Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 7, Issue 2, Pages 21-28, April-June 2023

Characteristics of the Tensile Properties of Natural Fiber Reinforce PET

S R Rajkumar[1*], R Raveen[2], P Rishikesh[3], M Sanjay bharathi[4] & C Somu[5]

*[1]Assistant Professor, [2-5]Student, [1-5]Department of Mechanical Engineering, Stella Mary's College of Engineering, Kanyakumari, Tamil Nadu, India. Corresponding author (S R Rajkumar) Email: rajkumarsmce@gmail.com**

DOI: https://doi.org/10.46382/MJBAS.2023.7204

Article Received: 15 March 2023 *Article Accepted: 25 April 2023* *Article Published: 16 May 2023*

ABSTRACT

Natural fiber composites frequently are used in a variety of applications of spacecraft and aircraft, ships, and construction work as a result of increased demands. Hemp and sisal fiber for reinforcement, and PET Resin were used for the preparation of composite materials in this project. The composite material specimens were prepared using the hand layup technique. The specimen is by with ASTM specifications using various percentages of the matrix and reinforcing components. we are making a trial using polyethylene terephthalate with 20% hemp, 20% sisal, 20% hemp + 10% sisal, and 20% sisal +10% hemp prepared. The mechanical behavior of the prepared com¬posite material was studied by conducting tensile test. The results showed that the specimen with PET + 20% hemp + 10% sisal has strengths and better mechanical behavior. Also, these have a high strength to weight ratio, are lightweight, are easy to manufacture, and have minimal production costs.

Keywords: Recycled polyethylene terephthalate; Hemp; Sisal; Tensile; UTM machine.

1. Introduction

The process of plastic recycling is deemed crucial as it aids in mitigating the volume of plastic waste that is deposited in landfills and the ecosystem [1].

The act of recycling not only serves to preserve finite resources, but also contributes to the mitigation of greenhouse gas emissions that are linked to the manufacturing of fresh plastic goods. Unfortunately, the current recycling rate of plastic waste is quite low, which means that there is a need for greater public awareness and initiatives to improve plastic waste management [2].

2. Materials and Method

2.1. Polyethylene terephthalate (PET)

Polyethylene terephthalate (PET) is a widely utilised resin within the polyester family, boasting a significant production volume of over 56 million tonnes [3].

The polymer's primary utilisation is in PET fibres, which constitute more than 60% of the worldwide demand, whereas bottle manufacturing represents approximately 30%. Polyethylene terephthalate (PET), commonly referred to as polyester, finds extensive usage in the textile industry, whereas PET is employed as an abbreviation for packaging purposes. Polyester ranks as the fourth most commonly produced polymer, following polyethylene, polypropylene, and polyvinyl chloride, and constitutes approximately 18% of the global polymer production.

a. Melting point: PET has a melting point of around 260°C, which means it can be melted and molded into different shapes.

b. Chemical formula: The chemical formula for PET is $(C_{10}H_8O_4)_n$, which means it is made up of repeating units of terephthalic acid and ethylene glycol.

c. Density: PET has a density of around 1.38 g/cm³, which means it is a relatively lightweight material.

MJBAS
PROMOTING RESEARCH & KNOWLEDGE
Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 7, Issue 2, Pages 21-28, April-June 2023

d. Molar mass: The molar mass of PET can vary depending on the specific formulation and production method, but it typically falls within the range of 10-50 kg/mol.

e. Thermal conductivity: The thermal conductivity of PET is relatively low, ranging from 0.15 to 0.24 W/(m·K).

