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UV-Protective Finish Using Natural Extracts of Guava, Mango, and Tulsi Leaves

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***Abstract*-- Ultraviolet (UV) rays from the sun pose serious risks to children's skin, increasing the need for UV protective clothing. Poly-cotton fabric is often used for children's clothes because it is comfortable, durable, and easy to care for. However, it provides limited natural UV protection. In recent years, eco-friendly and natural textile finishes have gained attention as alternatives to synthetic chemical finishes. Leaves from mango (Mangifera indica), guava (Psidium guajava), and tulasi (Ocimum sanctum) are rich in bioactive compounds like flavonoids, phenols, tannins, and antioxidants that have strong UV-absorbing qualities. These natural leaves are biodegradable, non-toxic, and safe to touch, making them perfect for children's clothing. This review highlights the suitability of poly-cotton fabric and the UV protective properties of mango, guava, and tulasi leaves, emphasizing their role in creating sustainable and child-safe UV protective textiles.**

***Keywords*-- UV protective fabrics, Poly-cotton textile, Mango leaves, Guava leaves, Tulsi leaves, Kids' clothing, Sustainable textile.**

I. INTRODUCTION

Exposure to ultraviolet (UV) rays can seriously damage skin, cause early aging, and lead to various skin-related health issues, especially in children with sensitive skin. Clothing acts as the first line of defense against UV rays, making it crucial to develop UV protective fabrics in textile research. Traditional UV coatings often contain synthetic chemicals, leading to skin problems and harmful environmental effects, creating a demand for safer, eco-friendly options. Poly-cotton fabric, a blend of cotton and polyester fibers, is commonly used in kids' clothing due to its softness, breathability, durability, and cost-effectiveness. Despite these advantages, poly-cotton fabric has limited natural UV protection and needs functional finishes to boost its protective abilities. Renewable natural plant-based materials have emerged as effective agents for textile finishing due to their functional properties and sustainability.

Mango, guava, and tulasi leaves are widely available and contain bioactive substances such as flavonoids, phenolic acids, tannins, and antioxidants that can absorb UV radiation. These leaves have been used in traditional medicine and are now being explored for textile enhancement. Using these natural materials for UV finishing offers an eco-friendly, safe, and sustainable approach, especially for kids' clothing. This review emphasizes the potential of mango, guava, and tulasi leaves as natural UV protectants for poly-cotton fabric, contributing to the development of safe and sustainable textiles for children's clothing.

II. MATERIALS

1. Guava (Psidium guajava)

Guava leaves have high levels of phenolic compounds, flavonoids, and tannins, known for their effective absorption of UV radiation. Guava leaf extracts have been used for medicinal purposes and are now being researched for textile enhancement. Studies show that cotton fabrics treated with guava leaf extracts have improved properties, including antioxidant, antibacterial, and UV protective features due to these bioactive compounds. The ability to absorb UV light comes from polyphenolic compounds that can shield against radiation in the UV range when applied to fabric.[1]

Action:

Guava leaf extracts are rich in flavonoids and phenols, whose structures enable them to absorb UV light. These molecules interact with UV light to convert harmful radiation into less dangerous energy. When bonded to fabric fibers using adhesion methods or natural mordants, these substances create a useful layer that offers UV protection. [2]

Eco-friendly Profile:

Guava leaves are typically agricultural byproducts that are environmentally friendly, biodegradable, and low in toxicity, making them sustainable substitutes for artificial UV absorbers. [3]

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Figure1: Guava Leaves

2. Mango (Mangifera indica)

Mango leaves and seeds also contain tannins, flavonoids, and polyphenolic compounds that provide UV absorption and antioxidant properties. Studies on wool fabrics treated with mango seed extracts show improved UV protection along with additional benefits like resistance to insect infestations and antibacterial properties. Although there are few direct studies on poly-cotton, the presence of similar phytochemicals suggests that mango leaf extract may offer comparable UV absorption when applied to poly-cotton.[4]

Action:

Mango leaf extracts contain gallotannins and various polyphenolic compounds that have UV-absorbing properties. Their natural structures enhance the absorption of UV radiation and can effectively create a protective barrier when applied to textile fibers. Their inherent aromatic configurations promote the absorption of ultraviolet radiation and can be efficacious when affixed to textile fibers, thereby generating a protective barrier that diminishes ultraviolet transmittance. [5]

Availability:

Mango leaves are extensively available in tropical and subtropical locales, rendering them a plentiful natural resource for research in textile finishing methodologies.

