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Tensile Properties of Natural Fiber Reinforced Unsaturated Polyester Composites

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Abstract: Natural fiber reinforced polymer composites were fabricated with sisal fiber as reinforcement and unsaturated polyester as matrix. The sisal fibre was extracted by water retting method followed by chemical modification of the fibers using 5%NaOH solution at room temperature. Randomly oriented chopped fiber with different fiber length (10mm, 30mm & 50mm) and constant weight fraction(10wt%) are used for the present experimental study. The fabrication of composites were carried out by hand lay-up technique and tensile test of the composite was carried out on the computerized universal testing machine. An attempt was made to find out the influence of fiber length on the tensile properties of composites. The results showed that the tensile strength, young's modulus and percentage of elongation of sisal fiber reinforced polymer composite increased with increasing in length of fiber.
Keywords: Natural fiber, Sisal fiber, Fiber length, Unsaturated polyester, Tensile properties

I. INTRODUCTION

In the last few years, the development of polymer composites by reinforcing natural fibers has attracted attention of researchers, engineers and scientists. The various advantages of natural fibers are absence of health hazards, biodegradability, easy availability, easy collection, good thermal properties, high strength to weight ratio, low density per unit volume, low cost, less abrasion to processing equipment, non-corrosive nature, non-irritation to the skin and renewability. However, high level of moisture absorption by the fiber leads to poor wettability and poor fiber/matrix interfacial bonding that leads to a loss in properties of the composites.

Natural fibers can be derived from plant, animal and minerals. Plant or cellulose fibers are the most commonly used natural fibers in the generation of fibre reinforced polymer composites. The plants, which produce cellulose fibers can be classified into bast or stem fibers (flax, hemp, isora, jute, kenaf, kudzu, madar, mesta, nettle, okra, ramie, rattan, roselle, urena and wisteria), seed fibers (cotton, kapok, loofah and milkweed), leaf fibers (abaca, agave, banana, cantala, caroa, curaua, date palm, fique, henequen, istle, piassava, pineapple, raphia and sisal), fruit fibers(coir, oil palm and tamarind), stalk fibers(barley, maize, oat, rice, rye and wheat), grass and reed fibers (bagasse, bamboo, canary, corn, esparto, rape and sabai) and wood(soft wood and hard wood).

Chemical composition is one of the important elements that influence the mechanical properties of a natural fiber. Chemical compositions such as cellulose, hemicellulose, lignin, pectin, wax, moisture and ash content vary with various natural fibers. Chemical composition of some natural fiber is shown in table-1. From 80 to 90% of natural fibers made up of cellulose, hemicellulose, lignin and pectin. Chemical composition of the natural fibers mainly depend on several factors such as nature of the plant source, growing conditions of the plant, age of the plant, weather conditions and extraction process of the fibers. The mechanical properties of fibers mainly depend on the percentage of cellulose content. The rich content of cellulose tends to improve the mechanical properties. The low hemicellulose content tends to reduce the moisture absorption capacity. The presence of lignin content acts as a bonding agent between the cell wall structures to improve the rigidity and strength of the fiber. The wax content reduces the bonding characteristics between the fiber and polymer matrix in composite[1].

Table-1 Chemical composition of some natural fiber

Fiber	Cellulose (wt%)	Hemicellulose (wt%)	Lignin (wt%)	Pectin (wt%)	Moisture content (wt %)	Wax (wt%)
Sisal	67–78	10–14.2	8–11	10	11	2
Jute	61–71.5	13.6–20.4	12–13	0.2	12.6	0.5
Kenaf	45–57	21.5	8–13	0.6	6.2-12	0.8
Hemp	70.2–74.4	17.9–22.4	3.7–5.7	0.9	10	0.8

Ramie	68.6–76.2	13.1–16.7	0.6–0.7	1.9	8	0.3
Flax	71–78	18.6–20.6	2.2	2.3	3.9–10.5	1.7
Coir	32-43	0.15-0.25	40-45	3-4	8	-
Banana	63-64	10	5	-	10-12	-
Cotton	85-90	5.7	-	0-1	7.8-8.5	0.6

