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THERMAL STABILITY AND DEGRADATION BEHAVIOR OF BIO-BASED AND SYNTHETIC FIBER-REINFORCED COMPOSITES: A TGA STUDY

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Abstract: *This study analysis the thermal stability and degradation behavior of six fiber-reinforced composites—carbon, glass, flax, banana, raffia, and seagrass—using thermogravimetric analysis (TGA). Carbon fiber showed the highest thermal stability (onset at 327°C, 13.26% residual mass), followed by glass fiber (291°C, 9.3%). From tested natural fibers composites, flax reached the best thermal performance (onset at 287°C, peak at 536°C), closely approaching glass fiber but still far from carbon fiber performance. While natural fibers show in general lower thermal resistance, flax is shown as a promising sustainable alternative with huge potential for thermal optimization in aerospace, automotive, and even construction applications.*

Keywords: *natural fiber composites, sustainability, ecodesign, glass fiber, carbon fiber, polymers, TGA analysis, flax fiber, banana fiber, seagrass fiber, raffia fiber.*

1. INTRODUCTION

1.1. Research Background and Motivation

Owing to excellent mechanical properties, low density, and anti-corrosive nature, fiber-reinforced polymer (FRP) composites have attracted significant attention from various industries such as automotive or aerospace. [1]Synthetic fibers (glass, carbon, etc.) have also traditionally been applied as reinforcements in composite manufacturing due to high strength/stiffness and durability.[2], [3] Nonetheless, worries [4] about environmental sustainability and resource depletion have heightened interest in natural fiber reinforcements, including flax, banana, raffia, and seagrass. Such bio-based fibers exhibit several advantages over synthetic reinforcements, such as renewable biodegradability, and low production costs.[5]

However, due to thermal stability and degradation behavior, natural fibers have a few drawbacks when used as composites. [6] Natural fibers differ from synthetic fibers in that they have a substantial cellulose, hemicellulose, and lignin content, which governs their thermal resistance and degradation behavior when exposed to higher temperatures.[7] Fibers, as reinforcement in the composites, provide thermally stable characteristics which in turn determines the applicability of the fiber-reinforced composites in the high-temperature environments as thermal stability is a key factor that plays an important role in the material integrity, performance and lifespan. So, it is necessary to know the thermal behavior of various fiber reinforcements to optimize composite formulations and to extend their possibilities to application.[8]

One of the best-known methods for investigating the thermal stability of composite materials is thermogravimetric analysis (TGA). This procedure offers insights into the degradation characteristics, weight loss mechanisms, and residual mass of composites exposed to ramping temperatures. This particular move on comparing the thermal degradation of several fiber-reinforced composites enables the researcher to know about the model that is more thermally stable and so, the thermal performance can be improved. In this study, TGA is utilized to assess the thermal stability of six different fiber-reinforced composites: glass, carbon, flax, banana, raffia, and seagrass fibers. The findings

will provide insights into the impact of fiber type on the thermal performance of composites, thus enabling the choice of appropriate reinforcements for a given industrial sector.

1.2. Importance of Thermal Stability in Fiber-Reinforced Composites

Fiber-reinforced composites possess a very important feature regarding their heat insulation. In aerospace structures and automotive engine components, as well as in high-temperature electronic enclosures, it is crucial to maintain material integrity when composites are subjected to high temperature service. The heat resistance of a composite preserves its weight over time in extreme heat applications, ensuring lasting materials.[9]

Thermal degradation for natural fiber-reinforced composites mainly takes place from degradation of the organic parts. Cellulose begins to decompose between 280°C and 350°C, while hemicellulose degrades at lower temperatures (200°C–280°C). The most thermally stable component, lignin decomposes slowly over a large temperature range (250°C–500°C). In contrast, synthetic fibers including glass and carbon can remain thermally stable up to or above 500°C before considerable weight loss occurs. Hence, knowledge of these degradation trends is essential to formally adjust composite formulations for these resins, making them suitable for high-performance applications.[6], [9], [10]

