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Synthesis of Rice Straw Fiber Reinforced Natural Rubber Composite and Effects of Surface Treatment in its Mechanical Properties

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Abstract*—In the last decade the use of natural fiber in reinforcement of composite materials is increased, because of growing environmental awareness. The main objective of present work is to study the mechanical properties of rice straw fiber reinforced natural rubber composites at different weight fractions (20%, 30%, 40%, 50% and 60%) of rice straw fiber under treated and non treated conditions. At first the fiber is treated with NaOH, and then composite is manufactured for both untreated and treated fiber. After the synthesis of rice straw fiber reinforced natural rubber composite, The effects of surface treatment in its mechanical properties are studied. Rice straw fiber reinforced natural rubber composites were manufactured according to ASTM standards using compression molding technique. The developed composites were then tested for their mechanical properties, tensile, tear, density, abrasion, hardness, compression, and water absorption properties. The standard test methods used is, ASTM-D638M for tensile properties.*

***Keywords*—Mechanical properties, Natural rubber, composite material, Rice straw fiber, Surface Treatment.**

I. INTRODUCTION

In the last decade, using natural fiber-reinforced materials in the manufacturing of composite materials has significantly increased due to growing environmental awareness. The main components of the composites are,

- Matrix material.
- Reinforcing material.

The matrix materials are the majority part of the composite, which bound the fiber each other in the composite to increase the adhesion between the matrix and fiber. The reinforcing materials that are mainly fiber materials, and the are used to increase the strength and stiffness of the matrix. The natural fiber reinforced composite materials are more biodegradable than other composites. The natural fiber reinforced composite having a great - advantage in design sectors. Natural fiber-reinforced materials have a great environmental advantages such as reduced dependence on non-renewable energy/material sources, lesser strength to weight ratio, less pollutants and greenhouse emissions. The composite materials can be classified in to many types, basically it is of tow types, they are based on the matrix material used, based on reinforcing material used and based on reinforcing material structure. They are,

Based on matrix material,

- Metal Matrix Composites (MMC).
- Ceramic Matrix Composites (CMC)
- Polymer Matrix Composites (PMC)

Base on reinforcing material used,

- Natural composites
- Synthetic composites

Based on reinforcing material structure

- Particulate Composites
- Fibrous Composites
- Laminate Composites

II. LITERATURE REVIEW

In the modern world the study in the composite materials is having a great need and applications. In the aircraft part, manufacturing the metal matrix composite having great applications. Similarly in automobile sectors latest trend is natural fiber composites. The natural fiber composite having a good design possibility, high strength to weight ratio and they are biodegradable too. So, it is preferable in the modern world to choose such composite materials to avoid environmental pollutions. So more study is needed in the field of natural composite. Recent studies carried out in composites are the reinforcement of resin material with coir, coconut shell, human hair so on.

2.1 Investigation Of Mechanical Properties Of Rice Straw Fibre Polypropylene Composites [1]:- The present work carried out in the field of rice straw fiber reinforcement in composites is done by K Sudhakar and CH Srinivas. They were studied the tensile and flexural and impact strength of rice straw fiber reinforced

polypropylene composite. Where the tensile strength is decreasing with the increase in fiber loading.

2.2 A Review on Coconut Shell Reinforced Composites:- The paper studies mechanical properties of composites with coconut shell reinforcement in various matrix materials like Recycled Polypropylene, Epoxy resin, Epoxy resin SY-12(319), etc.

2.3 Mechanical property evaluation of natural fiber coir composite:- S.harisha,D.peter michaelb, A.benselyb, D.mohan lalb, A.rajaduraic were studied the tensile properties of coir fiber reinforced composite, and the surface morphology is carried out. The surface morphology study gives a complete idea about the surface properties of the composite material. Generally the surface morphology study is carried out in various composite materials, and that are aims to explain the break part of composite. The part that are broken by tensile test and tear test is checked for the surface morphology study to study how much the final composite material having the surface finish. And also the surface morphology study helps to identify the adhesion rate of fiber and rein material.

