Kenaf Fiber Reinforcement and Application in Polymer Composites: A Brief Review

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Abstract:

Synthetic fiber-reinforced polymer composites play an important role in the automotive industry and give fuel-efficient cars a paradigm shift etc.But due to the non-recyclability of the synthetic fibers, it evolve the major problems related to the environment and global warming. All these concerns leads to require a sustainable material which do not have any foot prints on the environment. This critical study of polymer composites reinforced by natural fibre gives an insight on the benefits in structural applications, automobile applications and medical sector etc. Physical and mechanical properties and morphological analysis of kenaf fiber reinforced polymer composites has been discussed.

Keywords: Polymer composite, kenaf fiber, SEM

1. Introduction:

Because of its optimized properties such as high strength and less weight, more precise strength etc., natural fiber reinforced composites play an important role in advanced technology. Natural fiber composites are used in most applications, starting from household products, interior decoration, and automotive applications, as well as in medical applications, due to global environmental concerns.Lot of car companies are beginning to develop the cars ' interior products from natural fiber reinforced composites. Natural fibers are mainly classified according to their source. Figure 2.1 show the types of natural fibers.

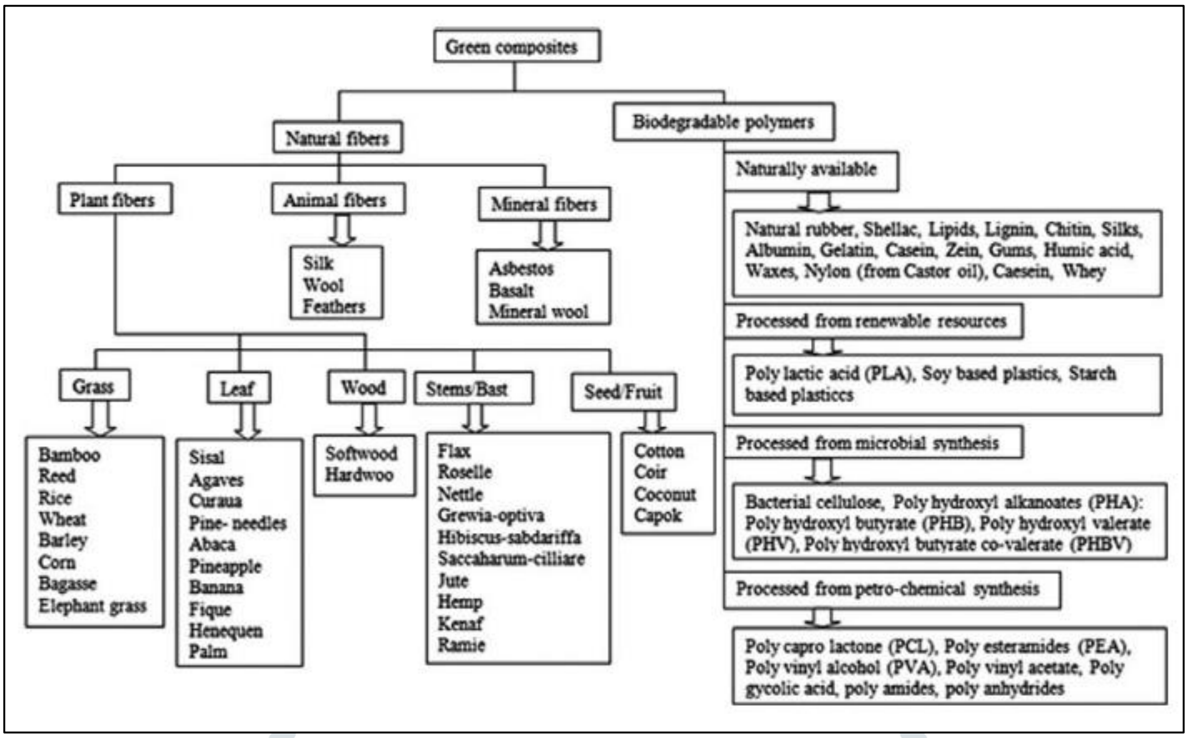

Figure 1 Constituents of Green Composites[1]

The whole stalk and external bast fibers of Kenaf have many possible specific uses, containing as paper and composite. The use of kenaf fibers is also particularly important from the point of view of environmental approachability.A number of new uses for kenaf products are currently emerging including paper products, building materials, absorbents, bedding for feed and livestock. kenaf is one of the major seed crops grown in temperate climates by synthetic oils. Figure 2 shows the kenaf fiber structure.