In addition, the thermal behavior of composites affects their processing conditions and their recyclability.[4] Low thermal stability of composites can adversely affect degradation of composites at processing processes like molding, extrusion as well as curing. Moreover, the thermal stability is important in determining their end-of-life disposal and recyclability. Manufacturers can use the studied data to guide their choices concerning material selection, processing parameters, and recycling strategies based on the degradation behaviors of the individual fiber types. [6], [9]

1.3. Objective of the Study: Comparing the Thermal Performance of Natural and Synthetic Fiber Composites

The want to explore the thermal steadiness as well as the degradation behavior of the fiber-reinforced composites through thermo-gravimetric analysis. This study aims to analyze six different types of fibers—glass, carbon, flax, banana, raffia, and seagrass—and compare their thermal performance to determine the best reinforcement for applications operating at high temperatures. This research will help to understand the potential of using natural fibers as a replacement for synthetic reinforcements.

Therefore, in order to accomplish this goal, this study will answer the following research questions:

Research Questions

Q1. How does the thermal stability of natural fiber-reinforced composites compare to that of synthetic fiber-reinforced composites?

- **H_0 (Null Hypothesis)**: There is no significant difference in the thermal stability between natural and synthetic fiber-reinforced composites.
- **H_1 (Alternative Hypothesis)**: Synthetic fiber-reinforced composites exhibit significantly higher thermal stability compared to natural fiber-reinforced composites due to their inorganic composition and superior heat resistance.

Q2. What are the variations in degradation behavior among different types of natural fiber-reinforced composites?

Hypotheses

- **H_0 (Null Hypothesis):** All-natural fiber-reinforced composites exhibit similar thermal degradation behavior under thermogravimetric analysis.
- **H_1 (Alternative Hypothesis):** The thermal degradation behavior of natural fiber-reinforced composites varies significantly depending on their chemical composition, structural properties, and fiber morphology.

The results of this research will add new empirical data on thermal properties of natural fibers to the scientific discussions on sustainable materials and ecodesign. This will help manufacturers and engineers make informed decisions about the viability of bio-based composites for different products and types of

industrial application, including automotive, aerospace, construction, and packaging.

2. MATERIALS AND METHOD

2.1 Materials

2.1.1. Polyurethane resin matrix

Polyurethane matrix used in this research is NEUKADUR MultiCast 1, a two-component low-viscosity fast-cast polyurethane system with excellent impact strength and low shrinkage.

Composite fabrication often benefits from this resin system which achieves good through-curing but also with a relatively long pot life. Due to high mechanical strength, thermal stability, and easy processing, widely used in mold-making, prototyping, and fiber-reinforced composite manufacturing.

NEUKADUR MultiCast 1 has a low density (0.95 g/cm³) that allows lightweight composites without compromising the structures. mixing ratio 1:1 with NEUKADUR ISO 2 hardener guarantees polymerization and consequently a homogeneous and high-strength polymer matrix. This coupled with its tensile strength of 33 MPa and a flexural strength of 52 MPa provides the robustness required for composite applications. With a demolding time of ~30 minutes, this resin is efficient to work with and process. Table 1 provide few technical parameters extracted from MDS.

Table 1

Technical Parameters of NEUKADUR MultiCast 1

Property	Value	Standard
Tensile Strength (MPa)	33	DIN 53455
Flexural Strength (MPa)	52	DIN 53452
Modulus in Flexure (MPa)	650	DIN 53457
Impact Strength (kJ/m²)	14	EN ISO 179
Thermal Stability (HDT) (°C)	75	-

2.1.2. Synthetic and natural fibers

The composite materials analyzed in this study were reinforced with six different fiber types: glass, carbon, flax, seagrass, raffia, and banana fibers. Each fiber was chosen based on its mechanical properties, availability, and potential application in composite manufacturing. The properties and sources of these fibers are summarized in Table 2.

