressing are the most popular methods utilized for the production of biodegradable composite as they are cost competitive and quite simple. Hamdy Ibrahim et. al [10] employed hot pressing to prepare starch based biodegradable composite reinforced with date palm and flax fibers whereas Srinivas Shenoy et al. [14] used hand layup process followed by hot pressing to manufacture starch based biodegradable composite.

II. MATERIALS AND METHODS

Coconut Leaf sheath, Sodium hydroxide pallets (Merk life science private Ltd), acetic acid, glycerol, corn starch, potato starch and Polyvinyl alcohol (K. M. Shah and Sons Mumbai) were used as received

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A. *Treatment of Leaf sheath*

In order to improve the adhesion and surface characteristics chemical treatment of natural fibers is carried out Coconut leaf sheath collected from local coconut trees were washed several times to remove debris and dried for two days in sunlight. Dried leaf sheaths were then immersed in a 5% NaOH solution for an hour at room temperature and then neutralized with 5% acetic acid. Treated leaf sheath were dried for two days.

B. *Development Of Biodegradable Matrix And Composite*

Two separate biodegradable matrices were prepared using corn starch and potato starch respectively, the process used for the preparation of biodegradable starch matrix is as follows

10 grams of polyvinyl alcohol was dissolved in 100 grams of water, 20 grams of starch was then added in the solution along with 5 grams of glycerol, the mixture was stirred for 30 minutes and transferred to steel vessel then it was heated to 80ºC with continuous stirring the solution starts becoming semisolid the process is continued till the solution completely converts into semisolid state.

C. *Biodegradable Composite Preparation*

The composites were prepared by hand layup process by applying the semisolid starch matrix over the coconut leaf sheaths using 20 cm×10cm mold. Prepared composites were then cured at room temperature for 24 hours. Two types of composites were prepared by using corn starch matrix and potato starch matrix by varying the reinforcement.

Low density Polyethylene based coconut leaf sheath reinforced composite preparation.

Low density polyethylene granules were heated at 80ºC to convert it into semisolid state and applied over coconut leaf sheath using hand layup followed by hot pressing at 80ºC for 30 minutes.

TABLE 1
THE COMPOSITION OF DIFFERENT COMPOSITES

Formulation no.	Matrix used	No of sheath layers	Fiber weight percentage
C1	Corn Starch	1	14.28
C2		2	28.37
C3		3	33.33
P1	Potato Starch	1	15.71
P2		2	27.66
P3		3	34.1
L1	Low Density Polyethylene	1	11.77
L2		2	19.13
L3		3	25.52

D. *Tensile Testing of composites*

The tensile testing of composites was done by using ASTM D 638 standards. Tensile test was done at a gauge length of 110mm using Universal testing machine (model STS 248, Star Testing Systems, India) with a load capacity of 980 N with speed of 10 mm/ min.



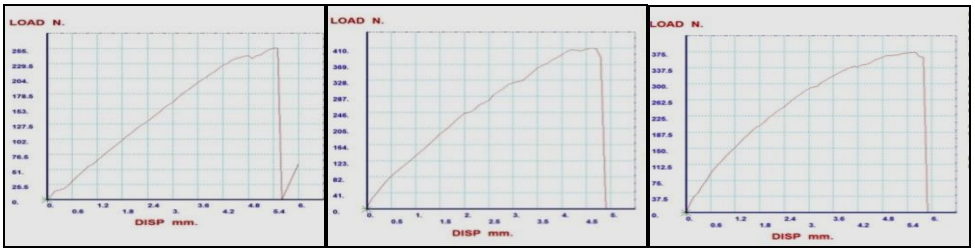
(a) (b) (c)

Fig. 1. Tensile test specimens of (a) corn starch based composites (b) Potato starch based composites (c) Low density polyethylene based composites