III. EXPERIMENTAL SETUP

This chapter describes the details of processing of the composites and the experimental procedures followed for their characterization and mechanical evaluation. The raw materials used in this work are

1. Rice Straw Fiber
2. Natural rubber resin

3.1 Objectives of the Research Work

The objectives of the project are outlined below.

- Fabrication of rice straw fiber reinforced natural rubber composite.
- To study the effects of surface treatment of rice straw fibre on the mechanical properties of the composites.
- Evaluation of mechanical properties of untreated and treated rice straw reinforced natural rubber composite, and its comparison. (tensile strength, tear strength, density, abrasion, hardness, compression water absorption etc.).
- Also this work is expected to introduce a new class of polymer composite that might find many engineering applications.

3.2 Experimental Procedures

3.2.1 Specimen Manufacturing

Rice straw fibers are reinforced with natural rubber composites were manufactured according to ASTM standards using compression molding technique. Composites of five different compositions for each untreated and treated rice straw fiber i.e. 20wt%, 30wt% , 40wt%, 50wt% and 60wt% are made. Specimens of suitable dimension are cut for different tests.

- Fiber Preparation
- Resin Selection
- Mixing
- Cure Time Calculation
- Molding

3.2.2 Mechanical testing of RSRNRComposites

- Tensile Testing
- Tear Testing
- Density Testing
- Abrasion Testing
- Hardness Testing
- Compression Testing
- Water absorption testing

Fiber Preparation:- To enhance interfacial bonding and to reduce moisture absorption, The fibers were taken for special treating process. For that the fibers were pre washed with distilled water and dried at 50 degree Celsius for 24 hr and at room temperature for another 24 hours. After that the fiber is treated with NaOH solution (5 % w/v) for 1 hour time, then the fiber is washed with distilled water until the sodium hydroxide was fully eliminated, that is, until the water no longer indicated any alkalinity reaction. The treatment with NaOH solution is called Alkali treatment, otherwise called as mercerization. The mercerization is one of the most popular chemical treatment of natural fibers, it helps to increase the adhesion between rice straw and natural rubber.

Table. 1:chemicals used

Chemicals used(Addings)	Weight in grams
Zinc oxide	5 grams
Stearic acid	3 grams
MBTS	0.2 grams
TMTD	1.5 grams
Sulphur	1.5 grams

Mixing:- The mixing process is the blending of rice straw and natural rubber, It is using the tow roller mixing machine, and some chemicals used that are activators accelerators and hardening chemicals, that are shown in above table, here ZnO and Stearic acid are activators and MBTS and TMTD are accelerators and sulphur is hardening or vulcanizing agent.

Fig. 1: Two roller mixing machine

Fig. 2: Compression molding machine

Here, in this synthesis of rice straw fiber reinforced natural rubber composite the compression technique is used for the manufacturing of the composite. The compression molding is carried out in a pressure of 10 to 15 mpa and at a temperature of 150 to 160 degree Celsius. Water absorption testing:- The water absorption is conducting by taking the weight difference of the mold after and before dipping in water for 24 hour time. Here, the water absorption is calculating for 24 hour time. And the equation to calculate the water absorption percentage is as shown below.

$$WA(\%) = \frac{(M2 - M1)}{M1} * 100$$

Where,
M1-mass before dipping in water
M2 mass after dipping in water
WA %- water absorption percentage.

IV. RESULT AND DISCUSSIONS

For the manufacturing of the composite material, the compression molding technique needs cure time. The mould is made by compression for the time of cure time, at a temperature of 150 to 160 degree Celsius. Curing is a term in polymer chemistry and process engineering that refers to the toughening or hardening of a polymer material by cross-linking of polymer chains. In rubber, the curing process is also called vulcanization.

