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Mechanical and Wear Characterization of Nano Based Calotropis Gigantea Fiber Reinforced Polyester Composites

K. Bintu Sumanth, G Dilli Babu, S Satish Kumar

Abstract**:** ***The growing interest on development of biodegradable materials led to growing concern about bio-based composite materials among the bio fibers applications one of the lightweight materials. Very minor research work is available in the mechanical characterization of CGF composites. In this paper the mechanical properties like tensile strength, flexural strength, impact strength and hardness of the CGF reinforced polymer composites were investigated. Also the impact of naturally modified montmorillonite (MMT).Nano clay on mechanical properties of the CGF composites was studied. The maximum volume fraction of the Specimens is 35%. The results demonstrate that the properties of nano-based CGF composites are better than the non-nano based composites. Tri-biological behavior of the CGF composites also studies and observed that nano CGF composites are having good wear characterization***

Index Terms**:** ***Calotropis Gigantea fibers (CGF), polyester resin, Nano clay (MMT), Mechanical Properties.***

I. INTRODUCTION

The curiosity in green Fiber Reinforced Polymer (FRP) composites is increasing both in terms of needed research and engineering applications. Bio-fibers have become attractive to researchers as substitute material for FRP composites. In this study a new fiber from CGF plant is identified and extracted to study the mechanical and wear characterization. CGF (Madar plant) could be an average sized ligneous plant or tiny plant that rises up to 4 meter. CGF generally known as Madar in English and Arka in Sanskrit has been guaranteed in writing to be important against a wide assortment of illnesses [1-3].

Some of the literatures in the area of natural fiber reinforced composites are presented here. Venkateshwaran et al. studied the mechanical and water assimilation behavior of hybrid natural FRP composites to improve the mechanical characteristics. [4]. Ravi et al. developed Coconut & Banana fiber reinforced polypropylene (PP) Hybrid composites by using injection molding machine and their mechanical properties were studied, here the properties are improved and achieve the previous range of mechanical properties [5]. Srivasthava et al. studied the tri-biological characteristics of natural fiber composites [6].Ahmadi. H et al. studied the tensile properties of plain and Nano clay reinforced syntactic foams [7].

There are many new fiber inventions such as like hibiscus Cannabinus fiber [8], Abaca fiber [9], Borassus Seed Shoot fiber [10] and fish tail palm tree fiber [11]. Biodegradable resins and advanced green composites are also developed in the current years. The composites made up of renewable soy protein based resins and high strength liquid crystalline cellulose fibers [12] and jute reinforced biodegradable Nano-bio composite using soy milk as matrix and Nano clay as additive [13] are recently invented and their properties were studied. Marina et al. studied the characterization of Green Coconut Fiber Composites [14].

In this work a new bio-fiber based Nano composites were fabricated with the help of hand lay-up technique. The mechanical properties and wear characteristics of these composites were studied.

II. MATERIAL AND METHODS

2. 1 Extraction of Fiber

The extractions of CGF (madar) were done by soaking or waterlogging, retting and remove the outer bark. CGF plant and extracted fiber were shown in figure.1. Another process for extracting the CGF is soaking at hot water and subjecting to D5 enzymes treatment.

The matrix material used for composite specimen's fabrication was polyester resin. The nano-clay used was naturally modified montmorillonite (MMT). Specimens are prepared by adding an amount of 2% and 4% MMT nano-clay.

Figure 1. Calotropis Gigantea plant (CGF) and extracted fiber

2.2 Fabrication

Nano-clay was thoroughly mixed with the polyester matrix by using Sonicator for nearly 60 min. Hand lay-up technique was utilized for fabrication of composites. The volume fraction of the fiber was varied by 5%, 15%, 25% and 35% in the composite specimens.

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***Correspondence Author(s)**
G Dilli Babu, Department of Mechanical Engineering, V R Siddhartha Engg. College, Vijayawada, Andhra Pradesh, India.
K. Bintu Sumanth, Department of Mechanical Engineering, V R Siddhartha Engg. College, Vijayawada, Andhra Pradesh, India.
S.Satish Kumar, Department of Mechanical Engineering, V R Siddhartha Engg. College, Vijayawada, Andhra Pradesh, India.

2.3 Testing of composites

Tensile test specimens were prepared as per ASTM D 638M standards and flexural test specimens were prepared as per ASTM D 790 M standards. Five identical samples were tested for every volume fraction of the fibers. The tensile and flexural strengths were tested by using at Tensometer.