2.2. PET waste recycling method

The PET waste recycling process typically involves several steps, which may vary depending on the specific recycling method used [4]. However, the following is a general outline of the steps involved in mechanical recycling:

a. Collection: Used PET bottles and containers are collected from households, businesses, and other sources.

b. Sorting: The collected PET waste is sorted based on color, shape, and other characteristics. Contaminants such as caps, labels, and other materials are removed.

c. Cleaning: The sorted PET waste is thoroughly cleaned to remove any remaining contaminants, such as dirt, oil, and other debris [5].

d. Shredding: The cleaned PET waste is shredded into small flakes or pellets using specialized equipment.

e. Melting: The PET flakes or pellets are melted in a heating chamber at high temperatures to form a viscous liquid in (Figure 1).

Figure 1. Recycled PET resin

2.3. Natural fiber

Natural fibers are fibers that come from natural sources, such as plants, animals, and minerals [6]. They have been used for thousands of years in textiles, clothing, and other products. Some examples of natural fibers include:

a. Cotton is a fibrous material that is characterised by its soft and fluffy texture. It is derived from the bolls or protective capsules of the cotton plant. The natural fibre that finds the most extensive application globally is utilised in the production of textiles, clothing, and bedding.

b. Wool is a naturally occurring fibre that is derived from the fleece of various animals, including sheep, goats, alpacas, and llamas. The material in question is renowned for its thermal properties, tactile comfort, and robustness, and is frequently employed in the fabrication of garments and floor coverings.

c. Silk is a naturally occurring fibre that is generated by the silkworm, a species of moth. Renowned for its supple texture, sheen, and durability, this material finds application in garments, linens, and other opulent fabrics.

d. Flax is a type of plant fibre that is utilised in the production of linen, a robust and long-lasting textile that finds widespread application in the manufacturing of apparel and household items.

e. Hemp is a naturally occurring fibre derived from the stem of the hemp plant. The material in question is renowned for its robustness and resilience, rendering it a popular choice for garments, fabrics, and various other commodities.

f. Jute, a plant-based fibre, is utilised in the production of hessian, a robust and rough-textured fabric that is frequently employed in the manufacturing of bags and other commodities [7].

2.4. Sisal fiber

The natural fibre known as sisal is derived from the leaves of the Agave sisal Ana plant, originally indigenous to Mexico but currently cultivated in various regions across the globe such as Africa, Brazil, and China [8]. The sisal fibre possesses high strength and durability, rendering it a popular choice for manufacturing various commodities such as ropes, twines, carpets, and other related items [9]. The sisal fibre possesses numerous advantageous characteristics that render it a favoured option for diverse applications. The material exhibits high tensile strength and remarkable resistance to elongation, rendering it a suitable candidate for incorporation into ropes and twines that are intended to withstand substantial weight-bearing capacities [10]. The material's resistance to saltwater renders it a suitable option for marine purposes, including but not limited to mooring lines and fishing nets. The utilisation of sisal fibre is deemed as an environmentally conscious and sustainable practise. The agave plant, which serves as the source of sisal, exhibits rapid growth and low water requirements, rendering it a viable option for arid regions that may not support the growth of alternative crops [11].

Figure 2. Sisal fiber in mat form

2.5. Hemp fiber

Hemp fiber is a natural fiber that comes from the stem of the Cannabis sativa plant, which is grown for industrial and commercial purposes. Hemp fiber has been used for thousands of years for various applications, including textiles, paper, and cordage [12]. Hemp fiber has several desirable properties that make it a popular choice for various applications. It is very strong and durable and is resistant to abrasion, rot, and mildew. Hemp fiber is also highly absorbent, which makes it a good choice for use in textiles and paper products. Hemp fiber is also

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 7, Issue 2, Pages 21-28, April-June 2023

eco-friendly and sustainable. The hemp plant is easy to grow and requires very little water or pesticides, making it a good choice for farmers who are looking for more sustainable crop options. Hemp fiber is also biodegradable and can be composted after use.

Figure 3. Hemp fiber in mat form

2.6. Hybrid materials

Hybrid materials refer to the class of materials that are produced through the amalgamation of two or more distinct materials at the nanoscale or molecular level [13]. The resultant material manifests properties that are distinct from those of the individual components. Hybrid materials can be composed of both organic and inorganic materials and can be engineered to exhibit specific properties such as improved strength, toughness, and durability. Hybrid materials are used in a wide range of applications, including electronics, energy storage, biomedical devices, and catalysis, among others.

