Materials Physics and Mechanics 8 (2009) 165-173 Received: November 25, 2009

IMPROVING MECHANICAL PROPERTIES OF BANANA/KENAF POLYESTER HYBRID COMPOSITES USING SODIUM LAULRYL SULFATE TREATMENT.

M. Thiruchitrambalam[1], A.Alavudeen[2], A.Athijayamani[3], N.Venkateshwaran[4] and A.Elaya Perumal[4]

[1] Department of Mechanical Engineering, Kalasalingam University, Krishnankoil- 626 190, Tamilnadu, India.

[2] Department of Mechanical Engineering, Tamilnadu College of Engineering, Coimbatore-641 659.

[3]Department of Mechanical Engineering , A.C.College of Engg and Technology, Karaikudi

[4] Department of Mechanical Engineering ,Anna University Chennai

Abstract: The aim of this study is to investigate the effect of alkali and SLS (Sodium Lauryl Sulphate) treatment on Banana/Kenaf Hybrid composites and woven hybrid composites. The fibers are treated with 10% of sodium hydroxide (NaOH) and 10% Sodium Lauryl Sulfate (SLS) for 30 minutes. Woven banana and kenaf fiber reinforced unsaturated polyester (USP) composites were fabricated by moulding technique. The fiber content in the composite is kept constant to 40 %. The variation in the Mechanical properties (Tensile, Flexure and Impact strength) and morphological changes are studied.

Key words: Hybrid composites; Banana fiber, Kenaf Fiber, Polymer; SLS.

1. Introduction

There is a growing interest in the use of natural fibers as reinforcing components for both thermoplastic and thermoset matrices, because of the ideal benefits offered by natural fibers such as convenient renewability, biodegradability, and environmentally friendliness. The natural fibers such as sisal, coir, jute, ramie, pineapple leaf, and kenaf have the potential to be used as a replacement for glass or other traditional reinforcement materials in composites. These fibers are abundant, cheap and renewable. Natural fiber reinforced composites have attracted the attention of research community mainly because they are turning out to be an alternate solution to the ever depleting petroleum sources. The production of 100 % natural fiber based materials has been extended to almost all fields. Nowadays, use of natural, cellulosic fibers as reinforcing fillers for commodity plastics has received much attention because of number of advantages over traditional, inorganic ones such as good specific strength, high toughness, and good thermal insulation, less abrasion, minimal dermal and respiratory irritation, biodegradability, and natural abundance. Conventional and traditional fiber reinforced composite materials are composed of carbon fibers, glass fibers which are incorporated into polyester resin.

These composite materials have excellent mechanical properties but these materials cause environmental pollution due to the non degradability of fibers.

The use of kenaf fiber as reinforcement has grown substantially in the past decade and they are other products, such as extruded plastic fencing, decking, and furniture padding. Plant bast fibers, such as kenaf, hemp, and flax, have low density and high specific strength, and are of utmost interest in applications striving for lightweight and high strength. In the past decade, natural fiber composites with thermoplastic and thermoset matrices have been embraced by European car manufacturers and suppliers for door panels, seat backs, headliners, package trays, dashboards, and interior parts of automotives.

M. Zampaloni et al. [1] discussed the Kenaf–maleated polypropylene composites manufactured have a higher Modulus/Cost and a higher specific modulus than sisal, coir, and even E-glass thereby providing an opportunity for replacing existing materials with a higher strength, lower cost alternative that is environmentally friendly. D.Maldas ,et al [2] analysed the Impact strength of PS 201-based composites improved the most compared to even that of the original polymer when silicate along with isocyanate were used as a coating component of the fiber were reviewed . Sherely Annie Paul, et al [3] investigated that NaOH concentration has an influence on the thermo physical properties of the composites. A 10% NaOH treated banana fiber composites showed better thermo physical properties than 2% NaOH treated banana fiber composites. S. Mohanty et al. [4]. observed that the composites prepared at 21 volume percent of fibers with 1% MAPP concentration exhibits optimum mechanical strength. The thermal properties of the composites were analyzed through DSC and TGA measurements. SEM investigations confirmed that the increase in properties is caused by improved fiber-matrix adhesion for two ethylene-propylene impact copolymers; the uncoupled systems had much higher Young's moduli than the coupled systems. The dynamic storage moduli of the uncoupled impact polymers were higher than the coupled composites at temperatures up to about 50°C. At higher temperatures the presence of the coupling agent resulted in higher storage moduli. D. Feng, et.al [5] analysed the level of improvement decreases with an increase in the molecular weight of the matrix polymer. After treatment the surface topography of hemp, sisal and jute fibres is clean and rough. The surface of kapok fibres is apparently not affected by the chemical treatments. X-ray diffraction shows a slight initial improvement in the crystallinity index of the fibres at low sodium hydroxide concentration. However, high caustic soda concentrations lower the fibre crystallinity index.