Izod impact test specimens were prepared as per ASTM D 256 M standards. A sharp record with a point of 45˚ was drawn over the focal point of the saw slice at 90˚ to the specimen pivot to acquire a steady starter crack.

The wear is conducted on DUCOM; TL-20 Tribometer. Wear is evaluated by measuring the wear groove with a profilometer and measured the measure of material expelled.

A durometer tester is used for determining the hardness of the composite specimens. The depth of the indentation mirrors the hardness of the material.

III. RESULTS AND DISCUSSIONS

3.1.Experimental results and discussion

Tensile strength and tensile modulus of CGF polymer composites with and without addition nano-clay is presented in the figure 2 and 3. From figure it is very clear that the tensile properties are increasing with increase of volume fraction of the fibers in the composites. The graph also shows that the enhancement of tensile property by addition of nano-clay. At 35% volume fraction of fiber, the tensile strength of nano-clay based composite specimens was 93.5Mpa which is 30% more than that of without nano-clay composite specimens.

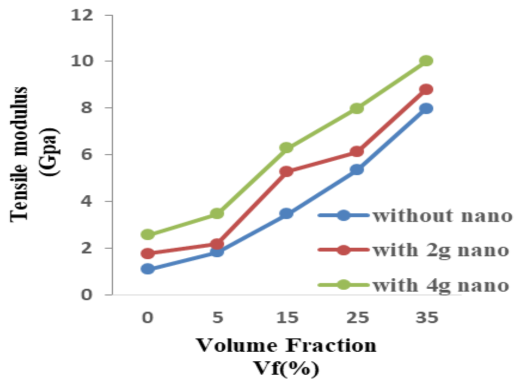

Figure: 2. Tensile strength of CGF composites

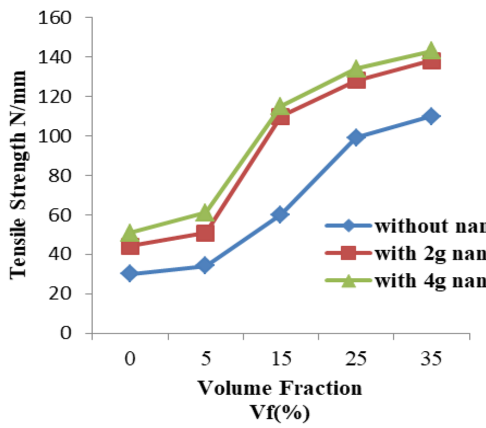

Figure: 3. Tensile modulus of CGF composites

The flexural strength and flexural modulus of CGF polymer composites with and without addition of nano-clay is presented in the figures 4 and 5. The flexural properties also increasing by increase the volume fraction of the fibers in the composites. At maximum volume fraction fiber (35%) with addition of nano-clay composites are having 40% higher flexural strength when compared with without nano-clay composites.

Impact strength with respect to percentage of volume fraction of fiber is shown in the figure 6. It is observed that the impact strength of CGF fiber composites increases linearly against volume fraction of the fiber. The impact strength of nano-clay composites shows 50% higher strength than the without nano-clay composites.

Density at different volume fractions of CGF composite made with and without Nano clay is shown in figure 7. The density of composites decreases with addition fibers in the composites. It indicates that CGF composites can be used in the light weight applications like partitions, automobile interior and exterior body parts.

