PLANT BASED FIBERS AND THEIR PROCESSING TECHNOLOGIES

Guravtar Singh Mann[1] , Ankur Bahl[2] , Satnam singh [3]

[1,2,3]School of Mechanical Engineering, Lovely Professional University, Phagwara 144411 India.

Abstract

Fiber based composites are getting recognizable quality due to the higher solidarity to weight extent. Further, delivering structures add to the non-recyclable wastes which are pernicious to the earth. Nevertheless, the current part watches out for the focal points and employments of animal fiber based composites. Plus, various examinations on the plant fiber based composites are discussed. Furthermore, exceptional plant based fibers which are being utilized are analyzed. The composing showed a basic focal points with the plant based fibers and their processing technologies are highlighted.

Keywords: Plant fibers, Green composites, Processing technologies, Leaf, Seeds.

1. Introduction

The high consumption of products based on petroleum has a negative environmental impact. Whereas Natural fibers are classified as environmentally friendly materials with many favorable properties compared to synthetic fibers. The cellulosic and synthetic fibers widely dominated the fabrics produced in the industry, but the animal protein fibers still have their importance when the categories of the textile demands for high quality fabric in the fashion market. The earliest examples of building composite around 3400 B.C. when Mesopotamians glued wood strips at a different angle to plywood created, and Egyptians often rendered fibers by heat processing the glass content at very high temperatures. In an around 1200BC, Mongols develop the first modern composite bow [1]. The contemporary composite can develop after world war-2 because the world war-2 was mostly fought with fighter planes, which requires material to be lightweight and robust. Therefore, phenolic resin was used for the first time in the fighter planes by the British royal air force in its mosquito bomber aircraft. Further, the use of radar technology resulted in the development of glass fiber reinforced plastics which were used to make the covering of radar equipment [2]. Modern-day the strength of concrete is high. Another example is wood which is made up of cellulose and lignin. Plywood is also a form of good composite used for making furniture. Our bone is also a composite material containing collagen fiber and hydroxyl appetite matrix. The main advantages of these materials are that they can be manufactured by adding different epoxies and unsaturated polyester resins to these materials according to the requirements for different applications [3]. Plant filaments are discovered appropriate to strengthen polymers. The characteristic fiber covers a wide scope of vegetables and mineral strands. Accessibility of characteristic strands and simplicity of assembling is enticing scientists to attempt nearby accessible cheap characteristic strands as fortification in polymer lattice and yearly production is shown in table 1[4] [5].In this paper various plant fibers and their processing technologies are discussed.

Table 1. Classification of natural fibers, origin and yearly production around the world [6].

Fiber type (plant)	Botanical name	Origin	Production (10^3 tons)
Abaca	Musa textilis	Leaf	91
Bagasse	Saccharum officinarum L.	Stem	1,02,000
Banana	Musa uluguruensis Warb	Leaf	200
Bamboo	Gigantochloa scortechinii Dendrocalamus apus	Stem	10,000
Coir	Cocos nucifera L.	Fruit	650
Cotton	Gossypium spp.	Seed	19,010
Flax	Linum usitatissimum	Stem	830
Hemp	Cannabis sativa L.	Stem	214
Jute	Corchorus capsularis,Corchorus olitorius	Stem	2850
Kapok	Ceiba pentandra	Seed	123

Kenaf	Hibiscus cannabinus	Stem	970
Phormium	Phormium tenax	Leaf	-
Pineapple	Ananas comosus Merr.	Leaf	-
Ramie	Boehmeria nivea Gaud	Stem	100
Sisal	Agave sisalana	Leaf	318.8

2. Composition of plant fibres

The synthetic piece just as the arrangement of the plant strands is genuinely confused. Plant filaments are basically a bio composite with cellulose micro fibrils are implanted in a grid basically made out of lignin and hemicelluloses[7] Moreover Gelatine, colors, and extractives are also present. They are essentially an unbending, crystalline cellulose micro fibril–fortified nebulous lignin with or deprived of hemicellulose network as shown in figure1.

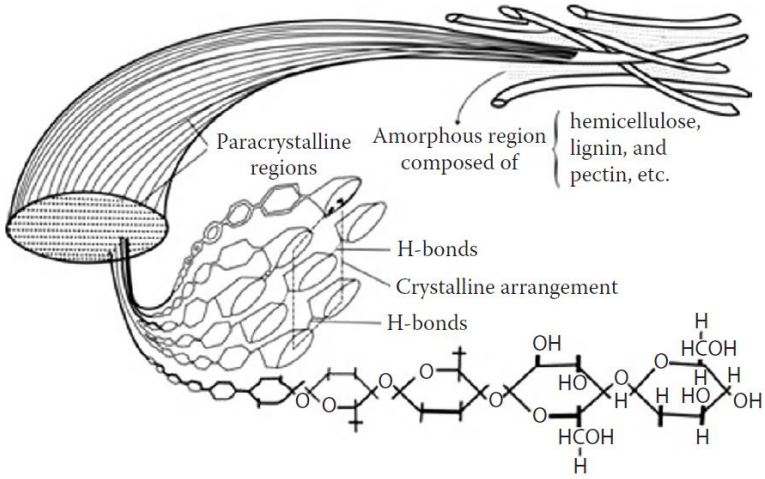

Figure 1. Structure of plant fiber [8]

