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2ND INTERNATIONAL SCIENCE,
ENGINEERING AND TECHNOLOGY
COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A
SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

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ISETC 2025 Proceedings Editors

FORENSIC ANALYSIS OF BURNED FABRICS THROUGH ATR-FTIR SPECTROSCOPY COUPLED WITH PRINCIPAL COMPONENT ANALYSIS

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Abstract: Accurate identification of fabric evidence in fire-related forensic investigations can be challenging due to the physical and chemical changes induced by combustion. Traditional methods often fail to distinguish between fabric types when materials are charred or melted. This study investigates the effectiveness of Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy combined with Principal Component Analysis (PCA) in identifying five types of fabrics cotton, linen, nylon, polyester, and rayon in both unburned and burned conditions. Fabric samples were subjected to controlled burning and analysed using ATR-FTIR in the range of 4000–400 cm^{-1} . The spectral data were then processed using PCA to reveal patterns and differences between fabric types. Results showed distinct clustering of fabric types in both unburned and burned states, with burned fabrics forming tighter clusters due to consistent spectral changes post-combustion. These findings demonstrate that ATR-FTIR coupled with PCA is a valuable, non-destructive tool for differentiating fabric types in forensic fire investigations.

Keywords: *Fabric identification, forensic analysis, burned fabrics, PCA, ATR-FTIR spectroscopy*

INTRODUCTION

In fire-related forensic investigations, particularly in arson cases, burned fabric evidence is frequently encountered at the scene (Falatová et al., 2021). However, the identification of these fabric remnants can be challenging due to alterations in their physical and chemical properties caused by combustion. Standard identification methods often fall short when fabrics are melted or charred. Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy offers a non-destructive approach for analyzing both unburned and burned fabric samples by identifying their functional groups. Principal Component Analysis (PCA) is a statistical technique that reduces the dimensionality of complex data sets, allowing for the visualization of patterns and classification of materials based on their spectral features (Ghader et al., 2025). When combined with ATR-FTIR, PCA helps to simplify and distinguish the spectral data of different fabric types. This study aims to evaluate the effectiveness of ATR-FTIR spectroscopy combined with PCA in differentiating various types of fabrics in both unburned and burned conditions for forensic applications (Aljannah et al., 2022).

MATERIALS AND METHODS

Five types of fabrics cotton, linen, nylon, polyester, and rayon were cut into 10×10 cm squares, with three replicates prepared for each fabric type for both unburned and burned conditions. Three replicates of each fabric were burned until approximately 90% of the material was degraded. The burned samples were then collected and stored in airtight containers prior to analysis. The unburned fabric replicates were analysed directly (Syed et al., 2020). All samples were examined using an ATR-FTIR spectrometer within the range of 4000–400 cm^{-1} , at a resolution of 4 cm^{-1} with 16 scans per sample. Principal Component Analysis (PCA) was applied to process and analyse the spectral data to differentiate the fabric types and their burn conditions. To enhance visualization of grouping patterns, PCA plots were generated using ellipses at an 85% confidence level.

RESULTS AND DISCUSSION

Principal Component Analysis (PCA) was applied to the ATR-FTIR spectral data to differentiate fabric types in both unburned and burned conditions. The PCA results, visualized using 85% confidence ellipses, reveal clear patterns of separation and clustering that are significant for forensic analysis.

Table 1. Fabric codes

Code	Fabric Type	Condition
UC	Cotton	Unburned
UL	Linen	
UN	Nylon	
UP	Polyester	
UR	Rayon	
BC	Cotton	Burned
BL	Linen	
BN	Nylon	
BP	Polyester	
BR	Rayon	

Figure 1 demonstrates that in the unburned state, the five fabric types of cotton, linen, nylon, polyester, and rayon exhibited distinct clustering. This reflects the unique infrared spectral profiles of each fabric, allowing accurate discrimination. The PCA loading plots that was not shown, likely indicate that functional groups such as OH, C=O, and C-H were responsible for the observed variance between fabrics (Sidou & Borges, 2020).

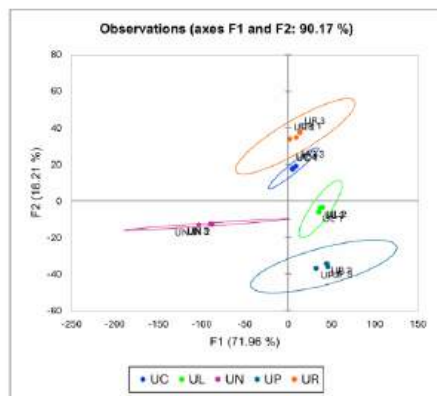


Figure 1. Ellipses 85% of unburned fabric

In Figure 2, burned samples showed a tighter clustering pattern within each fabric group. This suggests that thermal degradation induces more uniform chemical changes across the same fabric type. Despite the significant spectral changes post-burning, PCA was still able to differentiate the fabric types, confirming the robustness of this analytical approach even under altered conditions. This is particularly important in forensic scenarios where only partially degraded fabric evidence is available.

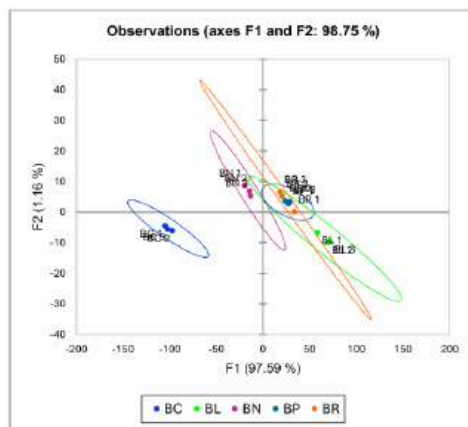


Figure 2. Ellipses 85% of burned fabric

Figure 3, which combines both burned and unburned samples, further emphasizes the effectiveness of ATR-FTIR coupled with PCA. The separation of unburned and burned fabrics across the principal components suggests that combustion significantly alters the spectral fingerprint of the fabric. However, even with these transformations, intra-fabric grouping is still evident. This indicates that while combustion causes consistent chemical shifts, these are still distinct enough across fabric types to allow classification.

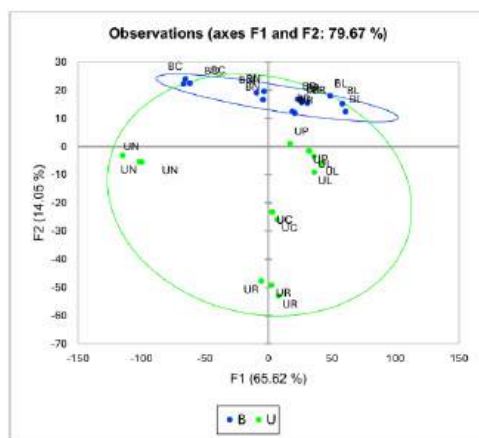


Figure 3. Ellipses 85% of combined unburned and burned fabric

CONCLUSIONS

This study confirms that ATR-FTIR spectroscopy combined with PCA is an effective method for distinguishing different fabric types in both unburned and burned conditions. The clear clustering in PCA plots highlights consistent spectral differences, even after combustion, allowing reliable identification of fabric types. This non-destructive, rapid technique holds strong forensic value, particularly in fire investigations where fabric evidence is often degraded, providing a robust tool for accurate material classification especially for crime scene reconstruction.

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Setuju.

27.1.2023

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