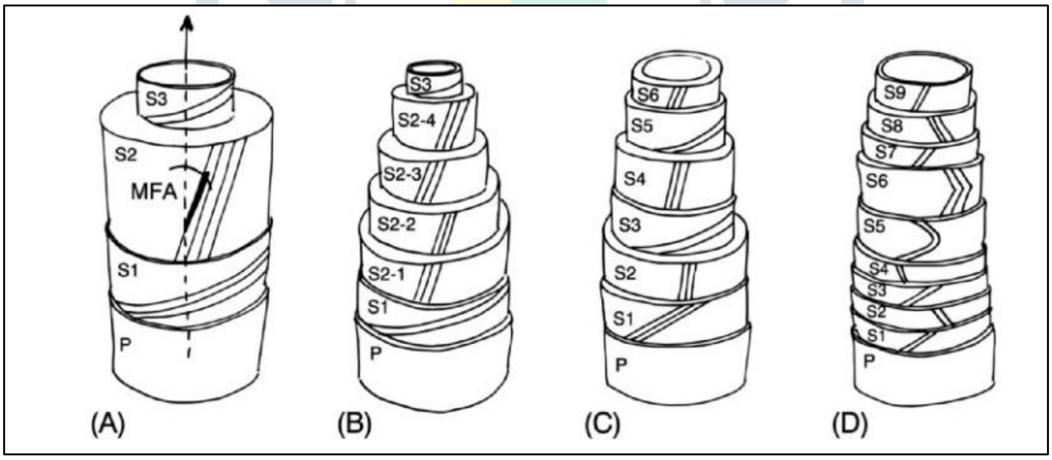

Figure 2 Schematics of possible cell wall organisation in (A) wood fibres, (B) bastfibres, (C) plant fibres and (D) seed fibres. Black lines indicate orientation of cellulose microfibrils.

2. Kenaf Fiber

The kenaf plant has a lifecycle of 90–125 days including growth, flowering, and maturation periods. The kenaf stem has a diameter of 1–2 mm in size, with a height of about 80 cm. The fundamental fibers which are both cellulose material are the primary and secondary cell walls.Cellulose fibrils (diameter between 0.2 μm and 0.25 μm) are introduced into a compact lamella consisting of approximately 3%

pectins and 14% hemicellulose, resulting in thermal fiber and water degradation. Thekenaf plant grows when the temperate climate suffices for humidity. There are two kinds of plants ofkenaf seed and fiber keanf. Keanf is cultivated for both seeds and fibres. Fiber keanf is designed for small, strong fiber growth. The kenaf plant is an annual plant that reaches a height of approximately 100 cm. The plants are pulled by hand or machine and all the fiber from the top to the root is intact. Figure 3 shows the kenaf plant.

Figure 3 Kenaf Plant

The stem part is taken for the after pulling retting operation. The fleshy portion of the stem is rotted almost for a week due to contact with water. Finally, the kenaf stem is pushed and pounded on a sharp edge, where fibers are loosened.

3. Kenaf Fiber Physical and Mechanical Properties

Kenaf is the best among organic cellulosic fibres. Kenaf is two to three times more wear- and abrasion-resistant than cotton fiber. It absorbs well moisture, and is a very breathable fabric.Because of the lack of elasticity of kenaf fibers, fabrics made from kenaf do not seem to lose their shape quickly. In recent years, the use of kenaf fibers in the automotive industry has increased dramatically. [2]. As regards properties, kenaf fiber has the potential to replace the synthetic fibers. Some of the investigators had researched the properties of kenaf fibers. According to Pan et al. [3]kenaf fiber reinforced with PLLA improve the mechanical properties as well as to accelerate the crystallization of PLLA. Bernard et al. [4]The effect of processing parameters on the mechanical properties of the kenaf / PP composites was investigatedand it reveals that the processing parameters have a great impact on properties of the composites. Nitta et al. [5]explored the influence of alkali treatment on tensile properties of kenaf fibers and results reveals that tensile strength is greatly improved with 15 wt % NaOH for one hour as compared to the un-treated fiber. Figure 4 shows the SEM imagesraw fibers and surface treated kenaf fibers.

