

# Detection Of Latent Fingerprints Using Natural Reagents on Non-Porous Surfaces (Glass, Steel and Tile)

Ms. S. Swathi<sup>1</sup>, Ms. Aryasree<sup>2</sup>

<sup>1</sup> III BSc Forensic Science, Department of Forensic Science,

Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

<sup>2</sup> Assistant Professor, Department of Criminology and Forensic Science,

Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

**Abstract**—Latent fingerprint examination remains a cornerstone of forensic identification, providing reliable and unique evidence linking individuals to crime scenes. Traditional fingerprint development techniques largely depend on synthetic chemical powders, which, despite their effectiveness, present concerns related to toxicity, environmental hazards, and cost. This study explores the feasibility of using natural plant-based reagents as eco-friendly alternatives for detecting latent fingerprints on non-porous surfaces such as glass, stainless steel, and tiles. Various plant materials—including drumstick leaves, bougainvillea, neem, banana bract, tulsi, amaranth, and marigold—were processed into fine powders and applied using standard dusting techniques. The developed fingerprints were evaluated based on clarity, contrast, and ridge detail visibility. Results indicated that powders derived from drumstick leaves, banana bracts, and amaranth produced superior ridge definitions across all tested surfaces, while others demonstrated moderate to low effectiveness. The findings highlight the potential of natural reagents as sustainable, non-toxic, and cost-effective alternatives in forensic science. This study contributes to the growing field of green forensics, emphasizing the importance of environmentally responsible methodologies without compromising investigative accuracy and reliability.

**Index Terms**—Latent fingerprints; Natural reagents; Eco-friendly forensics; Non porous surfaces.

## I. BACKGROUND AND EVOLUTION OF FINGERPRINT SCIENCE

Fingerprint science has long been regarded as one of the most reliable methods of human identification due to the uniqueness and permanence of friction ridge patterns. These patterns develop during fetal growth and remain unchanged throughout an individual's life,

even after minor injuries. This biological consistency forms the scientific basis for the use of fingerprints in forensic investigations.

Historically, the use of fingerprints dates back to ancient civilizations such as Babylon and China, where they were used as signatures on legal documents. However, the scientific foundation of fingerprint identification emerged in the nineteenth century. Sir William Herschel first observed the permanence of fingerprints in India, while Sir Francis Galton later provided statistical validation of their uniqueness. The classification of fingerprints into loops, whorls, and arches simplified identification processes and laid the groundwork for modern forensic systems. Fingerprint evidence is considered highly reliable because it directly links an individual to a surface or object. Unlike testimonial evidence, which may be subjective, fingerprints provide physical proof that can be independently verified. Latent fingerprints, which are invisible impressions formed by sweat and oils, are particularly significant in criminal investigations. Their detection requires specialized techniques, making their study a vital area of forensic science.

The evolution of fingerprint science also reflects advancements in technology and methodology. From simple ink-based recording systems to automated fingerprint identification systems (AFIS), the discipline has continually adapted to improve accuracy and efficiency. Despite these advancements, traditional methods such as powder dusting remain widely used due to their simplicity and effectiveness. In recent years, the field has shifted towards

sustainable and environmentally friendly practices. Concerns regarding the toxicity and environmental impact of conventional reagents have led researchers to explore natural alternatives. This transition marks a significant evolution in fingerprint science, aligning it with broader global efforts toward sustainability.

## II. ANATOMY, PHYSIOLOGY, AND CHEMICAL COMPOSITION OF FINGERPRINTS

Friction ridge skin, found on the fingers, palms, and soles, plays a crucial role in fingerprint formation. This specialized skin consists of raised ridges and furrows that enhance grip and tactile sensitivity. The structure of friction ridge skin is determined by the interaction between the epidermis and dermis during fetal development, ensuring the permanence of fingerprint patterns. The presence of eccrine sweat glands along the ridges contributes significantly to latent fingerprint formation. These glands secrete water, salts, amino acids, and other organic compounds that form the primary components of fingerprint residue. Although sebaceous glands are absent in friction ridge skin, oils from other parts of the body are often transferred to the fingertips, adding lipid-based components to the residue. Latent fingerprints are complex chemical mixtures composed of both endogenous and exogenous substances. Endogenous components include sweat and sebum, while exogenous substances may include cosmetics, dust, or environmental contaminants. This variability affects the quality and detectability of fingerprints, making their analysis a challenging task. The adhesion of fingerprint powders is based on the interaction between powder particles and these chemical residues. Fine particles adhere to moisture and lipid components, revealing ridge patterns. Understanding the chemical composition of fingerprints is therefore essential for selecting appropriate development techniques.

