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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



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ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:

三重大学
MIE UNIVERSITY

2nd International Science, Engineering and Technology Colloquium

(ISETC 2025)

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025
Publication date: 9th September 2025

Proceedings of Extended Abstracts

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e-ISBN: 978-629-97630-5-5

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Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

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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
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

INFLUENCE OF DATA PROCESSING METHODS ON ATR-FTIR-BASED CLASSIFICATION OF PEN INKS

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Abstract: This research investigates the impact of data processing techniques on the accuracy and discrimination capability of ATR-FTIR spectroscopy in differentiating blue ballpoint pen inks through non-destructive analysis of ink directly from ink barrels. Six commercial pen brands (Artline, BiC, Faber-Castell, Faster, G'Soft, and Home & Office) were examined by analysing ink samples directly from the pen barrels without causing any damage to the pens. Initially, optimum parameters for establishing the ATR-FTIR method were identified to enhance data quality and reproducibility. Each functional group within the spectra was carefully identified and associated with specific ink components, such as solvents, colorants, resins/binders, and additives. This detailed interpretation was essential to understand the chemical composition of the inks before applying chemometric techniques for more efficient and objective data classification. By applying Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC), the study successfully discriminated between several pen samples based on their brand and type, demonstrating the potential of these chemometric techniques in forensic ink analysis. Through direct analysis of ink from the ink barrel surface, this study effectively eliminates paper-related interferences that could otherwise affect ink characterization. The establishment of optimum analytical parameters is essential to minimize variations during pen ink analysis and offers a reliable reference method for future studies. Furthermore, the application of PCA and AHC has proven to be effective statistical tools for chemical data classification, providing a more objective and efficient alternative to traditional manual comparison methods.

Keywords*: Data processing, ATR-FTIR spectroscopy, analysis of ink, Principal Component Analysis (PCA), Agglomerative Hierarchical Clustering (AHC)*

INTRODUCTION

Ink analysis is a key component of forensic document examination, especially in questioned documents where evidence can be derived from knowing the ink's origin and/or authenticity This study examines the non-destructive analysis of blue ballpoint pen inks by ATR-FTIR spectroscopy, using samples taken straight from the ink barrel so that no differences due to paper were present. Six commercially available pen brands were investigated, with spectral data being optimized for characterization quality and reproducibility. Each functional group within the ink was identified in order to understand the ink composition, before conducting chemometric analyses using Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC). The study demonstrated the effectiveness of correlating ATR-FTIR with statistical measures for precise, and objective discrimination of inks in forensic studies.

MATERIALS AND METHODS

Six different brand blue ballpoint pens were selected for ATR-FTIR spectroscopy. To not cross-contaminate the samples while taking readings, the ATR crystal (and the surrounding surface) was cleaned with ethanol between all samples. Samples of the ink were non-destructively extracted by removing the pen tip and placing the ink directly onto the ATR crystal. Gloves were worn for all handling to ensure there was no contamination. Spectral data were collected using a JASCO FTIR spectrometer, which were then smoothed for visual purposes, followed by multivariate data analysis (Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) using XLSTAT Version 2024 statistical software). PCA and AHC were completed on the data to allow for classification and separation of the ink samples.

RESULTS AND DISCUSSION

This study confirmed that the ATR-FTIR spectroscopy techniques used in conjunction with careful data processing will effectively allow differentiation of blue ballpoint pen inks. The raw spectral features between brands exhibited some overlapping once visualized, and chemometrics improved classification significantly. Utilizing PCA, six cluster groups emerged with 78.71 percent of the total variance and AHC corroborated those groups with a dendrogram analysis. The functional group interpretation from the spectra confirmed that characteristic bonds were present in the ink compositions. The results in this study show that data preprocessing and subsequent multivariate analysis play an important role in forensic ink discrimination.

