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Effect on Tensile and Flexural Properties of Coconut Fiber Reinforced With Fresh plus Recycled High Density Polyethylene Based Natural Fiber Composites

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Abstract-The present work is based upon preparation and investigation on mechanical properties of coconut fiber reinforced high density polyethylene composites.The samples were manufactured by chemically treated coconut fiber with hydrogen peroxide solution and sodium hydroxide acid. The chemical modification helped to remove excess waxy substances and moisture from the structure of coconut fiber. The different proportions of coconut fiber i.e. 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19% and 20% used along with (fresh + recycled) HDPE to manufacture the desired composites. The tensile samples of CFHDPE having dimensions 165 X 13 X 3.2(in mm) and flexural samples of CFHDPE having dimensions 127 X 12.7 X 3.2(in mm) were manufactured using injection molding process. The dies used for tensile samples and flexural samples in accordance with ASTM D 638 and ASTM D 790 standards respectively. The mechanical properties of the samples were determined, namely the tensile strength and flexural strength. From the results obtained it was clear that on addition of coconut fiber with fresh HDPE and 50-50 mixture of fresh and recycled HDPE. The value of tensile strength first increased up to 14% coconut fiber and further decreased with addition of fiber. The Flexural strength showed a continuous increase in value with the addition of fiber. Further, the worn surface morphology was examined by using Scanning Electron Microscope (SEM) to analyze the mechanical behavior of the composites. In this work the lagging of tensile and flexural strength is due to fiber pull outs, delaminations, random orientation and waxy substances.

Index Terms-Natural fiber composites, Coconut fiber, High Density Polyethylene, Mechanical properties, Surface morpholog***y.***

1. THE MAIN TEXT

Composites materials do not need recognition and attention as in recent times, they were used by builders for construction of structure by the use of reinforced mud with twinges. As composites have been in use for so long because of their less weight and high strength, the most challenging factors now is to make them cost effective. It is clear enough that to overcome the hurdle of cost, the improvement in manufacturing technology alone is not sufficient. A composite material can provide superior and unique mechanical and physical properties, because it combines the most desirable properties of its constituents while suppressing their least desirable properties. **Girisha et al. (2014).**

Coconut fiber reinforced PP composites were prepared and their mechanical, thermal, morphological and water absorption properties were characterized. The fiber treatment and adding MAPP improved the mechanical properties, cellulose decomposition temperature and water resistance of the PP composites. Alkalization and heat treatment provided better mechanical properties to the coconut fiber/PP composites. Increasing fiber content led to increased Tensile strength and modulus of PP composites and water absorption also increased but impact strength and elongation decreased. **(Kaewkuk et al., 2013).**

The natural living world provides food, fiber, timber and absorbs waste contributing to the well-being of humanity and sustainability of our future. Since 1960's man-made fibers have revolutionized the industry, but provided competition to the natural fibers that were reproduced from various plant and animal sources. Fibers can be obtained in natural form from plants and animals as well as in synthetic form. Manmade or synthetic fibers are either made up of chemicals and they are very difficult to recycle. However, natural fiber based composites are also environment friendly to a large extent **(Kabir et al. 2010).**

Increase environment awareness has promoted designs that are compatible with environment, non-toxic to human body so eco-friendly. **Siddika et al. (2013).** Green environmentally friendly, bio-degradable and sustainable composites produced from the natural fibers are highly demanded by today's industries.

In the present research work, the polymer matrix composites has been fabricated using coconut fiber as reinforcement and HDPE (fresh + recycled polyethylene) as matrix. The tensile and flexural behavior of HDPE composites have been estimated and analyzed through SEM technique.

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2. EXPERIMENTAL DETAILS

2.1 Raw Material

Coconut fiber, HDPE both fresh and recycled, H_2O_2 solution and NaOH solution

Fig. 1 Coconut fiber

Fig. 2 Fresh HDPE

Fig. 3

Recycled HDPE

2.2 Chemical Treatment

In this investigation, the coconut fibers are chemically treated with two different types of chemicals namely H_2O_2 and NaOH at varies concentrations levels. The purpose of chemical treatment is to remove the waxy substances, moisture content of coconut fiber and to improve the mechanical properties of fiber and increase the tensile strength of coconut fiber.The coconut fibers (100g) were pretreated with 1L alkaline solution which is prepared in NaOH, for an hour under constant stirring and for 24hrs at room temperature. Then fibers will be washed with distilled water till pH=7 i.e. neutral. Now the fibers will treated with H_2O_2 for 24 hrs. at room temperature. After that coconut fibers are dried in open air for 6 to 7 days.

