International Journal of Engineering Research and General Science Volume 3, Issue 5, September-October, 2015
ISSN 2091-2730

Review on Mechanical Properties of Sisal and Banana Reinforced Composites

L Laxmana Naik[1, 2], K Gopalakrishna[2], B Yogesha[1]

[1] Department of Mechanical Engineering, Malnad College of Engineering, Hassan, Karnataka, India.

[2] Centre for Emerging Technologies, Jain University, Bangalore, Karnataka, India.

lln@mcehassan.ac.in and +919448438358

Abstract—This review article concerning about natural fibers like sisal and banana fiber reinforced polymers, it gives possible applications in the material group. This paper is a review of the chemical and mechanical properties of natural fibers like sisal and banana reinforced polymer composites. Natural fibers are rich in cellulose and they are cheap and easily renewable source of fibers with the potential for polymer reinforcement. Natural fibers are emerging as low cost, lightweight and apparently environmentally superior alternatives to glass fibers in composites. In most of the cases, the specific properties of the natural fiber composites were found to compare favorably with those of glass.

Keywords— Sisal, Banana, Polymers, Chemical properties Mechanical properties.

INTRODUCTION

Natural fibers are increasingly gaining attention as their application is diversified into engineering end uses such as building materials [1] and structural parts for motor vehicles where light weight is required. Low cost and less tool wear during processing are among the known advantages of plant fibers, and ease of recycling makes them environmentally friendly [2, 3]. The low density of natural fibers is very beneficial in the automotive industry. A study has been carried out which, shows that when 30% of glass fibers is substituted with 65% of hemp fibers, the net energy saving of 50,000 MJ (3 tons of emission) can be achieved [4]. Natural fiber offers many technical and ecological benefits for its use in reinforcing composites. Many types of natural fibers have been investigated for use in plastics including jute, straw, Flax, hemp, wood, sugarcane, bamboo, grass , kenaf, sisal, coir, rice husks, wheat, barley, oats, kapok, mulberry, banana fiber, raphia, pineapple leaf fiber and papyrus etc. and the matrix material used for reinforcing the fibers are classified as thermosets, thermoplastics and elastomers[5]. While, natural fibers traditionally have been used to fill and reinforce thermosets, natural fiber reinforced thermoplastics, especially polypropylene composites, has attracted greater attention due to their added advantage of recyclability. Natural fiber composites are also claimed to offer environmental advantages such as reduced dependence on non-renewable energy/material sources, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery, and end of life biodegradability of components [6]. In general, plant based fibers are lignocellulose in nature composed of cellulose, hemicellulose and lignin eg. Jute, coir, sisal, cotton etc., whereas animal based fibers are composed of proteins e.g. silk and wool [7, 8]. Natural fibers are low-cost fibers, highly available and renewable, with low density and high specific properties as well as they are biodegradable and less abrasive to expensive molds and mixing equipment. However, their potential use as reinforcement is greatly reduced because of their incompatibility with the hydrophobic polymer matrix, their poor resistance to moisture and their tendency to form aggregate during processing. The mechanical properties of natural fiber composites are much lower than those of the synthetic fiber composites. To produce the reactive hydroxyl groups and the rough surface for adhesion with polymeric materials, plant fibers need to undergo physical and/or chemical treatment to modify the surface and structure. Though the synthetic fibers have very good mechanical properties, their disadvantage is difficult recycling. Another advantage of synthetic fiber is their moisture repellency, whereas poor resistance to moisture absorption has made the use of natural fiber reinforced composites less attractive. In this paper, a review of the Physical and Mechanical Properties of natural fibers like sisal and banana reinforced polymer composites are carried out.

PROPERTIES OF SISAL/BANANA REINFORCED POLYMER COMPOSITES

Natural fibers are chemically treated to remove lignin, pectin, waxy substances, and natural oils covering the external surface of the fiber cell wall. This reveals the fibrils, and gives a rough surface topography to the fiber. Sodium hydroxide (NaOH) is the most commonly used chemical for bleaching and/or cleaning the surface of plant fibers. It also changes the fine structure of the native cellulose I to cellulose II by a process known as alkalization [9-12].

SISAL FIBER

Sisal fibers are extracted from Sisal plant by water retting process. The major portion of the fiber contains cellulose that is about 60% and some percentage of lignin. This plant grows enormously in the western hemisphere, Africa and Asia. The plant contains fleshy leaves usually long and narrow, which grow out from a central bud. Usually leaves are 1-2m long, 10-15cm wide and about 6mm thick at the center. The fibers are embedded longitudinally in the leaves and are most abundant near the leaf surfaces. Table 1 shows chemical properties of sisal fiber.