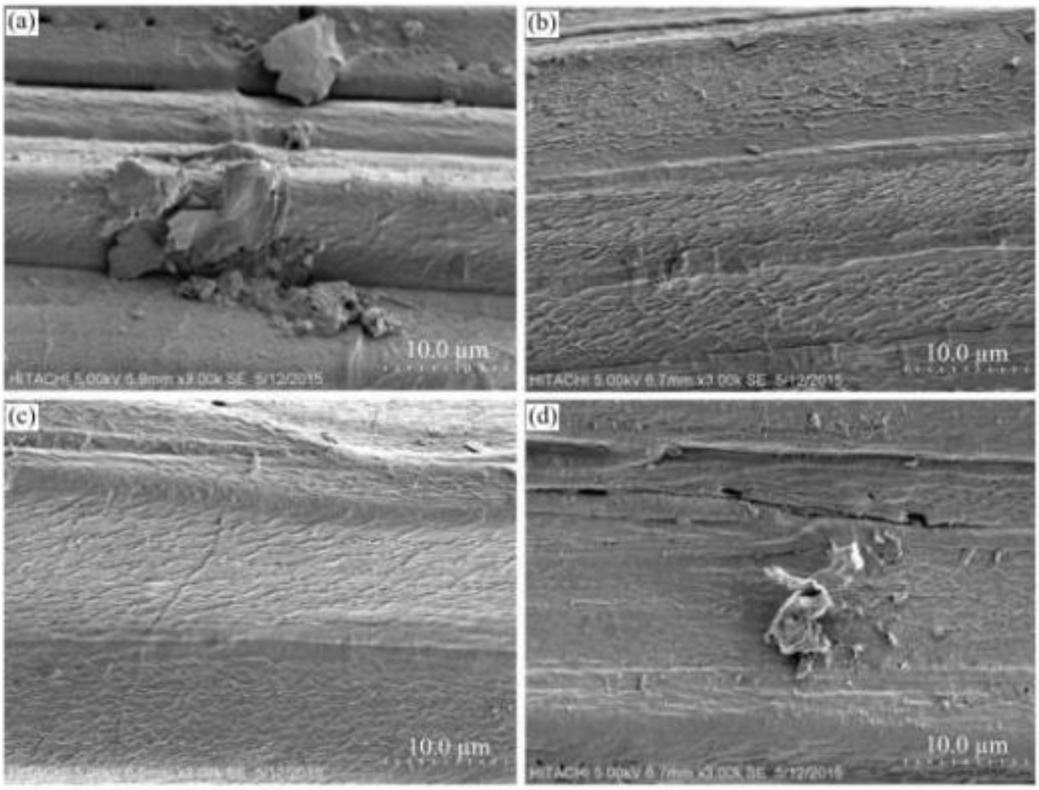

Figure 4a SEM of (a) untreated, (b) Alkali solution, (c) Silane and (d) Alkali-Silane treated Kenaf fiber[6]

Bajpai et al. [7]developed the jute/hemp/Flax reinforced hybrid composite and investigated its mechanical properties. Mechanical characterization results reveal that the ductile properties are more in hybrid composite as compared to the jute fiber reinforced epoxy, flax fiber reinforced epoxy and hemp fiber reinforced epoxy composites. Figure 5a shows the SEM images of jute/hemp/flax reinforced epoxy composites.

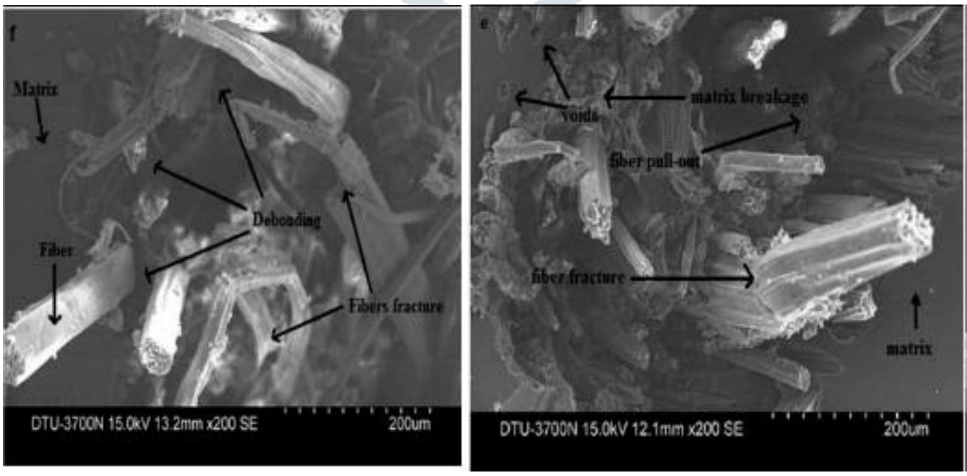

Figure 5 SEM image of a) jute/hemp/flax reinforced epoxy composites b) Hemp/Flax/Epoxy Composite [7]

Interfacial bonding among the fiber and matrix shows avitalpart for defining the mechanical properties of the composite material[8]. Some of the findings are tabulated in the table 1.

Table 1 shows the physical and mechanical properties of Kenaf fibers.

