J. Myanmar Acad. Arts Sci. 2020 **Vol. XVIII.No.1**B

EFFECT OF ALKALI TREATMENT ON MECHANICAL PROPERTIES OF BANANA STEM FIBER REINFORCED NATURAL RUBBER COMPOSITES

Nyein Chan Aye[1], Nyo Nyo Myint[2], Thinzar Nu[3]

Abstract

In this present work, composites are made by using untreated banana stem fiber, alkali treated banana stem fiber and natural rubber. A mixture of 4 % NaOH and 2 % Na_2SO_3 were used for modification of banana stem fiber (BSF). The alkali treatment was conducted to reduce the lignin content on the surface of fiber and to improve the adhesion between the rubber and matrix. The natural rubber-banana stem fiber composites were prepared by moulding method with various weight ratio (5%, 10%, 15%, 20%) of untreated and treated banana stem fiber. The untreated and alkali treated banana stem fiber were characterized by modern techniques such as FT IR and SEM. The mechanical properties such as hardness, specific gravity, tensile strength, elongation at break and tear strength of natural rubber- banana stem fiber composites were then determined by standard rubber testing methods.

Keywords: Natural rubber, banana stem fiber, composite, alkali treatment, mechanical properties, FT IR, SEM

Introduction

Banana belongs to Musa family. Banana plant is a large pereminal herb with leaf sheaths that form pseudo stem. Its height can be 0-40 ft (3.0-12.2 m) surrounding with 8-12 large leaves. The leaves are up to 9 ft long and 2 ft wide (2.7m and 0.61m). Its fruits are approximately 4-12 inches (10.2-30.5 cm). Different parts of banana trees serve different needs, including fruits as food sources, leaves as food wrapping and stems for fiber and paper pulp (Sonu, 2014).

Reinforcing efficiency of natural fibers depends upon the nature of cellulose and its crystallinity. Components which are present in natural fibers are cellulose (α cellulose), hemicelluloses, lignin, pectin and waxes (Raghavendra *et al*., 2013).

Use of natural fibers as reinforcements has increased due to their good mechanical properties, low cost and density, their ability to recycle, relatively no abrasion and comparative performance in terms of specific strength. The mechanical properties are determined by the amount of cellulose content and microfibrillar angle. Fibers with high cellulose content and low microfibrillar angle provide higher properties and are preferred for composite preparation (Ezema *et al*., 2014).

Literatures on the use of banana stem fibers are very limited. These fibers from banana are emerging materials for composite manufacture with high conversion rate from agro-waste to high economic value products because banana fibers are available all year round and in every part of the world (Maleque *et al.,*2006).

Surface modifications is performed to increase the number of reactive sites on the surface of fibers, which increases the interfacial bonding between fiber and matrix. Increase in the properties of composites made of chemically treated fibers is attributed to improve interfacial

[1] Assistant Lecturer, Department of Chemistry, Mawlamyine University
[2] Dr, Associate Professor, Department of Engineering Chemistry, Technological University (Mawlamyine)
[3] Dr, Associate Professor, Department of Chemistry, University of Yangon

bonding between fibers and the matrix, decrease in moisture absorption, increase in fiber crystallinity due to variation in treatment time and temperature (Mahesh *et al*., 2014).

Materials and Methods

Materials

Natural rubber (Grade 1) was obtained from Mudon Township, Mon State. The banana stems were collected from Mayangone Quarter, Mawlamyine Township, Mon State. The other compounding ingredients used were zinc oxide, stearic acid, N-cyclohexyl-2-dihydro-benzothiazolesulphonamide (CBS), 2,6-di-tert-butyl-4-hydroxytoluene (BHT) and sulphur, which were supplied by Ministry of Agriculture, Livestock and Irrigation, Department of Agriculture, Rubber Research and Development Centre.

Surface Modification

Banana stem was washed with water several times and extracted by hand to obtain banana stem fiber. These fiber were soaked in the mixture of (4% NaOH and 2% Na_2SO_3) solution for 24 h. Treated fibers were rinsed at least ten times with distilled water till neutral pH value was obtained. Fibers were dried under hot sun and then these dried fiber were ground by grinding machine (Figures 1 and 2).

