Research Journal of Forensic Sciences ISSN 2321–1792
Vol. **14(2),** 13-17, July **(2026)** *Res. J. Forensic Sci.*

Development of latent Fingerprint technique: incorporating Biopolymer developed from Banana sheath fibre and utilizing it in Fuming method

Labhini Rahangdale[1]* and Lokashree Dharmalingam[2]
[1]Schiio of Biosciences and Bioengineering, Division of Forensic Science, DY Patil International University, Akurdi, Pune, Maharashtra-411044, India
[2]Division of Forensic Science, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu-641114, India
labhini241119997@gmail.com

Available online at: www.isca.in, www.isca.me
Received 22th December 2025, revised 27th March 2026, accepted 25th May 2026

Abstract

The objective of this study was to create a new method as an alternative to the cyanoacrylate fuming technique and other chemical processes typically employed in forensic science for latent fingerprint enhancement. By harnessing the potential of extracted biopolymers, we aim to move away from the use of carcinogenic chemicals in the development of latent impressions. Our goal is to explore a more natural approach to latent impression enhancement. A fume hood was used to heat a beaker containing cellulose content. Coconut oil, a natural ester, was added and heated until fumes were produced. A non-porous surface, such as a glass slide with a fingerprint, was placed inside the fuming chamber. After 5 minutes, the fumes reacted with the fingerprint, resulting in a white deposition over it. This study focuses on the natural approach of extracting biopolymer from banana sheath fibre. The decision to focus on banana sheath fibre was made due to the significant cellulose content present in it, making it a promising source for biopolymer extraction. This research deliberately selected a bio-ester that aligns with the project's natural ethos. The chosen bio-ester is coconut oil, a widely recognized natural ester that is rich in fatty acids and triglycerides, demonstrating potential for effective biopolymer formation. In the course of experiments, fuming method was used for development of latent impression over glass surface, a distinct white deposition was observed on the glass surface where the fingerprint had been placed.

Keywords: Latent fingerprint, Biopolymer, Banana sheath fibre, Cellulose extraction, Fuming method, Non-porous surfaces.

Introduction

Dextran-based biopolymers show great potential as alternative materials for fingerprint development in forensic science. Their biocompatibility, non-toxicity, and water solubility make them appealing candidates for enhancing the safety and efficacy of fingerprint development techniques. Further research and development are necessary to fully harness the potential of dextran-based biopolymers and overcome the challenges associated with their use in forensic investigations[1].

The newly developed HPTLC method provides a rapid and cost-effective solution for differentiating polysaccharides, distinguished by their unique fingerprints. This method involves a simplified sample preparation process that includes methanolysis, allowing for the simultaneous separation of up to 21 samples on HPTLC silica gel plates in just 20 minutes. Postchromatographic derivatization with the aniline diphenylamine o-phosphoric acid reagent enables the selective determination of methylated monomeric units in the UV-VIS range[2].

The potential of benzazole dye-based micro-structured fluorescent powders for fingerprint detection on a variety of surfaces, including porous and non-porous materials of different colours, is significant. These powders exhibit intense and stable photoluminescence properties, along with high sensitivity, making them promising candidates for forensic applications[3]. When fingerprints were exposed to Selenium dioxide, prints were revealed on metal surfaces, which were enhanced by the formation of copper-selenide upon exposure to moisture. Phosphorus sesquisulfide exhibited a higher percentage of prints with stability in air, while (Hexachlorophosphazene) produced prints of lower quality. Despite the challenges, all compounds are commercially available for sublimation techniques. Modified DNA analysis detected Alu polymorphisms from latent prints both before and after chemical treatment with Selenium dioxide, Phosphorus sesquisulfide, and Polythiazyl polymer[4].

Methodology

The study involves the preparation of cellulose through chemical treatment. This process includes alkali treatment, autoclave processing, fibre bleaching, and treatment of bleached fibre. Once the final cellulose preparation is complete, the next step is the fuming method, which involves coupling natural esters for latent fingerprint development on non-porous surfaces. The method was further explained through illustrations.