Diameter (mm)	Ultimate stress (MPa)	Density (kg/m^3)	Young's Modulus (GPa)	Water absorption (%)	Source
0.16-0.40	370-630	1510	13-51	0.85	[9]
	229-970	1200-14500	15.7-57	13-17	[10]
0.13-0.29	950	1460	57	11-18	[11]
0.85	953	1500	56	12-18	[12]
-	800	1500	15.5-58	12-15	[13]

4. Kenaf F Reinforced Polymer Composites

Nowadays lot of researchers are working in the area of hybrid composites especially for the structural applications. Srinivasan et al. [14]evaluate the tensile and thermal properties of banana-kenaf/epoxy hybrid composites with the help of compression moulding machine. Mechanical properties such as tensile strength, flexural strength and impact strength have been investigated and structural morphology has been tested using SEM. Results found that the mechanical properties of glass-banana-kenaf based hybrid composites possesshigher values as compared to the glass/epoxy, banana/epoxy and keanf/epoxy composites. Ghani et al. [15]deliberated the mechanical behavior of kenaf/PLA composites and record that the 35% fiber volume fraction leads to better mechanical properties. It was also found that at less fiber volume fraction, mechanical properties gets deteriorated. Poor bonding between the matrix and reinforcement was observed at higher fiber loading. Apart from the mechanical properties of the kenaf reinforced polymer composites, researchers had also tried to study the effect of ageing on the ductile properties. In one of the study, Immersion of the composites into the water has been shown to have a degrading effect on the mechanical properties.Figure 6 shows the SEM images of fractured bio composites. Atiqah et al. [16]deliberate the impact of hygrothermal ageing on the ductile properties of kenaf/epoxy based composites. Results indicates that the mechanical properties were affected significantly due to the ageing process. Jacob et al. [17]studied the environmental influences on the fabrication of kenaf textile yarn. Reducing environmental influences associated with the production of hemp yarn should give priority to reducing energy consumption during the fiber processing and yarn production phases and reducing eutrophication during the crop production phase. Yang et al. [18]premeditated the effect of thermal treatment on kenaf fibers for the improvement of wetting and swelling properties. The thermal treatment has been shown to make fibers less hydrophilic.

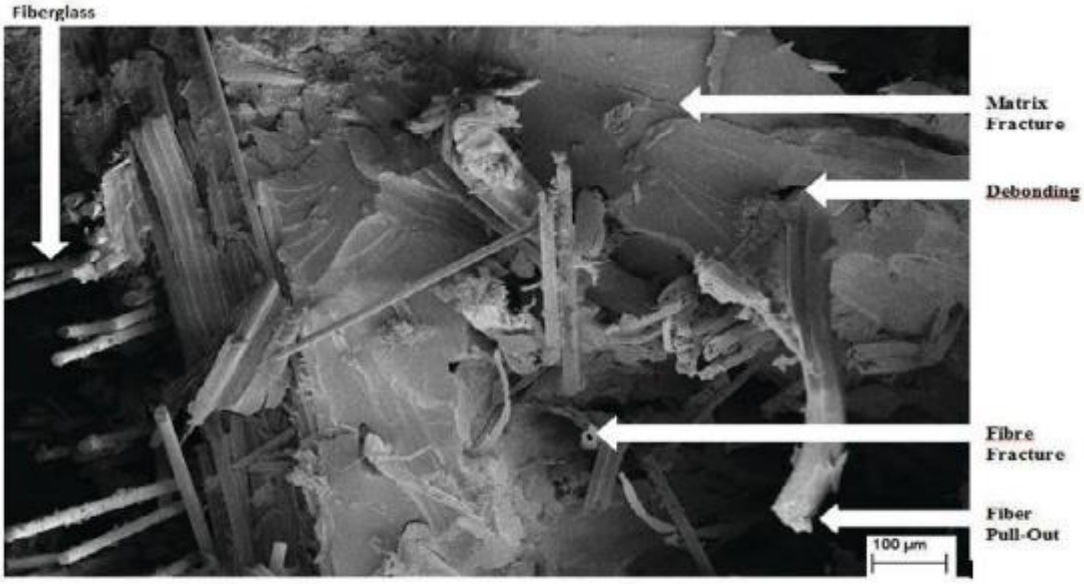

Figure 6 shows the SEM images of fractured bio composites [15]

5. Conclusions

The complete study, focus on the critical review for the reinforcement of kenaf fibers in the polymer composites. Natural fibre-reinforced polymer composites have increased wide interest because of eco-friendly and sustainable content.Specific polymer composites of kenaf fiber were intentionally the possible material for substituting synthetic fibers for polymer composites.kenaf fiber is one of the natural fiber having a more mechanical properties as compared to other fibers. The complete review also touched upon the different mechanical properties of kenaf fibers and its applications.