Figure 4. Sisal with hemp and hemp with sisal fibers

3. Composite sheet making

The composite sheet making in Hand layup process. The table- 1 shows different formulation of composite

Formulation	Recycled Polyethylene terephthalate	Hemp fiber	Sisal fiber
1st trail	PET	-	20% SISAL
2nd trail	PET	20% HEMP	-
3rd trail	PET	20% HEMP	10% SISAL
4th trail	PET	10% HEMP	20% SISAL

4. Tensile Test

The tensile test is a mechanical evaluation method that is utilised to quantify the tensile strength and ductility of a material when subjected to stretching forces [14]. The present experiment involves the application of a progressively augmenting uniaxial force on a specimen of the material under investigation, until the point of rupture or fracture is reached. Throughout the testing process, the force that is applied and the resulting deformation or extension of the sample are meticulously documented [15]. The practise of conducting tensile testing is frequently employed in order to ascertain a range of mechanical characteristics of materials. These may include the ultimate tensile strength (UTS), yield strength, modulus of elasticity, and elongation at break. Figure 5 depicts a tensile sample [16].

The subsequent computations are to be performed.

- The calculation of the tensile strength at the yield point involves dividing the maximum load by the original cross-sectional area of the specimen.

- The calculation of tensile strength at break involves dividing the maximum load by the minimum cross-sectional area of the specimen in the region of fracture.

- The elongation at the yield point is determined by dividing the distance between the reference lines at the yield point by the original gauge length of the specimen and expressing it as a percentage.

- The elongation at break is determined by dividing the distance between the reference lines at break by the original gauge length of the specimen and expressing the result as a percentage.

- The modulus of elasticity can be determined by dividing the corresponding strain by the stress at any point on the stress-strain curve within the proportional limit, where stress is directly proportional to strain.