Exclusion and inclusion criteria: In this study, we have intentionally excluded porous surfaces and instead focused on non-porous surfaces.

Procedure followed for cellulose preparation: Step-1: Alkali treatment of the fibre is a cost-effective surface treatment method that significantly enhances the properties of natural fibers. This process involves preparing a caustic soda (NaOH) solution with concentrations ranging from 1.5% to 7.5% and immersing the sheath fibers in the solution for 6 hours at room temperature. The purpose of this treatment is to eliminate impurities and extend the longevity of the sheath fibers for optimal performance.

Step-2: Autoclave Process: The steam pre-treatment process involves inserting NaOH-treated fibres directly into the autoclave under high steam pressure. The mercerized sheath fibres are subjected to a pressure of 103 Pa for 1.5 hours. Following the steam explosion, the fibres are extracted and meticulously cleaned with distilled water. Subsequently, the cleaned fibres are dried for 4 hours at 60°C in a hot air oven.

Step-3: Fibre Bleaching Process: In this step, the fibres underwent a bleaching treatment using a solution consisting of 5% sodium chlorite in Hydrochloric acid with a pH of 2.3. Sodium chlorite is an inorganic sodium salt commonly used as a bleaching agent. The fibers were submerged in the solution for duration of 1 hour on a magnetic heater set at 50°C. The primary objective of the bleaching process is to effectively remove any residual lignin present in the fibers.

Step 4: Acid Treatment of Bleached Fibers: After undergoing the bleaching process, the fibers are subjected to a mild acid treatment using varying concentrations of oxalic acid (2%, 5%, 7.5%, and 10%) for acid hydrolysis. The fibers are immersed in an oxalic acid solution for duration of 1.5 hours. Subsequently, the fibers are thoroughly rinsed with water to eliminate any residual traces of acid.

Characterization of the extracted cellulose was conducted using analytical technique: X-ray diffraction (XRD) analysis was performed using a Carl Zeiss Jena URD-6 diffractometer, with monochromatic Cu-Kα radiation generated at a voltage of 40 kV and a current of 20 mA. The scan rate was set at 20/min, with the Bragg angle ranging from 3^o to 50^o. Peak profiles were resolved using Microcal OriginTM 8.5 algorithms, incorporating Lorentz and Pearson VII functions for crystal peaks and a fifth-degree polynomial function for the background profile.

Fourier Transform Infra-Red spectroscopy was utilized to assess structural changes in the samples resulting from chemical treatments. A Nexus Thermo FTIR spectrophotometer was employed for this analysis. Samples were oven-dried for 45 hours at 105°C, then mixed with Potassium Bromide in a 1:200 (w/w) ratio and pressed into pellets under vacuum.

The FTIR spectrum was obtained in the transmittance mode within the range of 4000-500 cm^{-1}. Cellulose extraction from banana sheath fibers was carried out using two methods: chemical treatment and steam explosion. Chemical treatment with 2% NaOH and 5% oxalic acid yielded a maximum cellulose recovery of 46.50%. Steam treatment at 13 bar pressure, 192°C temperature, and a 5-minute residence period, with a particle size of 3 cm and 0.1M NaOH catalyst, resulted in a maximum cellulose recovery of 50.34% in the steam explosion method. The bleaching process effectively removed lignin and hemicellulose components from the raw fiber. FTIR spectroscopy analysis demonstrated that steam explosion proved to be more effective in removing hemicellulose and pectin from sheath fibers, while hydrogen peroxide bleaching was found to be more effective in removing lignin. The removal of non-cellulosic components led to an increase in crystallinity, with steam-exploded cellulose fibers achieving a maximum crystallinity index of 65.7% as revealed by XRD analysis. Additionally, there was a reduction in crystallite size from 4.63 nm (raw fiber) to 2.80 nm (steam-exploded cellulose).