6. Future Work

From the various studies illustrated, cited by the various researchers on the mechanical properties of polymer composites reinforced by kenaf fiber. The outcome of these research studies leads to provide the future scopes in the following areas

1. Most research involves the enhancement of mechanical properties with the use of fiber surface treatments.
2. The area of development in the surface finish of natural fiber-reinforced polymer composites has been less explored.

References

[1] H. Singh, S. Jai Inder Preet, Singh, V. Dhawan, and S. Kumar Tiwari, "A Brief Review of Jute Fibre and Its Composites," *Mater. Today Proc.*, vol. 5, no. 14, pp. 28427–28437, 2018.

[2] B. Yang *et al.*, "Effects of chemical versus enzymatic processing of kenaf fibers on poly(hydroxybutyrate-co-valerate)/poly(butylene adipate-co-terephthalate) composite properties," *Compos. Part B Eng.*, vol. 56, pp. 926–933, 2014.

[3] P. Pan, B. Zhu, W. Kai, S. Serizawa, M. Iji, and Y. Inoue, "Crystallization Behavior and Mechanical Properties of Bio-Based Green Composites Based on Poly (L -lactide) and Kenaf

Fiber," *J. Appl. Polym. Sci.*, vol. 105, pp. 1511–1520, 2007.

[4] M. Bernard *et al.*, "The effect of processing parameters on the mechanical properties of kenaf fibre plastic composite," *Mater. Des.*, vol. 32, no. 2, pp. 1039–1043, 2011.

[5] Y. Nitta, K. Goda, J. Noda, and W. Il Lee, "Cross-sectional area evaluation and tensile properties of alkali-treated kenaf fibres," *Compos. Part A Appl. Sci. Manuf.*, vol. 49, pp. 132–138, 2013.

[6] M. Bulota and T. Budtova, "Highly porous and light-weight flax / PLA composites," *Ind. Crop. Prod.*, vol. 74, pp. 132–138, 2015.

[7] V. Chaudhary, P. K. Bajpai, and S. Maheshwari, "Studies on Mechanical and Morphological Characterization of Developed Jute/Hemp/Flax Reinforced Hybrid Composites for Structural Applications," *J. Nat. Fibers*, vol. 15, no. 1, pp. 80–97, 2018.

[8] M. Jacob, C. Bellmann, and R. D. Anandjiwala, "Kenaf – polypropylene composites : Effect of amphiphilic coupling agent on surface properties of fibres and composites," *Carbohydr. Polym.*, vol. 82, no. 3, pp. 549–554, 2010.

[9] H. M. Akil, M. F. Omar, A. A. M. Mazuki, S. Safiee, Z. A. M. Ishak, and A. A. Bakar, "Kenaf fiber reinforced composites : A review," *Mater. Des.*, vol. 32, no. 8–9, pp. 4107–4121, 2011.

[11] W. Nor *et al.*, "Thermal Properties of PLA / Kenaf Green Nanocomposite : Effect of Chemi-Mechanical Treatment," *Adv. Mater. Res.*, vol. 576, pp. 342–344, 2012.

[12] M. N. Akhtar *et al.*, "Influence of alkaline treatment and fiber loading on the physical and mechanical properties of kenaf/polypropylene composites for variety of applications," *Prog. Nat. Sci. Mater. Int.*, vol. 26, no. 6, pp. 657–664, 2016.

[13] L. Gardner, T. Munro, E. Villarreal, K. Harris, T. Fronk, and H. Ban, "Thermal Characterization of Alkali Treated Kenaf Fibers and Kenaf-Epoxy Composites," *Fibers Polym.*, vol. 19, no. 2, pp. 393–402, 2018.

[14] V. S. Srinivasan, S. Rajendra Boopathy, D. Sangeetha, and B. Vijaya Ramnath, "Evaluation of mechanical and thermal properties of banana–flax based natural fibre composite," *Mater. Des.*, vol. 60, pp. 620–627, Aug. 2014.

[15] M. A. A. Ghani, Z. Salleh, K. M. Hyie, M. N. Berhan, Y. M. D. Taib, and M. A. I. Bakri, "Mechanical Properties of Kenaf / Fiberglass Polyester Hybrid Composite," vol. 41, no. Iris, pp. 1654–1659, 2012.

[16] A. Atiqah, M. A. Maleque, M. Jawaid, and M. Iqbal, "Development of kenaf-glass reinforced unsaturated polyester hybrid composite for structural applications," *Compos. Part B Eng.*, vol. 56,

pp. 68–73, 2014.