Table. 2:cure time of specimens

Sl. No.	Sample Fiber Content	T90 (min)
1	20 %	23.81
2	30 %	22.01
3	40 %	20.38
4	50 %	1.93
5	60%	5.11

Tensile test

Tensile test is carried out on a UTM (Universal Testing Machine) of ASTM (American Society for Testing and Materials) D-412 used primarily for vulcanized rubber. A dumbbell shaped specimen is cut from the molded specimen from each sample to do the testing according to ASTM standards.

Fig. 3: Specimen for tensile test

The specimen for the tensile test is dumbbell shaped.

Table. 3: tensile strength of each specimens

Specimens (fiber%)		S1	S2	S3	S4	S5
Tensile strength (Mpa)	Un-treated	2.32	2.38	2.54	2.6	2.77
	treated	7.53	8.13	8.83	9.67	9.21

Figure 3 represents the sample specimen used for tensile test.

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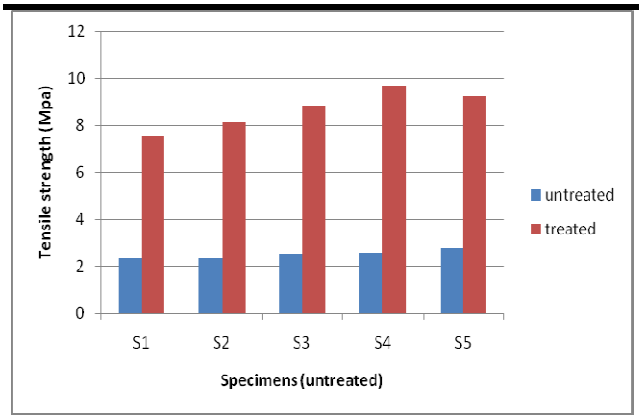

Fig. 4: comparing tensile of untreated and treated

The result of tensile test shows that , the tensile strength is increasing with the increasing the fiber loading. For the treated fiber composite, the result is highly appreciable. From the literature survey K sudhakar, ch srinivas were studied the tensile property of rice straw fiber reinforced Polypropylene Composites [1]. That paper shows a decreasing value of tensile strength with the increase in fiber loading. The tensile strength of rice straw with polypropylene is shown below

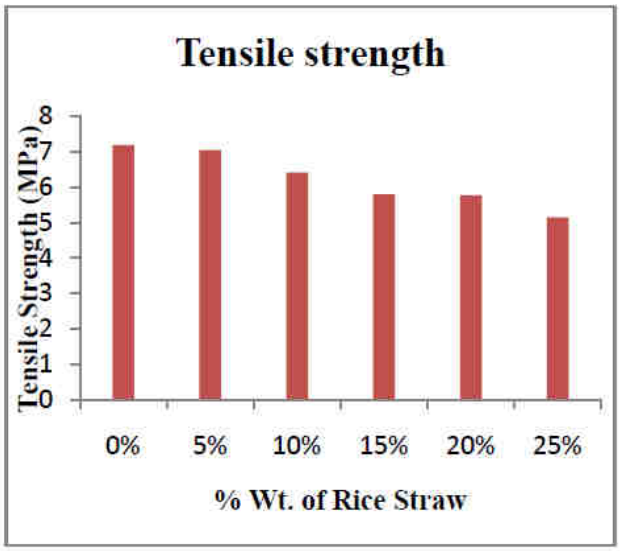

Fig. 5: Tensile strength of rice straw with polypropylene [1]

By comparing the result of previous rice straw fiber with polypropylene and this present study rice straw fiber with natural rubber, the percent study rice straw fiber with natural rubber composite having a better result in adding the fiber. The result shows the adhesion of rice straw fiber with natural rubber is more effective and good than the adhesion between the rice straw with polypropylene.

Tear Strength

The tear strength, a measure of the resistance of a material to tear force is determined on the same universal testing machine in accordance with the ASTM D624.

