

Comparative Preliminary Chemical Analysis of Burnt Fabrics in Suspected Arson Cases

S Krithi¹, Meera M², Aryasree A³

^{1,2}III B.Sc Department of Forensic Science, Nehru Arts and Science College, Coimbatore, India

³Assistant Professor, Department of Forensic Science, Nehru Arts and Science College, Coimbatore, India

Abstract—Arson investigation relies heavily on the detection and identification of ignitable liquid residues present in fire debris. This study focuses on the comparative preliminary chemical analysis of burnt fabric samples to identify commonly used accelerants such as petrol and kerosene. Various fabric types, including natural fibres (cotton, wool) and synthetic fibres (polyester, nylon), were examined to evaluate their absorption capacity, combustion behaviour, and residue retention characteristics. Controlled experimental burning was conducted under standardized laboratory conditions by applying measured quantities of accelerants to fabric samples. Post-combustion residues were extracted using solvent extraction techniques and analysed through chemical tests and chromatographic profiling methods. The findings indicate that petrol, due to its high volatility, undergoes rapid evaporation and results in partial loss of lighter hydrocarbons, leading to altered chemical profiles. In contrast, kerosene exhibits greater persistence because of its higher boiling point and heavier hydrocarbon composition. Fabric type significantly influences residue retention, with natural fibres showing higher absorption and better residue recovery compared to synthetic materials. The study highlights the importance of understanding substrate effects, evaporation dynamics, and chemical markers in forensic fire debris analysis. These insights contribute to improving the accuracy and reliability of accelerant identification in suspected arson cases.

Index Terms—Arson Investigation, Fire Debris Analysis, Accelerants, Burnt Fabrics.

I. INTRODUCTION

Arson is a serious criminal offence involving the intentional setting of fire to property, often to cause damage, conceal evidence, or commit fraud. In forensic investigations, determining whether a fire is accidental or intentional is a crucial step. One of the

primary indicators of arson is the presence of accelerants, which are substances used to initiate or intensify fire. Among various types of evidence, burnt fabrics are frequently encountered at fire scenes due to their widespread use in clothing, furnishings, and household materials. These fabrics often act as carriers of ignitable liquids, absorbing and retaining chemical residues even after exposure to high temperatures. The identification of such residues plays a vital role in reconstructing fire events and establishing criminal intent. The present study aims to analyse burnt fabrics exposed to petrol and kerosene under controlled conditions. By examining the chemical composition of residues, the research seeks to differentiate between accelerants and understand their interaction with various fabric types. This investigation contributes to enhancing forensic methodologies and improving the accuracy of fire scene analysis.

II. NATURE AND CLASSIFICATION OF ACCELERANTS

Accelerants are flammable substances used to accelerate the ignition and spread of fire. These substances are typically classified based on their volatility, boiling range, and chemical composition. Highly volatile accelerants, such as petrol, evaporate quickly and produce intense flames, whereas moderately volatile substances like kerosene burn more slowly and persist longer at fire scenes. From a forensic perspective, classification of accelerants is essential for interpreting chromatographic patterns and identifying residues. Petrol consists mainly of low molecular weight hydrocarbons, including aromatic compounds such as benzene and toluene. In contrast, kerosene contains heavier aliphatic hydrocarbons with higher boiling points. The classification also

influences the detectability of residues. Highly volatile liquids tend to evaporate rapidly, leaving minimal traces, while less volatile substances remain embedded in substrates. Understanding these differences is critical for accurate forensic interpretation and helps investigators distinguish between different types of accelerants in fire debris.

III. FIRE DEBRIS ANALYSIS AND FORENSIC SIGNIFICANCE

Fire debris analysis is a specialized field within forensic science that involves the examination of materials collected from fire scenes to detect the presence of accelerants. The process typically includes sample collection, extraction, and chemical analysis using advanced techniques such as gas chromatography mass spectrometry (GC-MS). The forensic significance of fire debris analysis lies in its ability to provide objective scientific evidence in arson cases. Identifying ignitable liquid residues can confirm the deliberate use of accelerants, thereby supporting criminal investigations. However, the process is complex due to the presence of pyrolysis products generated during combustion, which may interfere with the identification of accelerants. Accurate interpretation requires distinguishing between substrate-derived compounds and accelerant residues. This highlights the importance of understanding the chemical behaviour of materials under fire conditions and emphasizes the need for controlled experimental studies like the present research.