Figure 2: Mango leaves

3. Tulasi (Ocimum sanctum)

Tulasi, or holy basil, is valued in traditional medicine and contains bioactive compounds such as eugenol, rosmarinic acid, oleanolic acid, and various flavonoids. Research suggests that extracts from Tulasi leaves not only boost antimicrobial effectiveness but also provide UV protective properties when applied to textiles. Fabrics treated with Tulasi extracts show visible changes in color and function, linked to the binding of these compounds to the fibers. Textiles that have been treated with Tulasi extracts display inherent alterations in coloration and functional characteristics, attributable to the binding of these phytochemicals to the fiber matrix. [6]

Action:

Eugenol and similar aromatic compounds can absorb specific UV wavelengths due to their chemical structures. When applied to fabrics, these compounds can create a protective layer that blocks or absorbs UV radiation before it penetrates the fabric and reaches the skin. Upon application to textiles, these compounds can establish a protective surface matrix that effectively obstructs or absorbs UV radiation prior to its penetration through the fabric and subsequent exposure to the skin. [7]

Cultural & Environmental Relevance:

Tulasi is extensively cultivated in India and various other geographic locales, thereby providing a sustainable and culturally endorsed source of functional biomolecules for the enhancement of textile finishes.

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Figure3: Tulasi Leaves

III. Application Techniques For Natural Leaf Extracts

The typical approach to applying natural extracts to fabric involves extraction (using water, ethanol, or other benign solvents), followed by impregnation onto fabric fibres using pad-dry methods or similar low-temperature finishing processes. [8] Although detailed testing methods are outside the scope of this review, the focus remains on the concept of affixing bioactive compounds from leaves onto the poly-cotton surface. The success of the finish depends on the adhesion of natural molecules to the fibre and retention through wear and washing cycles.

IV. Advantages Of Natural UV Functional Finishes

- *Eco-friendly and non-toxic:*

  Unlike many synthetic UV absorbers, plant extracts are biodegradable and generally safe for skin contact, an important consideration for children's wear.

- *Renewable resources:*

  Leaves such as guava, mango, and tulasi are abundant and renewable, reducing reliance on petrochemical products.

- *Cost-effective:*

  Many of these materials are agricultural waste or by-products, offering a low-cost source of functional chemicals.

- *Low environmental impact:*

  Natural finishing reduces chemical load in effluents and minimizes harmful residues.

V. Challenges And Future Directions:

Even though natural extracts show potential, they come with issues like inconsistent makeup because of things like how old the plant is, when it's picked, and how it's extracted. We really need to nail down the extraction and application steps so that results can be repeated. It's also super important to keep digging into how these things stick to fabric fibers and how long the UV protection actually lasts when you're wearing and washing clothes normally. To make natural UV finishes on poly-cotton fabrics even better and more eco-friendly, we should look into developing green cross-linking agents and binders that are good for the environment.

VI. Results And Discussion:

FTIR Test:

The FTIR analysis identified both samples as cellulosic materials, characterized by strong O-H stretching near 3300 cm^ {-1} and C-O-C vibrations at 1000 cm^{-1}. Sample 1 (18703) emerged as the superior specimen, achieving a high library match score of 918 against Microfibrillated Cellulose. Sample 2 (18704) showed a lower correlation score of 885 compared to Tencel, indicating less structural purity. The higher spectral clarity of Sample 1 suggests it is the more stable and reliable substrate for technical textile applications. Consequently, Sample 1 is recommended for further chemical processing to ensure uniform and high-quality results.

