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"Biomimetic Waterproofing: A Study On The Devolpment And Characterization Of A Sustainable Waterproof Wallet Made From Anas Platyrhynchos Feathers And Fish Scales"

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Abstract: This study explores the development of an eco-friendly, waterproof women's wallet using a woven fabric composed of duck feathers, kapok, and cotton. The project aims to offer a sustainable alternative to chemically coated waterproof wallets by utilizing natural fibers with inherent water-repellent properties. The duck feather fabric is further enhanced with a coating derived from mackerel fish scale powder applied via a paddle mangle process. This research examines the material's physical and mechanical properties, including tensile strength, breathability, moisture resistance, and biodegradability. The testing phase includes a drop test to assess water resistance and a pH test to ensure skin compatibility. Comparative testing with conventional chemically coated wallets highlights the sustainability, durability, and efficiency of the proposed innovation, paving the way for future applications of natural-based waterproof textiles in the fashion accessories industry. By replacing synthetic coatings with naturally derived substances, this project contributes to reducing environmental waste and promoting sustainable fashion.

Index Terms **-** Component, formatting, style, styling, insert.

I. INTRODUCTION

Traditional waterproof wallets are often made using synthetic leather or chemically treated fabrics, which pose significant environmental hazards due to their non-biodegradable nature. These materials take hundreds of years to break down and contribute to increasing levels of plastic waste in landfills and oceans. Moreover, the chemical treatments used in these synthetic wallets often release harmful toxins, negatively impacting both the environment and human health.

The increasing awareness of climate change and pollution has driven the need for eco-friendly alternatives in the fashion industry. Consumers are now seeking products that align with sustainability principles while maintaining durability and functionality. The shift towards biodegradable and natural materials in accessories has gained significant momentum, pushing researchers and designers to explore innovative ways of integrating natural fibers into fashion products.

This project presents an alternative by utilizing a woven duck feather fabric blended with kapok and cotton, coated with a naturally sourced fish scale powder. Duck feathers are naturally water-resistant due to their microstructure, making them an excellent base material for waterproof textiles. Kapok fibers, known for their buoyancy and insulation properties, further enhance the performance of the fabric, while cotton provides structure, flexibility, and comfort. The fish scale powder coating is derived from a biodegradable source and adds a protective hydrophobic layer, increasing the fabric's durability against water exposure.

By leveraging these materials, this study aims to introduce a new approach to sustainable fashion, proving that natural substances can be used to create highly functional and aesthetically appealing products. The study

investigates the functional properties of this material and its potential application in the sustainable fashion accessories industry.The textile industry is one of the largest contributors to environmental pollution, with conventional fabric production processes generating significant waste, excessive water consumption, and reliance on synthetic chemicals. In response to the growing demand for sustainable and eco-friendly textiles, the industry is shifting towards innovative solutions that prioritize environmental responsibility without compromising product quality and functionality. This study explores a revolutionary approach to sustainable sock manufacturing by integrating a circular weaving method with advanced fiber blending and natural finishing techniques.

OBJECTIVES

1. To develop a sustainable and waterproof women's wallet using natural fibers.
2. To replace synthetic waterproof coatings with a biodegradable fish scale powder coating.
3. To evaluate the physical and mechanical properties of the woven duck feather fabric.
4. To conduct comparative testing against chemically coated waterproof wallets.
5. To promote eco-friendly alternatives in the fashion accessories industry

PROPERTIES

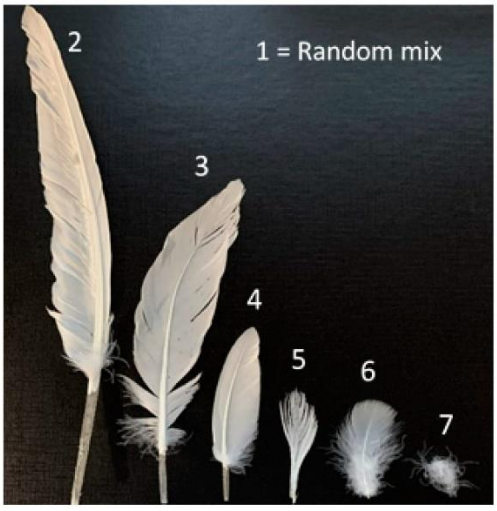
Physical and Mechanical Properties:

