International Journal of Integrated Sciences and Mathematics
Vol: 02; **Issue**: 01; **pg**: 001-005

A Case Study: Assessment of Characterization and Development of Polymer Composites Reinforced with Natural Fibres

V Ramesh[1*], Dr. Harber Singh[2]
[1] Research Scholar, Department of Chemistry, Glocal University, Saharanpur, Uttar Pradesh, India
[2] Assistant Professor, Department of Chemistry, Glocal University, Saharanpur, Uttar Pradesh, India

ABSTRACT

Polymer composites that are composed of synthetic resources are toxic and non-biodegradable. Additionally, they contain petroleum-grounded resources, which are greatly detrimental to both humans and the environment. The aim of the study is to assess the characterization and development of polymer composites reinforced with natural fibers. Chemical and thermal characterization (FTIR spectroscopy, XRD analysis, and TGA) were conducted, along with physical aspects (density, vacancy %, and moisture absorption behaviour). The actual density of the bio-Composite and hybrid composites that were developed was assessed utilising the Archimedes principle-grounded water immersion method. After water immersion, the jute/hemp/epoxy composites. exhibited a glass transition temperature of 76.2 0C, which is the fourth greatest value were made. The jute/hemp/flax/epoxy hybrid composites that was water-saturated attained the lowest value of tan δ (0.401). The mechanical properties of the majority of Natural fibers are satisfactory; however, they are inferior to those of synthetic fibres. Natural fibres, including flax, hemp, jute, has great specific strength and rigidity.
Keywords: *Birth rates, antioxidant, enzymes, oocytes, quality.*

INTRODUCTION

Composite materials are composed of two or more constituents that are wholly insoluble in each other and possess unique physical aspects and chemical compositions [1] possess such combinations of aspects [2]. The two primary components of composite material are the matrix, which is the continuous phase, and the reinforcement, which is the discontinuous phase. The selection of the fibre and matrix proportion is a critical component of the composite material processing procedure [3]. Composite materials with aspects that are distinct from those of their individual constituents should have a proportion of each constituent that is greater than 5% [4]. The matrix surrounds the fibre phase to deliver the correct shape and size to the developed composite material, while the reinforcement has a greater strength than the matrix, which delivers reinforcing to the material [5]. In recent years, there has been a surge in the interest of researchers in the field of composite material development and characterization [6]. In an effort to boost the performance capabilities of the composite material that has been developed, efforts are made to combine numerous fibres with the matrix and to hybridise the fibres [7].

Polymer composites are frequently employed owing to their substantial attributes, including their low weight (wt.) and great specific strength. A polymer composite material is formed by impregnating fibres with a polymer matrix (poly-mat), which forms a bond across them [8]. The matrix material for polymer composite can be either thermoset polymer (e.g., epoxy, polyester) or thermoplastic polymer (e.g., poly-lactic acid, polyvinyl alcohol) [9]. Biodegradable ploy-mat and synthetic ploy-mat are also subcategories of ploy-mat. Natural fibres that are reinforced with a synthetic ploy-mat are referred to as partially biodegradable polymer composite, while those that are reinforced with biodegradable polymer are referred to as fully biodegradable polymer composite [10].

Email ✉: vr8593407@gmail.com

Natural fibre reinforced composites are produced by reinforcing natural fibers with a ploy-mat. Depending on the specific needs, plant fibres can be reinforced with either a thermoset or thermoplastic ploy-mat [11]. The incorporation of plant fibres into a ploy-mat can take on numerous forms, like cut fibres, uni-directional fibres, mats, bi-directional woven mats, and arbitrarily oriented mats. Natural fibres are excerpted from numerous natural resources, including plants, animals, and minerals [12]. Wood fibres (soft and hard woods) and non-wood fibres, like straw fibres (rice, wheat, maize, etc.), seed fibres (cotton, coconut, etc.), leaf fibres (sisal, pineapple, etc.), and grass fibres (bamboo, elephant grass), are the four categories into which Natural fibers can be divided. The formation of bio- composites s is facilitated by the utilisation of a thermoset matrix (epoxy, polyurethane, polyimides, phenolic, etc.) and six thermoplastics (poly-lactic acids, poly-vinyl chlorides, cellulosic, acrylic, polypropylene, etc.) [13]. The melting points of the bio-composite that has been developed, including tensile, compressive, flexural, and impact strength, are contingent upon the fiber's rigidity, strength, density, ductility, and roughness, along with the volume fraction of reinforced fibres [14]. Various chemical treatments, including alkali treatment, silane treatment, acrylation, benzoylation, and permanganate treatment, are employed to boost the surface aspects of bio-fibers [15]. The objective of the study is to investigate the case study on the characterization and development of polymer composites reinforced with natural fibers.