Table 2

Fiber Reinforcements and Their Characteristics

Fiber Type	Source	Key Characteristics
Glass Fiber	Best Tools, Brașov, Romania	High tensile strength, moisture resistance, fire retardancy
Carbon Fiber	VEXED LAB, Bucharest, Romania	Lightweight, high stiffness, superior thermal conductivity
Flax Fiber	AppleoakFibre Works, Scarriff, Ireland	Renewable, moderate thermal resistance, biodegradable
Seagrass Fiber	Parkside	Unique hollow structure, moderate moisture absorption
Raffia Fiber	Parkside	High tensile strength, flexibility, impact resistance
Banana Fiber	Diversan, Westhoek, The Netherlands	Strong natural fiber, high lignin content, biodegradable

- **Pretreatment of Fibers**

As shown in the below Figure 1, all fibers underwent some pretreatment to enable better interfacial bonding between the fibers and polymeric resin consisting of surface treatment followed by washing and drying, and finally mechanical processing.

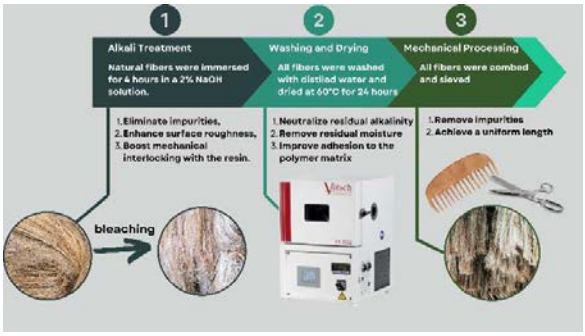

Fig. 1. Effect of Alkali Treatment on Coir Fibers

1. **Washing + Drying**: The fibers were rinsed with 1% diluted acetic acid to quench the residual alkalinity, followed by a final wash with distilled water and dried in an oven. To eliminate the trace amount of moisture found in the fibers and to increase the adhesion to the polymer matrix, all fibers were dried in a convection oven at 60 °C for 4 h.
2. **Alkali treatment**: Natural fibers immersed in the 2% NaOH solution to remove impurities, increase the surface roughness,

and enhance mechanical interlocking. The fibers were soaked for four hours, followed by a washing with distilled water.

3. **Mechanical processing**: The fibers were combed and sifted to remove impurities and obtain a length of 12 mm.

2.2 Composite Fabrication

Polyurethane resin matrix with 30% percent fibers by weight were used to fabricate these composites. The fabrication steps included mixing of fiber-resin, the preparation of the mold, casting and demolding. Subsequently, the fibers were pre-mixed with Multicast 1 polyurethane resin to ensure uniform distribution, and stirred for 10 min before hardener addition. The composites were molded in silicone molds for accuracy and easy removal. Then the resin and the catalyst were mixed keeping a ratio of 1:1 (100:100 parts by weight), and the homogenized mixture was poured in the molds. The composites were demolded after 30 minutes curing at room temperature and further cured for another 24 h under ambient environment prior to thermal testing.

2.3 Thermal Analysis Using TGA

Thermo-Gravimetric Analysis (TGA) was employed to study the thermal stability of the fiber-reinforced matrix composites. The analysis was carried out on a BAXIT BXT-TGA-1600 thermogravimetric analyzer with controlled air atmosphere. Small composite samples (usually 21–42 mg) were loaded to a ceramic crucible and heated from room temperature to 750°C, while the weight loss was recorded as a function of temperature, enabling the calculation of degradation onset temperature, peak degradation stages, and residual mass.

TGA Conditions and Parameters

TGA was conducted by following a stepwise heating process for the determination of the thermal properties. As shown in Table 3, the heating program had three stages.

Table 3

TGA parameters

Nr. crt.	Temperature [°C]	Heating rate [°C/min]	Holding time [min]
1	250	35	1
2	450	20	1
3	750	20	0

On these conditions, decomposition profile of gradual type followed, which stems from the mechanism of thermal stability and interaction of bonds in different kinds of fiber-reinforced composites.