Chemical treatment of the natural fibers can clean the fiber surface, chemically modify the surface, decrease the moisture absorption process, increase the surface roughness and improve the bonding between matrix and fiber. The different kinds of chemical treatments used on natural fibers include acrylation, alkali, benzoylation, silane, peroxide, permanganate, acrylonitrile and acetylation grafting, stearic acid, isocyanate, triazine, sodium chloride and fungal. The alkali treatment is the most common method that is used for the treatment of natural fibre because this method is easy, effective and low cost. The alkali treatment process has some critical parameters like types of alkali used (NaOH, KOH & LiOH), concentration of the solution, treatment duration and temperature. A composite is a combination of two or more materials that result in better properties than when the individual components are used alone. Two constituents of the composite are normally a fiber and a matrix. Matrix is a binder material that holds the fibers in position and transfer the external load to the reinforcement. The polymer matrices can also provide a good surface finish to the composites and protects the reinforcing fibers against any kind of chemical attack and mechanical abrasion. The reinforcement is provided to enhance the strength, stiffness and thermal stability to the composite. The reinforcing fibre material is found in different forms, like long continuous fiber, short chopped fiber, woven fabric and mat. Polymer matrix composite is a material consisting of polymer matrix combined with a fibrous reinforcing dispersed phase. PMC's are very popular due to their cost effective and simple fabrication methods[2]. Also, the equipment required for manufacturing the polymer matrix composites are simpler than the metallic or ceramic composites. Thermoplastics and thermosetting plastics are two separate classes of polymers, which are differentiated based on their behavior in the presence of heat. Thermoplastics can be reversibly melted by heating and solidified by cooling in limited number of cycles without affecting the mechanical properties. Thermosetting plastics can only be heated and shaped once. Thermosetting plastics are generally stronger than thermoplastic materials and are also better suited to high-temperature applications. Thermoplastics widely used for natural fibers are Acrylic, Acrylonitrile butadiene styrene , polyvinyl chloride, polylactic acid, polybenzimidazole, Polycarbonate, Polyether ether ketone, Polyetherimide, Polyethylene, Polyphenylene, Polypropylene, Polystyrene, Polyvinylidene fluoride, Polytetrafluoroethylene and Polyoxymethylene, hereas epoxy , unsaturated polyester and vinyl ester are mostly utilized thermosetting matrices. Unsaturated polyester resins can be utilized in a wide range of manufacturing processes such as compression moulding, filament winding, hand lay-up process, injection moulding, pultrusion and resin transfer moulding.

II. MATERIAL AND METHOD

A. Sisal fiber

Sisal fibre was chosen for this investigation, because of its availability, ease of extraction, good strength, low cost and light weight.

B. Unsaturated polyester resin

The unsaturated polyester resin has been chosen as the matrix material because its dimensional stability, low cost, good corrosion resistance, ease of handling, easy of processing, lower shrinkage and good range of mechanical properties.

C. Catalyst and Accelerator

The most frequently catalyst used is Methyl Ethyl Ketone Peroxide (MEKP) with the amount varies from 1-2%. The catalyst is mixed directly in to the polyester resin. Accelerator is mixed with the polyester in combination with the catalyst. The name of the accelerator used is cobalt naphthalene. The catalyst does not take part in the chemical reaction but simply activates the process for curing process. The function of the accelerator is to make the process faster.

D. Extraction of Sisal Fiber

The sisal leafs are cut from sisal plants. After harvesting, sisal leaves are grouped in bundles. These bundles was immersed in water (river, pond or tank) until it becomes decay. This method required 10 to 20 days to degrade the hemicellulose, lignin etc. The period of retting depending upon the maturity of the crop at the time of harvesting and the temperature of water. The retted leafs are washed in running water and the top portion of the leafs are removed by manually to get the fiber separately and cleaned. Then this fiber dried under sun light for one day. Water retting generally produces fibers with a higher quality than those produced by dew retting. But the water retting process impacts the environment due to the consumption and contamination of large amounts of water.

E. Alkali treatment

Alkali treatment using sodium hydroxide (NaOH) is the most commonly used for modification of fiber surface to produce high-quality fibers. The alkali treatment reduced the hemicellulose, lignin and wax content of the fibers. They also found that the treated fibers have more tensile force than the raw fibers. Li Ma et al [3] investigated the effect of surface treatments on tensile properties of hemp fiber reinforced polypropylene composites. The fiber treated with different concentrations of NaOH(0 to 8%) solution. They reported that 5% NaOH treated fiber composite has maximum tensile strength.