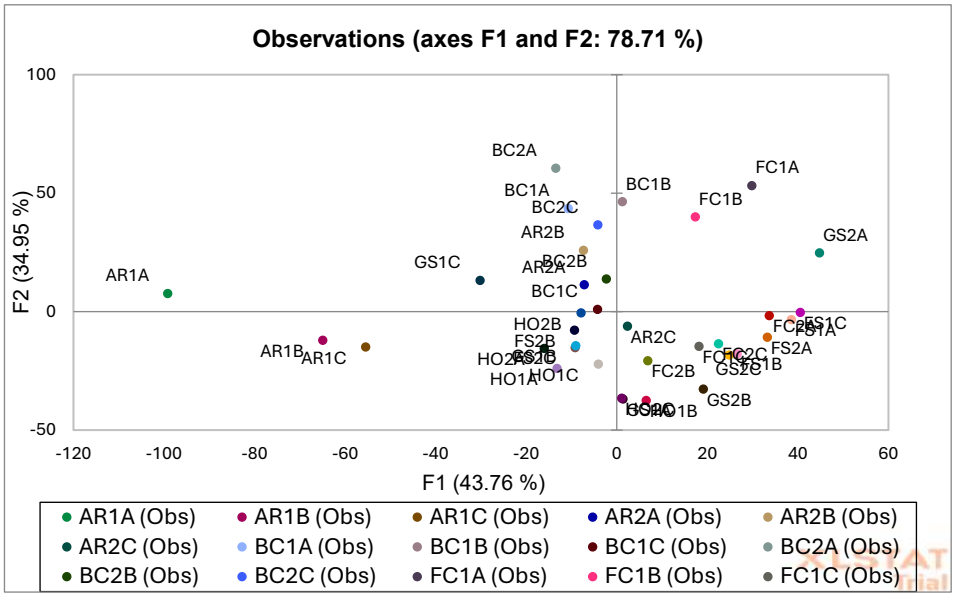


Figure 1. PCA Scatter Plot of All Twelves Samples using Complete Spectral Dataset

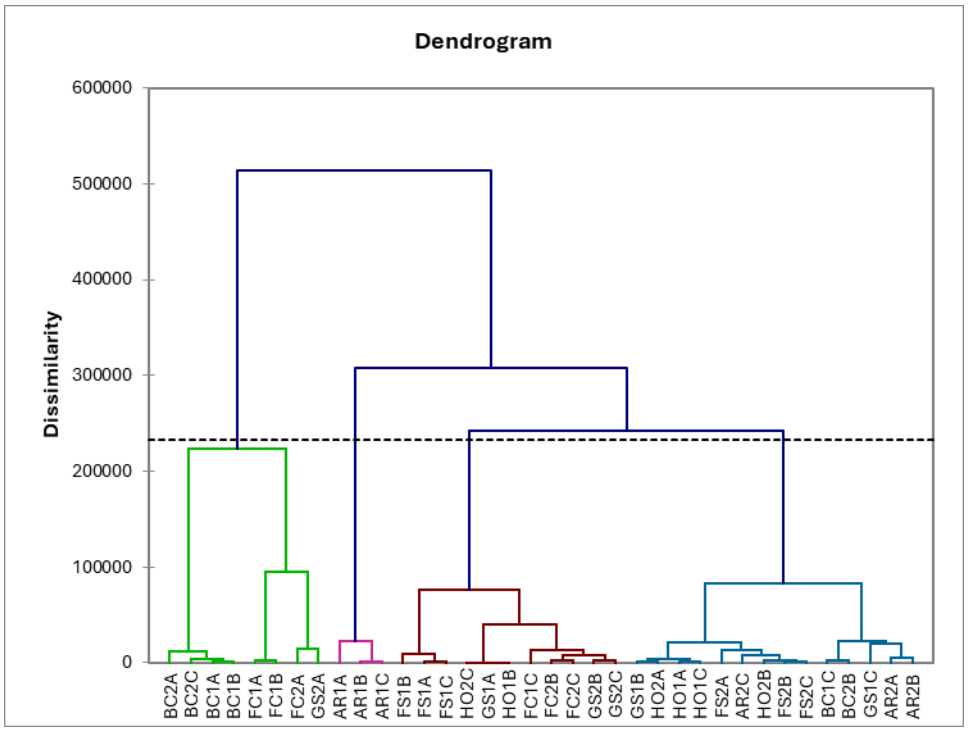


Figure 2. Dendogram of clustering of blue ballpoint pen inks

CONCLUSION

This study showed that ATR-FTIR spectroscopy, when used with appropriate data preprocessing and chemometric methods, including PCA and AHC, is a useful method to distinguish between blue ballpoint pen inks. Analysis from ink barrels avoided interference from paper, and boosted parameters enhanced the overall spectral quality. The use of PCA and AHC allowed for the objective classification of various pens from different brands, suggesting that spectroscopy can also be validly used in forensic document examination contexts.

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