Fig. 6: Specimen for tear test

A test specimen with 90°angle on one side and with tab ends is used to determine tear strength of rice straw fiber reinforced natural rubber composites. The specimen cut for tear test from the mould is shown above in figure

The tear strength also found out in UTM and the results are plotted below table

Table. 4: tear strength of each specimens

Specimens (fiber%)		S1	S2	S3	S4	S5
tear strength (KN/m)	Untreated	19.62	18.639	16.677	13.734	11.772
	treated	31.72	30.65	29.79	30.03	28.73

The tear strength of rice straw fiber natural rubber composite for various fiber loading for treated and untreted is shon below.

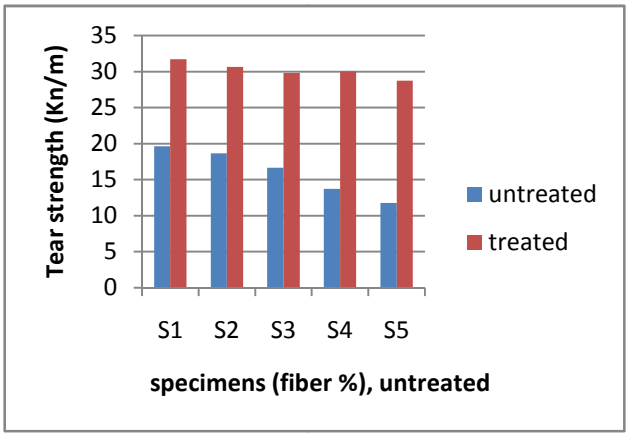

Fig. 7: comparing tear strength of untreated and treated

The result of tear strength of rice straw fiber reinforced natural rubber composite shows a decrease in value with the increase in fiber loading.

Density test

The density of the composite material is found out by using densimeter. In densimeter the relative density is

found out. It is done by finding the density in air and density in water.

Table. 5: Density of each specimens

Specimens (fiber%)		S1	S2	S3	S4	S5
Density (gm/cc)	untreated	0.996	1.007	1.066	1.102	1.145
	treated	0.952	0.998	1.021	1.073	1.121

The density of each specimens, each untreated and treated is shown below.

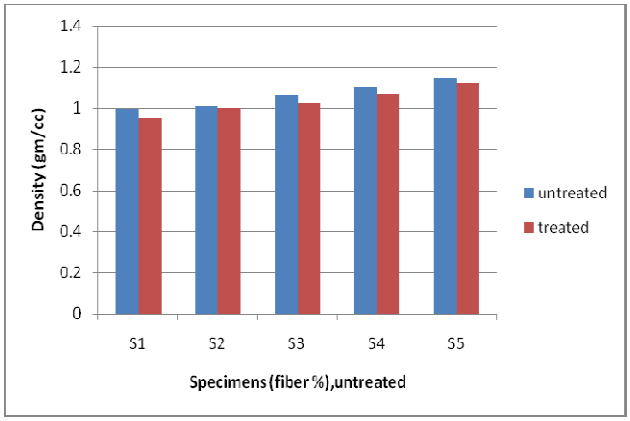

Fig. 8: Density of untreated and treated specimens

The result of density test shows that, there is a small increase in increase in fiber loading.

Abrasion test

The abrasion test, otherwise the wear resistance, calculate the volume loss when the rice straw fiber natural rubber composite specimen undergoes a continuous wear for a entire span of 40 meter.

Fig. 9: Specimen sample for the abrasion test

Table. 6: Abrasion of each specimens

Specimens (fiber %)		S1	S2	S3	S4	S5
Relative volume loss (mm3)	untreated	314.56	327.13	356.15	375.01	418.39
	treated	278.31	293.75	318.21	334.75	357.31

Wear, is the removal of material from a solid surface of any material, as a result of mechanical interactions and direct contact. There are mainly two type wear occurs, they are abrasive and adhesive.

