**International Journal of Materials Engineering and Technology**

Published Online: May 2014
Available online at http://pphmj.com/journals/ijmet.htm
Volume 11, Number 2, 2014, Pages 101-111

# REVIEW ON UREMIA LOBATA FIBRE REINFORCED POLYMER COMPOSITES

**E. N. Ikezue and O. D. Onukwuli**

Chemical Engineering Department
Anambra State University
P.M.B 02, Uli, Nigeria
e-mail: eddikezue@yahoo.com

## Abstract

The global demand for wood as a building material is steadily growing, while the availability of this natural resource is diminishing. This situation has led to the development of alternative materials. Of the various synthetic materials that have been explored and advocated, polymer composites claim a major participation as building materials. There has been a growing interest in utilizing natural fibres as reinforcement in polymer composite for making low cost construction materials in recent years. Natural fibres are prospective reinforcing materials and their use until now has been more traditional than technical. They have long served many useful purposes but the application of the material technology for the utilization of natural fibres as reinforcement in polymer matrix took place in comparatively recent years. Economic and other related factors in many developing countries where natural fibres are abundant, demand that scientists and engineers apply appropriate technology to utilize these natural fibres as effectively and economically as possible to produce good quality fibre reinforced polymer composites for housing and other needs. Among the various natural fibres, uremia lobata is of particular interest in that its composites have high impact strength besides having moderate tensile and flexural properties compared to other

Received: April 23, 2013; Accepted: October 9, 2013

Keywords and phrases: uremia lobata fibre, polymer composites, structure, properties.

lignocellulosic fibres. The present paper surveys the research work published in the field of uremia lobata fibre reinforced polymer composites with special reference to the structure and properties of uremia lobata fibre, processing techniques, and the physical and mechanical properties of the composites. The results of the mechanical properties determination show the maximum tensile strength to be 30.3229N/mm$^2$ and optimum fibre volume fraction to be 32.18% and optimum fibre length to be 50mm and flexural strength to be 18.3799N/mm$^2$.

## Introduction

In our everyday life, timber plays a significant role. However, timber resources are getting depleted continuously while the demand for the material is ever increasing. According to the literature, by the beginning of the next century, the wood will be scarce for the whole world. This situation has led to the development of alternative materials. Among the various synthetic materials that have been explored and advocated, plastics claim a major share as wood substitutes. Plastics are used for almost everything from the articles of daily use to the components of complicated engineering structures and heavy industrial applications. Plastics find an extensive application in buildings as flooring material because they are resistant to abrasion, have a low heat conductivity and low water absorption, sufficient hardness and strength. They fail to swell when moistened, readily take on varnishes and paints. Hardware items like door and window frames, flushing cisterns, overhead water storage tanks and water fittings are commercially available and are finding acceptance in the building industry. Plastics are used to manufacture various sanitary wares, which include wash basins, bathtubs, sinks, shower cabins, washing racks and others. Plastic pipes are widely used in the installation of various industrial purposes, water supply, etc.

However, during the last decade, the study of filled plastic composites has simulated immense interest in meeting the future shortage of plastic materials. In fact, synthetic fibres such as nylon, rayon, aramid, glass, polyester and carbon are extensively used for the reinforcement of plastics

(Erich et al. [12]). Nevertheless, these materials are expensive and are non-renewable resources. Because of the uncertainties prevailing in the supply and price of petroleum based products, there is very need to use the naturally occurring alternatives. In many parts of the world, besides the agricultural purposes, different parts of plants and fruits of many crops have been found to be viable sources of raw material for industrial purpose. In recent years, polymer composites containing vegetable fibres have received considerable attention both in the literature and in industry. The interest in natural fibre reinforced polymer composites is growing rapidly due to the high performance in mechanical properties, significant processing advantages, low cost and low density. Natural fibres are renewable resources in many developing countries of the world; they are cheaper, pose no health hazards and, finally, provide a solution to environmental pollution by finding new uses for waste materials. Furthermore, natural fibre reinforced polymer composites form a new class of materials which seem to have good potential in the future as a substitute for scarce wood and wood based materials in structural applications.