Data Collection and Preparation

Weight loss (%) as a function of temperature was measured during the TGA analysis in real time. DTG curve was used to identify several main degradation stages. The onset decomposition temperature (T_{onset}), peak degradation temperature (T_{max}), and residue mass at 750°C were calculated for comparative analysis. The data were analyzed by the BAXIT software, which enabled the accurate determination of differences in thermal stability between the examined fiber-reinforced composites.

The thermal behavior of natural and synthetic fiber composites was compared through TGA curves obtained of the samples.

3. RESULTS AND DISCUSSION

Thermogravimetric analysis (TGA) was used to evaluate the thermal stability and decomposition characteristics of the fiber-reinforced composites for high-temperature applications. The outcomes offer a wide-ranging overview encompassing the decomposition behavior, mass loss characteristics, and residual stability of natural and synthetic fiber composites, enabling a comparative assessment of their tactile characteristics.

3.1 Thermal Decomposition Profiles of Different Composites

In the thermogravimetric analysis (TGA) graphs presented in Figures 2–7, three visual elements describe the thermal behavior of the tested composites. The blue curve represents the TGA curve, showing the percentage of weight loss as temperature increases, indicating the material's thermal degradation profile. The green curve is the DTG curve, which reveals the rate of weight loss (%/°C) and allows identification of the main decomposition stages, such as the breakdown of hemicellulose, cellulose, or polymeric resin. The red vertical lines are not functional curves, but rather

reference markers that indicate key thermal transition points — such as the onset degradation temperature, peak degradation temperature, or end of decomposition — helping to pinpoint significant thermal events along the curve.

3.1.1. Carbon Fiber Composite

The carbon fiber composite (Figure 2) demonstrates significantly higher thermal stability, as reflected in its onset degradation temperature of 327°C, which is 37% higher than banana fiber composites.

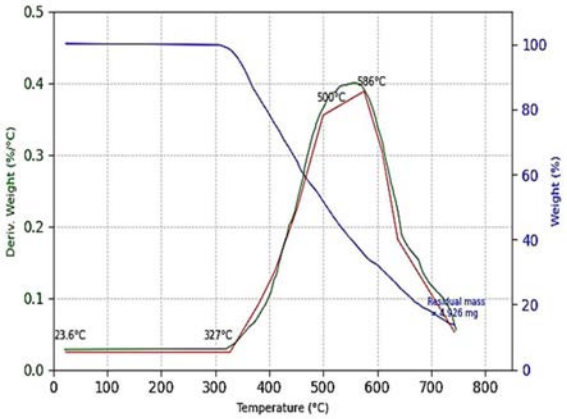

Fig. 2. Thermogravimetric analysis for carbon composite

Carbon fibers, unlike natural fibers, have ordered graphitic structures, which provide increased thermal stability.

Two major mass loss stages account for the thermal decomposition of the composite, with degradation peaks at 500 °C and 586 °C. The first mass loss region reflects the loss of the matrix as polymeric binders are decomposed, while the second stage reflects the degradation of residual organic species within the composite.

As carbon fibers are inorganic substances, there was a 4.926 mg residual mass at 750°C, which accounts for about 13.26% of the original mass, indicating that the carbon fibers' structure stays intact even when subjected to extreme temperatures.

Carbon fiber composites demonstrate superior thermal properties as compared to natural fiber composites, suggesting that carbon fiber composites are better suited for applications involving high temperature exposure and prolonged thermal stress when compared to natural fibers.

3.1.2. Glass Fiber Composite

The glass fiber composite (Figure 3) demonstrates thermal stability comparable to carbon fibers, with an onset degradation temperature of 291°C.

