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Effect Of Fiber Selection And Fiber Treatment On The Composite Performance

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Abstract: Recently, a tremendous growth has been observed by the natural fiber reinforced green composite (NFRPCs) industries. Appealing properties of natural fibers such as biodegradability, low specific weight, low density, high specific strength, non-corrosive etc. make them applicable in various domestic and industrial applications. A lot of effort has been put up by the researchers and scientists to improve the applicability of natural fibers as a reinforcement instead of synthetic fiber. There are various factors such as type of fiber, orientation of fibers and treatment methods which can affect the mechanical behaviour of composites made of natural fibers under numerous loading or non-loading applications. The present study aims to review a large spectrum of factors influencing the performance of natural fibers used in NFRPCs.

Index Terms—*Natural fibers, composites, fiber treatment, fiber orientation, dispersion, tensile strength, young's modulus*
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1 Introduction

Natural fiber is the constituent of composite which carries the load in various loading applications. Therefore, it is very intuitive to select such fibers which can perform the required functions of the application. Figure 1 explains the basic procedure for the development of natural fiber reinforced polymer composites (NFRPCs).

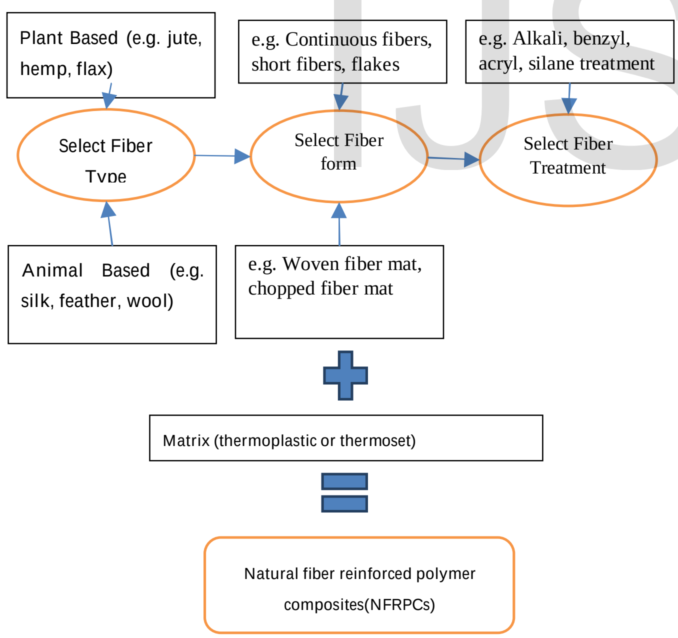

Figure 1. Basic procedure for NFRPCs development.

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Though, the selection of fiber depends on the availabity and the cost of the fiber, there are also some otherenvironmental factors which can influence the mechanical strength of the composite [1].Table 1 represents some fundamental choices available while designing a composite using natural fiber as a reinforcement

Table 1. Choices of fiber selection and in which form fiber can be used.

Parameter	Choi
Extraction	Plant based, animal ba
Pre-processing	Treated fiber, Un
Length	Continuous fibers, sh
Directionality	Unidirectional fibers, b
Form	Dispersed fiber mat,

Selection of fiber

Selection of fiber on the basis of their extraction is quite easy and a lot of literature is available giving enough information about the various properties of natural fibers. On the basis of extraction, fibers can be categorized into three groups: fibers extracted from plant, fibers extracted from animals and fibers extracted from minerals. Among animal based fibers, only silk possess good mechanical properties but it is not in use due to its higher price. Mineral based fibers (asbestos group)are generally avoided due to their toxic effect on human health [2]. Hence, on the basis of extraction, plant fibers (consist cellulosic structure) are mostly being used in various applications because of easy availability, lower price, easy extraction method and good mechanical characteristics. The fibers extracted from the bast of the plant (e.g. jute, hemp, flax, ramie) which contains more cellulosic micro fibrils aligned in the direction of fiber, are proved to have more mechanical strength[2]. The content of cellulose present in the fiber also improves the mechanical properties. Before presenting the mechanical properties of natural fibers, it is necessary to state that there are variations in properties in

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various literature because of variation of some other factors which affect the properties such as testing conditions, moisture content of fiber, gauge length and temperature. Table 2 presents some commonly used natural fibers and their mechanical properties.

