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Green Synthetic Method for development of Latent Fingerprints

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ABSTRACT:

The development of latent fingerprints is pivotal in forensic investigations, aiding in the identification of suspects & linking them to criminal activities. Traditional methods for latent fingerprint development often involve hazardous chemicals & solvents, posing environmental & health risks. In response, the field has seen a growing interest in developing green synthetic methods that are not only effective in revealing latent fingerprints but also its eco-friendly & safe for use. This abstract explores recent advancements in green synthetic methods for the development of latent fingerprints. These methods leverage sustainable & environmentally benign materials, reducing the re-alliance on harmful chemicals commonly used in conventional techniques. The utilization of natural products, <u>such as</u>- Plant extracts, Enzymes, & nanoparticles, has shown promising results in enhancing the visibility & equality of latent fingerprints while minimizing the impact on the environment. Key strategies in green synthetic methods include the incorporation of renewable resources, biodegradable materials, & non-toxic reagents. For instance, green solvents <u>like</u>- Ionic liquids & Supercritical Carbon dioxide(scCO2) offer safer alternatives to traditional organic solvents, reducing pollution & health risks associated with their disposal. Furthermore, the use of enzymatic reactions & bio-based polymers allows for the gentle & selective development of latent fingerprints without compromising the integrity of the evidence. The effectiveness of green synthetic method is assessed through various parameters, including- Sensitivity+ Specificity+ Reproducibility. Comparative studies with conventional techniques demonstrate the potential of green synthetic method to achieve comparable or, superior results in latent fingerprint development while aligning with principles of safety & sustainability. Overall, the adoption of green synthetic method represents a paradigm shift in forensic science towards more environmentally conscious practices. By embracing innovation & sustainability, forensic investigators can enhance the efficiency & reliability of latent fingerprint development while reducing their ecological footprints & also safeguarding the human health. This abstract shows the importance of advancing green synthetic method as a progressive approach to forensic analysis in the pursuit of justice.

Keywords:

Significance of Latent Fingerprint Development, Challenges with Traditional Methods, Shift towards Green Synthetic Method, Key Strategies in Green Synthetic Method, Recent Advancements, Effectiveness Evaluation, Paradigm Shift in Forensic Science.

INTRODUCTION:

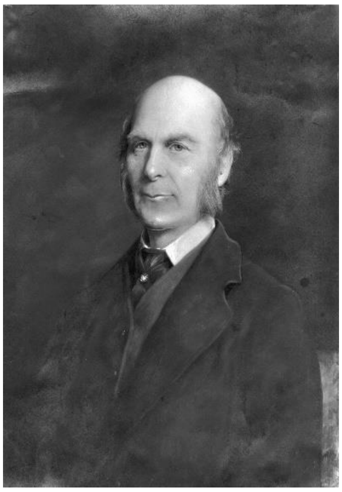
Lateral Fingerprints, invisible to the naked eye, are the crucial evidence in forensic investigations, as they can link individuals to crime scenes or, objects. The development & visualization of these fingerprints are essential for their analysis & comparison with known fingerprint records. Traditional methods for developing latent fingerprints often rely on hazardous chemicals, such as- Cyanoacrylate (Superglue) fuming, Metal-based reagents & Fluorescent dyes. These methods pose risks to human health & the environment due to their toxicity, carcinogenicity, & potential for environmental contamination. In recent years, there has been a growing emphasis on developing eco-friendly & sustainable methods in various fields, including forensic science. The application of green chemistry principles to latent fingerprint development has gained significant interest, aiming to reduce the use of harmful chemicals & minimize the environmental impact of forensic practices. The research paper presents a green synthetic method for the development of latent fingerprints, utilizing the fluorescent nanoparticles derived from natural sources. The proposed method addresses the shortcomings of traditional techniques by offering an environmentally friendly & sustainable approach to fingerprint visualization.