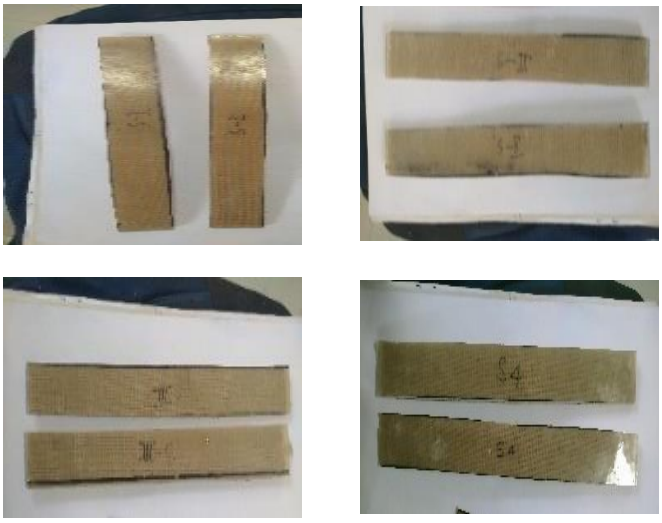


Figure 5. Tensile sample

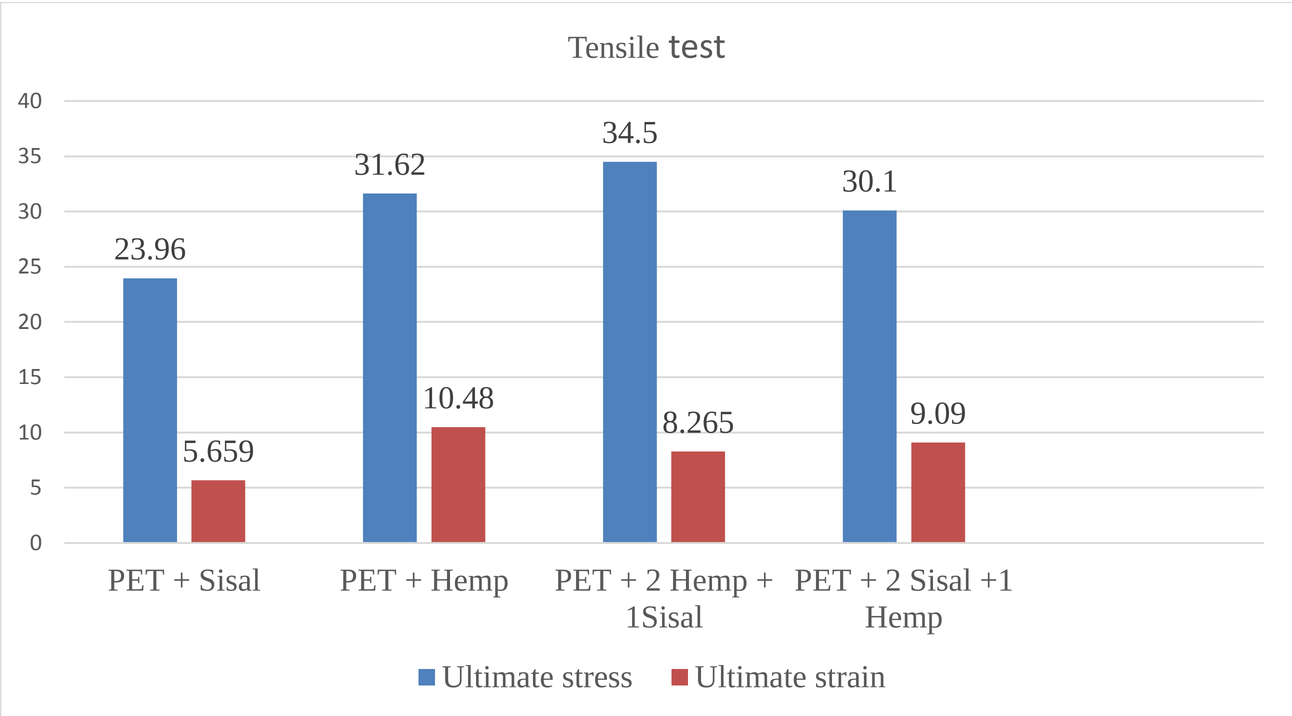
Tensile test result

The table-2 refer tensile test values elongation, young's modulus, ultimate stress and ultimate strain.

S.No.	Sample Formulation	Elongation	Young's Modules	Ultimate Stress (Mpa)	Ultimate Strain (%)
1	PET + Sisal	5.68	713	23.96	5.659
2	PET + Hemp	10.5	656	31.62	10.48
3	PET + 2 Hemp + 1Sisal	8.7	685	34.50	8.265
4	PET + 2 Sisal +1 Hemp	9.2	681	30.10	9.090

Tensile graph

The graph represented the ultimate stress and strain value of composite



5. Conclusion

Composites reinforced with natural fibres exhibit a reduced density in comparison to their synthetic counterparts, possess lower stiffness, and are economically more viable. In contrast to synthetic composites, which exhibit a greater density. This suggests that these materials possess the necessary qualities to be utilised in commercial sectors such as the construction and automotive industries. The mechanical properties of polymers in composites can be enhanced by the incorporation of natural fibres as reinforcements, according to recent findings. Based on the examination of mechanical analysis in specimens under various compositions, it is concluded that composite fewer than 20% HEMP+10% SISAL+PET have better properties and fiber orientation.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public or not-for-profit sectors.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Consent for Publication

The authors declare that they consented to the publication of this study.

References

[1] Kumar, Rakesh, Anurag Verma, Arkajyoti Shome, Rama Sinha, Srishti Sinha, Prakash Kumar Jha, Ritesh Kumar et al. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. Sustainability, 13(7): 9963.