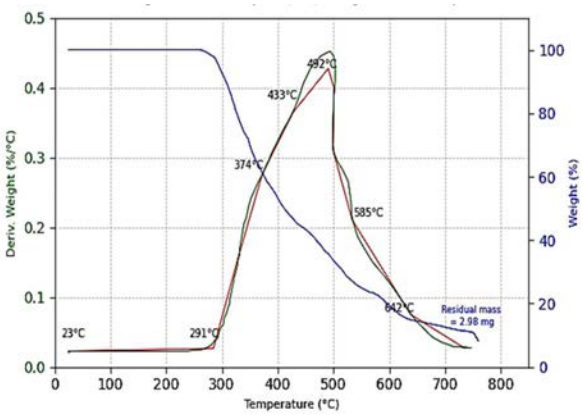

Fig. 3. Thermogravimetric analysis for glass composite

Glass fibers exhibit an inorganic nature, in contrast to natural fibers, which do not undergo volumetric loss induced by progressive thermal decomposition, but rather a gradual weight loss throughout the thermal treatment.

Thermal degradation of the fabric occurred in three stages with a maximum degradation temperature of 374°C, 433°C, and 492°C, which can be attributed to the decomposition of polymeric components instead of the fiber itself.

The mass left after heating up to 750°C is 2.98 mg, which indicates around 9.3% of the original mass confirming its very high heat-resistant property.

Thus, glass fiber composites can be seen as adequate and even better in high-temperature resistance than natural fiber composites for thermally demanding applications.

3.1.3. Banana Fiber Composite

The thermogravimetric analysis (TGA) of the banana fiber composite (Figure 4) reveals an onset degradation temperature (T_{onset}) of 239°C, which is in line with the characteristic thermal behavior of lignocellulosic fibers.

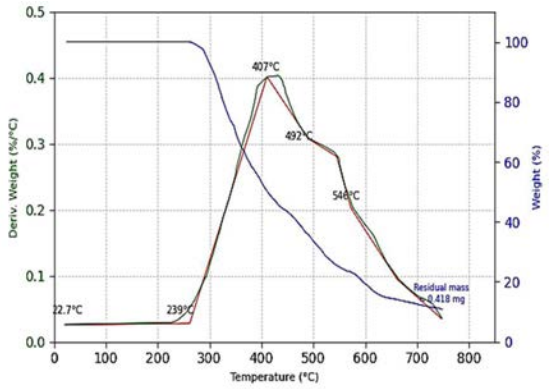

Fig. 4. Thermogravimetric analysis for banana composite

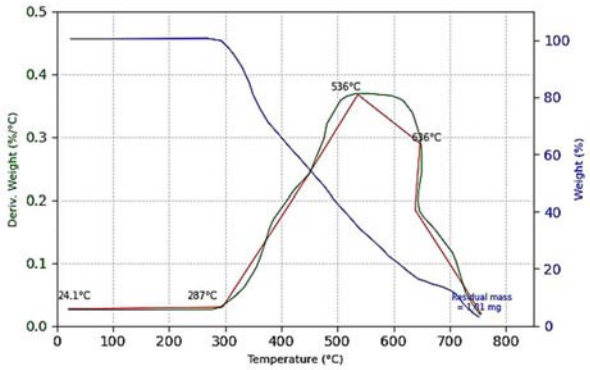

Fig. 5. Thermogravimetric analysis for flax composite

This early decomposition is mainly ascribed to the destruction of hemicellulose, one of the polysaccharide components which is characterized by low thermal stability. The main weight loss is divided into three separate processes, exhibited at temperature ranges of 407°C (hemicellulose), 492°C (cellulose), and 548°C (lignin).

Hemicellulose degradation accounts for an average mass loss of 16.5% at the first stage of decomposition (200°C-300°C), primarily due to moisture evaporation. Mass loss during the second step, with the highest mass loss of 52.3%, occurs between 350°C and 500°C, due to the thermal depolymerization of cellulose, leading to the generation of volatile gases and char residue. Ultimately, in the third phase, lignin decomposition occurs in the range of 500 °C to 600 °C, resulting in a further 18.7% mass loss.

At 750°C, the residual mass at the end of the thermal analysis is 0.418 mg, which corresponds to only 1.9% of the initial weight of the sample, indicating significant thermal decomposition and loss occurred among the organic components. It indicates that banana fiber composites have low thermal stability than synthetic fiber composites and, therefore, it can be thermal stabilized for high-temperature applications.