Thermal analysis of the fibres also indicates reductions in crystallinity index with increased caustic soda concentrations and that grafting of the acetyl groups is optimised at elevated temperatures. Alkalization and acetylation have successfully modified the structure of natural fibres and these modifications will most likely improved the performance of natural fibre composites by promoting better fibre to resin bonding [6]. The chemical modification of kenaf fibers was carried out by Edeerozey et al. [7]. Different concentrations of NaOH were used and the morphological changes were examined by SEM. The authors observed that treated kenaf fibers exhibited better mechanical properties than untreated fibers. Also, the optimum concentration of NaOH was found to be 6%. Figure 16a and b exhibits the SEM micrographs of untreated and treated kenaf fibers. A decrease in the amount of surface impurities was observed in the case of treated fibers. Fiber bundle tests were also performed and the strength of 6% NaOH-treated fiber bundles was found to be higher by 13%. The biodegradability of kenaf/PLA composites was examined for four weeks using a garbage-processing machine. Experimental results showed that the weight of composites decreased 38% after four weeks of composting [8].

S.H. Aziz, et.al, discussed the effect of alkalization on fiber alignment [9]. D. Maldas, et.al [10] investigated the influence of chemical treatment. Nishino et al. [11] investigated the influence of silane coupling agent (glycidoxypropyl trimethoxysilane) on kenaf fiber-reinforced PLA. The stress on the fibers in the composite under transverse load was monitored in situ and nondestructively using X-ray diffraction. Pothan et al. [12] investigated the influence of chemical modification on dynamic mechanical properties of banana fiber-reinforced polyester composites. A number of silane coupling agents were used to modify the banana fibers. The damping peaks were found to be dependent on the nature of chemical treatment. Joseph et al. [13] studied the environmental durability of chemically modified banana-fiber-reinforced phenol formaldehyde (PF) composites. The authors observed that silane, NaOH, and acetylation treatments improved the resistance of the banana/PF composites on outdoor exposure and soil burial. Idicula et al. [14] investigated the thermo physical properties of banana-sisal hybrid-reinforced composites as a function of chemical modification. Sisal and banana fibers were subjected to mercerization and polystyrene maleic anhydride (MA) treatments. The authors observed that chemical modification resulted in an increase of 43% in thermal conductivity when compared with untreated composites.In recent years; the natural fiber woven fabrics are attractive as reinforcements since they provide excellent integrity and conformability for advanced structural applications. When comparing the woven fabrics composites with non-woven composites, they have excellent drapeability, reduced manufacturing costs and increased mechanical properties, especially the interlaminar or interfacial strength. Several researchers has been investigated the mechanical properties of the woven fabrics polymer composite [15-23]

2. Experimental

2.1 Materials. Banana (Musa sepentium) / Kenaf (Hibiscus cannabinus) was reinforced with unsaturated Polyester matrix material. The properties of resin/matrix used are listed in table 1.

Table 1. Properties of Polyester Resin.

S.NO	Properties	Value	Unit
1.	Appearance	Colourless to pale yellow liquid	
2.	Specific gravity	1.12±0.01	g/cm^3
3.	Viscosity	450±50	Cp
4.	Tensile Strength	7300	MPa
5.	Tensile Modulus	5.3	GPa.
6.	Flexure Strength	15,250	MPa
7.	Flexure Modulus	6.27	GPa.

Unsaturated polyesters are extremely versatile in properties and applications and have been a popular thermoset used as the polymer matrix in composites. The matrix material was mixed with curing catalyst at a concentration of 0.01 w/w of the matrix for curing. Woven (Banana/ Kenaf) fiber combination directly procured from Banana Fiber Manufacturing Association, Chennai. One or more warp fibres alternately weave over and under two or more weft fibres in a regular repeated manner. This produces the visual effect of a straight or broken diagonal 'rib' to the fabric. Superior wet out and drape is seen in the twill weave over the plain weave with only a small reduction in stability. With reduced crimp, the fabric also has a smoother surface and slightly higher mechanical properties. In twill-weave the crossings of weft and warp are offset to give a diagonal pattern on the fabric surface.