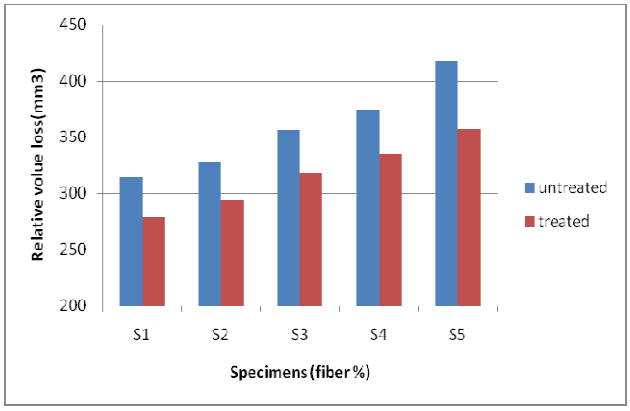

Fig. 10: Abrasion resistance of untreated and treated specimens

The instrument used in the finding of abrasion wear is "Din abrader". The Din abrader is shown below.

Fig. 11: Din abrader

The result of abrasion test shows a increasing value of volume loss or wear, to the increasing fiber loading. And also the surface treatment of fiber helps to reduce the volume loss. So that, the wear get reduced by the surface treatment. Hence, the abrasion resistance or wear resistance is decreasing with increase in fiber loading.

Hardness test

Hardness measurement of a substance implies the resistance of a material to undergo plastic deformation. Here, to find the hardness of rice straw fiber reinforced natural rubber composite we using shore A durometer. Usually for elastomers like natural rubbers, the shore A durometer is used for the hardness test. The shore A durometer having a reading upto 90 unit.

Fig. 12: Shore A durometer

The shore A durometer is just place above the specimen and applying 2 pound of force on it for 4 seconds of time, and take is for four tials, and average shore A reading o the 4 trials is taken as the hardness reading of that particular specimen.

Table. 7: Hardness of each specimens

Specimens (fiber%)		S1	S2	S3	S4	S5
Shore A	untreated	60	69	70	85	89
	treated	71	76	80	90	90

The shore A durometer is shown above fig 12

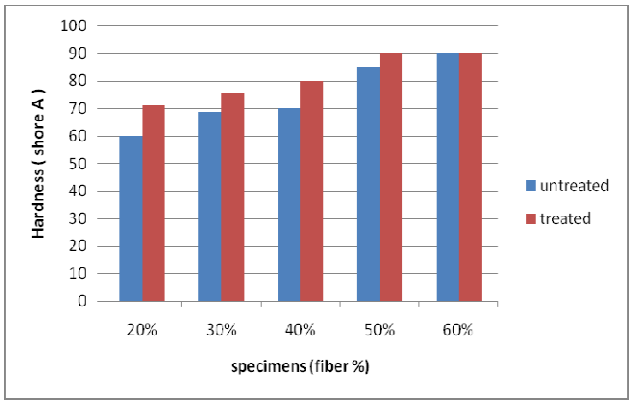

Fig. 13: Hardness of each untreated and treated

The result shows the increasing value of hardness with the increase in fiber loading. So for the better hardness the high fiber content specimen is preferable.

Compression test

The compression test is carried out in compression set apparatus. In compression set apparatus the specimen of rice straw fiber natural rubber composite is loaded for a 160 kgf for a 24 hour time period.

Table. 8: Compression set of each specimens

Specimens (fiber %)		S1	S2	S3	S4	S5
Compression set (%)	untreated	3.31	3.13	2.65	2.3	2.11
	treated	2.61	2.45	2.01	1.73	1.51

$$\textbf{compression set}\ (\%) = \frac{t1 - t2}{t1} * 100$$

The thickness of specimen before and after applying the force is applied is measured and the compression ratio is found out by the above equation.