3.1.4. Flax Fiber Composite

The flax fiber composite (Figure 5) exhibits an onset degradation temperature of 287°C, which is 20% higher than banana fiber composites but still lower than synthetic alternatives.

Flax fibers have higher cellulose content (~70%) than wood which results in better structural stability at high temperature which causes this phenomenon.

The thermal decomposition was characterized by two main derivation weight loss stages with peaks at 536°C and 636°C, corresponding to the degradation of cellulose and lignin, respectively. The total mass loss is distributed as follows:

In the initial stage (moisture and hemicellulose decomposition) (d, e), 18.2%

54.8% in Stage II (cellulose degradation)

14.9% in the final stage (lignin degradation and residual charring)

The 750°C residue mass of 1.01 mg corresponds to 2.4% of the original mass.

3.1.5. Raffia Fiber Composite

Among all tested materials, raffia fiber composites exhibit the lowest thermal stability, with an onset degradation temperature of 225°C, making them prone to early decomposition, as shown in Figure 6.

The degradation occurs rapidly, with major peaks at 345°C, 372°C, and 409°C, signifying fast hemicellulose and cellulose breakdown.

The total mass loss distribution is as follows:

- 22.7% in the first stage (hemicellulose degradation)
- 58.1% in the second stage (cellulose breakdown)
- 11.9% in the final stage (lignin decomposition and minor char formation)

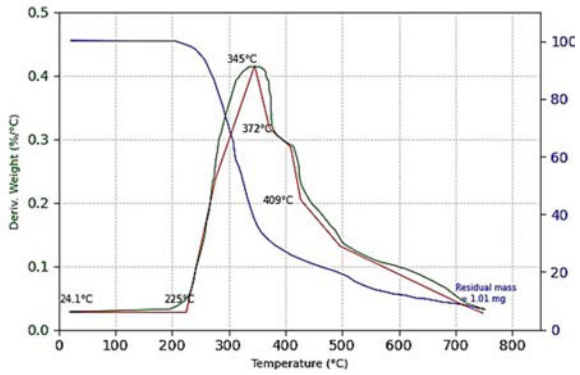

Fig. 6. Thermogravimetric analysis for raffia composite

The residual mass at 750°C is 1.01 mg and correspond with 2,5% from the initial mass, confirming poor thermal stability. These results suggest that raffia fibers may require additional chemical treatments to enhance their heat resistance.

3.1.6. Seagrass Fiber Composite

The seagrass fiber composite (Figure 7) has an onset degradation temperature of 271°C, ranking higher than raffia fiber but lower than flax and banana fibers.

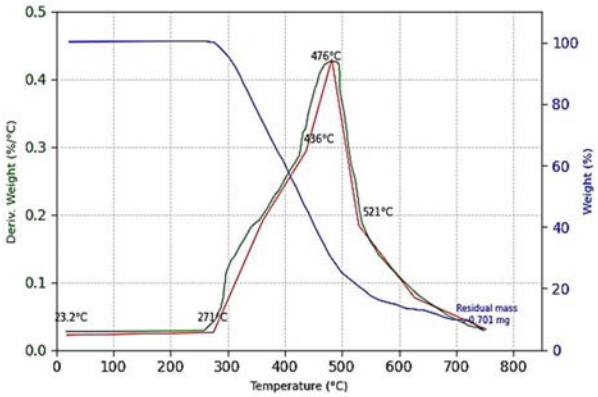

Fig. 7. Thermogravimetric analysis for seagrass composite

The peak weight loss occurs at 476°C, 496°C, and 521°C, indicating a moderate rate of degradation.