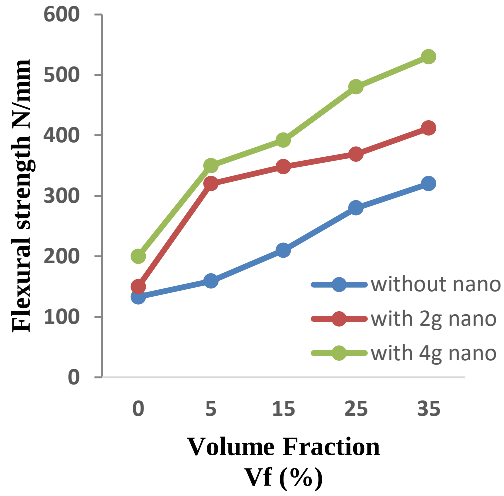

Figure: 4. Flexural strength CGF composites

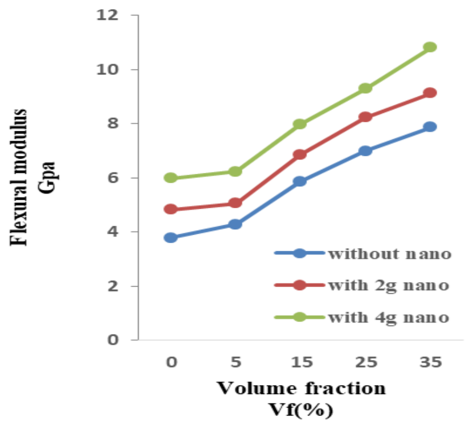

Figure: 5. Flexural modulus of CGF composites

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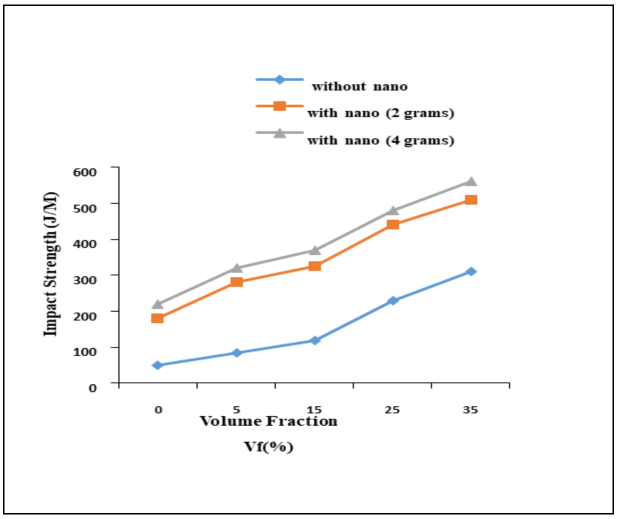

Figure: 6. Impact strength of CGF /polyester composites

3.5 Density of fiber composite

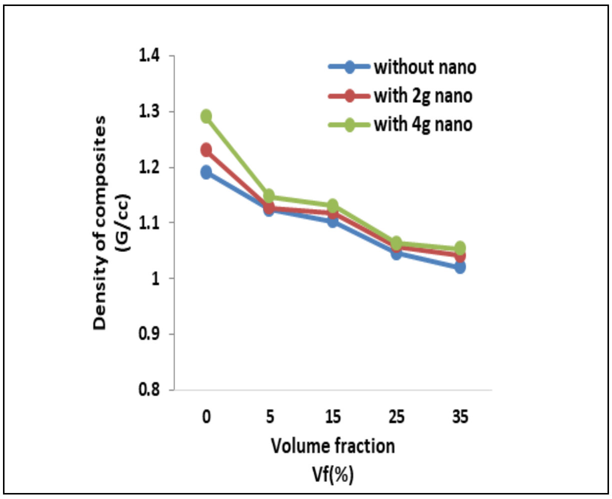

Figure: 7. Density of CGF Composites with and Without Nano Clay.

3.6 Wear Test

The wear characteristic is measured utilizing Tribometer (DUCOM; TL-20). The unit comprises of a gimballed arm to which the stick is connected. An apparatus which suits plates up to 150 mm in measurement and 10 mm thick, an electronic sensor for measuring the erosion constrain. The range of disc speed available is 0-8000 rpm.

Sliding velocity of 100cycles/min, 200cycles/min and 300cycles/min is used for study the wear rate. Specimens were tested with consistent load that is 20N. Machine is permitted to keep running for 5 min per specimen. Figure 8 and 9 shows wear rate graphs with respect to volume fraction of fibers for with and without addition of nano-clay. From graphs it is clear that the wear rates are increasing with increase of volume fraction of fibers in the composites. The mean co-efficient of friction between disc and specimen was 0.4.