Fig. 14: compression set apparatus

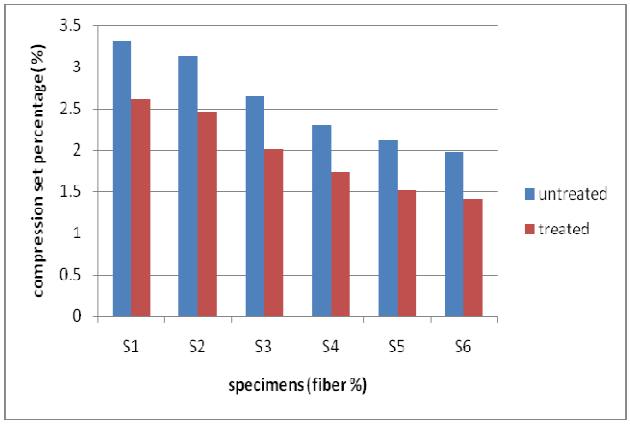

Fig. 15: Compression resistance of each untreated and treated

Here, the compression percentage decrease with the inrease in fiber loading. The compression resistance of rice straw fiber reinforced natural rubber composite inrease with the increase in fiber loading. That means, The plasticity (The ability to undergo permanent deformation of a material) tends to decrease with increase in fibre loading.

Water Absorption test

The water absorption is conducting by taking the weight difference of the mold after and before dipping in water for 24 hour time. Here, the water absorption is calculating for 24 hour time.

Table. 9: WA % of each specimens

Specimens (fiber%)		S1	S2	S3	S4	S5
WA (%)	untreated	1.2595	1.7357	2.2304	2.987	3.5275
	treated	0.6724	1.1227	1.6769	2.091	2.6309

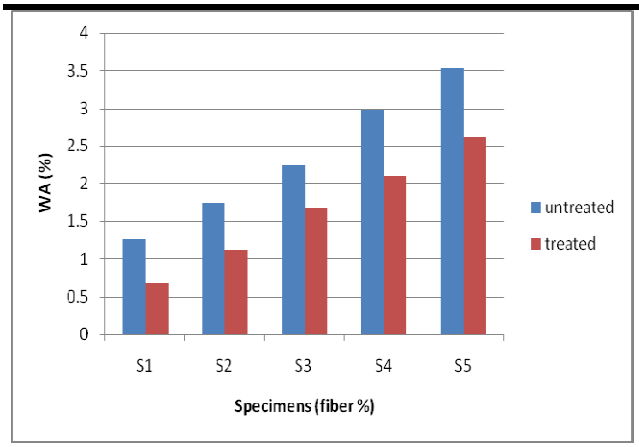

Fig. 16: Water absorption rate of both untreated and treated

The result of water absorption shows a increasing value of water absorption with the increase in fiber loading. For the treated and untreated rice straw fiber composite its same, that the water absorption is icreasing. But on comparing the treated and untreated, the treated fiber composite is lesser hydrophilic and more hydrophobic in nature. Surface treatment increases the hydrophobicity of the fibers and thereby reducing the water absorption properties, and thus increases the mechanical characteristics.

V. CONCLUSION

This work shows that successful fabrication of a rice straw fiber reinforced natural rubber composites. The rice straw fiber reinforced polypropylene composite[1] having a decreasing tensile strength with the increase in fiber loading, but in this thesis work, the rice straw fiber reinforced natural rubber composite, we got a increasing value of tensile strength with the increase n fiber loading. It indicates that the adhesion between rice straw fiber with natural rubber is more effective than adhesion between rice straw and polypropylene resin. The composite material made with treated rice straw fiber is more advantageous and it has comparable mechanical properties with other composite materials. The results obtained from this study conclude that 50% fiber with 3mm length is suitable for light weight and low load applications. Composite properties further improved by fibre surface treatment, which enhances adhesion between fibre and matrix. It is concluded in this study that surface treatment markedly improves the mechanical properties of the Rice straw reinforced natural rubber composite material. It having a great possibility is there to synthesis rice straw fiber and rubber to form a composite, and that can be a great change for the modern world, because it would be a biocomposite, and more environment friendly, and bio degradable. The rice straw is now a days, having low use, and it is fired in the field itself. The abundantly available rice straw fber can be made in to a useful composite material.