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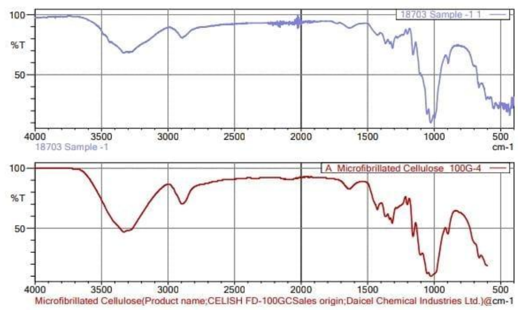
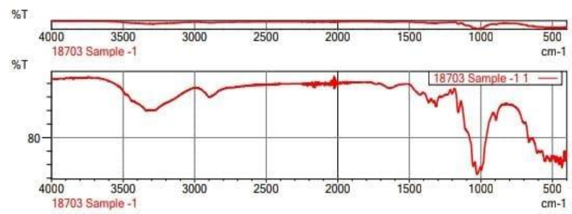
Sample 1





	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area	Comment
1								

The FTIR spectrum of Sample 1 (18703 Sample-1) displays the distinct peaks of cellulose, and the library matching outcome suggests that the sample resembles microfibrillated cellulose / microcrystalline cellulose.

Absorption Peaks and Their Significance

Approximately 3300–3400 cm⁻¹

A wide absorption band is observed in this area. This peak is associated with O–H stretching vibrations, which are characteristic of hydroxyl groups found in cellulose molecules.

Approximately 2900 cm⁻¹

This peak denotes the C–H stretching vibration of the aliphatic groups found in the cellulose structure.

About 1640 cm⁻¹

This band signifies O–H bending of absorbed water molecules. Cellulose has a tendency to attract water, meaning it typically holds some moisture.

Approximately 1430 cm⁻¹

This peak is associated with CH_2 bending vibrations, frequently observed in cellulose fibers.

Approximately 1370 cm⁻¹

This band signifies the bending vibration of C–H in cellulose.

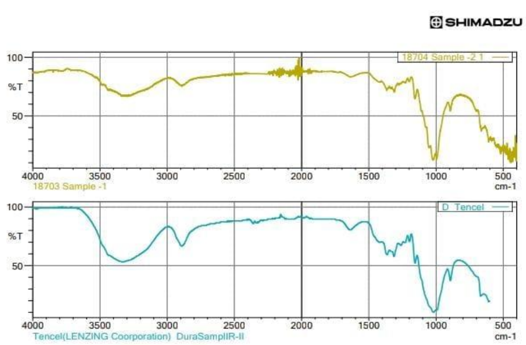
Approximately 1160 cm⁻¹

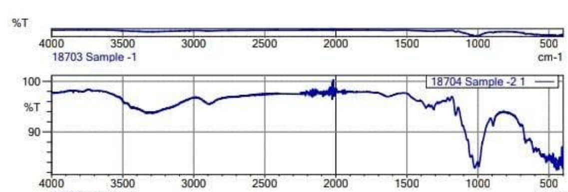
This peak results from the asymmetric stretching of C–O–C in the β-glycosidic bond found in cellulose.

Approximately 1030–1050 cm⁻¹

A pronounced peak in this area corresponds to the C–O stretching vibration of the polysaccharide structure.

Sample 2





	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area	Comment
1								

The library search results indicate that the highest similarity score (~885) corresponds to Tencel (Lyocell fiber). Tencel is a regenerated cellulose fiber, which makes its FTIR spectrum quite akin to that of cellulose.

Absorption Peaks and Their Analysis

Approximately 3300–3400 cm⁻¹

A wide peak is seen in this area because of O–H stretching vibrations of hydroxyl groups. This is a distinctive trait of cellulose-derived fibers.

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Approximately 2900 cm⁻¹

This band signifies the C–H stretching vibration of aliphatic groups found in the cellulose polymer chain.

Approximately 1640 cm⁻¹

This peak signifies O–H bending of absorbed water molecules, demonstrating that the fiber holds moisture.

Approximately 1430 cm⁻¹

This band is associated with the bending vibration of CH_2, which is typically present in cellulose structures.

Approximately 1370 cm⁻¹

This peak indicates the C–H bending vibration within the cellulose molecule.

