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MECHANICAL PROPERTIES OF NATURAL AND SYNTHETIC FIBRE REINFORCED DEGRADABLE HYBRID POLYMER COMPOSITES - A REVIEW.

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Abstract

The natural fibre is more utilized for reinforcing polymer composites than using synthetic fibre nowadays. Natural fibres are completely renewable, environmental friendly, high specific strength, non-abrasive, low cost, and bio-degradability. Due to these characteristics, natural fibres have recently become attractive to researchers and scientists as an alternative method for fibres reinforced composites. However, these natural fibres are relatively poor moisture resistance, fibre wetting, and its adhesion to the matrix, which affecting mechanical properties. Then some structural modifications are necessary for improvements. A more efficient way to enhance properties of polymer composites is to produce a hybrid composite, so that their individual characteristics may be transferred to the final composite, originating a material with intermediate properties and with potential. This review paper summarized the history of natural fibres and its applications. Also, this paper focused on different mechanical properties of natural fibres (such as banana, jute and rice straw etc) and its applications which were used to substitute glass fibre..

Keywords: Biodegradation, Hybridization, Natural Fibres, Synthetic Fibres, Mechanical property

1. Introduction

1.1 DEFINITION

The most widely used meaning is the following one, which has been stated by Jartiz "Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form". The weakness of this definition resided in the fact that it allows one to classify among the composites any mixture of materials without indicating either its specificity or the laws which should given it which distinguishes it from other very banal, meaningless mixtures. The term 'composite' in material science refers to a material made up of a matrix containing reinforcing agents. Reinforcement is the part of the composite that provides strength, stiffness, and the ability to carry a load.

1.2 FIBRE REINFORCED POLYMER COMPOSITES

Common fibre reinforced composites are composed of fibres and a matrix. Fibres are the reinforcement and the main source of strength while matrix glues all the fibres together in shape and transfers stresses between the reinforcing fibres. The fibres carry the loads along their longitudinal directions. Sometimes, filler might be added to smooth the manufacturing process, impact special properties to the composites, and / or reduce the product cost. In manufacturing, fibres are the most commonly used reinforcement that yields Fibre Reinforced Composite (FRC). A fibre reinforced polymer (FRP) is a composite material consisting of a polymer matrix imbedded with high-strength fibres, such as glass, aramid and carbon, natural fibre etc. [1]. The FRPCs are developed by using synthetic fibres or natural fibres, these may fabricated with or without fillers. Synthetic FRPCs have unique advantages over monolithic polymer materials. Besides high strength and high stiffness, these composites have long fatigue life and adaptability to the intended function of the structure. Additional improvements can also be realized in the synthetic FRPCs with regarding corrosion resistance, wear resistance, appearance, temperature-dependent behaviour, environmental stability, thermal insulation and conductivity.

1.3 NATURAL FIBRE REINFORCED COMPOSITES (NFRCs)

The interest in natural fibre-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibres, are more and more often applied as the reinforcement of composites. The growing interest in using natural plant fibres as reinforcement of polymer-based composites is mainly due to their availability from renewable natural resources, satisfactorily high specific strength. The biodegradability of the natural plant fibres may present a healthy ecosystem while the low costs and good performance of these fibres are able to fulfil the economic interest of industry. But still the mechanical strength of a natural fibres reinforced polymer composite (NFRPC) could not match that of a SFRPC and the natural fibres would not replace synthetic fibres in all applications. Actually, natural fibres has gained attention as an alternative to synthetic fibre by using natural fibres as reinforcement in plastic to reduce cost, increase productivity and improve mechanical properties of product. However, the applications are limited due to its poor mechanical properties and high moisture absorption, compared to composites with synthetic fibres. So minimize these problems and to enlarge the possible applications, a more efficient way to enhance properties of these composites is to combine distinct fibres, i.e., to produce a hybrid composite, so that their individual characteristics may be transferred to the final composite, originating a material with intermediate properties and with potential increase in the range of applications