5.1 Advantages

- Producible with low investment at low cost, which makes the material an interesting product for low wage countries.
- Fully degradable, so highly environmental friendly.
- The raw fiber material (rice straw fiber) is abundantly available.
- Now a days rice straw is fired in the field, because of the less demand on the rice straw fiber. That can be avoided by this application of rice straw

5.2 Limitations.

- Can't be used for high strength applications.

5.3 Applications

- Good for washers.
- Transportation: automobile and railway coach interior, boat, etc.
- As a substitute for plywood.
- Mat production.
- Toys

5.4 Scope For Future Work

- The chemicals used in this synthesis of rice straw fiber reinforced natural rubber composite, influence in the mechanical properties of the composite, The better combination of the used chemicals needs a further study.(eg the sulfur used when mixing process helps to increase the hardness of the composite.)
- There is a very wide scope for future scholars to explore this area of research. Many other aspects of this problem like effect of fiber orientation, loading pattern, weight fraction of ceramic fillers on wear response of such composites require further investigation.
- This study leaves wide scope for future investigations. It can be extended to newer composites using other reinforcing phases and the resulting experimental findings can be similarly analyzed.

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REFERENCES

[1] K sudhakar, ch srinivas,"Investigation Of Mechanical Properties Of Rice Straw Fibre Polypropylene Composites." www.ijera.com,ISSN: 2248-9622, Vol. 4, Issue 1(Version 2), January 2014, pp.182-187

[2] A. grozdanova, a. buzarovskaa, g. bogoeva-gacevaa, m. avellab, m.e. erricob, g. gentilleb "Rice Straw As An Alternative Reinforcement In Polypropylene Composites."HAL Id: hal-00886354 Submitted on 1 Jan 2006

[3] R. Udhayasankar1 and B. Karthikeyan,"A Review on Coconut Shell Reinforced Composites",international journal of chemtech research coden (usa): ijcrgg issn: 0974-4290 vol.8, no.11 pp 624-637, 2015

[4] S.harisha, D. peter michaelb, A.benselyb, D.mohan lalb, A.rajaduraic "Mechanical property evaluation of natural fiber coir composite"
materials characterization 60 (2009) 44–49

[5] andressa cecília milanese, maria odila hilário cioffi and herman jacobus cornelis voorwald "Mechanical behavior of natural fiber composites", av dr ariberto pereira da cunha n°333 12516-410 – guaratinguetá/sp – brazil

[6] Pradeep upadhyaya, Manoj garg, Vijai kumar, Ajay K.Nema "The effect of water absorption on mechanical properties of wood flour/wheat husk polypropylene hybrid composites" Received 12 April 2006; received in revised form 22 June 2006; accepted 29 June 2006

[7] Nwigbo S.C, Atuanya C.U, Ulasi O "The study of the mechanical properties of female african human hair reinforced polypropylene composites".
A.international journal of engineering and mathematical sciences jan.- june 2013, volume 3, issue – 1, pp. 103 – 114

[8] M.R.Ismail, Ali.A. M.Yassen, and M.S.Afify "Mechanical properties of rice straw fiber-reinforced polymer composites" received september 17, 2010; revised march 3, 2011; accepted march 6, 2011

[9] Mehul Bagadiya1,Prof. R.N Desai, Prof.S.J.Padhiyar "Reinforcement of natural rubber by using human hair" vol-2 issue-3 2016 ijariie-issn(o)-2395-4396

[10] Susheel Kalia, B.S. Kaith, Inderjeet Kaur "Pretreatments of Natural Fibers and their Application as Reinforcing Material in Polymer Composites-A Review" Singhania University, Pacheri Bari, Jhunjhunu-333 515 Rajasthan, India