The steam explosion treatment yielded the highest cellulose content at 42.5%, surpassing the 28.4% obtained through chemical treatment. Comparatively, steam explosion treatment emerged as the superior method due to its reduced chemical usage, quicker cellulose extraction process, and environmentally friendly nature in cellulose preparation, as illustrated in Figure-1.

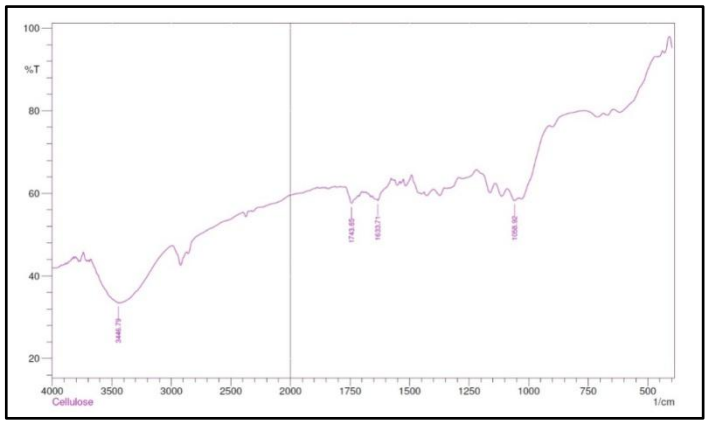

Figure-1: Characterization of the Extracted Cellulose using FTIR.

Methodology for performing fuming technique: A fume hood was used to heat a beaker containing cellulose content. Coconut oil, a natural ester, was added and heated until fumes were produced. A non-porous surface, such as a glass slide with a fingerprint, was placed inside the fuming chamber. After 5 minutes, the fumes reacted with the fingerprint, resulting in a white deposition over it. Fingerprints were not developed on non-porous surfaces like paper, but were successfully developed on surfaces such as glass slides and aluminium foil.

Results and Discussion

The principle underlying the cyanoacrylate fuming method involves the polymerization of monomeric compounds through heating at a temperature of 200 degrees. After careful consideration, this study has chosen to take a natural approach by extracting biopolymer from banana sheath fiber. This decision is based on the high cellulose content found in banana sheath fiber, making it a promising source for biopolymer extraction. The percentage of cellulose compounds within the fiber will be determined through a comprehensive extraction process involving chemical, physical, and physiochemical methods.

Opting for a chemical extraction process, further analysis has been initiated to explore the complex composition of the biopolymer. Since the cyanoacrylate fuming method requires the presence of esters, a bio-ester has been deliberately selected to align with the project's natural focus. Coconut oil, a well-known natural ester rich in fatty acids and triglycerides, has been chosen for its potential in effective biopolymer formation.

During experiments, a visible white deposition (illustrated in Figure-2) was observed on the fingerprint layer of a glass surface. This intriguing development sets the stage for a detailed examination and discussion of the subsequent results, which will provide insights into the effectiveness of the chosen extraction method and the suitability of the biopolymer for various applications.

Figure-2: White Depositions Over Latent Fingerprints Developed Using Extracted Biopolymer on Glass Surface.