1.4 SYNTHETIC FIBRE REINFORCED POLYMER COMPOSITES (SFRPCs)

Synthetic fibre is the reinforcement agent most used in polypropylene (pp) based composites, as they have good balance between properties and costs. However, their final properties are mainly determined by the strength and stability of the polymer-fibre inter phase. Fibres do not act as an effective reinforcing material when the adhesion is weak. Also, the adhesion between phases can be easily degraded in aggressive environmental conditions such as high temperatures and/or elevated moisture, and by the stress fields to which the material may be exposed [3]. Glass fibres (GF) are the most common reinforcement for polymeric matrix composites. Their principal advantages are the relationship between their low cost, high tensile strength, high chemical resistance, and insulating properties. The disadvantages are low tensile modulus, relatively high specific gravity, sensitivity to abrasion during handling, low fatigue resistance, and high hardness. E-glass and s-glass are the types of fibres more commonly used in the fibre-reinforced plastic industry. E-glass fibres have the lowest cost of all commercially available reinforcing gfs, which is the reason for their widespread use in the fibre-reinforced plastic industry. S-glass, originally developed for aircraft components and missile casings, has the highest tensile strength among all fibres in use. However, the compositional difference and higher manufacturing cost make it more expensive than e-glass [4-6].

1.5 HYBRID FIBRE COMPOSITES

Hybrid composites [2] are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fibre reinforced composites. Normally it contains a high modulus fibre with low modulus fibre. The high- modulus fibre provides the stiffness and load bearing qualities, whereas the low-modulus fibre makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies. Hybrid composites are includes multiple reinforcing such as natural as well as synthetic fibre. Hybrid composites may replace or reduce utilization of synthetic fibres in application of automotive, building industries, aircraft. The properties of a hybrid composite mainly depend upon the fibre content, length of individual fibres, orientation, extent of intermingling of fibres, fibre to matrix bonding and arrangement of both the fibres.

1.5.1 HYBRID FIBRE BIODEGRADABLE COMPOSITES

Hybrid bio composites consists of a biodegradable natural fibres with synthetic fibres along with a matrix. The natural to natural fibre hybridization has good biodegradability but its resistance is less than that of synthetic fibre. The properties of a hybrid composite depend on the fibre content, fibre length, orientation of fibre, extent of intermingling of fibres, fibre to matrix interface, layering pattern of both fibres and also dependent on the failure strain of individual fibres.

1.6 BIO FIBRE-SYNTHETIC FIBRE HYBRID COMPOSITE

Hybrid bio composites can be designed by the combination of a synthetic fibre and natural fibre (biofibre) in a matrix and a combination of two natural fibre / biofibre in a matrix. Hybridization with glass fibre provides a method to improve the mechanical properties of natural fibre composites and its effect in different modes of stress depends on the design and construction of the composites. In general, composite containing 10% EFB/10% glass fibre gave an optimum tensile and impact strength for treated and untreated hybrid composites. Tensile properties were found to increase with addition of coupling agent. Material characterization showed improved stiffness, strength, and moisture-absorption stability, while flexural tests on laboratory-scale plates demonstrated enhanced structural behavior. These hybrid cellular bio fibre-based composites were found to provide an economic and environmentally friendlier alternative to entry-level synthetic composites.. The fibres play an important role in the impact resistance of the composites as they interact with the crack formation in the matrix and act as stress transferring medium. Hybridization with a synthetic fibre also has a profound effect on the water absorption property of composites. The water uptake of hybrid composites was found to be less than that of un hybridized composites. Mechanical properties of the composites were found to increase with increase in the amount of glass fibre in the hybrid. Hybrid composites containing more of waste fibre showed good reinforcement effect than the composites reinforced with more of glass fibre. The hybrid blends of natural and synthetic fibres were fabricated and found to significantly improve the characteristics of bio composites with minimal cost and environmental impact. The bio composites have adequate short-term performance and that they can efficiently compete with housing.

2. LITERATURE REVIEW

Altaf et al.[7] the selected raw material of the fibre for this project work was Green Coconut fibre and the matrix material was HDPE (High Density Poly-ethylene). Mechanical properties viz., Tensile strength (TS), Flexural strength (FS) and Impact strength (IS) of the Flexural strength of the composite material decreasing with increasing the fibre volume fraction (Vf).green coconut fibre reinforced HDPE composite material is greatly influenced by fibre length as well as fibre volume fraction tensile strength of the composite material increases with increase in fibre volume fraction (Vf) up to40%, then after decreases slightly.

Mishra et al.[8]Successful fabrication of the bidirectional jute fibre reinforced epoxy composite has been done by the hand lay-up technique.Void content decreases with the increase in fibre loading. The hardness, tensile properties and impact strength of the jute-epoxy composites increases with the increase in fibre loading. Reducing the void content will increase the properties.