CASE PRESENTATION

In the present case study, the production of novel natural fiber-reinforced polymer composites is facilitated by the utilisation of nature-based fibre materials. This innovative natural fibre composite has the potential to be used as structural components that are subjected to moderate loads. For instance, it can be used in the construction and manufacturing industry to create panels for separation and fall ceilings, partition boards, walls, floors, window and door frames, roof tiles and pre-fabricated buildings that can be installed in the event of normal calamities such as floods, cyclones, earthquakes, and short-term residents.

The research presented in this case study is broadly divided into four sections:

The chemical and thermal characterization (FTIR spectroscopy, XRD analysis, TGA, and DTA), along with the physical aspects (density and moisture absorption behaviour), of natural fiber reinforced epoxy composites are examined.

Fourier transform Infrared spectroscopy (FTIR) is employed as an algorithm to convert the raw data acquired by the spectroscope into the image format, which is then utilised to obtain the infrared spectrum of composites during FTIR spectroscopy. The results of spectroscopy are summarised in a graph that plots transmittance against wavenumber. FTIR spectroscopy was conducted by numerous authors on natural fiber-reinforced polymer composite. The results of O-H stretching, C-H stretching, and carbonyl C=C stretching were established at various wavenumbers in accordance with their research investigations. FTIR spectroscopy of the composites of debris and polypropylene. The absence of carbonyl (C=O), carbon-carbon (C=C), and methyl group (CH3) was demonstrated by the disappearance of three peaks at wavenumbers of 1725 cm-1, 1649.9 cm-1, and 1376.6 cm-1 owing to polymer degradation. The presence of chemical constituents in Natural fibers, like cellulose, hemicellulose, and lignin, was evident in the absorption peaks that appeared at various wavenumbers

When an X-ray is directed at a crystal of a material, the atoms of the material will diffract the X-ray in a manner that is dependent on their location. The information about the crystal structure of a material is delivered by these diffracted beams of varying intensities and angles. The study of crystal structure is essential for the comprehensive characterization of the biocomposites that were made, as many of their mechanical or microstructural aspects are dependent on the crystal structure of the material. The structure of the constituents of the composites that were made is investigated by numerous authors utilising XRD.

Thermogravimetric analysis (TGA) is employed to evaluate the evolution of the physical and chemical aspects of composites in response to temp. fluctuations. TGA also furnishes critical information regarding the degradation temp. of the composites that were made. TGA analysis was conducted in a nitrogen environment utilising kenaf filler/chitosan bio-composites. The first 22 degradation temp.s were documented by the authors, spanning from 25 °C to 140 °C, and the second degradation temperature were recorded from 110 °C to 220 °C. the temp.-dependent wt. change of composites grounded in PLA.

Thermogravimetric analysis was conducted in a nitrogen environment utilising the S11 Perkin Elmer Diamond TG/DTA (differential thermal analysis) apparatus, as illustrated in figure 3.6. In a nitrogen environment, samples in solid containers were subjected to a maximal temp. of 6300C at a rate of 100C/min. The wt. loss was quantified as the temp. increased. The DTA S11 Perkin Elmer Diamond TG/DTA apparatus was employed to conduct the differential thermal analysis (DTA) as

illustrated in figure 3.6. In a nitrogen environment, samples in solid pallet form were subjected to a maximal temp. of 6300C at a rate of 100C/min. The heat that was absorbed or released was quantified as the temp. increased.

The melting point of the composites that were developed were assessed before and after one year of water immersion, including tensile, flexural, impact, and hardness tests. SEM was employed to conduct a morphological analysis of the fractured surface during mechanical testing. c. Before and after one year of water immersion, DMA was conducted to evaluate the damping capability, storage modulus, and loss modulus of all composites that were developed. The DMA analyzer was utilised to record the damping capability (tan δ), storage modulus (E′), and loss modulus (E") curves in relation to temperature d. The pin-on-disc test apparatus was employed to investigate the dry sliding friction and wear behaviour of the epoxy-grounded composites that were developed against a steel counterface before and after one year of water immersion.

MECHANICAL CHARACTERISTICS

The composites that were developed underwent mechanical characterization (tensile, flexural, impact, and hardness tests) both before and after one year of water immersion. The composites that were developed were immersed in potable water at room temperature for a period of 12 months. After one year of immersion in water, the tensile, flexural, and hardness (shore D) aspects of the samples were assessed and compared to those of the dried specimens. Scan electron microscopy (SEM) was employed to investigate the interface across the matrix and fibre.