Figure 1 Alkali treated banana stem fiber

Figure 2 Banana stem powder

Characterization of Banana Stem Fiber by Modern Techniques

Prepared untreated and treated banana stem fiber were characterized by FT IR and SEM techniques. Fourier transfer infrared spectroscopy (FT IR) study was carried out to determine changes in the chemical composition of fibers after alkali treatment. Scanning electron microscopy (SEM) was used to study surface topography of untreated and treated banana stem fiber.

Preparation of the Rubber Composites

The formulation of the rubber is given in Table 1. The mixing of the rubber compounds were carried out by using a laboratory two roll open mixing mill at Rubber Research and Development Centre. The nip gap, mill roll speed ratio, time, temperature of mixing, number of passes and sequence of addition of ingredients during mixing were kept under same conditions for all compounds. The amount of fillers (banana stem fiber) were varied in the range of 5-20 % in each composites.

Table 1 Formulation of Rubber Composites

Ingredients	Composition of Ingredients in Natural Rubber-Banana Stem Fiber composites (g)			
Natural rubber (NR)	100	100	100	100
Zinc oxide (ZnO)	5.0	5.0	5.0	5.0
Stearic acid	1.0	1.0	1.0	1.0
N-cyclohexyl-2-benzothiazayl sulphenamide (CBS)	0.5	0.5	0.5	0.5
Sulphur	2.5	2.5	2.5	2.5
2,6-di-tert-butyl-4-hydroxytoluene (BHT)	1.0	1.0	1.0	1.0
banana stem fiber	5	10	15	20

NR-BSF = untreated banana stem fiber with various weight ratio of 5 to 20 g
NR-TBSF = treated banana stem fiber with various weight ratio of 5 to 20 g

Results and Discussion

Characterization of Banana Stem Fibers

Figure 3 illustrates the FT IR results of untreated and treated fibers. As a result of the alkali treatment, the hydroxy groups of the cellulose react with functional group of the coupling agent, which in turn bond to the polymer matrix and thus establish a good fiber/matrix bonding interaction. Decrease in vibration intensity at 2942 cm^{-1} and 1329 cm^{-1} from C-H of alkyl group and shifting of absorption band from 1254 towards 1109 cm^{-1}(treated BSF) indicate that there is a formation of carboxylic acid or ester which may disappear due to removal of hemicellulose and lignin. Figures 4 (a) and (b) show SEM micrographs of untreated and treated banana stem fibers. In treated banana stem fiber image, some microcracks and degradation of microstructure are seen on the surface of fiber due to the treatment with alkali solution.

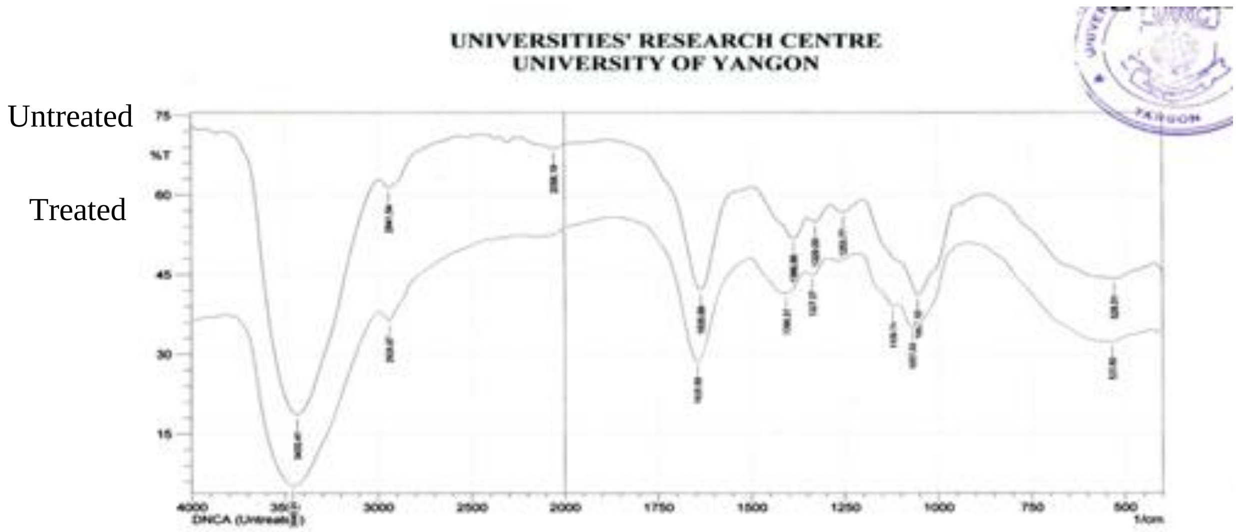
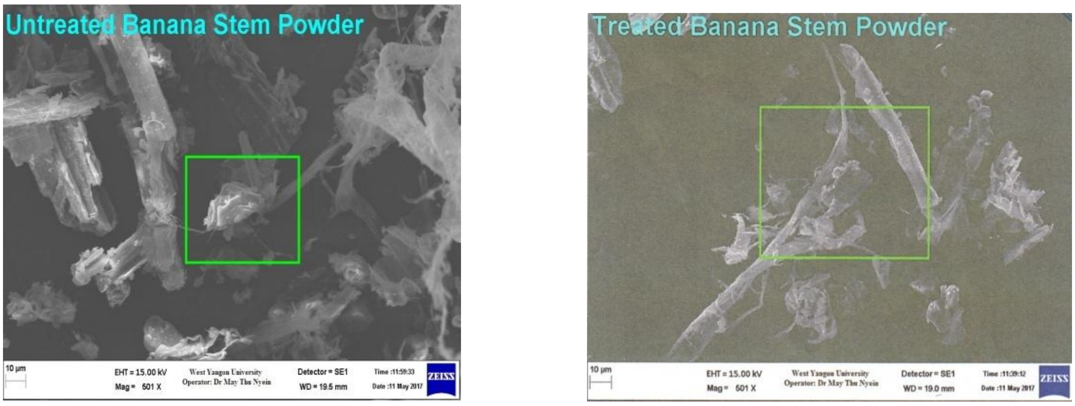


