Junior Science Communications
Faculty of Applied Sciences, UiTM Shah Alam
https://journal.uitm.edu.my/ojs/index.php/JSC

E-ISSN 2637-0689
Vol 47 2025

Colloquium on Applied Sciences 2 2024
8-14 July 2024, Faculty of Applied Sciences, UiTM Shah Alam, Malaysia

Forensic Analysis of Accelerant (Aerosol) On Different Conditions and Fabrics Using Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) And Chemometrics Techniques

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Structured Abstract

Background: Arson investigation is a critical aspect of forensic science, often relying on the detection and analysis of accelerants used to initiate fires. Aerosol accelerants are particularly challenging to identify due to their volatile nature and rapid evaporation. Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) is a powerful, non-destructive analytical technique that can provide detailed chemical information about trace evidence. When combined with chemometric techniques, which use statistical and mathematical methods to extract relevant information from complex datasets, ATR-FTIR can potentially offer improved sensitivity and specificity in accelerant detection. This study aims to evaluate the effectiveness of ATR-FTIR coupled with chemometric analysis in identifying aerosol accelerants on different fabric types and under various environmental conditions.

Methods: The fabrics (cotton and polyester) were exposed to aerosol accelerants (Baygon insecticide and Gatsby deodorant) and burned simultaneously using lighter. These burning is extinguished either in open air or by water and its corresponding debris were collected after the time intervals of 1, 2, 3, and 4 hours for ATR-FTIR analysis. The resulting spectra were analysed for their changes in functional groups and subjected to principal component analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) for statistical clustering and validation.

Results: The findings show that ATR-FTIR combined with PCA and AHC accurately detects and distinguishes the chemical components of aerosol. It showed that polyester fabrics had a high degree of hydrolytic degradation when extinguished with water, this resulted in carboxylic acids and other products of breakdown. Cotton fabrics exhibited oxidation and hydrolytic decomposition under similar conditions. The chemometric analysis revealed distinct spectral patterns that differentiate the accelerants and fabrics based on the extinguishing method and duration of exposure. Time intervals for extinguishing significantly impacted the observed degree of fabric degradation.

Conclusion: The study establishes that ATR-FTIR spectroscopy coupled with chemometric analysis is a useful methodology for the forensic analysis of fire debris. The findings enhance understanding of how different extinguishing methods and time intervals impacted the spectral characteristics of polyester and cotton fabrics. This knowledge aids forensic investigations of arson, providing reliable identification and classification of aerosol accelerants on various fabrics.

Keywords: Aerosol, Fabrics, Time Intervals, ATR-FTIR, Chemometrics Analysis

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