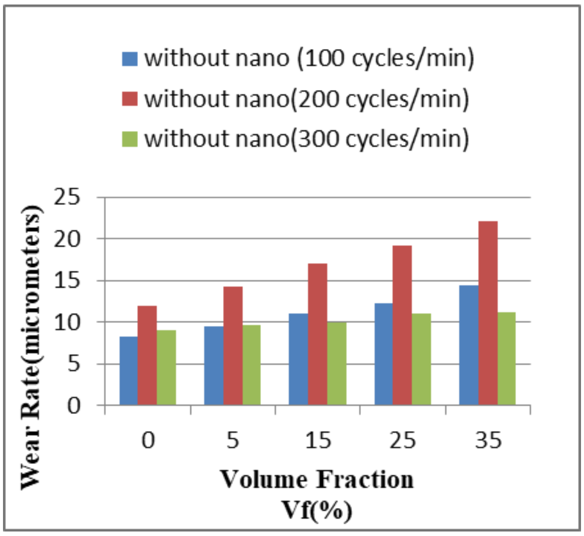

Figure: 8. Wear rate of CGF reinforced composites without addition of Nano-clay

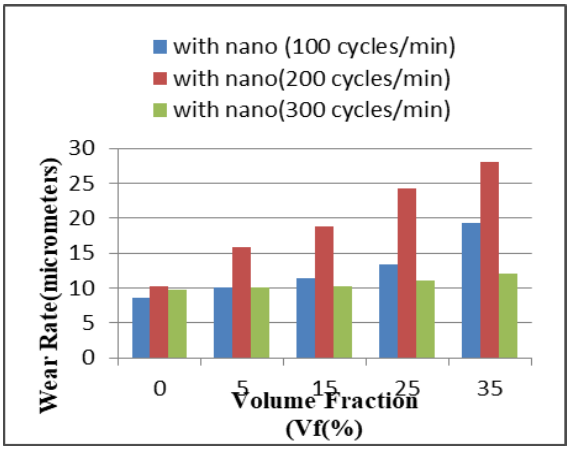

Figure: 9. Wear rate of CGF reinforced composites with addition of Nano-clay

3.7 Hardness Test

Micro hardness is measured by using Knoop hardness test (HK) instrument. The hardness verses volume fraction of the fibers I the composites is shown in the figure 10. CGF composite hardness values are increasing by addition of fibers in the composites. Nano clay mixing improves the hardness of the CGF composites. The maximum hardness value obtained for CGF based composites was 9.9 Hd. The maximum hardness value obtained for CGF nano-clay based composites was 13.9 Hd.

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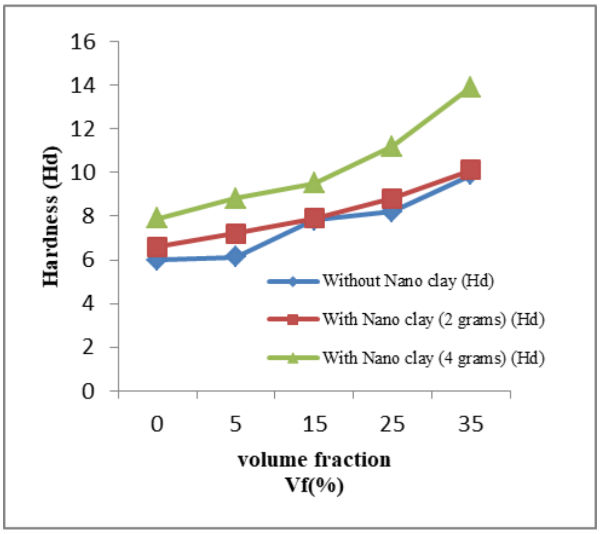

Figure: 10 Comparison of hardness between with and without nano clay

IV. CONCLUSIONS

1. The tensile strength, tensile modulus of nano clay filled CGF composites are by 30% and 25.35% more than those of without nano-clay CGF composites, respectively at 35% volume fraction of fiber.
2. The mean flexural strength, flexural modulus of nano clay filled CGF composites are by 65% and 37.57% more than those of without nano-clay CGF composites, respectively at 35% volume fraction of fiber.
3. The Impact strength of nano-clay CGF composites are 50% more than those of without nano-clay CGF composites at 35% volume fraction of fiber.
4. Low density of CGF composites shows an attractive parameter in designing light weight material.
5. Subjecting to the wear test the CGF reinforced polyester composites are light in weight, have the better wear characteristics.
6. The hardness of the CGF composites is increasing with respect to the increase of volume fraction of fibers. Addition of nano clay improves the hardness by 35% than without addition of nano clay.

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AUTHORS PROFILE

Mr. K. Bintu Sumanth completed his Master's degree from J N T University, Kakinada, in the area of Natural Fiber Reinforced composites characterization. Area of research interest is green fiber composites characterization, Nano composites, Advance materials etc.

Dr. G DIlli Babu completed a Doctorial degree from J N T University, Anantapur, in the area of Composite Machining. He published more than 20 research papers in the reputed journals and conferences. Area of research interest is natural fiber composites characterization, Machining of composites, Nanomaterials, etc. Currently working as Associate Professor in the Department of Mechanical Engineering, V R Siddhartha Engineering College, Vijayawada

Mr. S. Satish Kumar completed his Master's degree from J N T University, Kakinada, in the area of Natural Fiber Reinforced composites characterization. Area of research interest is green fiber composites characterization, Nano composites, Advance materials etc.

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