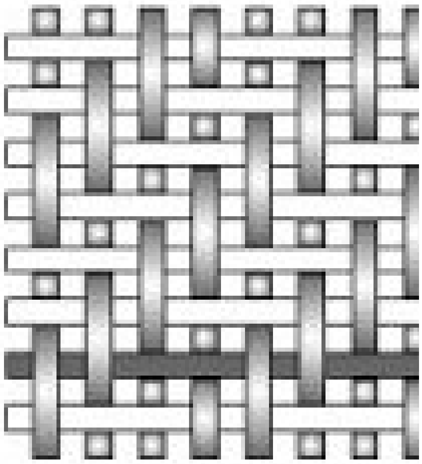

Figure 1. Typical Woven Style in making composite used as reinforcements in making composites.

2.2. Chemical Treatment. Two basic chemical treatments were employed for surface modification of fibers. Fibers (Banana and Kenaf) were treated with 10% NaOH and 10% Sodium Lauryl Sulfate (SLS) for 30 minutes and then washed with distilled water and dried .In this work we have tried the newer chemical treatment using SLS for surface modification of fiber. The basic properties of SLS are as shown in table 2.

Table 2. Properties of SLS.

Properties	
Molecular formula	$NaC_{12}H_{25}SO_4$
Molar mass	288.38 g mol^{-1}
Density	1.01 g/cm^3
Melting point	206 °C

2.3. Preparation of composites. The fiber contents were set at 40%, weight of the matrix with the banana and kenaf are set as 1:1. The balance of the mixture was made up of the unsaturated polyester, always to give a total weight batch size of 100%. The fiber length used is 10 mm. The natural fibers (banana and kenaf) reinforced polymer matrix composites were fabricated using moulding method. Unsaturated Polyester was used as matrix. For a proper chemical reaction cobalt naphthenate and methyl ethyl ketone were used as catalyst and accelerator respectively. An Acrylic sheet coated with remover of size 300 mm x 300 mm x 5 mm dimensions is used as mould where the composite were poured into it. With the help of roller composites was pressed so that proper spreading of resin will take place and also voids will be minimized. Then the mold was closed and kept for curing at room temperature for 24hrs. After curing composite was separated from the mould and the specimens were cut according to the ASTM and ISO standards.

2.4. Material Characterization. Tensile test was performed on a 1000 Ton computer controlled universal testing machine according to the guidelines of ASTM D638 with a gauge length of 50.8 mm. The flexural tests were performed using the 3-point bending method according to ASTM D790 standard with a gauge length of 50.8 mm. The impact test experiments were conducted according to ISO 180. Six sample specimens were tested to for each test and their average values are used to determine tensile strength, flexural strength, and impact strength.

3. Results and Discussion

3.1. Tensile Strength. As expected, surface modification by chemical treatment of fibers resulted in a significant increase in tensile strength. From the table 3 and figure 2 we can easily found that the SLS treatment provide better improvement in the tensile strength about 13% and 10% for non woven and woven hybrid composites when compared with alkali treatment.

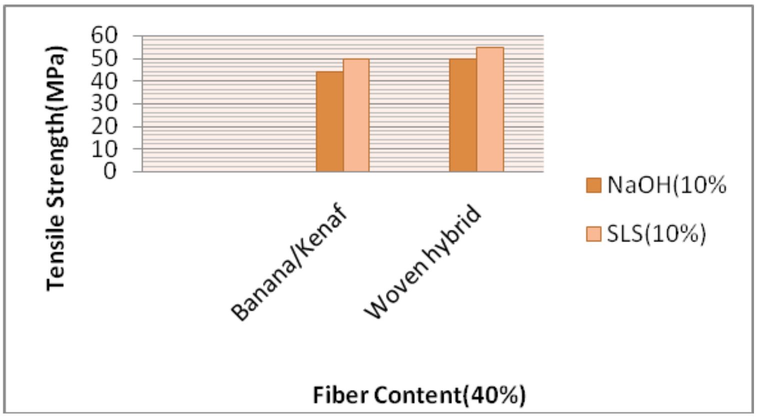

Figure 2. Variation of tensile strength due to alkali and SLS treatment

3.2. Flexure Strength. Similarly the bending properties of composites were tested by 3-point bending method and whose results are shown in figure 3.