Figure 3 FT IR spectra of untreated banana stem fiber and treated banana stem fiber



(a) (b)

Figure 4 Scanning electron micrographs of (a) untreated banana stem fiber and (b) treated banana stem fiber (501 × magnification)

Mechanical Properties of Natural Rubber-Banana Stem Fiber Composites

The results of mechanical properties are reported here. These include evaluation of hardness, specific gravity, tear strength, elongation at break and tensile strength that has been studied and discussed. Generally it was observed that the 4% NaOH and 2% Na_2SO_3 treated composites have higher values of hardness, specific gravity and elongation at break for various filler percent than untreated composites.

Hardness

Figure 5 shows that the hardness value of natural rubber-untreated banana stem fiber (NR-BSF) and natural rubber-treated banana stem fiber (NR-TBSF) composites. It can be seen that NR-TBSF composites has the higher hardness value than NR-BSF composites. This is due to the alkali treated fibers could have been the result of finer fibers. Moreover, the reduction in porosity (according to SEM) would then lead to an increase in hardness.

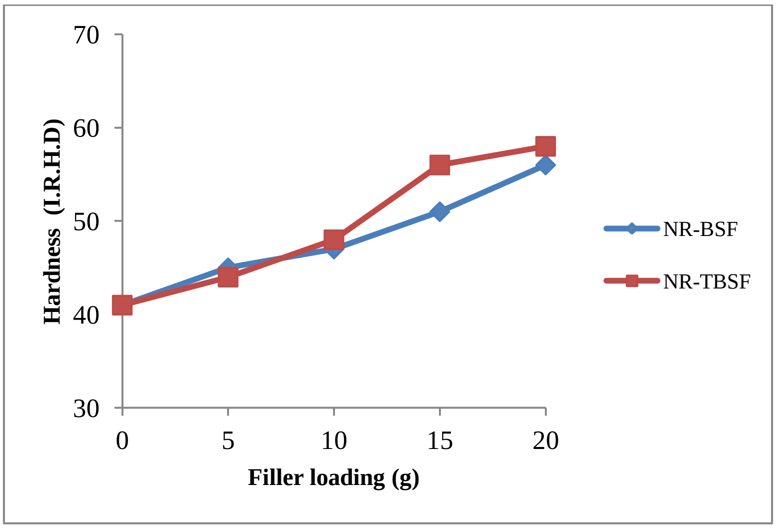


Figure 5 Hardness of the prepared rubber composites Vs various filler (BSF/TBSF) loading

Specific gravity

Figure 6 shows the specific gravity of banana stem fiber reinforced natural rubber composites. When comparing effect of alkali treatment on density of composites made using treated fibers with that of composites made using untreated fibers, an increase in composites density was observed.

