



KEMENTERIAN PENDIDIKAN TINGGI

# PITRAM 2026

Pertandingan Inovasi Antara Asasi Malaysia

## Extended Abstract Book



11 dan 12 APRIL 2026

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## **Algae-Shield SCOBY Leather: Development of Kombucha SCOBY-Based Vegan Leather**

Muhammad Adam Abd Rahim, Zulaikha Batrisya Zahrulail, Muhammad Faris Syahmi  
Faizulli, Darshini Subash Sun, Nur Amaleen Syahira Rahim, Nurul Izzah Mukri

Pusat PERMATA@Pintar Negara, Universiti Kebangsaan Malaysia (UKM), 43600  
Bangi, Selangor Darul Ehsan, Malaysia.

\*ap04696@siswa.ukm.edu.my

### **ABSTRACT**

SCOBY leather is a bio-composite material derived from bacterial cellulose produced through kombucha fermentation, with strong potential as a sustainable alternative to synthetic leather. While SCOBY leather possesses good inherent mechanical properties, it exhibits key limitations such as high hydrophilicity and poor water resistance, which restrict its durability in humid environments. This study aims to enhance the water resistance and functional performance of SCOBY leather through biopolymer-based modification. The proposed innovation, Algae-Shield SCOBY Leather, utilises an Interpenetrating Polymer Network (IPN) approach by incorporating sodium alginate and glycerol into the cellulose structure. This is followed by calcium chloride spraying to induce cross-linking, thereby improving structural stability and resistance to water penetration. This method replaces conventional surface treatments such as wax or oil coating with a more sustainable and structurally integrated approach. Results demonstrate a significant improvement in water resistance and flexibility of the treated SCOBY leather, accompanied by a slight reduction in tensile strength. Stress-strain analysis indicates increased elongation, suggesting enhanced flexibility suitable for practical applications. The use of seaweed-derived alginate also supports the “blue carbon” concept and aligns with Sustainable Development Goals (SDGs 9, 12, and 13). In conclusion, Algae-Shield SCOBY Leather presents strong potential as an eco-friendly material for the textile and fashion industries, particularly in applications requiring flexibility and water resistance, with promising commercial potential.

**Keywords:** SCOBY leather, biopolymer, sodium alginate, water resistance, sustainable material

### **1. INTRODUCTION**

With increasing global awareness of environmental sustainability, the demand for eco-friendly alternatives to synthetic materials has grown significantly. SCOBY leather, derived from bacterial cellulose produced during kombucha fermentation, has emerged as a promising biodegradable material with relatively good mechanical properties. However, its high water absorption and sensitivity to moisture limit its performance and durability in real-world applications.

Previous studies have shown that modifying polymer structures can enhance the functional properties of bio-composite materials. Conventional approaches such as wax or oil coatings mainly provide surface-level protection and do not significantly improve internal structural stability.

Therefore, this study introduces an Interpenetrating Polymer Network (IPN) approach using sodium alginate to improve the water resistance and overall functional performance of SCOBY leather. The objectives are to reduce water absorption, enhance flexibility, and evaluate its suitability for sustainable textile applications.

## **2. METHODOLOGY**

### **2.1 Research Question and Framework**

This study addresses the question: how can the water resistance of SCOBY leather be improved without compromising its functional usability? The research framework is based on modifying the internal structure of bacterial cellulose using a biopolymer-based Interpenetrating Polymer Network (IPN). This approach is relevant to both theory and practice, as it explores polymer interaction within bio-composites while addressing real-world limitations of SCOBY leather in humid conditions.

The IPN method was selected due to its ability to enhance material properties at a structural level rather than through surface modification alone. Compared to conventional coatings, IPN provides a more stable and integrated solution, making it suitable for improving durability and water resistance.

### **2.2 Material Preparation**

SCOBY was obtained from kombucha fermentation and thoroughly cleaned before being air-dried to form a uniform bio-leather sheet. The dried material was then cut into standardised sample sizes to ensure consistency during testing.

### **2.3 Interpenetrating Polymer Network (IPN) Formation**

A solution consisting of sodium alginate and glycerol was prepared. The SCOBY samples were immersed in this solution to allow penetration into the cellulose matrix. This step enables the filling of micro-pores within the structure, modifying internal interactions and enhancing flexibility.