IV. FABRIC TYPES AND THEIR ROLE IN FIRE ANALYSIS

Fabrics play a significant role in fire investigations due to their ability to absorb and retain accelerants. Natural fabrics such as cotton and wool have high porosity and absorbency, allowing them to retain liquid residues effectively. Synthetic fabrics, on the other hand, exhibit lower absorption capacity and may melt or degrade under heat. The type of fabric influences both the combustion behaviour and the chemical residues left behind. Natural fibres tend to produce oxygen-rich pyrolysis products, while synthetic fibres generate hydrocarbon compounds that may resemble accelerant residues. This similarity can complicate forensic analysis and requires careful interpretation.

Understanding fabric behaviour is essential for selecting appropriate analytical methods and ensuring accurate identification of accelerants. The study of fabric-accelerant interactions provides valuable insights into fire dynamics and improves the reliability of forensic conclusions.

V. METHODOLOGY FOR CHEMICAL ANALYSIS OF BURNT FABRICS

The methodology adopted in this study involves controlled experimental burning of fabric samples treated with accelerants. Standardized procedures were followed to ensure consistency and reliability of results. Fabric samples were prepared in uniform sizes and exposed to measured quantities of petrol and kerosene. After combustion, residues were collected and subjected to solvent extraction to isolate chemical compounds. Various chemical tests, including Baeyer's test, chromic acid test, and iodoform test, were used to identify functional groups. Instrumental techniques such as chromatographic analysis further aided in identifying characteristic compounds. The experimental setup ensured controlled environmental conditions, minimizing external interference. This methodological approach enables accurate comparison of chemical profiles and enhances the reliability of forensic findings.

VI. RESULTS AND COMPARATIVE ANALYSIS

The results of the study reveal significant differences in the behaviour of petrol and kerosene when applied to fabric samples. Petrol exhibited rapid evaporation due to its high volatility, resulting in partial loss of lighter hydrocarbons. Consequently, the chemical profiles obtained from burnt samples showed weathered patterns. In contrast, kerosene demonstrated greater persistence, retaining a higher proportion of its original chemical composition. The chromatographic profiles displayed a series of evenly spaced peaks corresponding to aliphatic hydrocarbons. Fabric type also influenced the results. Cotton fabrics showed higher absorption and better residue retention, while synthetic fabrics exhibited reduced recovery due to melting and degradation. These findings highlight the importance of considering both accelerant properties and substrate characteristics in forensic analysis.

VII. DISCUSSION: INTERPRETATION OF FORENSIC EVIDENCE

The interpretation of fire debris evidence requires a comprehensive understanding of chemical interactions and combustion processes. The study demonstrates that the identification of accelerants is influenced by factors such as volatility, temperature, and substrate properties. Petrol's rapid evaporation can lead to false negatives if evidence is not collected promptly. Kerosene, however, provides more reliable evidence due to its persistence. The presence of pyrolysis products further complicates analysis, as they may mimic accelerant compounds. Therefore, forensic investigators must adopt a cautious and systematic approach, combining chemical analysis with contextual information from the fire scene. This ensures accurate conclusions and prevents misinterpretation of evidence.

VIII. FORENSIC IMPORTANCE AND PRACTICAL APPLICATIONS

The findings of this study have significant implications for forensic science and criminal investigations. Understanding the behaviour of accelerants and their interaction with different fabrics enhances the accuracy of fire debris analysis. The study provides valuable insights for forensic experts, helping them identify accelerants more effectively and interpret evidence with greater confidence. It also highlights the need for proper evidence collection, storage, and analysis to prevent loss or contamination of residues. In practical terms, the research contributes to improving investigative techniques, supporting legal proceedings, and strengthening the overall reliability of forensic evidence in arson cases.

IX. CONCLUSION

The comparative chemical analysis of burnt fabrics provides critical insights into the identification of accelerants in suspected arson cases. This study demonstrates that both the nature of the accelerant and the type of fabric significantly influence residue detection and interpretation. Petrol, characterized by high volatility, tends to evaporate rapidly, leading to partial loss of identifiable compounds. In contrast, kerosene exhibits greater persistence due to its heavier

hydrocarbon composition, making it more detectable in post-fire analysis. Fabric properties also play a crucial role. Natural fabrics such as cotton and wool show higher absorption and retention of accelerants, whereas synthetic materials may degrade or produce interfering compounds during combustion. These differences highlight the importance of considering substrate characteristics in forensic investigations.

The study emphasizes the need for careful sample collection, controlled analytical procedures, and accurate interpretation of chemical data. Advanced techniques such as GC-MS enhance the reliability of results, but expertise is required to differentiate between accelerant residues and pyrolysis products. In conclusion, a multidisciplinary approach combining chemistry, material science, and forensic expertise is essential for effective fire debris analysis. The findings of this research contribute to improving the accuracy, reliability, and scientific validity of arson investigations.

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