Table.1 Chemical properties of Sisal fibers [13-17].

Property	**Value**
Cellulose (%)	**66-78**
Hemi-cellulose (%)	**10-14**
Lignin (%)	**10-14**
Pectin (%)	**10**
Moisture content (%)	**10-22**
Microfibrillar angle	**11**
Lumen size (mm)	**5**

BANANA FIBER

Mature banana pseudo-stem was obtained from the farm, and was cut to a length of 50cm sliced longitudinally into four pieces and each was totally submerged in water for 15 days, after which the stems were removed from the water and were loosened by swishing back and forth in a pool of tap water. They were subsequently sun dried for eight hours and further loosened by manual combing. The extracted fibers were then treated with 5% sodium hydroxide (NaOH) solution for four (4) hours, under total immersion conditions to avoid oxidation of the fiber, after which it was washed in overflowing tap water until neutral pH is attained [16]. The treated fibers were then dried in an oven for 24 hours at 105oC to remove free water, and were subsequently cut into lengths of 5, 10, 15, 20 and 25mm and stored separately in an air tight container. The properties of the banana fiber used in this study are given in Table 2.

Table.2 Chemical properties of Bananafibers [13-17].

Property	**Value**
Cellulose (%)	**62 – 64**
Hemi-cellulose (%)	**19 [15]**
Lignin (%)	**5**
Pectin (%)	**3-5**
Moisture content (%)	**10 – 11.5**
Microfibrillar angle	**20**
Lumen size (mm)	**11**

MECHANICAL PROPERTIES OF SISAL AND BANANA REINFORCED POLYMER COMPOSITES

Natural fibers also have non-uniformity and variety of dimensions, even between individual plants in the same cultivation. To generate fibers suitable for specific end products, the various types of raw material are separated. Bast or stem fibers, for example, are mainly used in the textile or rope industries because of the length of the fibers. Bast straw is not separated into single fibers but into fiber bundles, which may contain thousands of single fibers. In contrast, wood is usually separated into single fibers or very small fiber bundles suiting the particular needs of the pulp, paper or board industries. Thus, there are a great number of challenges for selecting fibers in different dimensions and properties. Natural polymer composites are more environmental friendly compared to polymer composites with synthetic fibers reinforced. Advantages of natural fibers ones plastic reinforcement are due to its low density, renewability, biodegradability, non-toxicity, good insulation property and machine wear. Natural fiber contains high hydroxyl content of cellulose that makes it susceptible to water absorption affecting the mechanical properties of materials. The mechanical properties of a composite depend on the nature of the resin, fiber, resin-fiber adhesion, cross-linking agents and not the least on the method of the processing. Therefore, any improvement in the property is evaluated and compared to that of the polymer matrix, undergoing the same process. The fibers are impregnated by the liquid resin usually at room temperature and then treated with some cross-linking agent for hardening. Usually with an increase in the fiber content in the composition, the tensile and flexural property gradually improves. Beyond certain limit of the fiber content, however, depending on the method of processing, the adhesion between the resin and the fiber decreases, resulting in the decrease in the strength of final products. Epoxy resin has excellent adhesion to a large number of materials and could be further strengthened with the addition of fiber. Table.3 shows Mechanical properties of Sisal and Banana fibers.

Table.3 Mechanical properties of Sisal and Banana fibers [18-21].

Fiber	Sisal	Banana
Density (g/cm3)	1.41	1.35
Elongation at break (%)	6–7	5–6
Tensile strength (MPa)	350 ± 7	550 ± 6.7
Youngs modulus (GPa)	12.8	20
Flexural strength (Mpa)	29.28-62.50	57.33
Flexural modulus	1.29-3.16	8.9
Impact strength (KJ/m2)	8.36	13.25

CONCLUSION

The use of Natural fiber as reinforcement of polymer based composites was reviewed from the viewpoints position and future expectations of natural bio-fibers, construction and properties of natural fibers, fiber surface modifications, and physical and mechanical characteristics of natural fiber based polymer composites. Natural fibers have well prospective as reinforcements in polymers (thermoplastics, thermosets and elastomers) composites. Due to the high specific properties and low density of natural fibers, composites based on these fibers may have very good implications in industry. Moreover, reduced abrasion and consequent reduction of re-tooling makes these composites one of the most effective alternatives. The natural fibers as a source of raw material in polymer industry not only provides a renewable resource, but can also produce a source of economic development for rural areas. From the above discussions, it is quite evident that newer composites using abundantly available natural fibers are on the horizon, this brings 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 fiber polymer composites in the future.