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III. RESULTS AND DISCUSSION

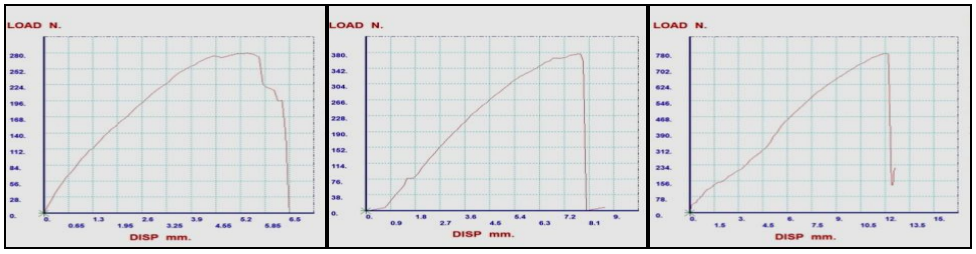
Mechanical properties of the composites is an important aspect from the application point of interest, tensile test of composite was done to measure the tensile strength of the prepared composite Fig 2 shows the load displacement curves obtained from tensile testing of corn starch based coconut leaf sheath reinforced composites. All composites exhibited non linear load displacement curve demonstrating ductile behaviour. With increase in reinforcement from 14.28 percent to 28.37 percent increase of 14.63percent in tensile strength is observed. Further increase of reinforcement from 28.37 percent to 33.33 percent increase of 7.93 percent in tensile strength has been observed. Maximum tensile strength of 11.16 MPa was obtained for C3 formulation at 33.33 percent weight fraction.



(a) (b) (c)

Fig. 2. Load Displacement curve for tensile testing of corn starch bsed composites with (a) single layer of reinforcement (b) two layers of reinforcement (c) Three layers of reinforcement

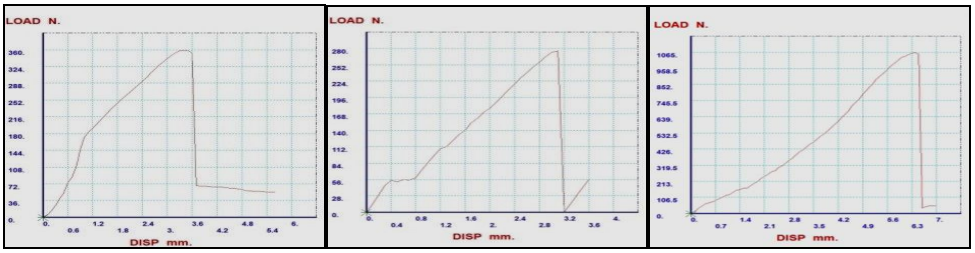
Fig 3 shows the load displacement curves obtained from tensile testing of Potato starch based coconut leaf sheath reinforced composites. All composites exhibited non linear load displacement curve demonstrating ductile behaviour. With increase in reinforcement from 15.71 percent to 27.66 percent no significant change has been observed in tensile strength whereas further increasing the reinforcement from 27.66 to 34.1 percent 95.43 percent increase in tensile strength has been observed. Maximum tensile strength of 17.14 MPa was obtained for P3 formulation at 34.1 percent weight fraction



(a) (b) (c)

Fig. 3. Load Displacement curve for tensile testing of Potato starch bsed composites with (a) single layer of reinforcement (b) two layers of reinforcement (c) Three layers of reinforcement

Fig 4 shows the load displacement curves obtained from tensile testing of Low density polyethylene based coconut leaf sheath reinforced composites. All composites exhibited non linear load displacement curve demonstrating ductile behaviour. With increase in reinforcement from 11.77 to 19.13 percent 43.36 percent increase in tensile strength has been observed further increase of reinforcement to 25.52 percent increase of 36.29 percent in tensile strength has been observed. Maximum tensile strength of 14.42 MPa was obtained for L3 formulation at 25.52 percent weight fraction



(a) (b) (c)

Fig. 4. Load Displacement curve for tensile testing of Low Density Polyethylene bsed composites with (a) single layer of reinforcement (b) two layers of reinforcement (c) Three layers of reinforcement