[2] Chen, Hui Ling, Tapan Kumar Nath, Siewhui Chong, Vernon Foo, Chris Gibbins, and Alex M. Lechner (2021). The plastic waste problem in Malaysia: management, recycling and disposal of local and global plastic waste. SN Applied Sciences, 3: 1–15.

[3] Ahmad, Ashfaq, Fawzi Banat, Habiba Alsafar, and Shadi W. Hasan (2022). An overview of biodegradable poly (lactic acid) production from fermentative lactic acid for biomedical and bioplastic applications. Biomass Conversion and Biorefinery, Pages 1–20.

[4] Thiounn, Timmy, and Rhett C. Smith (2020). Advances and approaches for chemical recycling of plastic waste. Journal of Polymer Science, 58(10): 1347–1364.

[5] Kumar, K. Suresh, T. Ananth Kumar, S. Sundaresan, and V. Kishore Kumar (2021). Green IoT for Sustainable Growth and Energy Management in Smart Cities. In Handbook of green engineering technologies for sustainable smart cities, Pages 155–172.

[6] Naik, Venkatesh, and Mohan Kumar (2021). A review on natural fiber composite material in automotive applications. Engineered Science, 18: 1–10.

[7] Shahzad A. (2013). A study in physical and mechanical properties of hemp fibres. Adv Mater Sci Eng.

[8] Duarte, Elizabeth AA, Caroline L. Damasceno, Thiago AS De Oliveira, Leonardo de Oliveira Barbosa, Fabiano M. Martins, Jurema Rosa de Queiroz Silva, Thais EF De Lima et al. (2018). Putting the mess in order: Aspergillus welwitschiae (and not A. niger) is the etiological agent of sisal bole rot disease in Brazil. Frontiers in Microbiology, 9: 1227.

[9] Sanjay MR, Yogesha B. (2016). Studies on mechanical properties of jute/e-glass fiber reinforced epoxy hybrid composites. J Miner Mater Charact Eng., 04(01): 15–25

[10] Adekomaya O. (2020). Adaption of green composite in automotive part replacements: discussions on material modification and future patronage. Environ Sci Pollut Res., 27(8): 8807–13.

[11] Dicker MPM, Duckworth PF, Baker AB, Francois G, Hazzard MK, Weaver PM. (2014). Green composites: a review of material attributes and complementary applications. Compos Part A Appl Sci Manuf., 56: 280–9.

[12] Crini, Grégorio, Eric Lichtfouse, Gilles Chanet, and Nadia Morin-Crini (2020). Applications of hemp in textiles, paper industry, insulation and building materials, horticulture, animal nutrition, food and beverages, nutraceuticals, cosmetics and hygiene, medicine, agrochemistry, energy production and environment: A review. Environmental Chemistry Letters, 18(5): 1451–1476.

[13] Kumar, T.A., G. Rajakumar, T.S.A. Samuel, and D. Nirmal (2022). An In Situ Design/Analysis Method of Antimicrobial Effect Using Nano TiO_2 for Disinfecting COVID-Affected Places. Journal of Testing and Evaluation.

[14] Balasubramanian, I., and R. Maheswaran (2015). Effect of inclusion of SiC particulates on the mechanical resistance behaviour of stir-cast AA6063/SiC composites. Materials & Design (1980-2015), 65: 511–520.

[15] Tirella, Annalisa, Giorgio Mattei, and A.R.T.I. Ahluwalia (2014). Strain rate viscoelastic analysis of soft and highly hydrated biomaterials. Journal of biomedical materials research Part A, 102(10): 3352–3360.

[16] Chaka, Kilole Tesfaye, Fitsum Etefa Ahmed, Lejalem Haile Zegeye, and Biruk Gedif Worku (2022). Compressive Strength of Floor Tile Composites from Recycled PET Reinforced with Natural Fibers. Journal of Natural Fibers, Pages 1–14.