Nagaraja et al.[9]1have studied about the Rice straw and chicken feather. Here combinations of both natural and avian fibre have been combined together in various percentage.The hybrid composites. Show an increasing trend till 30% of fibre volume and then decreases for 40% and again it increases.Untreated fibres are used due to this action chemical treatments have been avoided. The orientations of fibre are randomly placed. Due to random orientation the strength of the fibre has been increased.

Sakthivel et al.[10] in this researches both natural fibre and glass fibres have been used. Natural fibre used here are the banana. Hand lay-up method has been used for the manufacturing of plates.Glass fibre dust is so voluminous that it cannot be re-used as glass making material without treatment. Chemical treatment Noah will increases the flexural strength of the fibre up to 20-30% and removes the moisture content of the fibre. Regarding the glass fibre dust as an important resource for glassmaking the company decided to recycle it.

Ramanpreet Singh et al [14] studied the flexural behavior of hybrid natural fibre reinforced composite. In this work composites based on recycled high density polyethylene (RHDPE) and natural fibres were made. Their results showed that the maximum Flexural

Strength and maximum Specific Flexural strength is obtained from the sample having 20% Sisal fibre + 5% hemp fibre as reinforcement with HDPE as a matrix.

P Sivaraj et al [15] made a systematic approach to evaluate and study the effect of process parameters on tensile flexural and impact strength of coir and bagasse fibre reinforced polyester-based hybrid composites and also predicts the properties of random oriented hybrid composites.

K.MumtahenahSiddique1 et al.,2014 "Effects of Fibre Length and Fibre Ratio on the Biodegradability of Jute Polymer Composites". Their studies focuses on the fabrication of jute polymer composites, effects of fibre length and fibre ratio on the biodegradability of jute polymer composites and biodegradation. Weight loss of the composites revealed that composites are polymers didn't lose their weight.

U.S.Bongarde et al.,2014 "Review on natural fibre reinforcement polymer composites" This research deals with a view of different natural fibres reinforced polymer composite with its manufacturing processes and characterization especially coir and jute fibre. Hybrid composites may replace or reduce utilization of synthetic fibres in application of automotive, building industries, aircraft.

TABLE 1 PROPERTIES OF BANANA FIBRE [10]

PROPERTIES	BANANA FIBRE
Cellulose %	63–64
Moisture content %	10-11
Density (kg/m3)	1350
Flexural modulus (GPa)	2-5
Lumen size (mm)	5
Tensile strength (MPa)	54
Young's modulus (GPa)	3.4878

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TABLE 2 COMPARISON BETWEEN NATURAL AND GLASS FIBRES [10]

PARAMETER	NATURAL FIBRE	SYNTHETIC FIBRE
Density	Low	Twice that of natural fibre
Cost	Low	Low, but higher than NF
Recyclability	Yes	No
Energy consumption	Low	High
Distribution	Wide	Wide
CO2 neutral	Yes	No
Abrasion to machines	No	Yes
Health risk when inhaled	No	Yes
Disposal	Biodegradable	Not biodegradable
Renewability	Yes	No

RESULT AND REVIEW DISCUSSION

COMPARATIVE EVALUATION OF FIBRE REINFORCED POLYMER COMPOSITES

[12] Comparative evaluation for some of Natural Fibre Reinforced Polymer Composites, Synthetic Fibre Reinforced Polymer Composites and Particle Fibre Reinforced Polymer Composites has been done. Comparative evaluation of tensile property of fibre reinforced composites are evaluated and represented in Figure 1.