Discussion: In their 2001 publication, Lee, H. C., and Gaensslen, R. E. discussed advanced techniques for latent fingerprint development. However, they did not address polymer-based latent impression development[5]. Dextran-based biopolymers show great potential as alternative materials for fingerprint development in forensic science. Their biocompatibility, non-toxicity, and water solubility make them appealing candidates for enhancing the safety and efficacy of fingerprint development techniques. Further research and development are necessary to fully harness the potential of dextran-based biopolymers and overcome the challenges associated with their use in forensic investigations[6]. Cyanoacrylate fuming is a commonly utilized forensic technique for enhancing latent fingerprints. Despite its widespread use, the specific mechanisms involved in the reaction between fingerprint residue and cyanoacrylate vapor remain unclear. In this study, the polymerization of ethyl-cyanoacrylate vapor using sodium lactate and alanine solutions, two key components found in fingerprint residue was investigated. By analyzing the time-dependent mass uptake and resulting polymer molecular weight characteristics, gained valuable insights into the molecular-level processes that contribute to the effective development of latent fingerprints through superglue fuming. Study suggests that the carboxylate moiety plays a crucial role as the primary initiator of the polymerization process. Furthermore, it was observed that a basic environment hinders chain termination, while an acidic environment promotes it. Interestingly, results also indicate that water does not serve as the primary initiator in this forensic technique. Overall, this research sheds light on the intricate chemical reactions that occur during cyanoacrylate fuming and provides a deeper understanding of how latent fingerprints are developed in forensic investigations.

Fluorescent cyanoacrylate esters were synthesized and tested as agents for developing latent fingerprints. Reactive monomers with various fluorescent side groups, including benzyl, anthracyl, naphthyl, fluorenyl, propyl, and cyanomethyl, were created through a multi-step process. This process involved forming an ethyl cyanoacrylate, anthracene adduct, hydrolysing the ethyl ester to the acid, esterifying it with a desired alcohol, and releasing the monomer through retro-Diels–Alder with maleic anhydride.

The synthesized fluorescent monomers proved to be highly effective in developing latent fingerprints in solution, producing clear fluorescent fingerprint images suitable for forensic analysis. These monomers offer a valuable addition to the current use of nonfluorescent ethyl cyanoacrylate monomers for fingerprint development[7].

The objective of this study was to create a new method for developing latent fingerprints in forensic science as an alternative to the commonly used cyanoacrylate fuming technique. By harnessing the extracted biopolymer and employing the principle of polymerization through heat, we aimed to reduce the potential harm caused by acrylate esters. This was achieved by utilizing the cellulose compound in our innovative approach.

Our team conducted an analysis on various non-porous surfaces such as wood, metal, and bottles, with disappointing results. However, when focusing specifically on glass surfaces, we observed positive outcomes. Following the fuming process with cellulose (a biopolymer), we noticed the development of

white ridges. While we attempted this method on older prints, the effectiveness was not as significant. It is worth noting that this technique is most successful when applied to fresh latent prints that are no more than 2 to 3 hours old. In our experiments, we found that fresh prints aged for 3 hours on glass surfaces yielded positive results, with white deposits appearing on the ridges of the latent impressions.

Conclusion

Upon initial observation of a white deposition covering the fingerprint, it became evident that the print itself was not clearly visible, impeding further analysis. Recognizing the necessity for improved visibility, additional steps in the enhancement process were deemed essential to proceed effectively.

To enhance the view of the developed fingerprint, a variety of scanners with unique capabilities and settings were utilized. This approach aimed to utilize all available resources and technology to ensure the retrieval of the highest quality image.

Furthermore, the enhancement process went beyond traditional methods by incorporating a diverse range of natural dyes. These dyes, known for their ability to highlight specific components within fingerprints, were carefully chosen and applied to enhance the contrast and clarity of the print.

By exploring various avenues and employing advanced techniques, the primary goal remained unwavering: to obtain the most comprehensive and detailed view of the fingerprint, thereby facilitating accurate identification and analysis in forensic examination.

List of abbreviations: XRD: X-ray diffraction, UV-VIS: Ultra Violet Visible, FTIR: Fourier-transform infrared spectroscopy, HPTLC: High-performance thin layer chromatography.

References

1. Vučković, N., Dimitrijević, S., & Milašinović, N. (2020). Detection and enhancement of latent fingerprints using dextran-based biopolymer powders obtained from anthocyanin solution. In *Thematic conference proceedings of international significance [Elektronskiizvor]/ International Scientific Conference" Archibald Reiss Days", Belgrade, 18-19 November 2020.* (pp. 691-701). Belgrade: University of Criminal Investigation and Police Studies.