2.3 Fabrication of tensile and flexural specimens

The fiber was chopped into pieces of 4 to 5 mm length after chemical treatment. In order to investigate the influence of amount of coconut fibers on tensile and flexural properties of coconut fiber–HDPE composite, the specimens for tensile and flexural testing were prepared by varying content of coconut fibers as 11, 12, 13, 14, 15, 16, 17, 18,19 and 20 % (by wt.) in a matrix of HDPE (50 % fresh and 50% recycled). For the purpose of comparison, the samples, both tensile and flexural, were also prepared by taking 100% fresh HDPE and 50–50% (fresh and recycled) HDPE. The specimens were prepared with Injection moulding technique

The tensile test specimens were fabricated in Dog-bone shape while the flexural test specimens were flat in shape. Fig. 4 shows the specimens fabricated.

Fig. 4 Fabricated specimens

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Coconut fiber ratio (%)	Density	Tensile wt. (gm)	Fiber wt. (gm)	HDPE wt. (gm)	Flexural wt. (gm)	Fiber wt. (gm)	HDPE wt. (gm)
11	0.9631	8.610114	0.947113	7.663001	4.969596	0.546656	4.42294
12	0.9652	8.628888	1.035467	7.593421	4.980432	0.597652	4.38278
13	0.9673	8.647662	1.124196	7.523466	4.991268	0.648865	4.342403
14	0.9694	8.666436	1.213301	7.453135	5.002104	0.700295	4.301809
15	0.9715	8.68521	1.302782	7.382429	5.01294	0.751941	4.260999
16	0.9736	8.703984	1.392637	7.311347	5.023776	0.803804	4.219972
17	0.9757	8.722758	1.482869	7.239889	5.034612	0.855884	4.178728
18	0.9778	8.741532	1.573476	7.168056	5.045448	0.908181	4.137267
19	0.9799	8.760306	1.664458	7.095848	5.056284	0.960694	4.09559
20	0.982	8.77908	1.755816	7.023264	5.06712	1.013424	4.053696

Table 1 Raw material used for fabrication of specimens

2.4 Testing Sample

The specimens prepared were tested for tensile and flexural strength. The tests were carried out on universal testing machine **(Model: SS UTM 1205, Capacity 250KN, Make: P.S.I. Sales Pvt. Ltd.**) at Central Institute of Plastics Engineering Technology (CIPET), Amritsar. The dog bone shaped tensile specimens and flat shaped flexural specimens were tested as per ASTM standards ASTM D638 and ASTM D790 respectively. Corresponding to each coconut-HDPE composition, four similar tensile and flexural specimens were tested separately. The results obtained by testing four similar samples, corresponding to each composition, were averaged to estimate the tensile and flexural strength of a particular sample.

3. CHARACTERIZATION

3.1 Tensile Strength:-

In tensile strength specimens having 14% fiber ratio has highest tensile strength i.e. 19.75 MPa and sample having 19% has lowest tensile strength i.e. 18.23 MPa.As shown in **Fig. 5**, the specimen having fiber ratios 11%, 12% and 15% has closely and reduced values of tensile strength i.e. 0.3%, 0.2% and 1.9% as comparison to 14% specimen. But in case of 16% specimen the tensile strength as comparison to 11% specimen is reduced by 3.8%. This is mainly due to poor adhesion between fiber and HDPE. The same case can be seen in comparison with 13% specimen with 11% specimen. Here the tensile strength value of 13% specimen is 3.2% less as 11% specimen. If we compare lowest values of tensile strength, the 19% specimen has less tensile strength value than 19% has reduction in tensile strength than 17% by 2.9%. The 20% specimen strength has not much affected and deduct by 18% specimen as compared to 19% specimen. The specimen having 14% fiber ratio has 7.6% more tensile strength as compared to 19% specimen.

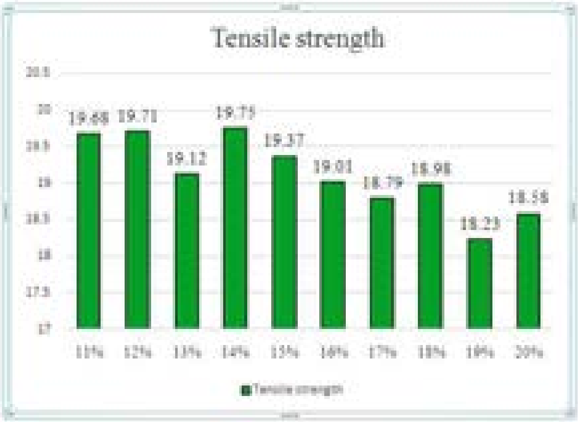

Fig. 5 Results of tensile strength

3.2 Flexural Strength

In case of flexural testing the more value of strength is obtained at 20% i.e. 20.02 MPa and less value of flexural strength is obtained at 12% i.e. 16.52 MPa. In case of highest strength, the specimen ratio of 11%, 17% and 19% are not much affected and reduced i.e. 0.5%, 0.9% and 1.6% respectively as compared to 20% specimen but in case of 18% the value of flexural strength is reduced by 4.2% than 20% specimen. In case of lowest value, the values of 14%, 13% and 15% specimens are 5.5%, 7.8% and 12.82% less as compared to 12% specimens. The value of