Environmental factors such as temperature, humidity, and surface characteristics also influence fingerprint quality. High humidity may cause residue diffusion, while dry conditions can lead to evaporation of volatile components. Similarly, the pressure applied during contact and the age of the fingerprint significantly affect its clarity. This intricate interplay of biological and environmental factors underscores the complexity of fingerprint analysis. It also highlights the need for

adaptable and efficient development techniques, particularly when exploring alternative reagents such as natural powders.

## III. CLASSIFICATION OF FINGERPRINTS AND SURFACES

Fingerprints are broadly classified into three types: visible (patent), plastic, and latent. Visible fingerprints are formed when substances like blood, ink, or grease are transferred onto a surface, making them immediately noticeable. Plastic fingerprints are three-dimensional impressions left on soft materials such as wax or clay. Latent fingerprints, however, are the most common and require development techniques for visualization. Latent fingerprints are particularly important in forensic investigations because they are often the only evidence left at a crime scene. Their detection depends largely on the nature of the surface on which they are deposited. Surfaces are generally classified as porous and non-porous. Non-porous surfaces, such as glass, metal, and tiles, do not absorb fingerprint residues, allowing them to remain on the surface. This makes them ideal for powder-based development techniques. In contrast, porous surfaces like paper absorb residues, requiring chemical methods such as ninhydrin treatment.

The interaction between fingerprint residue and surface characteristics plays a crucial role in determining the effectiveness of development techniques. Smooth surfaces tend to preserve ridge details better, while rough surfaces may distort or obscure patterns. Understanding these classifications helps forensic investigators choose appropriate methods for fingerprint detection. It also emphasizes the importance of developing versatile reagents capable of performing effectively across different surfaces.

## IV. CONVENTIONAL METHODS OF FINGERPRINT DEVELOPMENT AND THEIR LIMITATIONS

Traditional fingerprint development methods include powder dusting, chemical treatments, and advanced techniques such as cyanoacrylate fuming. Powder dusting remains the most commonly used method for non-porous surfaces due to its simplicity and

effectiveness. However, conventional methods have several limitations. Many commercial powders contain toxic substances such as heavy metals and synthetic dyes, posing health risks to forensic personnel. Prolonged exposure can lead to respiratory and skin problems.

Environmental concerns also arise from the use of non-biodegradable chemicals, which contribute to pollution. Proper disposal of these substances is often challenging and costly. Another limitation is the variability in effectiveness across different surfaces. A method that works well on one surface may fail on another, requiring multiple techniques and increasing the risk of evidence contamination.

Cost and accessibility are additional challenges, particularly in developing countries where forensic resources may be limited. Advanced techniques often require specialized equipment and trained personnel, restricting their use in field conditions. These limitations highlight the need for safer, more sustainable, and cost-effective alternatives, paving the way for the exploration of natural reagents.

#### V. GREEN FORENSIC SCIENCE AND THE USE OF NATURAL REAGENTS

Green forensic science emphasizes the use of environmentally friendly and sustainable methods in forensic investigations. This approach aims to minimize the ecological footprint of forensic practices while maintaining scientific accuracy. Natural reagents, particularly plant-based powders, offer a promising alternative to conventional chemicals. These materials are biodegradable, non-toxic, and readily available, making them suitable for widespread use. The use of natural materials aligns with the principles of sustainability by reducing dependence on synthetic chemicals and promoting the use of renewable resources. It also enhances safety for forensic personnel by eliminating exposure to hazardous substances.

Research in this area has shown that natural powders can effectively adhere to fingerprint residues due to their fibrous and porous structures. Additionally, natural pigments provide contrast without the need for artificial dyes. The adoption of green forensic methods

is particularly beneficial in resource-limited settings, where access to commercial reagents may be restricted. It also reflects a broader shift toward environmentally responsible scientific practices.