HISTORICAL BACKGROUND: -

The earliest documentation of fingerprints being used for identification purposes can be traced back to the late 19^{th} Century with pioneers like Sir Francis Galton & Dr. Alphonse Bertillon, who were instrumental in establishing the foundation of fingerprint analysis. Galton's pioneering work, "Fingerprints", published in 1892, laid the groundwork for understanding the uniqueness & permanence of fingerprints. He introduced the concept of friction ridge skin (the raised ridges on the skin that account for fingerprint patterns) & it's potential for personal identification. In the early 20^{th} Century, the development of fingerprint technology was further advanced by researcher like, 'Edmond Locard', who is credited with establishing the "Locard Principle"; which emphasizes the transfer of trace evidence in criminal investigations. The advent of fingerprint powders, such as- Black Powder & their use in developing latent fingerprints on various surfaces was a significant breakthrough in forensic science. This allowed investigators to visualize & preserve fingerprints collected from crime scenes or, victim remains. Advances in the 1980s & 1990s, such as the development of Cyanoacrylate (Superglue) fuming techniques & the use of dyes like- Rhodamine, furthered the ability to enhance & visualize fingerprint evidence, particularly on non-porous surfaces. The introduction of forensic techniques like the application of fingerprint powders & the use of Cyanoacrylate fuming for developing latent fingerprints on various surfaces has been pivotal in advancing the field of fingerprint technology. These methods have been widely adopted by forensic laboratories & law enforcement agencies around the world. In recent years, the focus has shifted towards exploring more environmentally friendly approaches, such as- the use of natural products like plant-based dyes or, commercially available superglue products, to aid in the visualization of fingerprints during forensic investigations.

(A)

(B)



(C)

Figure 1: (A) Dr. Alphonse Bertillon; (B) Francis Galton; (C) Edmond Locard

(D)

(E)

Figure 2: (D) Black Powder; (E) Rhodamine 6G Powder (Dye)

(F)

(G)

Figure 3: (F) Application of Fingerprint Powders; (G) Cyanoacrylate (Superglue) Fuming

MATERIALS:

1. **Natural sources for nano-particle synthesis –**
   - Plant extracts (Tumeric, Gardenia fruit, Green tea)
   - Biodegradable polymers (Chitosan, Sodium alginate)
   - Waste Materials (Fruit peels, Vegetable waste).
2. **Reagents for nano-particle synthesis –**
   - Solvents (Water, Ethanol)
   - Reducing agents (Sodium borohydride, Ascorbic acid)
   - Stabilizing agents (Polyvinylpyrrolidone, Citric Acid).
3. **Analytical instruments for nano-particle characterization –**
   - UV-V Spectrophotometer
   - Fluorescence Spectrophotometer
   - Dynamic Light Scattering (DLS) Analyzer
   - Transmission Electron Microscope (TEM)
   - Fourier-Transform Infrared (FTIR) Spectroscope.
4. **Fingerprint collection & development supplies –**
   - Non-porous surfaces (Glass, Metal, Plastic)
   - Semi-porous surfaces (Wood, Paper, Unglazed Ceramics)
   - Fingerprint Brushes or, Applicators
   - Fluorescence Imaging System (Forensic light source, Fluorescence microscope).

METHODS:

1. **Synthesis of Fluorescent Nano-particles –**
   - Extract the desired natural source material using appropriate solvents or, methods.
   - Mix the extract with the reducing agent & stabilizing agent under controlled conditions. (Temperature, pH)
   - Allow the reaction to proceed for a specific duration to form the fluorescent nano-particles.
   - Purify & isolate the nano-particles by centrifugation or, other separation techniques.
2. **Characterization of Nano-particles –**
   - Measure the UV-V & fluorescence spectra to determine the optical properties of the nano-particles.
   - Analyze the size distribution & zeta potential using DLS.
   - Examine the morphology & size using TEM imaging.
   - Identify the functional groups & chemical composition using FTIR spectroscopy.