Fibres obtained from the various parts of the plants are known as vegetable fibres. These fibres are classified into three categories depending on the part of the plant from which they are extracted:

1. Bast or stem fibres (jute, mesta, banana, etc.).
2. Leaf fibres (sisal, pineapple, screw pine, etc.).
3. Fruit fibres (cotton, coir, oil palm, etc).

Many of the plant fibres such as coir, sisal, jute, banana, palmyra, pineapple, talipot, hemp, etc. find applications and resource for industrial materials. Table 1 presents properties of some plant fibres. Properties of plant fibres depend mainly on the nature of the plant, locality in which it is grove age of the plant, and the extraction method used. For example, coir as a hard and tough multicellular fibre with a central port called “*lacuna*”. Uremia lobata is an important stem fibre and is very stronger. Pineapple leaf fibre is soft and has high cellulose content. The palm fibres are hard and tough, and show similarity to coir fibre in cellular structure. The elementary unit of a cellulose macromolecule is anhydro-d-glucose, which contains the alcohol hydroxyls (-OH) (Bledzki et al. [5]). These hydroxyls form hydrogen bonds inside the macromolecule its (intramolecular) and between other cellulose macromolecule (intermolecular) as well as with hydroxyl groups from the others. Therefore, all plant fibres are of a hydrophilic nature; the moisture content reaches 8-13%.

In addition to cellulose, plant fibres contain different natural substances. The most important of them is lignin. The distinguished cells of hard plant fibres are bounded together by lignin, actually as a cementing material. The lignin content of plant fibre influences its structure, properties and morphology. An important characteristic of vegetable fibre is their degree polymerization (DP). The cellulose molecules of each fibre differ in their DP and consequently, the fibre is a complex mixture polymer homologue $(C_6H_{10}O_5)_n$. Bast fibres commonly show highest DP among all the plant fibres (~10,000). Traditionally, these fibres have been used for making twines, ropes, coir as packaging material in sacks and gunny bags, as carpet-back and more recently, as a geotextile material.

**Table 1.** Properties of some natural fibres

| Fibre type | Diameter (μm) | Density (g cm$^{-3}$) | Cellulose (%) | Lignin (%) | *l*/*d* ratio* | Cell wall thickness (μm) | Microfibrillan angle (deg) |
|---|---|---|---|---|---|---|---|
| Sisal | 100-300 | 1.450 | 70 | 12 | 100 | 12.5 | 20-25 |
| Banana | 50-250 | 1.350 | 83 | 5 | 150 | 1.25 | 11-12 |
| Coir | 100-450 | 1.150 | 37 | 42 | 35 | 8.00 | 30.45 |

*Cell length (*l*)/Cell breadth (*d*) ratio

Vegetable fibres can be considered as naturally occurring composites consisting mainly of cellulose fibrils embedded in lignin matrix. These cellulose fibrils are aligned along the length of the fibre, irrespective of its origin, i.e., whether it is extracted from stem, leaf or fruit. It appears that such an alignment renders maximum tensile and flexural strengths, in addition to providing rigidity in that direction of the fibre as observed in the case of bamboo. Further, these fibres exhibit high electrical resistance in addition to being thermally and acoustically insulating. It can therefore be expected that when these fibres are incorporated in low modulus polymer matrices, they would yield materials with better properties suitable for various applications.

Since vegetable fibres are strong, light in weight, abundant, non-abrasive, non-hazardous and inexpensive, they can serve as an excellent reinforcing agent for plastics. Several cellulosic products and wastes such as shell flour, wood flour and pulp have been used as fillers in polymer, primarily to achieve cost savings and also to impart some desirable properties like decreasing shrinkage after molding, increasing elastic modulus and creep resistance, Kokta [28]. Cotton-polymer composites are reported to be the first fibre reinforced plastics used by the military for radar aircraft. However, over the past decade, cellulosic fillers of a fibrous nature have been of greater interest as they would give composites with improved mechanical properties compared to those containing non-fibrous fillers, Joseph et al. [17, 18] and Carvalho [6]. Vegetable fibres possess moderately high specific strength and stiffness and can be used as reinforcing materials in polymeric resin matrices to make useful structural composite materials.