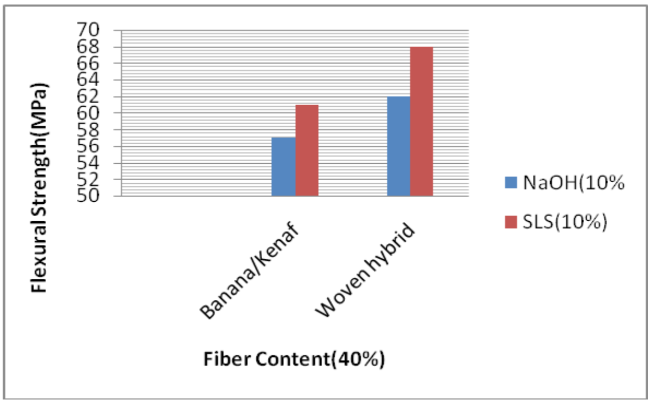

Figure 3. Variation of flexure strength on alkali and SLS treatment.

If we compare the percentage increase in flexure strength of alkali and SLS treated are 12% and 10 % for non woven and woven composites. It is due to increase in the interface adhesion between fiber and matrix, which is due to removal of foreign particle and decrease in the lignin level in fibers by SLS treatment when compared with alkali.

3.3. Impact Strength. The Effect of surface modification by alkali and SLS on the impact strength are shown in figure 3.

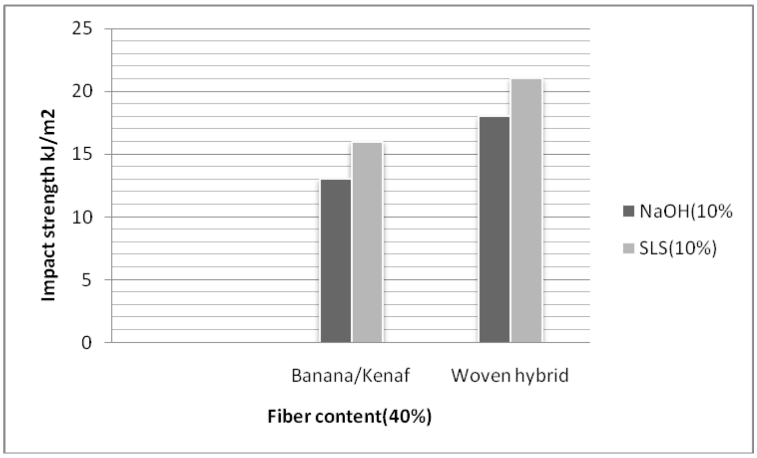

Figure 4. Variations of Impact strength on chemical treatment.

From figure 4 we can find the increase in impact strength because of SLS treatment was 23 % for random mix hybrid composite and 16% for woven hybrid composites.

Figure 5. SLS treated SEM(x300) of Woven Composite Specimen after tensile test

Figure 6. Alkali treated SEM image (x200) of composite specimen after tensile test

Figure 7. Alkali treated SEM image (x200) of composite specimen after flexural test

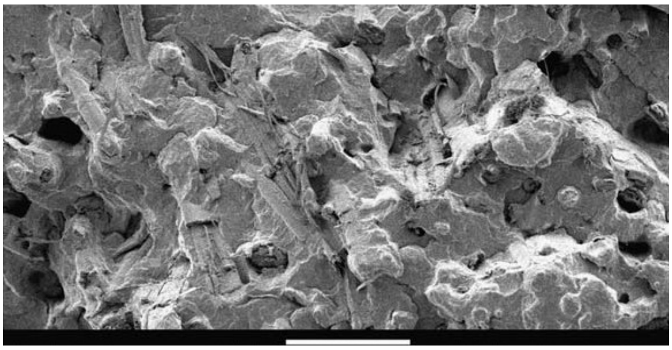

Figure 8. SLS treated SEM image (x200) after flexural test

SEM images of alkali treated and SLS treated specimens are shown in figure 5 to figure 8. Figure 5 show the SLS treated woven hybrid composite specimen after tensile test. From the image we can say that the SLS treatment has improved the adhesion between fiber and matrix which in turn improved the mechanical strength. On comparing the figure 6 and 7 SLS treatment have cleaned the surface of the fiber in a better way when compared with the alkali. Fibers pull out and voids are sown in fig 8.

4. Conclusions

It has been found from the earlier literature [2, 11, 21,25and 28] that the alkali treatment has improved the mechanical property of the composites. In this work we compared resulting mechanical properties of banana/kenaf hybrid composites subjected to alkali and SLS treatment. The surface modification by SLS has improved the mechanical properties than alkali. The morphological changes were also examined using scanning electron microscopy. The SLS treatment has improved the mechanical properties, tensile, flexure and impact strength of both the random mix and woven hybrid composite. Therefore we can conclude from the above results that the SLS treatment had provided better mechanical properties that the alkali treated.