Table 2. Comparison between some mechanical properties of natural and synthetic fiber [9]

Fibre	Density (g/cm^3)	Length (mm)	Failure strain (%)	Tensile strength (MPa)	Stiffness/Young's modulus (GPa)	Specific tensile strength (MPa/gCm^3)	Specific Young's modulus (GPa/gcm^3)
Ramie	1.4	900–1200	2.0–3.8	400–938	44–128	270–620	29–85
Flax	1.4	5–900	1.2-3.2	345–1830	27–80	230–1220	18–53
Hemp	1.4	5–55	1.6	550–1110	58–70	370–740	39–47
Jute	1.4-1.5	1.5–120	1.5-1.8	393–800	10–55	300–610	7.1–39
Harakeke	1.3	4–5	4.2-5.8	440–990	14–33	338–761	11–25
Sisal	1.3-1.5	900	2.0-2.5	507–855	9.4–28	362–610	6.7–20
Alfa	1.4	350	1.5-2.5	188–308	18–25	134–220	13–18
Cotton	1.5-1.6	10–60	3.0-10	287–800	5.5–13	190–530	3.7–8.4
Coir	1.2	20-150	15-30	131–220	4–6	110–180	3.3–5

Silk	1.3	Continuous	15-60	100–1500	5–25	100–1500	4–20
Feather	0.9	10–30	6.9	100–203	3–10	112–226	3.3–11
Wool	1.3	38–152	13.2-35	50–315	2.3–5	38–242	1.8–3.8
E-glass	2.5	Continuous	2.5	2000-3000	70	800–1400	29

3. Various categories of strengthening plant fibers

Plant fibre-fortified composites are called bio composites where every polymer frame is the link. Additionally, the strands fill in as a support in a fibre-fortified polymer, show high elasticity and firmness, while the lattice keeps the filaments together, transmits the shear forces, and also acts as a shielding. Usually, the material behaviour of frameworks is defined by a utilitarian relationship of time what's more, temperature, a much lower rigidity and a relatively higher expansion. The mechanical properties of the strands therefore determine the solidity what is more, the composite elasticity. Comparison of both natural and synthetic fibres is shown in table 2 .

3.1 **Leaf**

Additionally referred to as "tight" filaments the leaf strands are acquired from the leaves or leaf stalks of various monocotyledonous plants. Abaca, banana, flax, pineapple, sisal and so on are examples of plants that offer leaf strings. Retreating, bubbling, and mechanical extraction techniques may separate them from their leaves. Water retting is a traditional method of biodegradation involving microbial sisal degradation (breaking of the material obligations). Bubbling is another extraction technique, where sisal plant leaves are bubbled, beating is done in this way, and we may get the functional clean leaf strings in the wake of soaking and sun drying.

3.2 **Seed**

The seeds are usually grown from a solitary biological cell. It is known that more than one cell is a part of seed development. The seed fibers are the most vital in Cotton and Kapok.

3.3 **Fruit**

There are three types of coconut, the longest and best called "solid" in particular, a coarser one known as "fragile" and a shorter staple known as "sleeping pad." Fragile and bedding filaments are commonly referred to as "rust coloured." Typically, the retting procedure is used to remove coir groups. The decortication technique can also be used to isolate the pack[10].

3.4 **Wood**

The use of polymers and wood fortifying strands is another method to offer additionally renewable, biodegradable composite materials for bundling and essential applications. The wood strands are ideal for fortification in composite materials due to their low thickness and high mechanical properties[11].

4. **Properties of plant based fibers**

Plant strands, as support, have as of late pulled in the consideration of specialists as a result of their favourable circumstances over other set up materials. They are earth inviting, completely biodegradable, liberally accessible, sustainable and modest. The biodegradability of plant filaments can add to a sound biological system while their minimal effort and elite satisfies the financial enthusiasm of industry. At the point when characteristic fiber–strengthened plastics are oppressed, toward an amazing finish cycle, to ignition procedure or landfill, the discharged measure of CO2 of the filaments is impartial regarding the acclimatized sum during their development [12]. The rough idea of regular fiber–fortified plastics is a lot of lower driving to points of interest with respect to the specialized and reusing handling of the composite materials when all is said in done. Normal fiber–strengthened plastics, by utilizing biodegradable polymers as frameworks, are the most ecological agreeable materials, which break down toward a mind-blowing finish cycle. Plant fiber composites are utilized instead of glass for the most part in non structural

applications. Various car segments recently made with glass composites are currently being produced utilizing ecologically well-disposed composites.