Table 2. Specific properties of some natural fibers.

Fiber	Specific tensile Strength	Specific young's modulus
Flax	343-2000	27.6-103
Silk	100-1500	4-20
Abaca	400-980	6.2-20
Hemp	550-900	38-70
Bamboo	180-800	11-32
Harakeke	338-761	11-25
Sisal	511-635	9.4-22
Pineapple	400-627	1.4
Ramie	270-620	29-85
Jute	300-610	7.1-39
Kenaf	361	27.2
Cotton	190-530	3.7-8.4
Wool	38-242	1.8-3.8
Feather	112-226	3.3-11
Alfa	134-220	13-18
Coir	110-180	3.3-5
Cotton*	**4000**	**235**
E-glass*	**800-800**	**11-32**

*Carbon and E-glass fiber properties are given for comparison purpose only.

Treatment of fibers

The strength of composites also depend on the interfacial adhesion of fiber and matrix interphase. There are various chemical and non-chemical approaches which were used by various researchers to increase the interfacial strength of the composite. Treatment of fibers using alkali, acryl, benzyl and silane solution are in common practice. Asaithambi et al. [11] developed a PLA based composite using banana fiber as a reinforcement. Pre-treatment of fiber with 5% NaoH solution was done at room temperature for around two hours. After pre-treatment fibers were washed with distilled water. Acetic acid was used for the ph-value adjustment of the natural fiber. Main treatment of fiber was done using benzoyl peroxide for half an hour. Fibers were washed again using distilled water before using them as reinforcement. Authors concluded that there was a significant improvement in the mechanical properties of the composite using treated fibers in comparison to untreated fibers. Asgher et al. [12] used wheat straw as reinforcement to develop PVA based composite. The treatment of fiber was done by first performing delignification using ligninolytic consortium followed by bacterial cellulose integration. Composites made by using treated wheat straw achieved better mechanical properties in comparison to untreated fiber. Rout et al. [13] used coir fiber and polyester resin to manufacture the natural fiber composite. Three different treatments (alkali treatment, bleaching, vinyl grafting) were done on the coir fiber and were used to manufacture the composites. The fibers which were bleached at 65 °Cshowed the better results in comparison to other treated fibers. Rahman et al. [14] modified the surface of coir fibers using ethylene dimethyl acrylate (EMA). Post surface modification, a UV treatment of the fibers was also executed for the aging of fibers. Authors concluded that, treated fiber used as reinforcement in polymethacrylate matrix improved the mechanical properties of the composites. Haque et al. [15] manufactured polypropylene composites using coir and palm fiber as reinforcement. Fibers were first treated by dipping them directly into the benzene diazonium salt soulution mixed with 5% NaoH solution. After the treatment, fibers were washed with soap solution and then dried in open air. Both the fibers improved the mechanical properties of the developed bio composites.

Fiber orientation

Fibers aligned in the direction of loading provides better results in terms of mechanical properties. Norman et al. [16] aligned the fibers using an electric field. Improved mechanical properties of composites reinforced with these aligned fibers were reported by the author. Joshi et al. [17] concluded that fiber orientation along the direction of flow of matrix increased the shear rate of composite as observed by the SEM (Scan Electron Microscope) and hence improved mechanical properties were achieved by the composites.

Fiber dispersion

Fiber dispersion played an influential role while developing composite materials. Voids can be avoided by properly dispersing the fibers. Better fiber dispersion can be achieved by using twin-screw extruder for intensive mixingin a short interval of time during the fabrication of composite [2].

Conclusion

1. Besides the availability and cost of the fiber, strength of the fiber is prime factor to be considered for composite manufacturing.
2. Fiber treatment improves the wettability of the fibers and hence increasing the interfacial strength of fiber / matrix interphase.
3. Fiber orientation and fiber dispersion also affects the strength of the developed composites.

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