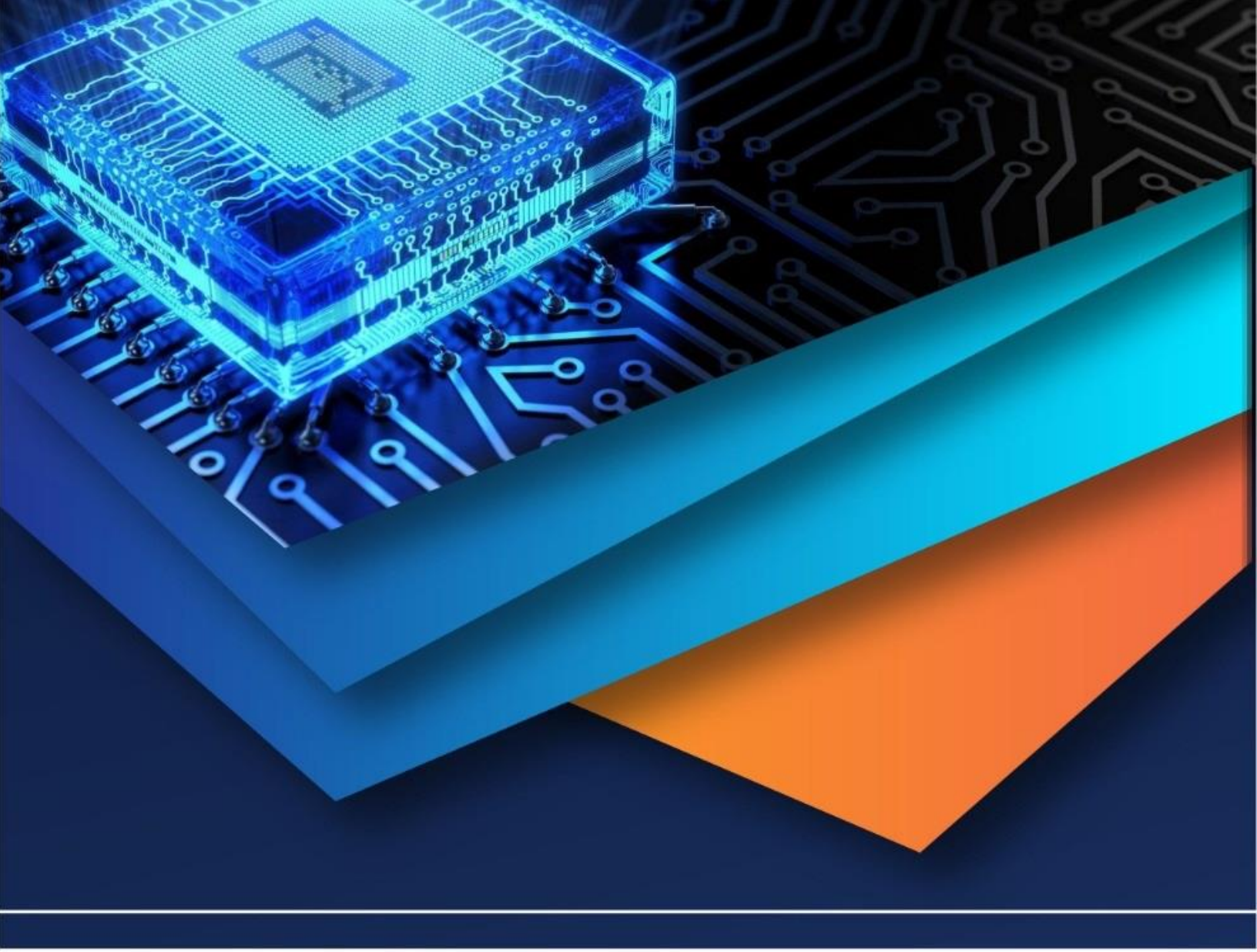
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IV. CONCLUSIONS

The objective of this study was to manufacture the novel coconut leaf sheath reinforced starch based biodegradable composite. The composites were prepared by hand layup technique varying the fiber loading. The tensile behaviour study of all composites has shown the ductile behaviour of composites increase of fiber content gave rise to considerable increase of tensile strength. Corn starch based composite shown highest tensile strength of 11.16MPa at 33.33 wt% reinforcement with three layers of coconut sheath. Potato starch based composite shown highest tensile strength of 17.14MPa at 34.1 wt% of reinforcement with three layers of coconut sheath where as LDPE based composite shown highest tensile strength of 14.42MPa at 25.52 wt% with three layers of coconut sheath. The study implies that Potato starch based composites exhibit more tensile strength as compared to corn starch based composites and LDPE based composites hence Potato starch based composites will find the application where low tensile strength and water resistance characteristics are not required

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