#### VI. METHODOLOGY: PREPARATION AND APPLICATION OF NATURAL POWDERS

The methodology involved the collection, preparation, and application of plant-based powders for fingerprint development. Selected plant materials were dried, ground into fine powders, and sieved to ensure uniform particle size. Fingerprints were collected from volunteers on non-porous surfaces such as glass, stainless steel, and tiles. The powders were applied using soft brushes, following standard dusting techniques.

The developed fingerprints were lifted using adhesive tape and transferred onto contrasting backgrounds for analysis. Evaluation criteria included ridge clarity, contrast, and background interference. This systematic approach ensured consistency and reproducibility of results, allowing for accurate comparison of different powders.

#### VII. RESULTS AND DISCUSSION

The results demonstrated that certain natural powders performed exceptionally well in developing latent fingerprints. Drumstick leaf, banana bract, and amaranth powders produced the clearest ridge details across all surfaces. Other powders, such as neem and tulsi, showed moderate effectiveness, while marigold produced less distinct patterns. These variations can be attributed to differences in particle size, texture, and chemical composition. The findings highlight the importance of selecting appropriate plant materials based on their physical and chemical properties. They also demonstrate the potential of natural reagents as viable alternatives to conventional methods.

#### VIII. COMPARATIVE ANALYSIS AND FORENSIC IMPLICATIONS

Comparing natural and conventional reagents reveals significant advantages for natural powders in terms of safety, cost, and environmental impact. While synthetic powders may offer higher sensitivity in some

cases, natural reagents provide a balanced combination of effectiveness and sustainability. The adoption of natural powders in forensic practice could reduce health risks, lower costs, and promote eco-friendly investigations. However, further research is needed to standardize these methods and validate their reliability in real-world scenarios.

#### IX. CONCLUSION

The study of latent fingerprint detection using natural reagents represents a significant step toward sustainable forensic science. By demonstrating the effectiveness of plant-based powders on non-porous surfaces, this research highlights the potential for replacing conventional chemical reagents with eco-friendly alternatives. The findings confirm that certain natural materials, particularly drumstick leaf, banana bract, and amaranth, can produce high-quality fingerprint impressions comparable to traditional powders. This suggests that natural reagents can meet the fundamental requirements of forensic investigations while addressing environmental and health concerns. One of the key advantages of natural reagents is their accessibility. In many regions, especially developing countries, access to commercial forensic materials is limited. Natural powders, being locally available and inexpensive, provide a practical solution for such contexts.

The study also underscores the importance of continued research in this field. While the results are promising, further investigations are needed to optimize preparation methods, improve consistency, and evaluate long-term reliability. In conclusion, the integration of natural reagents into forensic practice offers a sustainable and innovative approach to fingerprint detection. It aligns with global efforts to promote environmentally responsible science while maintaining the integrity and effectiveness of forensic investigations.

#### REFERENCES

- [1] M. L. Assis et al., "Nanomaterials in latent fingerprint development," *Forensic Sci. Rev.*, 2022.
- [2] K. Bhati et al., "Fluorescent nanomaterials for fingerprint detection," *J. Forensic Chem.*, 2021.

- [3] S. Chatterjee, "Aging of latent fingerprints under environmental conditions," *Forensic Res. J.*, 2024.
- [4] F. M. Gomes et al., "Advances in fingerprint analysis," *Forensic Sci. Int.*, 2023.
- [5] H. Mewada, "Techniques for latent fingerprint detection," *Int. J. Forensic Stud.*, 2025.
- [6] D. Nugroho et al., "Natural plant powders in fingerprint development," *J. Forensic Identif.*, 2023.
- [7] S. A. Sari et al., "Purple sweet potato powder for latent fingerprints," *Forensic Sci. J.*, 2020.
- [8] A. Srivastava et al., "Eco-friendly fingerprint powders," *J. Appl. Forensic Sci.*, 2024.
- [9] V. H. Thakre, *Plant-based reagents in forensic science*, Doctoral dissertation, 2024.