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Calotropis gigantea Fiber-Based Non-Woven Sheets with Enhanced UV Resistance for Automotive Interior

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Abstract: The UV characteristics of Calotropis gigantea Fiber-reinforced non-woven composites for automobile parts are examined in this work. Researchers have looked at the possibility of using Calotropis gigantea, a naturally occurring fibre obtained from plants, to produce sustainable materials. Using Calotropis gigantea fibre to produce a UV-enriched non-woven material is the aim of this study.

A needle-punching process was used to create the composites, and their chemical and physical characteristics were described. After the non-woven material was made using a spun bonding technique and combined with low melting polyester, its properties were evaluated.

The composites' tolerance to UV light was assessed. The findings demonstrated that the composites had outstanding UV resistance and that their characteristics little changed when exposed to UV light. A homogeneous distribution of fibres and strong interfacial adhesion between the fibres and matrix were found by the morphological investigation. Potential uses for the created composites include automobile parts.

Utilising Calotropis gigantea fibres reduces the environmental effect of the automobile sector by providing a sustainable and environmentally acceptable substitute for synthetic fibres. The study's findings highlight the potential of non-woven composites reinforced with Calotropis gigantea fibre for use in automotive applications.

Keywords: Sustainable materials, automotive composites, UV characteristics, Calotropis gigantea fibre, and non-woven composites.

I. INTRODUCTION

One plant fibre that has been discovered as a possible option for usage in composite materials is *Calotropis gigantea*. The fibre is a desirable substitute for synthetic fibres because to its exceptional UV resistance, sustainability, and durability. There is growing pressure on the automobile sector to lessen its environmental effect. Using sustainable materials instead of synthetic ones is one strategy.

However, more research and development are required because the use of natural fibres in composite materials is still relatively new. The purpose of this study is to examine the UV characteristics of non-woven composites reinforced with *Calotropis gigantea* fibre for use in automobile components.

A major component of this research is the creation of non-woven composites reinforced with *Calotropis gigantea* fibres by the use of a needle-punching process. A popular process for creating non-woven textiles, needle-punching has several advantages, such as low prices and high production rates. *Calotropis gigantea* fibres are anticipated to increase sustainability, durability, and UV resistance when used in non-woven composites.

Accelerated weathering experiments will be used to assess the produced composites' UV characteristics. A popular technique for assessing a material's UV resistance is the use of accelerated weathering tests, which have the advantages of quick testing and precise findings. Fabric weight and the mechanical characteristics of the composites, such as tensile strength and abrasion resistance, will also be assessed.

II. METHODS

A. Selection Of Plant Source

Calotropis gigantea, a violet-coloured plant, was gathered locally from Erode. For later extraction, the plant material was kept.

Fig 1. Plant source

B. Fiber Extraction

The process of extracting fibres from plant components such as stems, leaves, or bark is known as fibre extraction. Fibres are then carefully cleaned and dried.

C. Hand Stripping

Individual stems were peeled and cleaned, and stem bundles were manually separated.

Fig 2 Fibre extraction through hand stripping

D. Natural Drying

Over the course of seven days, the fibres were allowed to naturally dry in the sun.

Fig 3. Fibre drying

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E. Fibre Evaluation

1) Chemical Properties

- Ash Content: Determines the proportion of inorganic minerals in fibres by weighing samples both before and after they are burned at high temperatures.
- Wax Content: Uses solvents like ethanol to analyse natural wax on fibres, which is crucial for comprehending textile performance, dyeability, and moisture absorption.
- Lignin Content: Uses chemical processing and insoluble residue analysis to determine the percentage of lignin, a polymer found in plant cell walls.

2) Physical Properties

- Diameter: Talks about how fibre thickness affects softness, strength, and application compatibility.
- Density: Represents the mass of fibres per unit volume, which influences the weight and properties of the fabric.

F. Fiber Softening

The chosen 60 grammes of fibre were treated with equal amounts of salt (50 percent of the fibre weight) and Haritaki powder to soften the fibres for the creation of non-woven fabrics. The gumming parts were eliminated by salt treatment, allowing the fibre to be used to create fabric.

G. Selection Of Fabric Formation Method

Calotropis gigantea fibres were combined with low-melting polyester to create the cloth.

Fig 4.Layering the fibre

H. Needle Punching

This method uses barbed needles to poke fibres through the web to join dry lay and spin placed webs. With a working width of 500mm and a downward stroke of 60mm, the Trytex micro nonwoven system uses up to 1310 needles per board. For better outcomes, the web is needle-punched on both sides.

Fig 6. Needle punching

I. Thermal Bonding

This technique, which uses a laboratory thermal bonding equipment, is perfect for natural fibre nonwoven materials used in a variety of industries. *Calotropis gigantea* fibre and low melting polyester fibre are melted and bonded by passing the web between rollers at a steady 160°C. Bonding performance is optimised by an adjustable nip contact time.