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12% specimen is 17.48 less as compared to 20% specimen.

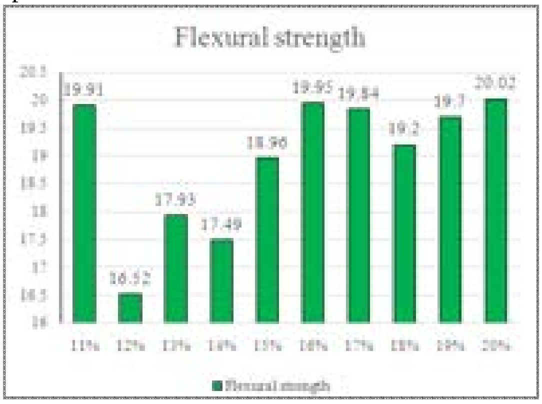

Fig. 6 Results of flexural strength

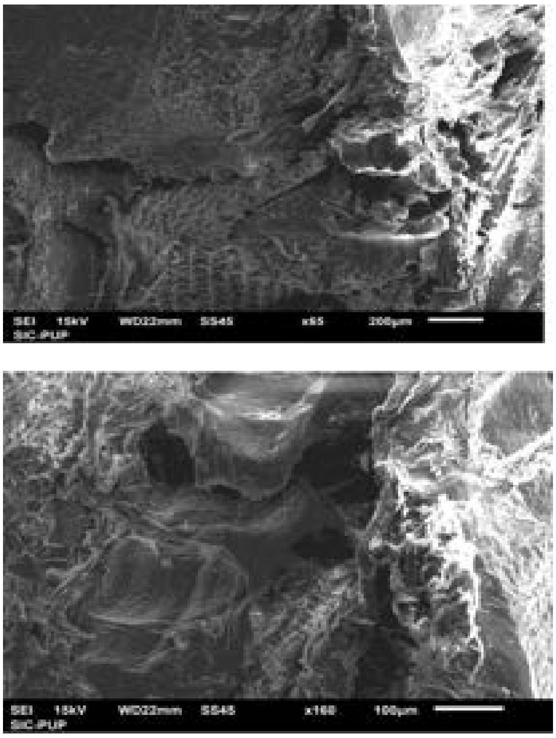

Fig. 7Micrographs of 15% coconut fiber specimen at a) 65x magnification (b) 160x magnification

Fig. 7 shows the micrographs of 15% (fresh + recycled) HDPE specimen at 65xand 160x magnification. A decrease in value of tensile strength was observed as compared to 11% fresh specimen.Addition of specimen 11% fiber to specimen 12% HDPE resulted in increase of tensile strength.

3.3 Scanning electron microscopy (SEM) analysis

The micrographs of the various specimens tested were taken with Scanning Electron Microscopy (SEM) equipment in order to analyze the reasons for increase or decrease in the values of tensile and flexural strength. The structures of all the specimens were viewed at 45x, 65x and 160x magnification.

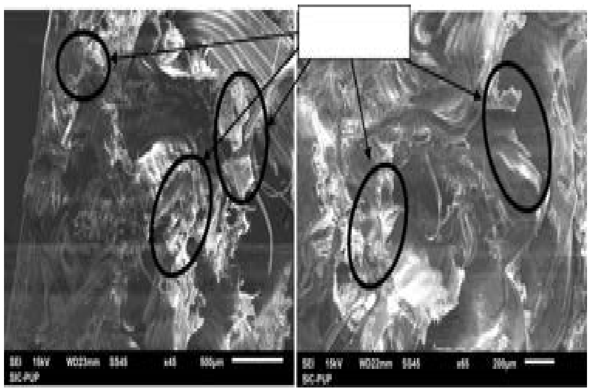

Fig. 8 Micrographs of 12% coconut fiber specimen at (a) 45x magnification (b) 65x magnification

By analyzing the overall microstructure in **Fig. 8 (a) & (b)** at 45x and 65x respectively, it can be said that the fracture in specimen occurred after the equal distribution of tensile load.