The flax/epoxy composites exhibited a greater hardness (98 Shore-D) and TS (46.2 MPa) than the jute/epoxy and hemp/epoxy composites, which respectively demonstrated a flexural and impact strength of 85.59 MPa and 7.68 kJ/m2. The results indicated that hybrid composites exhibited superior Melting point. Jute/hemp/flax/epoxy hybrid composites exhibited the max. TS, modulus, and impact strength, respectively, at 58.59 MPa, 1.88GPa, and 10.19 kJ/m2. The maximal FS of the jute/hemp/epoxy hybrid composites was 86.6 MPa. The TS and Young's modulus of the water-saturated jute/hemp/epoxy composites specimen were the most significantly reduced, at 46.9% and 51.8%, respectively.

The specimen of hemp/epoxy composites that was saturated with water exhibited the greatest reduction in FS, which was 45.1%. The jute/hemp/epoxy composites specimen obtained the greatest reduction in the flexural modulus, which was 39.7%. Moisture absorption did not result in a substantial drop in the values of hardness. The SEM images of the fractured surfaces of these biocomposites delivered pertinent information regarding the degradation of the fiber/matrix interface.

Analysis of dynamic mechanical systems

The dynamic mechanical analysis of all the composites that were made before and after one year of water immersion, including their damping capability, storage modulus and loss modulus. The % change in damping capability, storage modulus and loss modulus was analysed by comparing the results of dried specimens, and the effect of moisture absorption on these aspects was also examined. At a glass transition temperature (Tg) of 74 0C, neat epoxy demonstrated the max. damping capability (tanδ) of 0.81. The tanδ value of plain epoxy has been almost negligible as the temperature has increased from 0 0C to 60 0C, indicating low damping in this temperature range. The jute/hemp/flax/epoxy composites exhibited a maximal attenuation capability of 0.47 at a glass transition temperature of 79 0C, which was slightly greater (5 0C) than that of pure epoxy. The hemp/flax/epoxy hybrid composites demonstrated the second max. suspension capability (tanδ) of 0.68 and a minimum glass transition temperature of 60 0C.

The maximal attenuation capability of 0.66 was demonstrated by the jute/hemp/epoxy hybrid composites at a glass transition temperature of 620 C. The results obtained indicate that the glass transition temperature is the most influential parameter, as the polymer composite transitions from a "glassy," rigid state to a "rubbery" state at Tg, which is characterised by elevated molecular activities. The glass transition temperature of all the composites that were developed increased in comparison to the glass transition temperature of dried specimens after one year of water immersion. The jute/hemp/epoxy composites that is submerged in water has a maximal increase in glass transition temperature (23.7%) when compared to the dried specimen.

DISCUSSION

The commercial and domestic sectors have experienced a significant increase in the demand for products that are made from bio-Composite materials over the past decade [16]. The researchers have devised numerous processing techniques to ensure the successful production of bio-Composite components. The simplest and most cost-effective method for the

fabrication of relatively basic shapes is hand lay-up technique. Fibre and polymer resin are applied onto a reusable open mould in spray lay-up [11]. the bio- composites that utilise woven jute fabric as reinforcement and unsaturated polyester resin as a matrix. The authors deduced that the curing of the polymer and the resistance to fracture propagation were boosted by this fabrication procedure [13, 14].

For composites that are rather intricately shaped, the compression moulding technique is also greatly prevalent. A hybrid bio-composite grounded in polyester that employs short, irregularly oriented banana and sisal fibres as reinforcement. The authors employed the compression moulding technique and determined that composites produced through compression moulding exhibited a greater impact strength than those produced through resin transfer moulding [8, 9]. Melting point of bio- composites produced through the compression moulding process. The authors employed polyester as the matrix and sisal fibre as reinforcement. The melting point of compression moulded composites were compared to those of resin transfer moulded composites by the authors. In contrast to resin transfer moulded composites, compression moulded composites have a reduced strength, according to the authors. lactic acid thermoset polymer is employed to reinforce biocomposites with flax and flax/basalt fibre [6,7].

The authors initially impregnated fibres into resin through manual lay-up. Basalt/flax reinforced composites exhibited superior mechanical and thermodulusynamic aspects in comparison to pure flax fibre reinforced composites, owing to the superior wettability of basalt fibre [16]. The injection moulding process is typically employed for the production of composites in large quantities. By employing the injection moulding technique, bio- composites were produced with pineapple and cassava flour as fillers and polylactic acid as the matrix material [14]. The composites developed utilising the injection moulding process exhibited a great degree of interfacial adhesion across the fiber/matrix interface and a reduced count of cavities. This, in turn, contributed to the increased tensile and flexural strength of the composites. injection moulding of polybutylene succinate bio composites grounded in lignin [3].