Firstly 5% NAOH solution was prepared using sodium hydroxide pellets with distilled water. NaOH solution were taken in trays, then all sisal fibers were soaked in the solution for 1 hour, at room temperature. The fiber to solution weight ratio was maintained at 1: 20. After 1 hour fibers were washed with distilled water to remove the excess of NaOH sticking on the fibers. Treated sisal fibers were dried in sun light for two days before using as reinforcement in polymer composite.

F. Manufacture of composite

Hand lay-up technique is the most common and least expensive method because it requires the least amount of equipment. A steel mold is used for preparing the test specimen and having dimension of 300mm x 300mm x 3mm. The mould was first cleaned with wax so that the laminate easily comes out of the mould after hardening. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. In matrix preparation, initially 2% of catalyst-Methyl Ethyl Ketone Peroxide (MEKP) mixed with unsaturated polyester resin. Finally 2% of accelerator is added with resin mixture and stirred slowly for 1 minute to form a uniform mixture. Initial layer of the mould was filled with resin mixture and then sisal fibers were randomly spread over the resin mixture. Then, the pouring was continued till the thickness reached 3 mm and then pressed heavily for 5 hours. Then, the plastic sheet was removed from the mould and cured at room temperature for 24 hours.

G. Tensile test

Tensile test specimens were made according to the ASTM D3039 to measure the tensile properties. The samples were 250 mm long, 25mm wide and 3mm thick. Tensile tests were conducted using computerized universal testing machine with across head speed of 2mm/min. Tests were carried out at room temperature and each test was performed until tensile failure occurred. Mechanical testing was carried out at LMP R&D Laboratory, Near jeeva shed, Pallipalayam, Erode, Tamilnadu.

III. RESULTS AND DISCUSSION

Table-2 Tensile test results

S.No	Fiber length (mm)	Tensile strength (MPa)	Young's modulus (GPa)	Percentage of elongation
1	10	09.79	0.631	1.55
2	30	12.63	0.671	1.88
3	50	14.39	0.702	2.05

A. Tensile Strength

It is clearly evident from table-2 that the tensile strength of sisal fiber reinforced USP composites is increasing with increase of fiber length. The tensile strength is increasing from 10mm length of fibre up to 50mm. The results showed that fiber length had major role on the tensile strength of composites. Similar result was reported by Rafah A.Nasif [4] investigated the effect of coir fiber length and content on mechanical properties of unsaturated polyester composites that were prepared with different fiber lengths of 10, 30, and 50mm and various weight fractions of 5,10, 15 and 20%. The tensile strength is increasing from 10mm length of fibre up to 50mm for all the fibre weight fractions. Moreover, Ajay Naik[5] has studied the effect of fibre length with constant fibre loading on dynamic mechanical properties. Alkali treated Kenaf fiber reinforced epoxy composites were prepared with fiber lengths of 5, 10, 30 and 50 mm and constant fibre content. The trend of this tensile strength increase starts from the fiber length of 5 mm. The maximum tensile strength was found at 50 mm in fiber length of composite.

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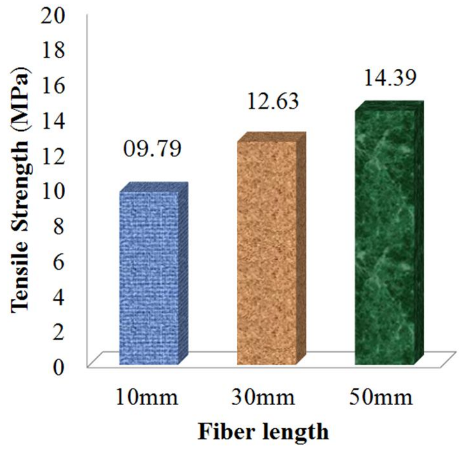


Figure-1

B. Young's Modulus

Figure-2 shows the young's modulus of the composites versus the length of fiber. The young's modulus of 50 mm length of fiber composite were found maximum value compare to other all the composites. Similar trend was observed by Dhanavendhan et al [6], they investigated the mechanical properties of natural fibers reinforced with egg shell. In this study, polyester composite with different fiber length (10, 30 & 50mm) were fabricated and tested. Increasing the length in the composite materials will increase the young's modulus. The maximum young's modulus was obtained at 50mm fiber length composite. In another research done by Ajay naik et al [5] prepared kenaf fiber epoxy composites and investigated the mechanical properties. They reported that 50mm kenaf fiber reinforced epoxy composite exhibited the highest young's modulus than 5mm, 10mm and 30mm length of fiber composites.