### **2.4 Cross-Linking Process**

Following immersion, the samples were treated with a calcium chloride solution via spraying. This induces ionic cross-linking between alginate chains, forming a stable network within the SCOBY structure. This process is essential for improving resistance to water penetration and enhancing structural integrity.

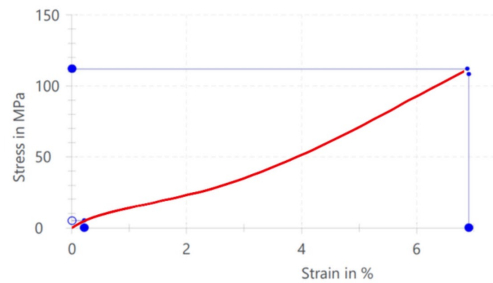
## 2.5 Mechanical and Physical Testing

Mechanical properties were evaluated using stress–strain and elongation tests to assess tensile strength and flexibility. Water absorption tests were conducted to measure the effectiveness of the treatment in reducing moisture uptake. These methods were chosen as they directly evaluate the key performance indicators relevant to material application in textile and fashion products.

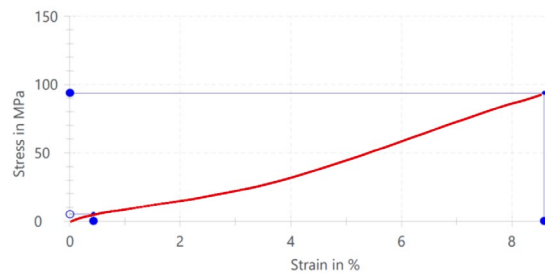
## 3. RESULTS AND DISCUSSION

This section presents and critically analyses the experimental results on tensile strength, flexibility, and water resistance of Algae-Shield SCOBY leather developed using an Interpenetrating Polymer Network (IPN) system, compared with control and wax-coated samples.

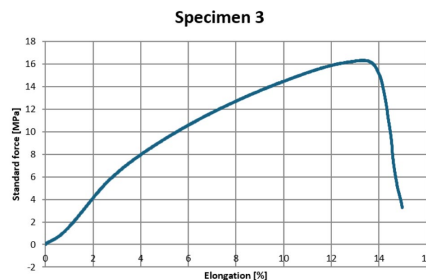
### 3.1 Figures and Images



**Figure 1.** Stress–strain graph of control SCOBY leather



**Figure 2.** Stress–strain graph of wax-coated SCOBY leather



**Figure 3.** Stress–elongation graph of Algae-Shield SCOBY leather



Figure 1 illustrates the comparison of tensile strength among the control, wax-coated, and Algae-Shield SCOPY leather samples. The results show that the Algae-Shield sample exhibits a slight reduction in tensile strength compared to the control and wax-treated samples. This decrease is attributed to the incorporation of sodium alginate and glycerol, which introduce a plasticising effect within the cellulose network.

Despite the reduction in tensile strength, the Algae-Shield sample demonstrates increased elongation before breakage, indicating improved flexibility. This suggests that the material becomes less brittle and more suitable for practical applications that require bending and shaping, such as fashion accessories.

In terms of water resistance, the Algae-Shield samples exhibited visibly improved resistance to moisture compared to untreated SCOPY leather. The treated material maintained better structural integrity and showed slower water absorption during exposure, indicating enhanced resistance to water penetration. This improvement is attributed to the formation of a cross-linked alginate network that reduces pore accessibility within the cellulose structure.

#### **4. CONCLUSION**

This study demonstrates that the Interpenetrating Polymer Network (IPN) technique effectively enhances the water resistance and flexibility of SCOPY leather while maintaining acceptable mechanical performance. The Algae-Shield SCOPY Leather innovation shows strong potential as a sustainable material for applications that prioritise flexibility and moisture resistance. From a commercial perspective, this material is suitable for producing fashion accessories such as bags, wallets, and other lifestyle products. Future work may focus on optimising the balance between strength and flexibility as well as scaling up production.

#### **ACKNOWLEDGEMENT**

The authors would like to express their gratitude to Universiti Kebangsaan Malaysia for providing support and facilities throughout this study.

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