5. **Green Composites Manufacturing**

The creation of normal composites is a difficult undertaking as the inborn properties of these filaments are very unique in relation to inorganic filaments. The significant contemplations for preparing of these strands are their hygroscopic nature and low protection from high temperature because of which just constrained saps could be utilized as lattice. The procedures and hardware utilized for creation of these strands are like that of regular inorganic fiber composites. The handling technique for these strands as a rule relies on the lattice tars and preparing conditions rely upon the sort of normal fiber utilized. In this way low consistency thermosetting tars are generally utilized as a grid as these can undoubtedly impregnate the characteristic filaments and don't cause any harm identified with warm debasement. The normal handling techniques utilized for the manufacture of these strands are pressure forming, Injection embellishment, (RTM) and (VARTM). The strands can be utilized as mats or in woven structure. Pressure and infusion forming strategies are favored advances for large scale manufacturing of plastics also, regular composites parts because of their high accuracy and quick process durations. Rajendran et al.[13] created the biocomposites utilizing infusion forming process for mechanical portrayal. new biodegradable polymer mix based network framework was utilized for creation and impact of soften preparing parameters on the effect quality of the bio composite was considered by planning full factorial test structure. The outcomes uncovered that preparing parameters, fiber length fundamentally influenced the effect quality of the bio composites.

6. **Conclusion**

With the rise in global energy crisis and environmental risk, the unique benefits of biological fibers such as abundance, non-toxic, hair, eye or respiratory irritation, non-corrosive properties, biological fiber-reinforced polymer materials are attarcting considerable attention due to their ability to serve as alternatives to synthetic ones. Because of their ecological and economic benefits, the use of natural fibers in composites is increasing. Natural fiber composite materials of high performance were created from decades of research. To order to improve the properties, extensive work is currently being carried out worldwide on natural fibers and their composites. The fibers and composites are categorized with respect to applications with multiple utilizations for different properties. Renewable animal fibers provide an exciting opportunity to develop bio-composite materials that are sustainable. Because of their easy availability, light weight, low cost and eco-friendly nature, researchers ' focus has now been increased on these animal fiber reinforced composites. . The material will give long lasting response to the problems of humidity retention (poor gum similarity), affectability in outdoor environment and impotence for withstanding long-haul presentation, swaying, and unforgiving street trail conditions; some of the fundamental obstacles to their fully developed modern solicitation. It appears that the use of these type of materials in vehicle body sheets is possible to the degree that green composites have equivalent mechanical execution with manufactured ones. Then again, because of their decomposable existence, green composites appear, by all accounts, to be truly dangerous. The issue of biodegradability is one that needs to be looked at when it is essential to apply 100% bio-based composites, especially when monitoring external sheet assistants for future vehicles The development of service among end customers, along with ongoing policy and the association of standard bodies, would help achieve further progress in the future. The only concern is whether these can be pooled in the most suitable way to achieve the degree of execution of their precursors at a low cost. The approach shown above could be an initial phase of multifaceted basic leadership in the tremendous region.

References

1. Matthews, F. L., & Rawlings, R. D. (1999). *Composite materials: engineering and science*. CRC press.
2. Chawla, K. K. (2012). *Composite materials: science and engineering*. Springer Science & Business Media.
3. Satyanarayana, K. G., Arizaga, G. G., & Wypych, F. (2009). Biodegradable composites based on lignocellulosic fibers—An overview. *Progress in polymer science*, *34*(9), 982-1021.

5. Dong, H., Strawhecker, K. E., Snyder, J. F., Orlicki, J. A., Reiner, R. S., & Rudie, A. W. (2012). Cellulose nanocrystals as a reinforcing material for electrospun poly (methyl methacrylate) fibers: Formation, properties and nanomechanical characterization. *Carbohydrate Polymers*, *87*(4), 2488-2495.
6. Mwaikambo, L. (2006). Review of the history, properties and application of plant fibres. *African Journal of Science and Technology*, *7*(2), 121.
7. Bledzki, A. K., & Gassan, J. (1999). Composites reinforced with cellulose based fibres. *Progress in polymer science*, *24*(2), 221-274.
8. Philip, B. M., Eldho Abraham, D. B., Pothan, L. A., & Thomas, S. (2013). Plant Fiber–Based Composites. *Green Composites from Natural Resources*, 95.
9. Shah, D. U., Porter, D., & Vollrath, F. (2014). Can silk become an effective reinforcing fibre? A property comparison with flax and glass reinforced composites. *Composites Science and Technology*, *101*, 173-183.
10. Jarman, C. G., & Jayasundera, D. S. (1975). *The extraction and processing of coconut fibre* (No. Folleto 6161).
11. Almgren, K. M. (2010). *Wood-fibre composites: Stress transfer and hygroexpansion* (Doctoral dissertation, KTH).
12. Wambua, P., Ivens, J., & Verpoest, I. (2003). Natural fibres: can they replace glass in fibre reinforced plastics?. *Composites science and technology*, *63*(9), 1259-1264.
13. Muthuraj, R., Misra, M., Defersha, F., & Mohanty, A. K. (2016). Influence of processing parameters on the impact strength of biocomposites: A statistical approach. *Composites Part A: Applied Science and Manufacturing*, *83*, 120-129.