Fig 7. On the process of thermal bonding

J. Fabric evaluation:

- Abrasion: The intrinsic fragility of natural fibre nonwoven textiles renders them vulnerable to wear and tear from mechanical stress and friction, which diminishes their strength and durability.
- Tensile Strength: This attribute, which is determined by evaluating the force required to rip the fabric, may be improved by fibre mixing, better construction, and finishing techniques.
- Fabric Weight: Referred to as mass per unit area and measured in grammes per square metre, or GSM. determined the mass and area of the cloth samples using an electronic balance and a GSM cutter.

K. Functional Evaluation

UV Resistance: Excellent UV protection is exhibited by nonwoven textiles made using CG fibre. Tests like as UV transmittance, reflectance, and absorption are used to assess their qualities.

Fibre extraction, purification, nonwoven fabric creation (using methods like spun-lacing and needle-punching), and UV treatment are all steps in the development process. These materials are perfect for industrial textile, medicinal, and agricultural applications including apparel, furniture, and filtration because of their longevity and resilience to UV light.

III. RESULT AND DISCUSSION

A. Physical properties:

TABLE 1: Physical properties of the CG and LMP fibre

S.NO	TEST	SAMPLE	
		CG	LMP
1.	Density	1.17 g/cm^3	1.38 g/cm³
2.	Diameter		
	Maximum	0.1037 mm	0.37 mm
	Minimum	0.0500 mm	0.32 mm
	Average	0.0726 mm	0.34 mm

In the above table 1 The density of *Calotropis gigantea* fibre is 1.17 g/cm³, lower than LMP's 1.38 g/cm³, making it lighter and suitable for lightweight nonwoven composites.

In terms of diameter, *Calotropis gigantea* fibre shows variability (0.0500–0.1037 mm, average 0.0726 mm), whereas LMP fibres exhibit uniformity (0.32–0.37 mm, average 0.34 mm). LMP's consistent structure enhances mechanical strength, while the lightweight nature of Calotropis gigantea adds versatility.

B. Chemical Properties

TABLE 2: Chemical properties of the CG and LMP fibre

S.NO	**TEST**	**SAMPLE**	
		CG	**LMP**
1.	Lignin content %	1.24 %	0
2.	Wax content %	0.76 %	0.4 %
3.	Ash content %	4.70 %	1.6 %

In table 2 the *Calotropis gigantea* (CG) fibre and low melting polyester (LMP) were analysed for thermal stability, biodegradability, and composite compatibility.

- Lignin Content: CG fibre contains 1.24% lignin, enhancing rigidity, while LMP has 0%, offering chemical stability.
- Wax Content: CG fibre has higher wax content (0.76%) than LMP (0.4%), which affects hydrophilicity and bonding but can be improved with pretreatment.
- Ash Content: CG fibre has 4.70% ash content, indicating potential for fire resistance, whereas LMP shows 1.6%, suitable for maintaining mechanical integrity.

Blending CG with LMP can produce eco-friendly composites with balanced durability and sustainability.

C. Tensile strength:

TABLE 3: Tensile strength of the CG layered non – woven and commercially available

	CG FIBER LAYERD NON – WOVEN	**COMMERCIALLY NON - WOVEN**
Mean	89.6	120
Standard deviation	1.020	8
Co-efficient of variation	1.138 %	5 %

In the above table 3 CG fibre non-woven fabric shows a mean tensile strength of 89.6 N, lower than the 120 N of commercial fabric, which benefits from advanced fibre blends and manufacturing methods.
While CG fabric has lower strength, its results are more consistent, with a standard deviation of 1.02 and a coefficient of variation (CV) of 1.138%, compared to 8 and 5% for commercial fabric, respectively. This indicates better uniformity and quality control in CG fabric.

D. Abrasion Resistance

TABLE 4: Abrasion resistance for the CG layered non – woven and commercially available

	CG LAYERED NON-WOVEN	**COMMERCIALLY AVAILABLE**
Mean	12.5%	2.5 %
Standard deviation	1.0	0.3
Co-efficient of variation	8.0 %	12%

In the above table 4 The CG nonwoven sheet shows a mean weight loss of 12.5%, higher than the commercial fabric's 2.5%, indicating better abrasion resistance in the commercial material, ideal for high-durability automotive applications.
Standard deviations are 1.0 for CG and 0.3 for the commercial sample, with CVs of 8% and 12%, respectively. CG has consistent performance, while the commercial fabric exhibits slightly greater variation.

E. Fabric Weight (GSM)

TABLE 5: Fabric weight for the CG layered non – woven and commercially available

GSM	
CG layered non – woven	0.5
Commercially available	3

In the above table 5 the CG nonwoven fabric has a GSM of 0.5, indicating lightweight and breathability, but lower durability and tensile strength. In contrast, commercial nonwoven fabric has a GSM of 3, offering greater density, durability, and mechanical integrity, ideal for demanding automotive applications like sunroof linings.