CONCLUSION

The jute/hemp hybrid composite in comparison to other hybrid composite combinations, has demonstrated superior wear performance. The analysis of interfacial temperature during attrition demonstrates that the temperature at the interface continues to rise as the applied load increases. The tribological performance of the composite specimens is significantly influenced by the development of interfacial temperature during wear analysis.

There is a vast amount of potential for future researchers to investigate numerous additional aspects of the refining of natural fiber-reinforced Polymer composite, as evident in the current research. The following are some suggestions for future research: a. A future investigation may involve the examination of the bearing of various chemical treatments on the aspects of the composites that were made. b. Under lubricated conditions, the wear analysis of the composites that were made can be conducted. c. Available simulation software may be employed to conduct finite element modelling on numerous processing aspects for these composites.

REFERENCES

1. Lee CH, Padzil FN, Lee SH, Ainun ZM, Abdullah LC. Potential for natural fiber reinforcement in PLA polymer filaments for fused deposition modeling (FDM) additive manufacturing: A review. Polymers. 2021 Apr 27;13(9):1407.
2. Silva TT, Silveira PH, Ribeiro MP, Lemos MF, da Silva AP, Monteiro SN, Nascimento LF. Thermal and chemical characterization of kenaf fiber (Hibiscus cannabinus) reinforced epoxy matrix composites. Polymers. 2021 Jun 20;13(12):2016.
3. Kumar SS, Babu BS, Chankravarthy CN, Prabhakar N. Review on natural fiber Polymer composite. Materials Today: Proceedings. 2021. 46:777-782.
4. Oliveira MS, da Luz FS, Monteiro SN. Research progress of aging effects on fiber-reinforced polymer composites: a brief review. Characterization of Minerals, Metals, and Materials 2021. 2021:505-15.
5. Suárez L, Castellano J, Díaz S, Tcharkhtchi A, Ortega Z. Are natural-based composites sustainable?. Polymers. 2021 Jul 15;13(14):2326.
6. Bhardwaj D, Gupta A, Chaudhary V, Gupta S. Hybridization of natural fibers to develop the polymeric composite materials: a review. Advances in Engineering Materials: Select Proceedings of FLAME 2020. 2021:355-63.
7. Venkatarajan S, Athijayamani AJ. An overview on natural cellulose fiber reinforced polymer composites. Materials Today: Proceedings. 2021 Jan 1;37:3620-4.
8. Reddy PV, Reddy RS, Rao JL, Krishnudu DM, Prasad PR. An overview on natural fiber reinforced composites for structural and non-structural applications. Materials Today: Proceedings. 2021 Jan 1;45:6210-5.

9. Zaman HU, Khan RA. Acetylation utilised for natural fiber/Polymer composite. Journal of Thermoplastic Composite Materials. 2021;34(1):3-23.
10. Olhan S, Khatkar V, Behera BK. Textile-grounded NF-reinforced polymeric composites in automotive lightwt.ing. Journal of Materials Science. 2021;1-44.
11. Kumar SS, Muthalagu R, Chakravarthy CN. Effects of fiber loading on mechanical characterization of pineapple leaf and sisal fibers reinforced polyester composites for various applications. Materials Today: Proceedings. 2021 Jan 1;44:546-53.
12. Kuan HT, Tan MY, Shen Y, Yahya MY. Mechanical properties of particulate organic natural filler-reinforced polymer composite: A review. Composites and Advanced Materials. 2021 May 6;30:26349833211007502.
13. Singh T, Gangil B, Ranakoti L, Joshi A. Effect of silica nanoparticles on physical, mechanical, and wear properties of natural fiber reinforced polymer composites. Polymer Composites. 2021 May;42(5):2396-407.
14. Gokulkumar S, Thyla PR, Prabhu L, Sathish S. Characterization and comparative analysis on mechanical and acoustical properties of camellia sinensis/ananas comosus/glass fiber hybrid polymer composites. Journal of Natural Fibers. 2021 Jul 3;18(7):978-94.
15. Singh PK. Natural Fibre Reinforced Hybrid Composite: Thermal & Mechanical Characterization. InIOP Conference Series: Materials Science and Engineering 2021 Apr 1 (Vol. 1116, No. 1, p.012035). IOP Publishing.
16. Subramanian M, Arunkumar N, Rethnam GS, Balasubramanian T. Exploration of the damping characteristics of basalt hybrid composites reinforced with natural fibers and epoxy resin. Fibers and Polymers. 2021 Jun;22:1684-92.