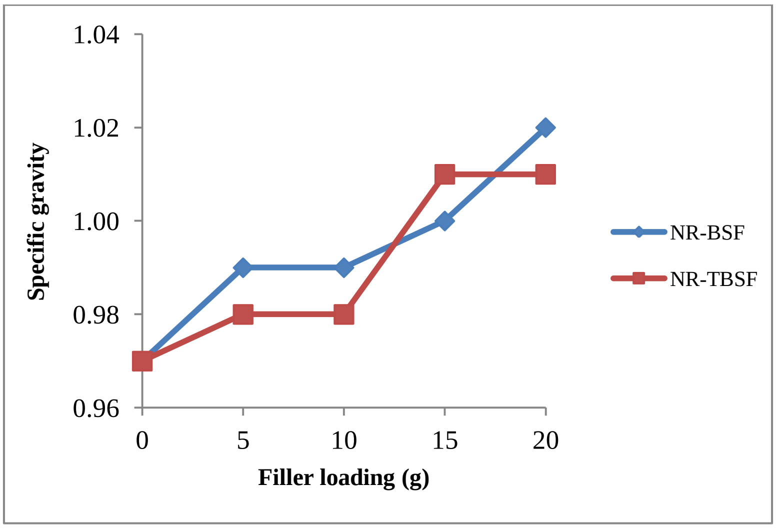


Figure 6 Specific gravity of the prepared rubber composites Vs various filler (BSF/TBSF) loading

Tensile strength

Figure 7 represents the tensile strength of untreated and treated rubber composites. According to Figure 7, ultimate tensile strength at 5 % NR-TBSF composite was 18.30 MPa while that of NR-BSF composite of same filler percent was 18.10 MPa.

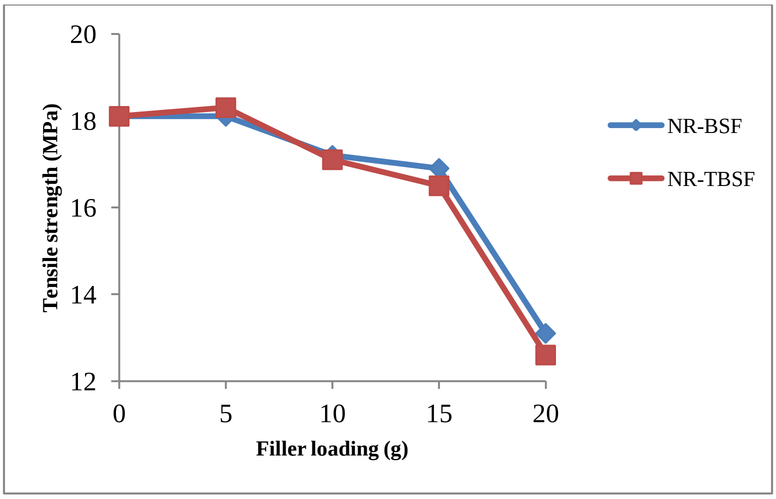


Figure 7 Tensile strength of the prepared rubber composites Vs various filler (BSF/TBSF) loading

Elongation at break

In Figure 8, it could be seen that the elongation at the break of NR-TBSF composites increased with increasing filler loading. Alkali treatment which resulted in removal of hemicellulose and lignin exposed the functional groups present in cellulose in the fibers that would react chemically with the polymer leading to the formation of strong covalent bonds which in turn results in increased mechanical properties.

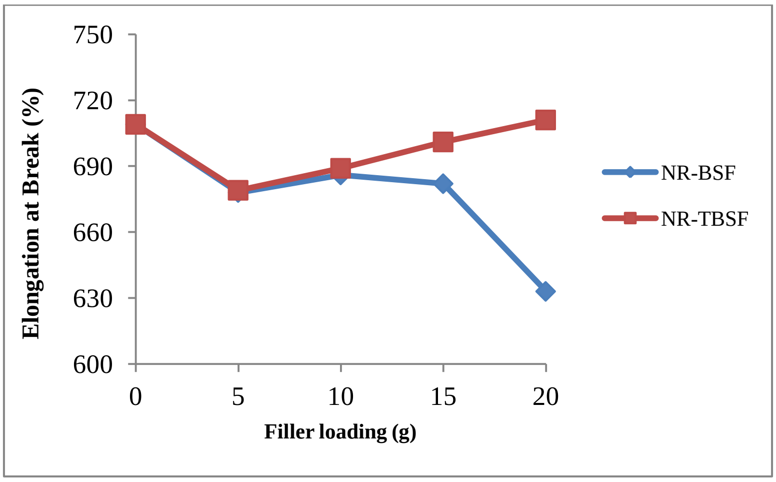


Figure 8 Elongation at break (%) of the prepared rubber composites Vs various filler (BSF/TBSF) loading