2. Morlock, G., & Gamlich, F. (2012). Analysis of biopolymers—The fingerprint of plants' polysaccharides used as thickening agents. *JPC-Journal of Planar Chromatography-Modern TLC*, 25(3), 244-250.

3. Barros, H. L., & Stefani, V. (2019). Micro-structured fluorescent powders for detecting latent fingerprints on different types of surfaces. *Journal of Photochemistry and Photobiology A: Chemistry*, 368, 137-146.

4. Murthy, H. A., Desalegn, T., Kassa, M., Abebe, B., & Assefa, T. (2020). Synthesis of green copper nanoparticles using medicinal plant Hageniaabyssinica (Brace) JF. Gmel. leaf extract: Antimicrobial properties. *Journal of nanomaterials*, 2020(1), 3924081.

5. Lee, H. C., & Gaensslen, R. E. (2001). Methods of latent fingerprint development. *Advances in fingerprint technology*, 2(105-176), 10.

6. Vuckovıc, N., Koturevıc, B., & Mılasınovıc, N. (2022). Chitosan and Dextran Based Powders–The Preparation, Performance Comparison and Potential Application in Forensic Examination of Latent Fingermarks. *Adli Bilimler ve Suç Araştırmaları*, 4(1), 3-18.

7. Bentolila, S., Oh, J., Hanson, M. R., &Bukowski, R. (2013). Comprehensive high-resolution analysis of the role of an Arabidopsis gene family in RNA editing. *PLoS genetics*, 9(6), e1003584.

8. Morlock, G., & Gamlich, F. (2012). Analysis of biopolymers—The fingerprint of plants' polysaccharides used as thickening agents. *JPC-Journal of Planar Chromatography-Modern TLC*, 25(3), 244-250.

9. Bleay, S. M., Croxton, R. S., & De Puit, M. (2018). Fingerprint development techniques: theory and application. WILEY Publication.

10. Shah, B. C. (2013). Novel fingerprint development techniques (Doctoral dissertation, Loughborough University).

11. Ezhilmaran, D., & Adhiyaman, M. (2017). A review study on latent fingerprint recognition techniques. *Journal of Information and Optimization Sciences*, 38(3-4), 501-516.

12. Wargacki, S. P., Lewis, L. A., & Dadmun, M. D. (2007). Understanding the chemistry of the development of latent fingerprints by superglue fuming. *Journal of forensic sciences*, 52(5), 1057-1062.

13. Lewis, L. A., Smithwick III, R. W., Devault, G. L., Bolinger, B., & Lewis Sr, S. A. (2001). Processes involved in the development of latent fingerprints using the cyanoacrylate fuming method. *Journal of Forensic Sciences*, 46(2), 241-246.

14. Madkour, S., El Dine, F. B., Elwakeel, Y., & AbdAllah, N. (2017). Development of latent fingerprints on non-porous surfaces recovered from fresh and sea water. *Egyptian journal of forensic sciences*, 7(1), 3.

15. Bentolila, A., Totre, J., Zozulia, I., Levin-Elad, M., & Domb, A. J. (2013). Fluorescent cyanoacrylate monomers and polymers for fingermark development. *Macromolecules*, 46(12), 4822-4828.

16. Montgomery, L., Spindler, X., Maynard, P., Lennard, C., & Roux, C. (2012). Pretreatment Strategies for the Improved Cyanoacrylate Development of Dry Latent Fingerprints on Nonporous Surfaces. *Journal of Forensic Identification*, 62(5).

17. Risoluti, R., Filetti, V., Iuliano, G., Niola, L., Schiavone, S., Arcudi, G., & Materazzi, S. (2019). Updating procedures in forensic chemistry: one step cyanoacrylate method to develop latent fingermarks and subsequent DNA profiling. *Microchemical Journal*, 147, 478-486.