3. **Fingerprint Development –**
   - Collect fingerprint samples from volunteers or, use pre-deposited fingerprints on various surfaces.
   - Apply the fluorescent nano-particle solution to the surface using brushes, sprays or, dipping methods.
   - Allow the nano-particles to interact with the fingerprint residues for a specific duration.
   - Rinse or, clean the surface to remove excess nano-particles.
4. **Fingerprint Imaging & Analysis –**
   - Illuminate the developed fingerprints using a forensic light source or, fluorescence microscope with the appropriate excitation wavelength.
   - Capture high-resolution images of the fluorescent fingerprints using a camera or, imaging system.
   - Enhance the images using Image Processing Techniques (IPT);
     IPT – (Contrast Adjustment, Ridge Enhancement)
   - Analyze the fingerprint patterns & compare them with known fingerprint records or, databases.
5. **Control Experiments & Validation –**
   - Conduct control experiments using traditional fingerprint development methods (Powder dusting, Cyanoacrylate fuming) for comparison.
   - Evaluate the performance of the green synthetic method on different surface types & under various environmental conditions.

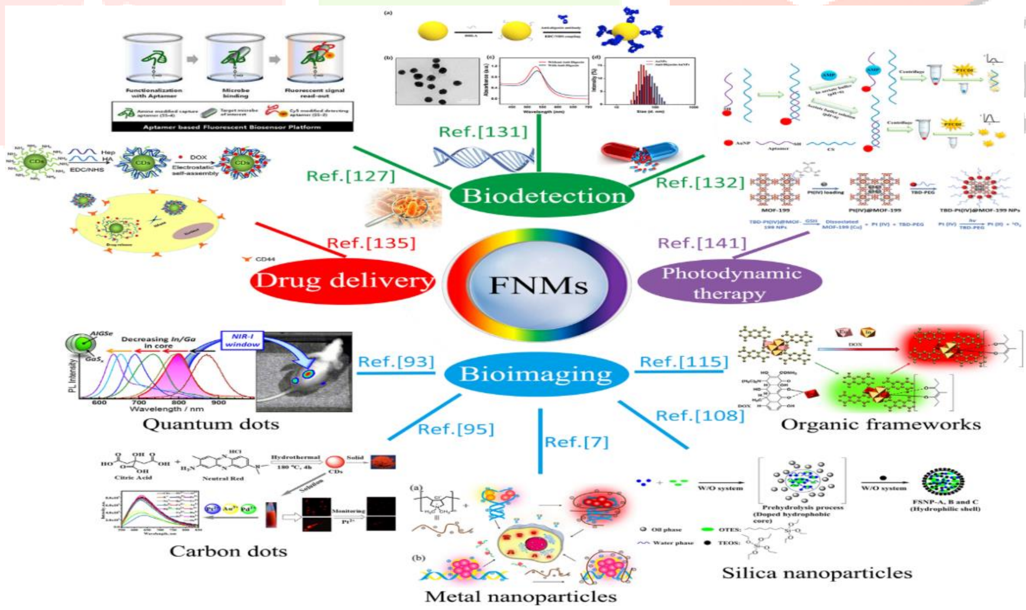


Figure 4: Synthesis of Fluorescent Nano-particles

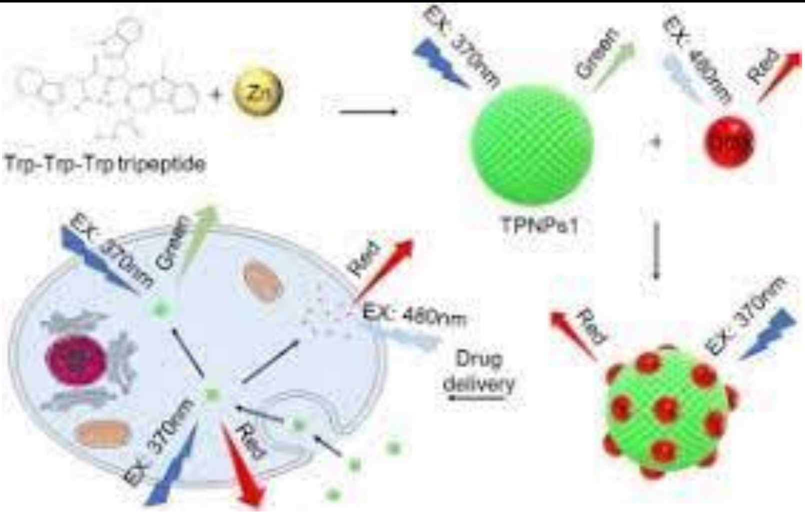


Figure 5: Characterization of Nano-Particles

Figure 6: Fingerprint Development

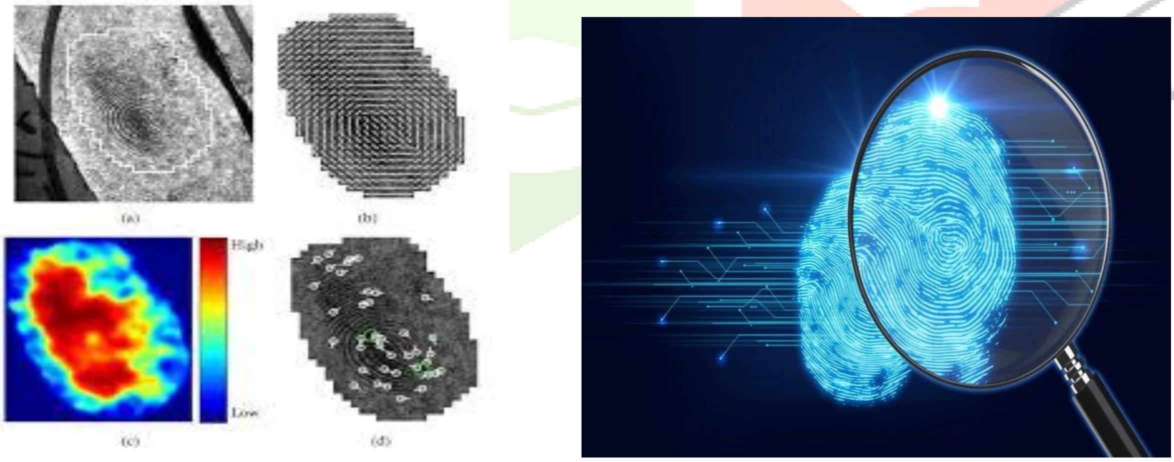


Figure 7: Fingerprint Imaging & Analysis

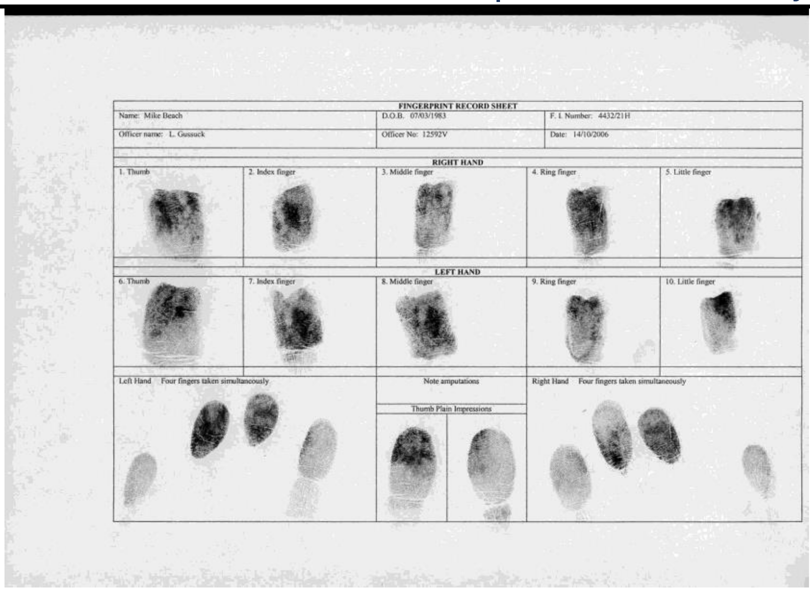


Figure 8: Control Experiments & Validation

RESULTS & DISCUSSION:

The experimental results demonstrate the efficacy of the green synthetic method in developing high-quality latent fingerprints on various non-porous & semi-porous surfaces. The fluorescent nano-particles effectively bind to the fingerprint residues, enabling clear visualization & detailed ridge patterns.