Lignocellulosic fibres like jute, sisal, coir and pineapple have been used as reinforcements in polymer matrices. Among these fibres, uremia lobata is of particular interest in that its composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. However, a large quantity of this renewable resource is being under-utilized. Uremia lobata fibre is mainly used for the manufacture of ropes for use in marine industry and agriculture, for making twines, cords, padding, mat making, fishing nets, fancy articles such as purses, wall hanging, table mats, etc. The use of uremia lobata fibre as a textile fibre by mankind began with Weindling's work during forties.

## Materials and Method

Stem-length *uremia lobata* (abari) fibres separated from the bark of *uremia lobata* plant by retting in water for 21 days were obtained from the Centre for Composite Research and Development (CCRD), JuNeng Nigeria

Limited, Nsukka, Nigeria. The bast fibres were conditioned at an ambient temperature of 28°C and a relative humidity of 50% until an equilibrium moisture content (EMC) of 8% was obtained. The stem-length fibres were macerated to obtain single fibres for property characterization. Hydrogen peroxide $(H_2O_2)$ was used to macerate the kenaf fibre bundles. The average length of the fibre is approximately 750-1000mm.

**Result and Discussion**

The use of uremia lobata fibre as reinforcing agent in polymer base composites was reviewed from viewpoints of status and future expectations of natural fibres in general, structure and property of uremia lobata fibre, surface modifications, and physical and mechanical properties of uremia lobata fibre based polymer composite. Uremia lobata fibres have good potential as reinforcements in polymer (thermoplastics, thermosets and rubbers) composites. Due to the low density and high specific properties of uremia lobata fibre composites based on these fibres may have good implications in the automotive and transportation industry. Moreover, reduced equipment abrasion and subsequent reduction of re-tooling costs will make these composites more attracting. The use of uremia lobata fibres as a source of raw material in plant industry not only provides a renewable resource, but coir also generates a non-food source of economic development farming and rural areas. Since Nigeria is the one of the largest uremia lobata fibre producing countries in the world, uremia lobata fibre reinforced polymer composites and the subsequent applications would be very attractive from the economic point of view. From the above descriptions, it became quite evident that newer composites using abundantly available uremia lobata fibres are on the horizon, this brings new trends in composite materials. It is worth mentioning that these composites can be used as a substitute for wood. However, suitable cost-effective design and fabrication techniques for manufacture should be developed. Uremia lobata be developed and characterized so as to arrive at a series of composites which may find use in several areas such as marine, structural consumer articles and industrial applications. Thus, it can be concluded that with systematic and persistent research, there will be a good scope and better future for uremia lobata fibre-polymer composites in the coming years. From Figure 1, we could observe that the maximum tensile strength was 30.3229N/mm$^2$ for optimum fibre volume fraction of 32.18% and optimum fibre length of 50mm. The maximum flexural strength is seen to be 18.3799N/mm$^2$ for optimum fibre volume fraction of 50% and optimum fibre length of 10mm (Figure 2). This shows an improvement over unreinforced polyester polymer matrix. Figure 3 shows the creep variation for each fibre volume fraction and fibre length.

Optimum fibre length = 50.0000mm (this is a local optimal)

Optimum fibre volume fraction = 32.1795% (this is a global optimal)

Maximum tensile strength = 30.3229 (probable actual value of maximum possible tensile strength = 32.0098)

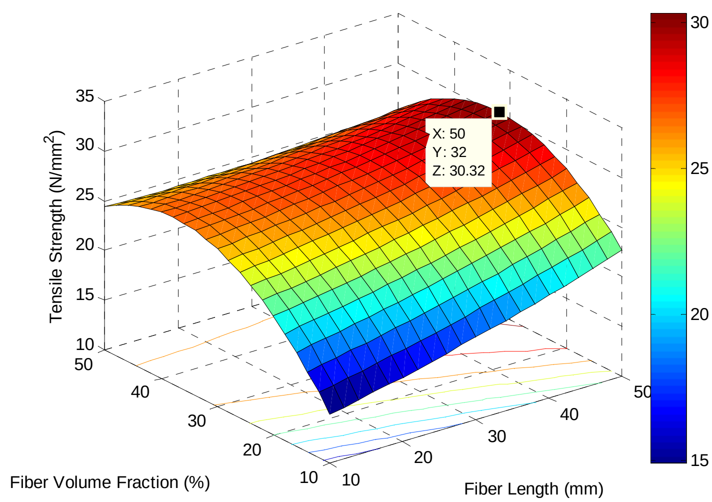


**Figure 1.** Tensile strength variation with fibre volume fraction and fibre length.

Optimum fibre length = 10mm (Local optimum)