The total mass loss percentages are:

- 19.3% in the first stage (hemicellulose breakdown and moisture release)
- 53.7% in the second stage (cellulose degradation and volatile compound release)
- 16.2% in the final stage (lignin decomposition and partial char formation)

With a residual mass of 0.701 mg (2.3% from initial mass), seagrass composites offer better thermal stability than raffia but remain inferior to flax and glass fibers. These results indicate that seagrass fiber composites could benefit from thermal modification techniques to enhance their high-temperature durability.

3.1.7. Summary of TGA Analysis

The Thermal Gravimetric Analysis (TGA) indicates that synthetic and natural fiber composites exhibit various degrees of thermal stability. At that point with the steepest slope in the increasing region, the maximum peak degradation temperature is considered that condition at which event the material reaches its maximum degradation.

A summary of these essential findings appeared in Table 4 below.

Table 4

TGA results summary

Fiber Type	Onset Degradation Temp (°C)	Highest Peak Degradation (°C)	Total Mass Loss (%)
Carbon	327	500	86.74
Glass	291	492	90.7
Banana	239	407	98.1
Flax	287	536	97.6
Raffia	225	345	97.5
Seagrass	271	476	97.7

The peak degradation temperature of flax fiber composite (536 °C) was greater than that of other natural fibers including banana (407 °C), seagrass (476 °C), and raffia (345 °C) fibers.

This suggests that flax fibers have better thermal resistance than other natural reinforcements, which might be ascribed to their high cellulose content (about 70%) and their crystalline structure.

Flax composites have a lower degradation rate than other bio-based fibers, translating into greater thermal stability, as reflected in the total mass loss of only 97.6% at 600 °C.

Among natural fibers, carbon fiber composites showed the best thermal stability, initiating degradation at 327°C and peaking at 500°C with the most residual mass at 13.26% as compared with natural fibers. Glass fiber composites exhibited excellent temperature

resistance, with an initial 291°C and a peak at 492°C, indicating they could be employed in high-temperature environments.

Despite the fact that, in general, synthetic fibers (carbon and glass) have better thermal stability than natural fibers, flax fibers remain as the most thermally resistant among bio-based reinforcements.

These findings indicate the potential of flax fibers as a promising option for sustainable composite applications, especially when combined with thermal modification methods to improve their high-temperature performance.

3.2. Effect of Fiber Type on Thermal Stability

Fiber type plays a very important role in the thermal stability of fiber-reinforced composites, as synthetic fibers show better thermal resistance than natural fibers. The carbon and glass fiber composites showed higher onset degradation temperatures of 327°C and 291°C, respectively, as well as lower total mass loss, indicating that both exhibited improved thermal stability. In comparison, natural fibers like flax, banana, raffia, and seagrass highlighted lower degradation temperatures because of their involving organic structures, principally cellulose, hemicellulose, and lignin.

The degradation kinetics of natural fibers showed a multi-stage decomposition process, with the degradation of hemicellulose first (200–300°C), then cellulose (300–500°C) and lignin (>500°C). Peak degradation temperatures differed, where flax fiber composites had the greatest peak temperature (536°C), triggering that of other natural fibers. The comparison data show that although natural fibers provide sustainability benefits, and thermal modifications or hybridization was needed to improve performance at high-temperature environments.

3.3. Comparative Analysis with Literature

The thermal decomposition behaviours noted here are consistent with prior reports like [6], [10], [11]

TGA analysis studies suggest that thermal stability is heavily dependent on the chemical composition of the fibers, the type of fibers, and the interactions between the fibers and the matrix.[11]

As other studies [6], [12], [13] already showed, natural fiber composites exhibited three stages of degradation at 200–300°C (hemicellulose), 300–500°C (cellulose), and >500°C (lignin). Banana, raffia, and seagrass fibers were also lose initial mass, which validates its lowest thermal stability. With 536°C, flax fibers presented the highest peak degradation temperature of all the tested natural fibers because a rich cellulose content (≈70%) and a low lignin content. [5]

In contrast, synthetic fiber composites exhibited better thermal endurance[14], with carbon (327 °C) and glass (291 °C) fibers degrading at significantly higher temperatures. Similar values were obtained in other works like [15]. Carbon fiber composites with PEEK matrices have a high activation energy for decomposition [16] while glass fibers remain stable with some potential for sizing degradation at extreme temperatures.