The physical and mechanical properties of the materials used in this project are critical in determining their suitability for waterproof wallet applications. Various properties, including tensile strength, elasticity, moisture retention, and biodegradability, were evaluated to ensure the fabric met the required standards for durability and sustainability.

1] Duck Feathers:

Duck feathers are naturally lightweight and feature microscopic barbs that interlock, creating a structure that repels water. This property allows the fabric to remain dry while maintaining breathability. Additionally, the feathers provide insulation, preventing temperature fluctuations inside the wallet and ensuring the safety of stored items such as banknotes, cards, and receipts.

[Fig 1: Raw Material of Duck Fibres]



[Fig 2: Size Variations of Duck Fibres]

2] Kapok:

Kapok is a natural fiber known for its hypoallergenic and moisture-resistant qualities. Its hollow fiber structure makes it buoyant and resistant to microbial growth, ensuring that the material does not degrade easily when exposed to moisture. Kapok also enhances the softness of the fabric, making the wallet comfortable to handle while maintaining its structural integrity.

[Fig 3: Kapok Fibre]

3] Cotton:

Cotton plays an essential role in the blend by adding flexibility and durability. As a widely used natural fiber, cotton ensures that the fabric maintains its shape while allowing for easy manipulation in design and production. Additionally, cotton fibers enable proper breathability, ensuring the wallet does not trap heat or moisture.

[Fig 4: Cotton Fibres]

4] Fish Scale Powder Coating:

Fish scale powder, derived from dried mackerel fish scales, is rich in hydroxyapatite and chitin, two components known for their hydrophobic and antimicrobial properties. The powder is applied to the woven fabric through a paddle mangle, creating a protective layer that enhances water resistance while maintaining breathability. This coating ensures that the fabric remains effective against water exposure without compromising its sustainability.

[FIG 5: Collection of Fish Scales]

[FIG 6: Methodology of Fish Scale Powder]

METHODOLOGY

1. Material Collection and Preparation:

- Duck feathers collected, cleaned, and de-stemmed to retain the soft fibers (60%)
- Kapok and cotton blended in a 40% ratio to balance softness and durability
- The woven fabric was constructed using specialized loom weaving techniques to interlock fibers for enhanced strength and water resistance.

[FIG: Woven Fabric made from Blended og Duck fibre,Kapok & Cotton]

2. Coating Process:

- Mackerel fish scales collected, thoroughly cleaned, dried, and finely ground into powder
- Powder mixed with a natural binder to ensure adhesion without synthetic chemicals
- Applied using a paddle mangle, a textile processing method that ensures even coating and maintains the fabric's flexibility

3. Testing:

- Drop test conducted to measure the hydrophobic effectiveness of the coated fabric under simulated water exposure
- pH test performed to assess the fabric's skin compatibility and ensure it does not cause irritation
- Tensile strength test conducted to determine the resistance of the material against wear and tear
- Breathability test carried out to ensure the fabric does not trap moisture inside the wallet
- Absorption capacity test measured the extent of water resistance under prolonged exposure conditions.

4. Advantages:

- Fully biodegradable and environmentally friendly
- Free from synthetic chemicals and non-toxic
- Breathable and lightweight, ensuring comfort and functionality
- Natural water resistance with added durability from the coating
- Reduction in plastic pollution and chemical waste
- Aesthetic appeal with unique textures from natural fibers

5. Disadvantages:

- High production costs due to manual labor-intensive processes
- Limited raw material availability in some regions
- Durability may be slightly lower than synthetic chemically coated wallets
- Requires further refinement for large-scale production

6. Manufacturing Process Of Wallet:

Step 1: Cutting
- Cut the fabric into the required shape and size for the wallet.