References

1. Zampaloni, et.al., Kenaf Natural Fiber Reinforced Polypropylene Composites: A Discussion on Manufacturing Problems and Solutions", Composite Part A: applied science and manufacturing, 38A (6), 1569-1580, (2007).

2. D.Maldas, B.V.Kokta, R.G.Raj, and C.Daneault Polystyrene composites by chemical treatment, Polymer. 29 (7):1255–1265(1988).
3. Sherely Annie Paul, et.al., Effect of fiber loading and chemical treatments on thermophysical properties of banana fiber/polypropylene commingled composite materials , Composites Part A Applied Science and Manufacturing, Volume 39, Issue 9, September 2008, Pages 1582-1588.
4. S. Mohanty S.K Nayak, S.K Verma and S.S. Tripathy. Influence of fiber treatment on the performance of sisal-polypropylene composites, Journal of Reinforced Plastic Composite, 23:625(2004).
5. D. Feng, D.F.Caulfield, and A.R. Sanadi. Effect of compatibilizer on composites, Polymer Composites, 22:506 (2001).
6. L. Y. Mwaikambo and M.P.Ansell., Chemical modification of hemp, sisal, jute, fibers by alkalisation, Journal of Applied Polymer Science., 84(12) :2222–34(2002).
7. A.M Mohd Edeerozey ,et.al.,Chemical modification of kenaf fibers, Materials Letters., 61:2023–2025(2004).
8. Shinji Ochi., Mechanical properties of kenaf fibers and kenaf/PLA composites, Mechanics of Materials., 40: 446–452(2008).
9. S.H. Aziz, M.P. Ansell, The effect of alkalization and fibre alignment on the mechanical and thermal properties of kenaf and hemp bast fibre composites: part 1—polyester resin matrix, Composites Science and Technology 65 (Oct. 2003) 525–535.
10. D. Maldas B.V Kokta R.G.Raj, and C. Daneault (1998). Polystyrene composites by chemical treatment, Polymer., 29 (7):1255–1265.
11. T. Nishino, K. Hirao, and M. Kotera, Compos. A, 37, 2269 (2006).
12. L.A. Pothan, S. Thomas, and G. Groeninckx, Compos. A, 37, 1260 (2006).
13. S. Joseph, Z. Oommen, and S. Thomas, J. Appl. Polym. Sci., 100, 2521 (2006).
14. M. Idicula, A. Boudenne, L. Umadevi, L. Ibos, Y. Candau, and S. Thomas, Compos. Sci. Technol., 66, 2719(2006).
15. S. M. Sapuan and M. A. Maleque, Design and fabrication of natural woven fabric reinforced epoxy composite for household telephone stand,
14. Materials and Design ,26,Issue 1, February 2005, Pages 65-71.
16. S.M.sapuan, N.Harun and K.A Abbas, Design and fabrication of a multipurpose table using a composite of epoxy and banana pseudostem fibers, Materials & Design ,45(1-2):66-68(2007).
17. Laly a. Pothan, Nn. R. Neelakantan and Bhaskar rao ,Sabu Thomas stress relaxation behavior of banana fiber- reinforced polyester composites Journal of REINFORCED PLASTICS AND COMPOSITES, Vol. 23, No. 2(2004).
18. Fiber Reorientation in Laminated and Woven Composites for Finite Element Simulations, ALA TABIEI* AND IVELIN IVANOV, Journal of THERMOPLASTIC COMPOSITE MATERIALS, Vol. 16,457(2003).
19. Laly a. Pothan, Petra Potschke, Rudiger habler and Sabu thomas , The static and dynamic mechanical properties of banana and glass fiber woven fabric-reinforced polyester composite, Journal of COMPOSITE MATERIALS, Vol. 39, No. 11(2005).
20. AHMET YAPICI, Elastic-plastic Stress Analysis of Thermoplastic Matrix-woven Fiber Composite Laminated Plates Under In-plane loading, Journal of reinforced plastics and composites, vol. 23, No. 11(2004).
21. Bulent Murat , Buket Okutan , Ramazan Karakuzu ,Failure Strength of Woven Glass Fiber-epoxy Composites Pinned Joints , Journal of COMPOSITE MATERIALS, Vol. 37, No. 15(2003).
22. W.L.Lai and M. Mariatti The properties of Woven Betel palm Reinforced polymer composites , Journal of reinforced polymer composite, 27;925(2008)

23. Modeling of Process Induced Residual Stresses in Resin Transfer Molded Composites with Woven Fiber Mats HOSSEIN GOLESTANIAN AND A. SHERIF EL-GIZAWY1 *Journal of Composite Materials* 35; 1513(2001).