Optimum fibre volume fraction = 50% (Local optimum)

Maximum flexural strength = 18.3799

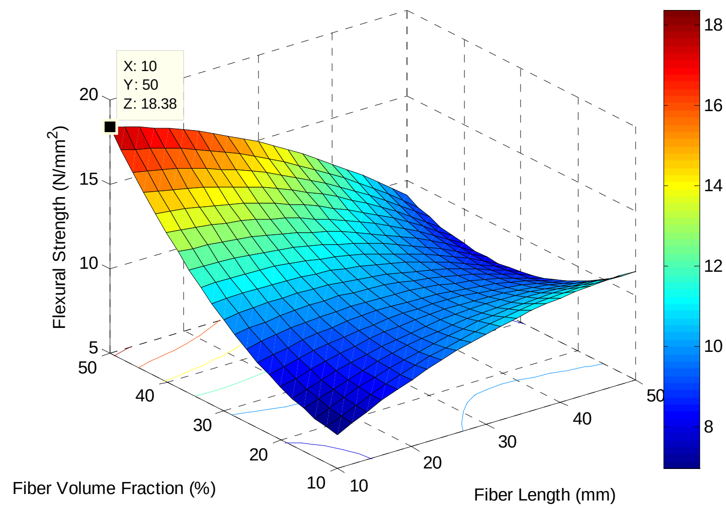


**Figure 2.** Flexural strength variation with fibre volume fraction and fibre length.

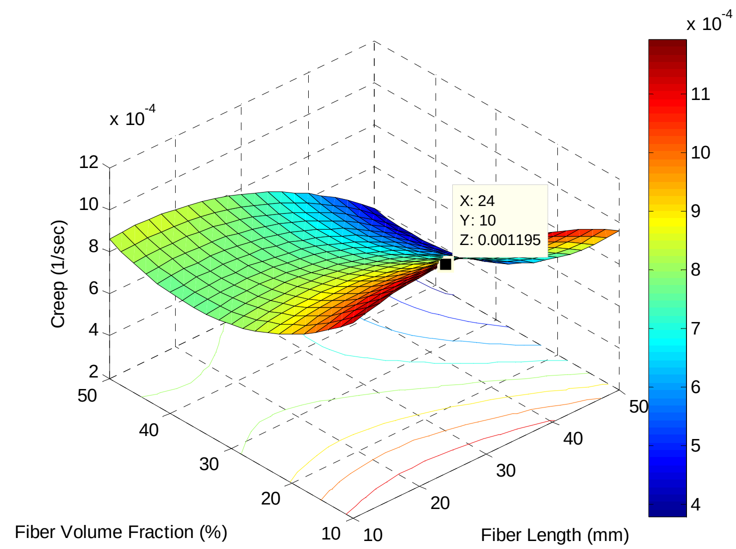


**Figure 3.** Creep variation with fibre volume fraction and fibre length.

## References

[1] S. L. Bai, C. M. L. Wu, Y. W. Mai, H. M. Zeng and R. K. Y. Li, Failure mechanisms of sisal fibres in composites, Advanced Composites Letters 8(1) (1999), 13-17.

[2] B. C. Barkakaty, Some structural aspects of sisal fibres, Journal of Applied Polymer Science 20 (1976), 2921-2940.

[3] S. S. Bhagavan, D. K. Tripathy and S. K. De, Stress relaxation in short jute fibre-reinforced nitrile rubber composites, Journal of Applied Polymer Science 33 (1987), 1623-1634.

[4] E. T. N. Bisanda and M. P. Ansell, The effect of silane treatment on the mechanical and physical properties of sisal-epoxy composites, Composites Science and Technology 41 (1991), 165-178.

[5] A. K. Bledzki, S. Reihmane and J. Gassan, Properties and modification methods for vegetable fibres for natural fibre composites, Journal of Applied Polymer Science 29 (1996), 1329-1336.

[6] L. H. Carvalho, Chemical modification of fibres for plastics reinforcement in composites, Lignocellulosic-plastics Composites, A. L. Leao, F. X. Carvalho and E. Frollini, eds., USP and UNESP, Sao Paulo, 1997, pp. 197-222.