F. Functional Evluation

UV Resistence

TABLE 6: UV resistance test analysis

UV-A blocking	92.60 %
UV-B blocking	97.95 %
UPF rating	30

Scan	UPF	Critical wavelength
Location 1	31.25 %	384
Location 2	33.80 %	383
Location 3	30.45 %	384
Location 4	32.75 %	383

In the above table 6 and figure 6 The fabric exhibits excellent UV resistance, with 92.60% UV-A blocking and 97.95% UV-B blocking, effectively reducing skin exposure to harmful radiation. UPF Rating: With a UPF value of 30, the fabric blocks 96.7% of UV rays, making it suitable for sun-protective applications like outdoor wear and coverings. Sample Variability: UPF values ranged from 30.45% to 33.80%, with critical wavelengths between 383–384 nm, showing consistent UV-blocking performance across the fabric surface.

IV. CONCLUSION

In conclusion, the sustainable development of UV-resistant nonwoven sheets from *Calotropis gigantea* fibres for automotive applications has shown promising results. This innovative material offers a viable alternative to traditional materials, providing benefits such as sustainability, biodegradability, and improved performance. The development of these nonwoven sheets has the potential to contribute to a more environmentally friendly and sustainable automotive industry. Further research and development are needed to fully explore the potential of *Calotropis gigantea* fibres and to address any challenges that may arise.

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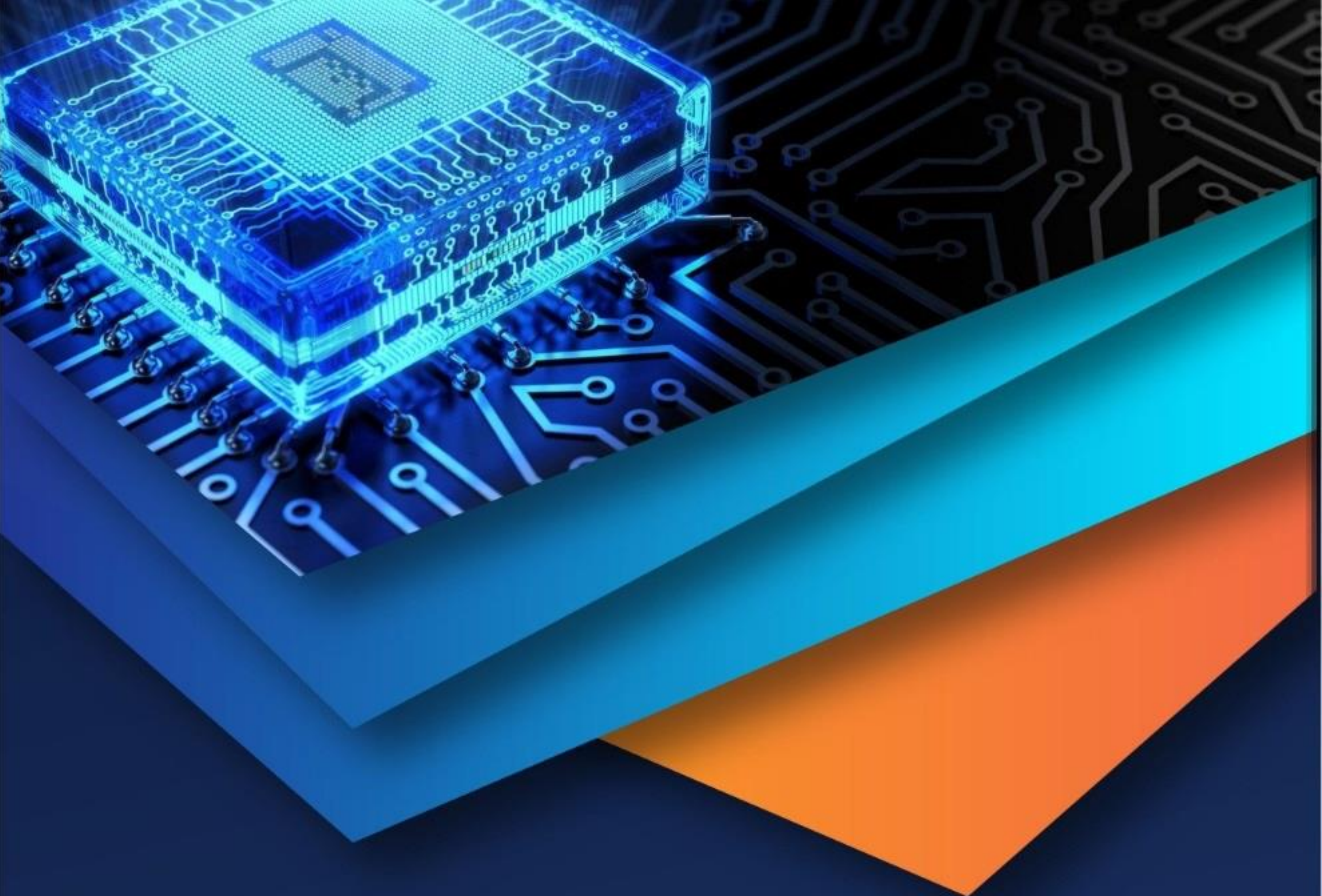

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