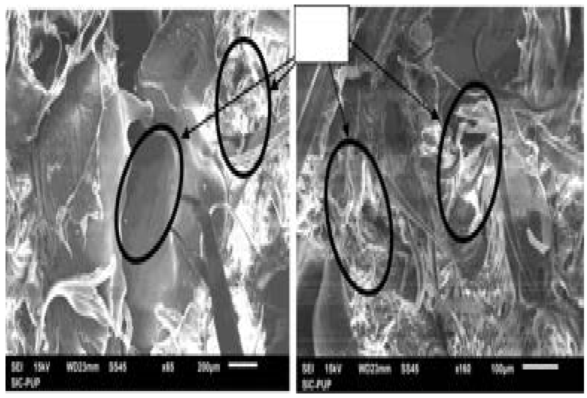

Fig. 9 Micrographs of 11% coconut fiber specimen at (a) 65x magnification (b) 160x magnification (b)

Fig. 9 (a) & (b) shows the micrographs with 11% fiber at 65x and 160xmagnification, Improper fiber distribution over all sides and presence of only HDPE for absorbing the tensile load may be the reason for fall in value of tensile strength in this case.

The lightening in the figures shows that waxy substances were present due to which the fiber could not adhere properly with HDPE.

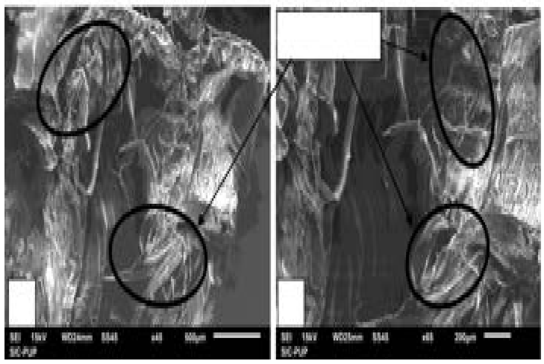

Fig. 10 Micrographs of sample 14% Coconut fiber specimen at (a) 45x magnification (b) 65x magnification

Fig. 10 (a) & (b) shows the micrographs of the specimen which contains 14%fiber in proper combination with HDPE (fresh + recycled) at 45x and 65x magnification. The maximum value obtained in this case may be due to the proper adhesion between the fiber and the HDPE.

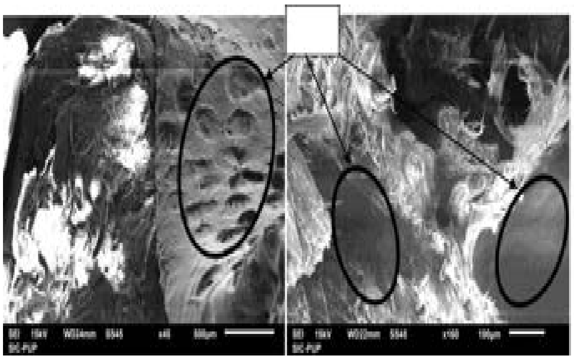

Fig. 11 Micrographs of sample 17% Coconut fiber specimen at 45x magnificationAnd Sample 19% Coconut fiber specimen at 160x specimen

On further addition of fiber to HDPE (samples 17% specimen), the tensile strength decreased. It can be depicted from the **Fig. 11 (a) and (b),** which contains 19% and 20% fiber respectively, that the fiber burned out and maximum HDPE was available for tensile loading.

4. CONCLUSIONS

- Environmental friendly coconut fiber reinforced HDPE (fresh and recycled) composite could be successfully manufactured by injection molding technique.
- The coconut fibers treatment with H_2O_2 and NaOH + distilled water + alkaline solution to remove the waxy substances from the surface of coconut fiber and leaves the roughness on the fiber surface.
- In tensile strength specimens having 14% fiber ratio has highest tensile strength i.e. 19.75 MPa and sample having 19% has lowest tensile strength i.e. 18.23 MPa
- The fiber ratios 11%, 12% and 15% has closely and reduced values of tensile strength i.e. 0.3%, 0.2% and 1.9% as comparison to 14% specimen. But in case of 16% specimen the tensile strength as comparison to 11% specimen is reduced by 3.8%
- In case of flexural testing the more value of strength is obtained at 20% i.e. 20.02 MPa and less value of flexural strength is obtained at 12% i.e. 16.52 MPa. V In case of lowest value, the values of 14%, 13% and 15% specimens are 5.5%, 7.8% and 12.82% less as compared to 12% specimens.
- The variation in result obtained was due to fiber delamination and improper mixing of fiber and matrix.

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