[7] N. Chand and S. K. Joshi, Effect of gamma-irradiation on dc conductivity of sisal fibres, Research and Industry 40(2) (1995), 121-123.

[8] A. Y. Coran, K. Boustany and P. Hamed, Rubber chemistry and technology, Akron 47 (1974), 396.

[9] B. Dahlke, H. Larbig, H. D. Scherzer and R. Poltrock, Natural fibre reinforced foams based on renewable resources for automotive interior applications, Journal of Cellular Plastics 34(4) (1998), 361.

[10] J. M. Dinwoodie, Timber - its Nature and Behaviour, van Nostrand Reinhold Company, New York, 1981.

[11] H. G. M. Edwards, D. W. Farwell and D. Webster, FT Raman microcopy of untreated natural plant fibres, Spectrochemica Acta Part A - Molecular and Biomolecular Spectroscopy 53(13) (1997), 2383-2392.

[12] F. Erich, G. Antonios and H. Michel, Carbon fibres and their composites, High Temperatures and High Pressures 16 (1984), 363-392.

[13] V. G. Geethamma, J. Reethamma and S. Thomas, Short coir fibre reinforced natural rubber composites: effect fibre length, orientation and alkali treatment, Journal of Applied Polymer Science 55 (1990), 583-594.

[14] H. E. Gram, Durability of natural fibres in concrete, Swedish Cement and Concrete Research Institute 1(83) (1983), 2.

[15] M. Gupta, A. Verma and B. Singh, A note on the investigation of fibre-matrix adhesion in sisal fibre-polyester composite, Current Science 74(6) (1998), 526-529.

[16] K. Joseph, S. Thomas and C. Pavithran, Viscoelastic properties of short sisal fibre filled low density polyethylene composites: effect of fibre length and orientation, Materials Letters 15 (1992), 224-228.

[17] K. Joseph, S. Thomas and C. Pavithran, Tensile properties of short sisal fibre reinforced polyethylene composite, Journal of Applied Polymer Science 47 (1993a), 17.

[18] K. Joseph, S. Thomas and C. Pavithran, Dynamic mechanical properties of short sisal fibre reinforced low density polyethylene composites, Journal of Reinforced Plastics and Composites 12 (1993b), 139.

[19] K. Joseph, C. Pavithran, S. Thomas and C. K. Baby Premalatha, Melt rheological behaviour of short sisal fibre reinforced polyethylene composites, Plastic Rubber and Composites Processing and Application 21 (1994), 237.

[20] K. Joseph, S. Thomas and C. Pavithran, Sisal fibre reinforced polyethylene composites: effect of isocyan treatment, SB Academic Review 6 (1995a), 6.

[21] K. Joseph, S. Thomas and C. Pavithran, Effect of age on the physical and mechanical properties of sisal fibre reinforced polyethylene composites, Composites Science and Technology 53 (1995b), p. 53, p. 99.

[22] K. Joseph, S. Thomas and C. Pavithran, Influence interfacial addition on the mechanical properties and fraction behaviour of short sisal fibre reinforced polymer composite, European Polymer Journal 32 (1996a), 10.

[23] K. Joseph, S. Thomas and C. Pavithran, Effect of surface treatments on the tensile properties of short sisal fibre-LD composites, Polymer 37 (1996b), 23.

[24] P. V. Joseph, K. Joseph and S. Thomas, The effect of process variables on the physical and mechanical properties of short sisal fibre reinforced polypropylene composites, Composite Science and Technology (1999), in press.

[25] G. Kalaprasad, K. Joseph and S. Thomas, Theoretical modeling of tensile properties of short sisal fibre reinforced low-density polyethylene composites, Journal of Material Science 32 (1997a), 4261.

[26] G. Kalaprasad, K. Joseph and S. Thomas, Influence of short glass fibre addition on the mechanical properties, Journal of Composite Materials 31 (1997), 5.

[27] S. K. Kallapur, Fibre reinforced natural rubber composite physical and mechanical properties, Bark and Leaf Fibre of India, KVIC, Bombay, 1962.

[28] B. V. Kokta, Use of wood fibres in thermoplastic composite, Polymer News 13 (1988), 331-339.