Step 2: Interfacing
- Apply an interfacing material to the fabric to give it stability and structure.

Step 3: Sewing
- Sew the fabric pieces together using an industrial sewing machine.

Step 4: Adding Hardware
- Add any hardware components such as buckles, zippers, or rivets.

Step 5: Card Slot and Pocket Creation
- Create card slots and pockets according to the wallet design.

Step 6: Folding and Shaping
- Fold and shape the wallet to its desired form.

Step 7: Final Stitching
- Perform final stitching to secure all the components together.

Step 8: Quality Control
- Inspect the wallet for any defects or quality issues.

Step 9: Packaging
- Package the wallet in a protective bag or box.

Step 10: Final Touches
- Add any final touches such as branding, labeling, or packaging inserts.

[FIG: Wallet Made From Duck Woven Fabric Blend with Kapok & Cotton]

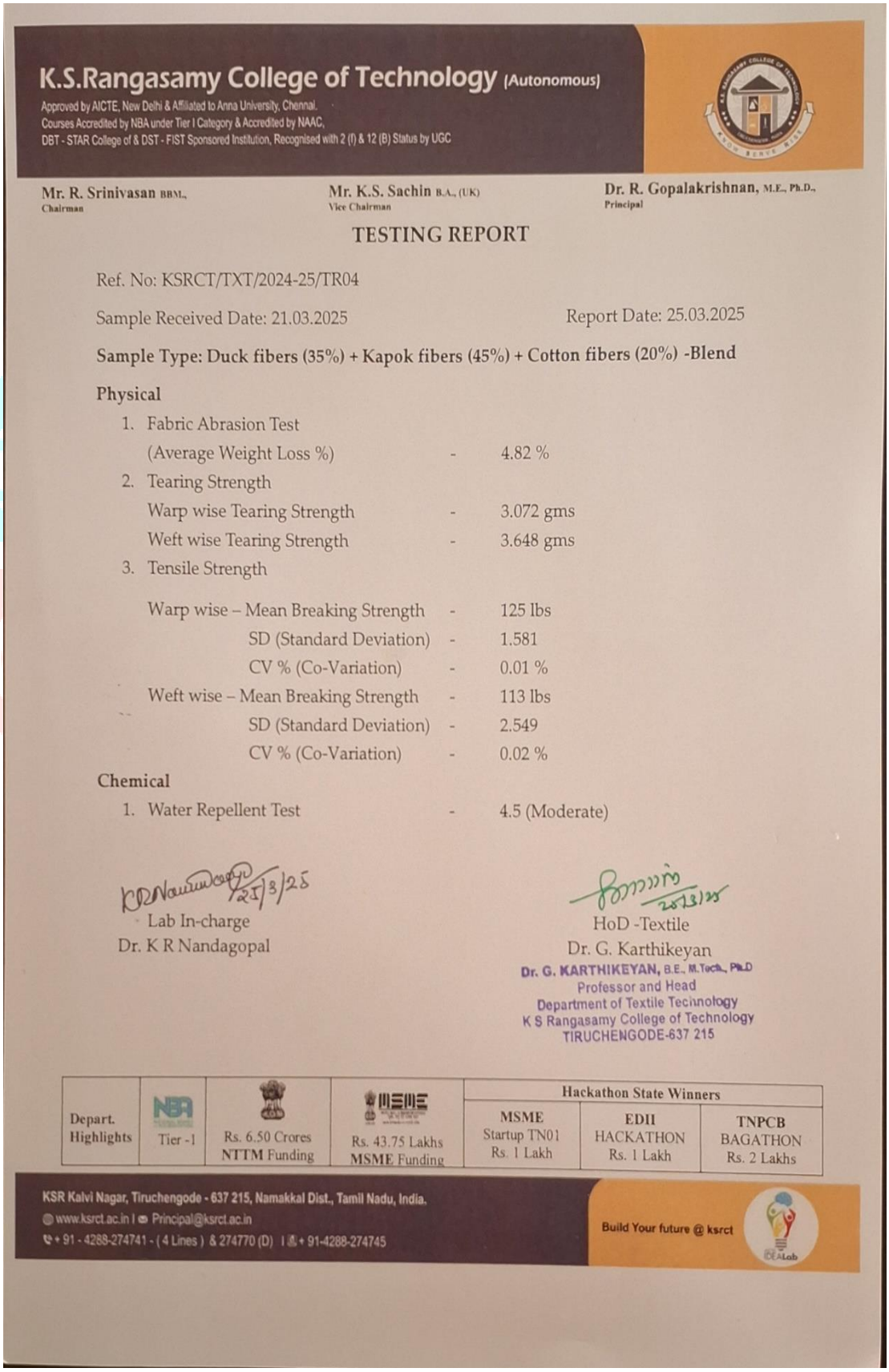
TEST REPORT:

1] CHEMICAL TEST:

- Water Repellency Test

2] PHYSICAL TEST:

- Tensile Strength Test
- Abrasion Test
- Tearing Test



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TESTING REPORT

Ref. No: KSRCT/TXT/2024-25/TR04

Sample Received Date: 21.03.2025 Report Date: 25.03.2025

Sample Type: Duck fibers (35%) + Kapok fibers (45%) + Cotton fibers (20%) -Blend

Physical

1. Fabric Abrasion Test
   (Average Weight Loss %) - 4.82 %
2. Tearing Strength
   Warp wise Tearing Strength - 3.072 gms
   Weft wise Tearing Strength - 3.648 gms
3. Tensile Strength

Warp wise – Mean Breaking Strength	-	125 lbs
SD (Standard Deviation)	-	1.581
CV % (Co-Variation)	-	0.01 %
Weft wise – Mean Breaking Strength	-	113 lbs
SD (Standard Deviation)	-	2.549
CV % (Co-Variation)	-	0.02 %

Chemical

1. Water Repellent Test - 4.5 (Moderate)

21/3/25
Lab In-charge
Dr. K R Nandagopal

25/3/25
HoD -Textile
Dr. G. Karthikeyan
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Depart. Highlights				Hackathon State Winners		
	Tier -1	Rs. 6.50 Crores NTTM Funding	Rs. 43.75 Lakhs MSME Funding	MSME Startup TN01 Rs. 1 Lakh	EDII HACKATHON Rs. 1 Lakh	TNPCB BAGATHON Rs. 2 Lakhs

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CONCLUTION:

This study successfully demonstrates the potential of using natural materials to create waterproof and sustainable fashion accessories. The woven duck feather fabric coated with fish scale powder offers an eco-friendly alternative to chemically treated wallets, addressing the environmental concerns associated with synthetic coatings. The incorporation of duck feathers, kapok, and cotton enhances the fabric's durability, breathability, and water resistance, making it a viable choice for long-term use.The test results confirm that the developed fabric performs efficiently in comparison to conventional chemically coated wallets, providing similar waterproofing properties without harmful environmental impacts. The drop test and pH test validate its effectiveness, ensuring that the product remains both functional and skin-friendly. Additionally, the tensile strength and breathability tests highlight its durability and comfort, making it a suitable option for daily use. By replacing synthetic waterproof coatings with a biodegradable and natural fish scale powder, this research contributes to reducing plastic pollution and promoting sustainability in fashion accessories. Future studies can focus on refining the coating process, optimizing production scalability, and exploring other natural alternatives to enhance waterproofing capabilities. The findings of this study pave the way for innovative, eco-conscious textile applications that align with the growing demand for sustainable and ethical fashion.

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