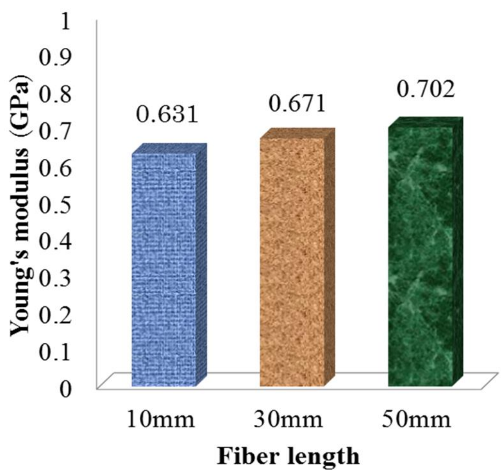


Figure-2

C. Percentage of elongation

Figure-3 shows the percentage of elongation of the composites at different length of sisal fiber. Results showed that the percentage elongation increased as the fiber length increased from 10 to 50mm. This is similar to the findings of Dhanavendhan et al [6] studied the mechanical properties of coconut coir fiber and egg shell reinforced polyester composites. Polyester composites were prepared with the coir fibers of length 10, 30 and 50mm by compression molding process. The reported the percentage of elongation of composites is increasing with increase of fiber length up to 50mm. Moreover, Nitya Santhiarsa [7] reinforced ijuk fiber in epoxy resin to make composites and investigated. It was found that 50mm ijuk fiber reinforced epoxy composite exhibited the percentage of elongation than 10mm length of fiber composites.

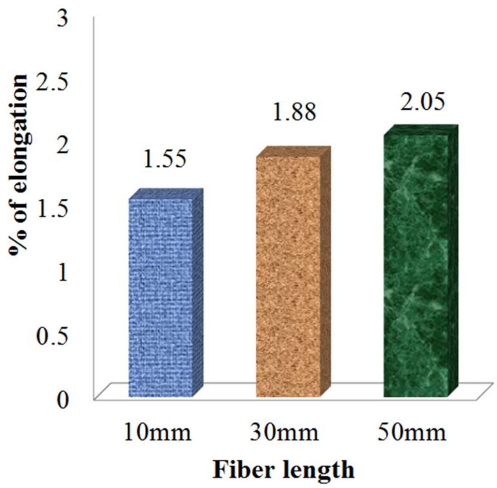


Figure-3

IV. CONCLUSION

Sisal fiber unsaturated polyester composites with different fiber length were fabricated by hand-lay-up technique. Tensile strength, young's modulus and percentage of elongation of composites were investigated. The results have shown that all of above properties increased as the sisal fiber length increased.

REFERENCES

[1] K. Raja, P. Senthilkumar, G. Nallakumarasamy and T. Natarajan, "Characterization of Natural Fiber Extracted from Sesbania rostrata: An Alternative Potential for Synthetic Fibers," journal of advances in chemistry, Vol. 12, pp. 4930- 4937, Nov 2016.

[2] T. Vijaya Kumar, Dr. K. V. Ramana and Dr. R B Chowdary, "Tensile behavior of banyan tree fiber reinforced composites," International Journal of Advanced Engineering Research and Studies, Vol. I, Issue II, pp.256-258, January-March 2012.