The combination of natural fibers with carbon or glass reinforcements to form hybrid composites has shown improvements in flame responsiveness and decreased thermal degradation rates, creating opportunity for engaging fire stability in synergy with sustainability.[10], [17]

4. CONCLUSION

For fiber-reinforced composites, the thermal degradation temperature is a crucial parameter determining their applicability in high temperature scenarios. Thermogravimetric Analysis (TGA) was employed to investigate the thermal degradation behavior of six fiber-reinforced composites prepared from glass, carbon, flax, banana, raffia, and seagrass fibers. These results offer a comprehensive understanding of the relative thermal properties of synthetic versus natural reinforced composites.

The studies confirmed that synthetic fibers, specifically, carbon and glass fibers have better thermal stability relative natural fibers. The onset degradation temperature (327°C) of carbon fibre composites was the highest among the materials studied and the residual mass was

still significant (13.26%) at 750°C, demonstrative of the extreme thermal stability of carbon fibre composites. It also showed similar behavior of high heat yield, with onset temperature at 291°C and residual mass at 9.3%, which is useful; especially for applications that require endurance at higher temperatures and stable long term mechanical properties.

The thermal stability of natural fibers was relatively better with flax fibers having an onset degradation temperature of 287°C and peak degradation temperature of 536°C, this is due to the high cellulose content and crystalline structure of the flax fibers which increases their thermal resistance. The other natural fibers, such as banana, raffia, and seagrass showed lower thermal stability, with the decomposition temperatures ranging between 225°C and 271°C and higher total mass loss percentages.

While natural fibers possess notable advantages in terms of sustainability, biodegradability, and cost of production, their thermal limitations render them unsuitable for direct usage in high-temperature environments. However, with suitable treatments and hybridization with thermosetting material, natural fibers can be well developed for diverse applications.

In conclusion, this study adds to the efforts of researchers investigating sustainable composite materials by manifesting the thermal stability of various reinforcing fibers. Please note that flax fibers are a fascinating alternative to synthetic reinforcements in many applications, especially so if the fibers were thermally modified. Therefore, advanced treatment methods should be investigated in future studies to improve the thermal resistance of natural fibre composites, allowing them to be suitable for high-performance applications such as those found in aerospace, automotive, and construction applications.

Future Research Directions

In future, thermal stability of natural fiber composites should be improvised by chemical modifications, hybridization and nanotechnology. Surface treatments on fibers can improve fiber-matrix adhesion. Bio-based resins could provide sustainable materials with enhanced heat resistance.

Long-term thermal aging and durability testing under cyclic heating should be addressed in future studies. Algorithms such as molecular dynamics and finite element analysis can help predict degradation and improve designs. Lastly, recyclability and disposal option assessment are important pillars in sustainable engineering and reducing the impact on the ecological system.

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Stabilitatea termică și procesul de degradare al compozitelor armate cu fibre naturale și sintetice: o analiză termogravimetrică

Acest studiu analizează stabilitatea termică și modul de degradare a șase tipuri de compozite polimerice armate cu fibre—carbon, sticlă, in, banană, rafie și iarbă de mare—prin analiză termogravimetrică (TGA). Fibra de carbon a demonstrat cea mai bună stabilitate termică (degradare inițială la 327°C, masă reziduală de 13,26%), urmată de fibra de sticlă (291°C, 9,3%). Dintre compozitele cu fibre naturale testate, inul a avut cea mai bună performanță termică (degradare inițială la 287°C, vârf la 536°C), apropiindu-se de fibra de sticlă, dar rămânând sub performanța fibrei de carbon. Deși fibrele naturale prezintă în general o rezistență termică mai scăzută, fibra de in se conturează drept o alternativă sustenabilă promițătoare, cu un potențial ridicat de optimizare termică pentru aplicații în industria aerospațială, auto și construcții

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