Approximately 1030–1050 cm⁻¹

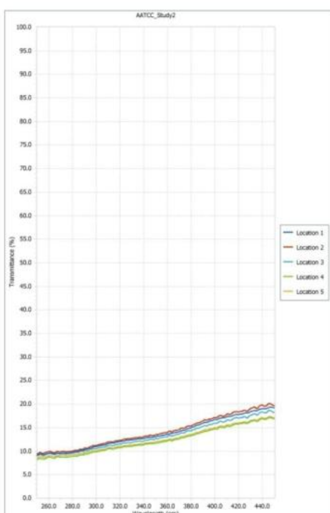
A significant absorption peak is observed in this area related to C–O stretching vibration, validating the polysaccharide structure.

Approximately 895 cm⁻¹

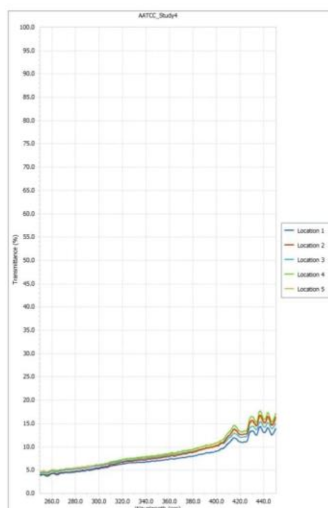
This band signifies the β-glycosidic bond between glucose units, verifying their presence.

UPF Test:

The UPF test results demonstrate that Sample 2 is significantly more effective, achieving a UPF rating of 16 compared to 9 for Sample 1. Sample 2 provides superior radiation shielding by blocking 91.83% of UV-A and 94.23% of UV-B rays. In comparison, Sample 1 exhibits higher transmittance, blocking only 86.77% and 89.58% respectively. With a mean UPF of 15.56, Sample 2 offers nearly double the protection of Sample 1. Consequently, Sample 2 is the preferred choice for developing technical garments with enhanced UV-protective properties.



Sample 1



Sample 2

Sample 1

The graph illustrates the transmission (%) of the sample across various wavelengths (250–450 nm) assessed at five distinct sites. The transmission values steadily rise as the wavelength becomes longer. At shorter wavelengths near 250 nm, the transmission is roughly 4–5%, suggesting minimal light is able to pass through the material. When the wavelength nears 400–450 nm, the transmission increases to approximately 14–17%. The curves for all five sites are nearly identical, suggesting that the sample possesses consistent characteristics throughout the surface.

The small differences among the lines indicate slight variations in measurement points, yet there is no significant inconsistency. In general, the findings suggest that the material exhibits steady transmission characteristics as the wavelength increases.

Sample 2

The graph illustrates the percentage of light passing through the sample at wavelengths ranging from 250 nm to 450 nm, recorded at five distinct sites. The transmission value slowly rises as the wavelength lengthens.

At about 250 nm, the transmission is roughly 8–10%, which shows reduced light passage through the material. As the wavelength approaches 450 nm, the transmission increases to approximately 16–20%. The measurements for all five locations are quite similar, indicating that the sample exhibits consistent optical properties in various regions. Minimal variations are noted across locations, likely attributable to slight differences in surface or thickness. The outcome shows that the material demonstrates stable transmission characteristics as the wavelength increases.

VII. CONCLUSION

Natural extracts from guava, mango, and tulasi leaves are pretty cool for making poly-cotton fabrics more eco-friendly when it comes to UV protection. These plants are packed with natural compounds that can absorb UV rays, meaning we can boost the UV protection factor of fabrics without using synthetic chemicals that might be bad for the environment or our health. We still need to figure out the best ways to apply them and how well they hold up over time, but using these plants is a really sustainable way to create functional textiles, especially for kids' clothes where being safe and comfy is super important. Sample 1 (18703) exhibited a superior chemical match with a score of 918, yet Sample 2 (18704) proved functionally superior with a UPF rating of 16 and higher UV blocking percentages.

While Sample 1 has higher structural purity, Sample 2 offers nearly double the radiation protection and better wash durability, making it the ideal choice for UV-protective technical textiles.

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