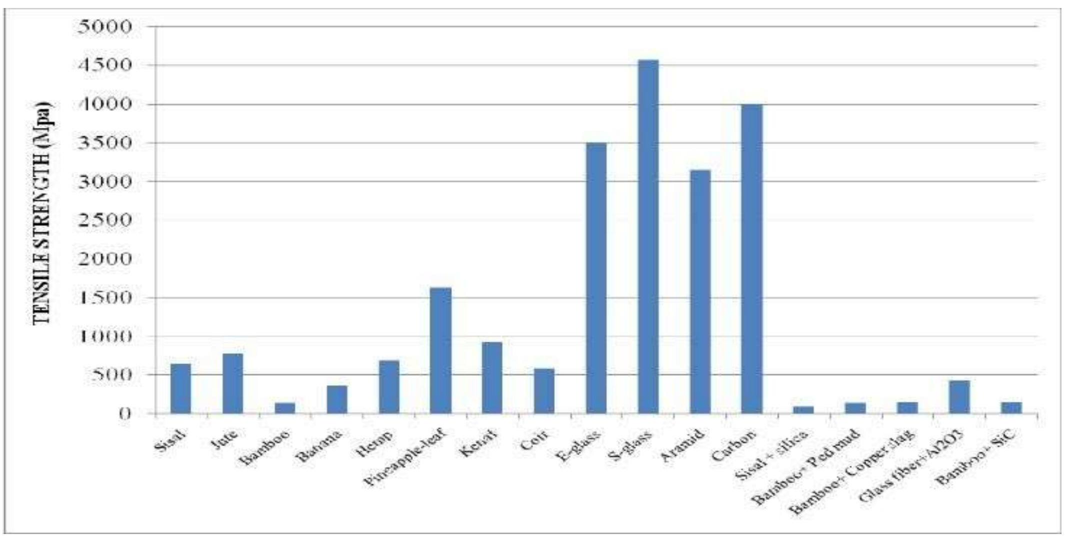

Figure 1. Comparative evaluation of tensile property of Fibre Reinforced Composites [12]

The use of natural and manmade fibres reinforced hybrid composite materials are growing day by day due to its characteristics like eco-friendly, recyclable, bio-degradable and user friendly in nature. Many researchers are working in this field to make the composites hybrid and to replace metals and alloy materials in the field of engineering and technology without affecting the load carrying capabilities and cost aspects**.**

[11] R. Bhoopathi et al. / Procedia Engineering 97 (2014) 2032 – 2041 experimental study, the banana and hemp fibres are hybridized with glass fibre and prepared hybrid composite laminates. Then the test specimen are prepared from the composite laminates as per ASTM standards and testing of materials has been carried out under tensile, flexural and impact loading conditions by using universal testing machine and impact testing machine. The experimental results on mechanical properties of the tested composite specimen are observed and presented in Table. 3.

TABLE 3 Experimental results of the hybrid composite samples

Sample	**Tensile strength (MPa)**	**Flexural strength (KN)**	**Impact strength (Joules)**
Banana-glass fibre composites	39.5	0.50	5.33
Hemp-glass fibre composites	37.5	0.29	5.33
Banana-hemp-glass fibre composites	28	0.51	8.66

[13] Ratna Prasad et al. has done an experimental study on rice straw fibre , the study result shown as rice straw fibre have been extracted and incorporated in polyester resin matrix to prepare rice straw reinforced polyester composites and the flexural properties of resultant composites studied. The composites with a mean flexural strength of 66.3 MPa. Which is greater than that of plain polyester (55.08 MPa).can be formulated with an optimum fibre volume of about 40%. The flexural modulus composites is found to be 2630 MPa which is about 1.5 times greater than of plain polyester. The specific flexural modulus is nearly 2 times greater than that of polyester resin. Rice straw based composites are suitable as core material for structural board products. Table 4 shows a mean flexural properties of rice straw composites as a function of fibre content.

Weight of Fibre (Wt) %	**Volume of Fibre (V_f) %**	**Density of composites kN/m^2**	**Flexural Strength MPa**	**Flexural Modulus MPa**
0	0	12.32	55.08	1790
4.60	10.29	11.59	52.00	1630
6.78	14.75	11.27	49.80	1620
8.96	20.00	10.97	47.40	1620
11.40	23.43	10.65	46.20	1610
14.23	28.30	10.30	49.50	1733
15.57	31.30	10.24	56.50	1950
18.16	34.56	9.06	59.60	2262
21.50	40.00	9.62	66.30	2630

Table 4 mean flexural properties of rice straw composites as a function of fibre content.

CONCLUSION

The present review focuses on the progress of degradable natural-synthetic fibre like banana fibre, rice straw and glass fibre reinforced composites. Now a day's research is going on development of bio-composites to replace synthetic composite materials. The combination of different natural fibres found to give better mechanical and physical properties. Natural fibres are biodegradable and their productions are associated with lower emission than that in the production of synthetic fibre. Production of natural fibre is labor-intensive and hence NFRPC industry will create new employment and will contribute to the poverty alleviation program in a number of developing countries. From the above discussions, it is quite evident that synthetic fibre composites show higher mechanical properties compared to other composites but production of fibre and cost is higher compared to natural fibres. Hence NFRPs are economical and new trends in composite materials. Thus it can be concluded that with methodical and constant research there will be a good possibility and better expectations for natural fibre polymer composites in the future.

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