Tear strength

According to Figure 9, the tear strength results for NR-TBSF composites decreased with increasing filler loading. On the other hand, the tear strength results for NR-BSF composites were fluctuated.

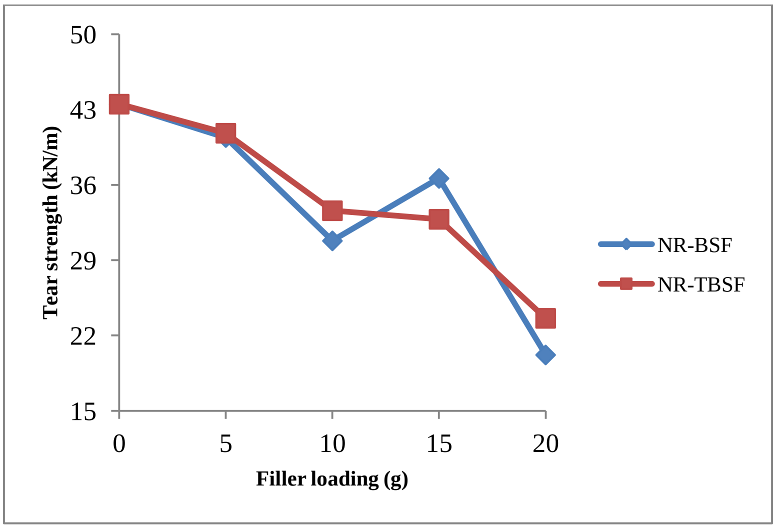


Figure 9 Tear strength of the prepared rubber composites Vs various filler (BSF/TBSF) loading

Conclusion

From the studies reported in this work, SEM micrographs showed removal of unwanted and excess material on the surface of banana fibers, separating the fibers from the fiber bundles. The surface modification by alkali treatment has improved the mechanical properties of treated fiber composites than those of untreated banana stem fiber-natural rubber composites. The alkali treated banana fiber has improved the mechanical properties like hardness, specific gravity and elongation at break. Therefore it is conclusive from the above results that the alkali treatment has provided better mechanical properties. In future various other natural reinforcing materials could be used to mix with banana fiber to form a better hybrid composite which has a better mechanical properties and as well as cost effective.

Acknowledgements

The authors would like to express their profound gratitude to the Department of Higher Education (Yangon Office), Ministry of Education, Yangon, Myanmar, for provision of opportunity to do this research and Myanmar Academy of Arts and Science for allowing to present this paper.

References

Ezema, I. C. and Ravindranatha Mean, A. R. (2014). "Effect of Surface Treatment and Fiber Orientation on the Tensile and Morphological Properties of Banana Stem Fiber Reinforced Natural Rubber Composite". *Journal of Minerals and Materials Characterization and Engineering,* vol.2, pp. 216-222

Mahesh, H., Harika, M. and Shaik, J. (2014). "Comparison of Effects of Alkali Treatment on Flax Reinforced Polyester and Polyester-biopolymer Blend Resins". *Journal of Polymer & Polymer Composites*, vol.23, pp. 229-240

Maleque, M. A., Belal, F. Y. and Sapuan, S. M. (2006). "Mechanical Properties Study of Pseudo-Stem Banana Fiber Resinforced Epoxy Composites". *The Arabian Journal of Science and Engineering*, vol. 32, pp. 359-364

Raghavendra, S., Lingaraju, P.B. and Mukunda, P.G. (2013). "Mechanical Properties of Short Banana Fiber Reinforced Natural Rubber Composites". *International Journal of Innovative Research in Science, Engineering and Technology,* vol. 2(5), pp. 1652-1655

Sonu, E. (2014). "Mechanical and Damping Properties of Rubber Reinforced with Natural Fiber". *The International Journal Engineering and Science*., vol.3(5), pp. 17-24