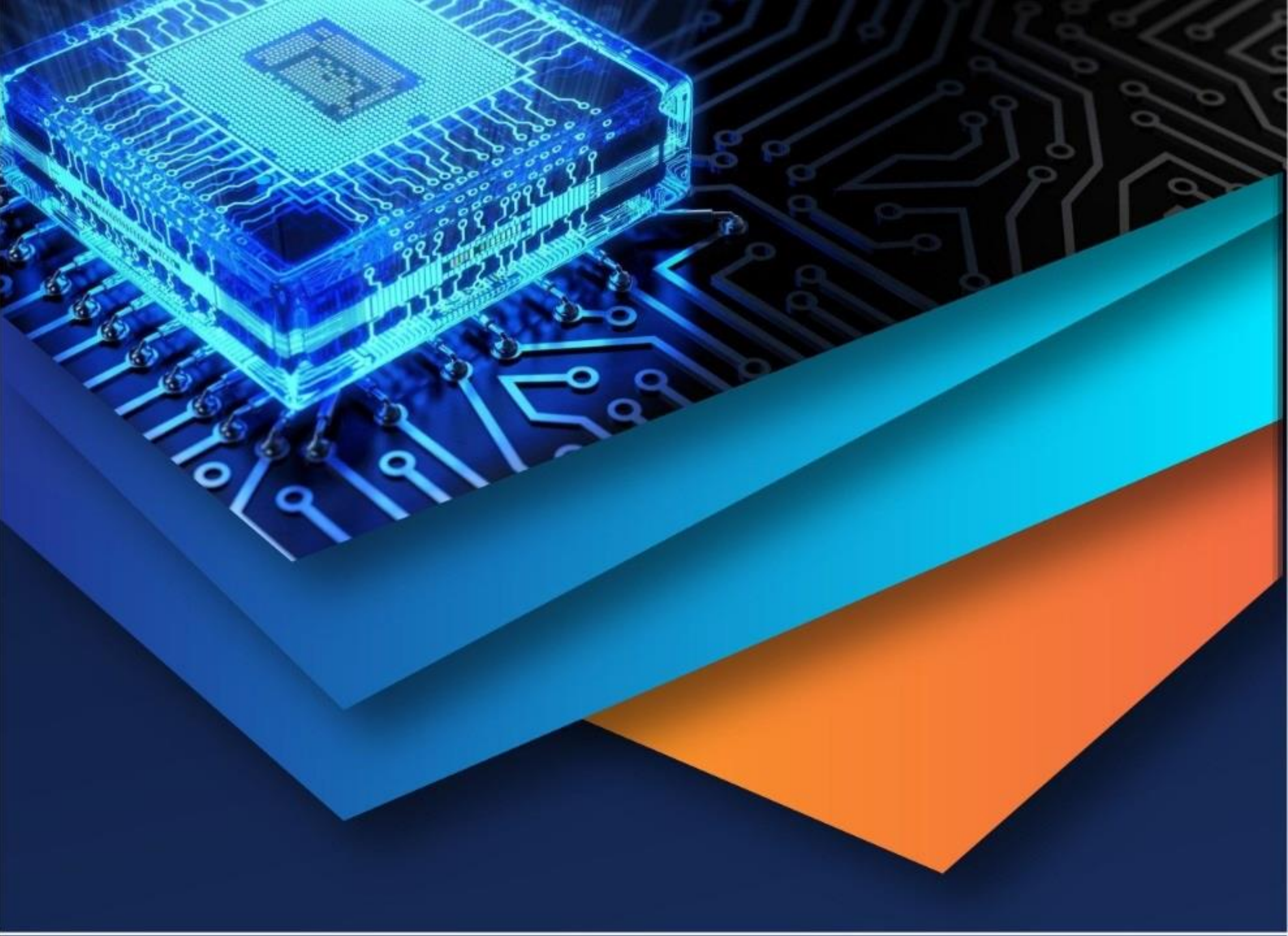
[3] Li Ma, Lujv He, and Libin Zhang, "Effect of surface treatments on tensile properties of hemp fiber reinforced polypropylene composites," AIP Conference Proceedings 1829, 020016 (2017); doi: 10.1063/1.4979748

[4] Rafah A.Nasif, "Effect of coir fiber length and content on mechanical properties of unsaturated polyester composites, IRAQI journal of applied physics, vol. 11, no. 3, pp. 27-29, July-September 2015.

[5] Ajay Naik, Rajnish Kumar, S. A. R. Hashmi and Subhash Nimanpure, "Enhanced dynamic mechanical properties of kenaf epoxy composites," Advanced Materials Proceedings, 2(11), pp.749-757, 2017.

[6] Dhanavendhan T, Elavarasan P, Jeevanantham R and Prasanna S.C, "Investigation on the mechanical properties of natural fibers reinforced with egg shell," Journal of Chemical and Pharmaceutical Sciences, Issue 3, pp.177-180, February 2017.

[7] I G.N. Nitya Santhiarsa, Effects of Alkaline Treatment and Fiber Length towards The Static and Dynamic Properties of Ijuk Fiber Strengthened–Epoxy Composite, Proceedings of the International Mechanical Engineering and Engineering Education Conferences (IMEEEC 2016) AIP Conf. Proc. 1778, 030022-1–030022-5; doi: 10.1063/1.4965756.



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