Compared to traditional methods, the "Green Synthetic Method" approach offers several advantages, those are –

1. **Environmental Sustainability** – By utilizing natural sources & minimizing the use of hazardous chemicals, this method significantly reduces the environmental impact associated with latent fingerprint development.
2. **Improved Safety –** The elimination of toxic chemicals enhances the safety of forensic practitioners & minimizes potential health risks associated with exposure to hazardous substances.
3. **Cost-effectiveness –** The use of readily available natural materials & eco-friendly processes may result in cost savings compared to traditional methods that require specialized chemicals & equipment.
4. **Versatility** – The "Green Synthetic Method" can be adapted to develop fingerprints on various surfaces, including those that may be challenging for traditional techniques, such as- Semi-porous materials.

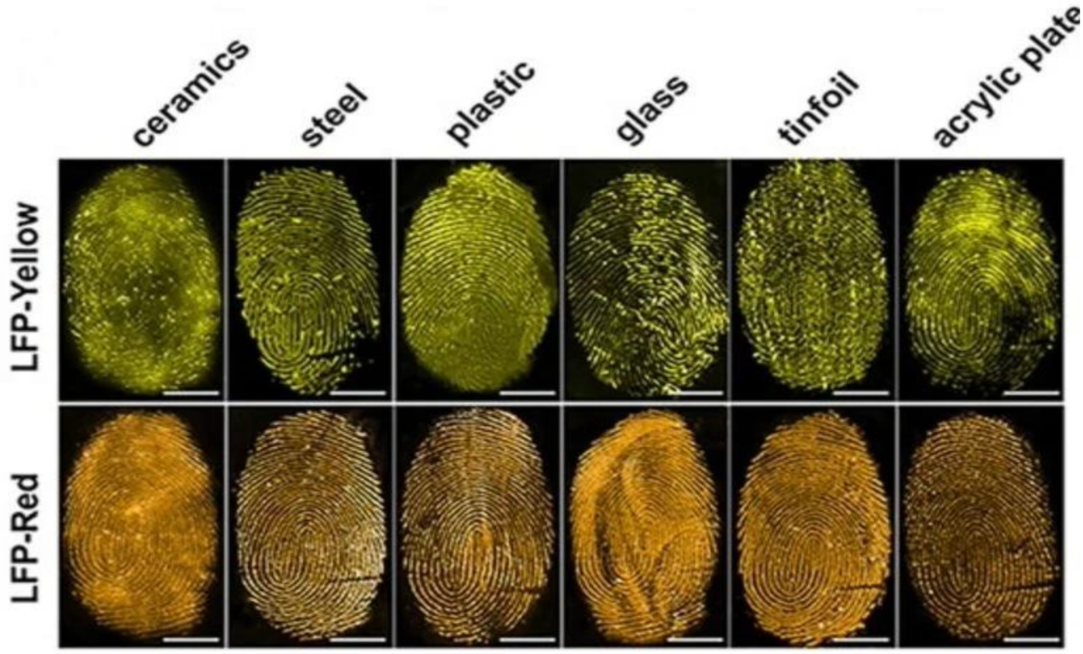


Figure 9: Green Synthetic Method for Latent Fingerprints Development

CONCLUSION:

The “Green Synthetic Method” for the development of latent fingerprint represents a significant step towards sustainable & eco-friendly practices in forensic science. By utilizing fluorescent nano-particles derived from natural sources, this approach offers a viable alternative to traditional methods that rely on hazardous chemicals. The proposed method has demonstrated its efficacy in developing high-quality fingerprints on various surfaces while minimizing environmental impact & improving practitioner safety. Further research & refinement of this technique may pave the way for widespread adoption in forensic laboratories, contributing to the pursuit of environmental sustainability & responsible forensic practices. Additionally, the successful implementation of this green synthetic method in real-world forensic settings will require the development of standardized protocols, training programs & quality assurance measures to ensure consistent & reliable results. Despite these challenges, the green synthetic method represents a significant step towards sustainable & responsible practices in forensic science. By addressing the environmental & health concerns associated with traditional fingerprint development techniques, this approach aligns with the growing demand for eco-friendly solutions across various scientific disciplines. Looking ahead, the integration of this green synthetic method with emerging technologies, such as- advanced imaging techniques & automated analysis systems, could further enhance its applicability & accuracy in forensic investigations. Collaborative efforts between researchers, forensic practitioners, & stakeholders will be crucial in refining & validating this method, ultimately contributing to the pursuit of justice while prioritizing environmental sustainability & human safety.

REFERENCES:

A. Peer-Reviewed Journal Articles –

1. Garg R.K., Kumari H., Kaur R. (2011). A new technique for visualization of latent fingerprints on various surfaces using powder from turmeric: A rhizomatous herbaceous plant (Curcuma longa). Egyptian Journal of Forensic sciences, 1(1), 53-57. https://doi.org/10.1016/j.ejfs.2011.04.011
2. Jasuja O.P., Kaur J., Kumar R., Singh G. (2015). Visualizing latent fingerprint on suitable surfaces using egg white as a nano-particle bio-resin. Forensic science International, 253, 94-106. https://doi.org/10.1016/j.forsciint.2015.05.013
3. Jaber N., Lesniewski A., Gabizon H., Shenawi S., Oaknin D., & Kraitzer A. (2020). Vis/NIR fluorescent nanocarbons formulation for latent fingerprint development. Forensic Science International, 311, 110268. https://doi.org/10.1016/j.forsciint.2020.110268
4. Levinton-Shamuilov G., Cohen Y., Azoury M., Chechik A., Almog J. (2005). Fingerprint detection using a novel 3D color imaging system. Journal of Forensic Sciences, 50(4), 1-6. https://doi.org/10.1520/JFS2004262

B. Books & Book Chapters –

5. Jasuja O.P., & Chadha V. (2015). Green chemistry for latent fingerprints development: A review. In J.F. Moye (Ed.), Fingerprints & Fingerprint Records (pp. 145-168). Nova Science Publishers.
6. Lee H.C., & Gaensslen R.E., (Eds.), (2001). Advances in fingerprint technology (2nd ed.). CRC Press. https://doi.org/10.1201/9781420041859
7. Champod C., Lennard C., Margot P., Stoilovic M. (2004). Fingerprints & other ridge skin impressions (2nd ed.). CRC Press. https://doi.org/10.1201/9780203495988

C. Government & Professional Organization Publications –

8. National Institute of Justice (NIJ), (2014). Latent print development. In Forensic Science Simplified (Vol. 3). U.S. Department of Justice. https://nij.ojp.gov/library/publications/forensic-science-simplified-volume-3
9. Scientific Working Group on Friction Ridge Analysis, study & Technology (SWGFAST), (2013). Latent print development. In Standards for Examining Friction Ridge Impressions & Resulting Conclusions. https://www.swgfast.org/standards.html

D. Conference Proceedings & Presentations –

10. Benton M., Chua M., Gunaratne T., Chan H.Y., & Rabbit A. (2019). Green synthesis & characterization of fluorescent nano-particles for latent fingerprint detection. Proceedings of the 27th International Symposium on the Forensic Sciences, Canberra, Australia.
11. Jasuja O.P., & Kaur R. (2017). Development of latent fingerprints by plant extracts – A green chemistry approach. Paper presented at the 3rd International conference on Forensic Research.