REFERENCES:

[1] White, N. M.; Ansell, M. P. J.M.Sci 1985, 18, 1549.

[2] Maguno, A. 2nd International wood and natural fiber composites symposium, Kassel, Germany, 29-1, June 28–29, 1999.

[3] Al-Qureshi, H. A.2nd International wood and natural fiber composites symposium, Kassel, Germany, 32-1, June 28–29, 1999.

[4] Faruk, Omar, Andrzej K. Bledzki, Hans-Peter Fink, and Mohini Sain. "Bio composites Reinforced with Natural Fibers: 2000–2010." Progress in Polymer Science (0). doi: 10.1016/j.progpolymsci.2012.04.003.

[5] Dr. Navdeep Malhotra, Khalid Sheikh and Dr. SonaRaniA "Review On Mechanical Characterization Ofnatural Fiber Reinforced Polymer Composites" Journal of Engineering Research and Studies E-ISSN0976-7916.

[6] Mohanty AK, Drazl LT, Misra M. Engineered natural fiber reinforced polypropylene composites: influence of surface modifications and novel powder impregnation processing. J AdhesSciTechnol 2002; 16(8):999–1015.

[7] Abu BakarHariharan , Abdul Khalil HPS (2005) Lignocellulose- based hybrid bilayer laminate composite: part 1–studies on tensile and impact behavior of oil palm fiber-glass fiber-reinforced epoxy resin. J Compos Mater 39(8):663–684.

[8] Panthapulakkal S, Sain M (2007) Injection-molded short hemp fiber/glass fiber-reinforced polypropylene hybrid composites-mechanical, water absorption and thermal properties. J ApplPolymSci 103:2432–2441.

[9] Shenouda, S. G. In Applied Fiber Science; Happey, F., Ed.; Academic Press: London, 1979, vol. 3, Chap. 7.

[10] Zeronian, S. H. In Cellulose Chemistry and Its Applications; Nevell, T. P.; Zeronian, S. H. Eds.; Ellis Horwood: Chichester, 1985, p. 159.

[11] Atkins, E. In Applied Fiber Science; Happey, F., Ed.; Academic Press: London, 1979, vol. 3, chap. 8.

[12] Nguyen, T.; Zavarin, E.; Barrall, E. M., II. J MacromolSci Rev MacromolChem 1981, C20.

[13] M. Sumaila, I. Amber, M. Bawa "Effect Of Fiber Length On The Physical And Mechanicalproperties Of Random Oreinted, Nonwoven Short Banana (Musa Balbisiana) Fiber /Epoxy Composite" ISSN.2186-2476, VOL.2,March 2013.

[14] SatishPujari, A. Ramakrishna and M. Suresh Kumar "Comparison of Jute and Banana Fiber Composites: A Review". International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.

[15] Venkateshwaran, N., Elayaperumal, A. &Sathiya, G. K. (2012). Prediction of tensileproperties of hybrid-natural fiber composites Composites: Part B, 43:793–796.

[16] Ajayi, J. O., Bello, K. A. & Yusuf, S. D. (2000). Influence of Retting media on thePhysical Properties of BastFibers, J. Chemical Society of Nigeria, 25: 112-5.

[17] Mukherjee KG, Satyanarayana KG. Structure and properties of some vegetable fibers. J Mater Sci 1984;19:3925–34.

[18] Maries Idicula , S.K. Malhotra , Kuruvilla Joseph , Sabu Thomas Dynamic mechanical analysis of randomly oriented intimately mixed short banana/sisal hybrid fiber reinforced polyester composites Composites Science and Technology 65 (2005) 1077–1087.

[19] Maleque M.A., Belal F.Y. and Sapuan S.M., Mechanical properties study of pseudo-stem banana fiber reinforced epoxy composite, Arab. J. Sc. Eng., 32(2B), 359-364 (2007).

[20] Leandro Jose da Silva, Tulio Hallak Panzera, Vania Regina Velloso, Andre Luis Christoforo, Fabrizio Scarpa (2012) Hybrid polymeric composites reinforced with sisal fibers and silica microparticles. Composites: Part B 43, pp.3436–3444.

[21] Olusegun David Samuel, Stephen Agbo, Timothy Adesoye Adekanye (2012) Assessing Mechanical Properties of Natural Fiber Reinforced Composites for Engineering Applications. Journal of Minerals and Materials Characterization and Engineering, 11, pp.780-784.

[22] Sanjay M R, Arpitha G R, B Yogesha, Study on Mechanical Properties of Natural - Glass Fibre Reinforced Polymer Hybrid Composites: A Review, Materials Today: Proceedings, Volume 2, Issues 4-5, 2015, pp: 2959-2967.