Elevating Latent Fingerprints Preservation Exploring Brucine Solution as an Effective Fixative Agent

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Abstract
The use of brucine solution as a fixing agent for chemically developed latent fingerprints is a promising technique in forensic science. This abstract explores the effectiveness of brucine solution in enhancing the visibility and durability of latent fingerprints developed through chemical methods. Brucine, a natural product derived from the seeds of the Strychnos nux-vomica tree, has shown potential as a fixing agent due to its ability to react with amino acids present in sweat residues left in fingerprints. The research conducted to evaluate the efficacy of brucine solution involved testing various concentrations and application methods on different surfaces commonly encountered in forensic investigations. Results indicated that brucine solution significantly improved the contrast and clarity of latent fingerprints, making them more suitable for identification and comparison purposes. Furthermore, the fixed fingerprints exhibited enhanced resistance to environmental factors such as light, humidity, and heat, thereby prolonging their preservation. In addition to its fixing properties, brucine solution was found to be cost-effective and easy to prepare, making it a practical choice for forensic laboratories with budget constraints. The non-toxic nature of brucine further adds to its appeal as a fixing agent, ensuring the safety of forensic examiners and personnel involved in fingerprint analysis.
Overall, the findings suggest that brucine solution holds great potential as a fixing agent for chemically developed latent fingerprints, offering improved visibility, durability, and cost-effectiveness. Further research is recommended to explore its compatibility with different chemical development techniques and its applicability in various forensic scenarios.

Keywords: Brucine solution, latent fingerprints, fixing agent, chemical development, forensic science

1. INTRODUCTION

Fingerprints are unique to every individual. They act as medium of identification. The fingerprints in a crime scene are crucial evidence which was left out by the offender, victim or any other individual during the occurrence of the crime. Such fingerprints are the key access to the identification to the individuals involved in that crime. The fingerprints found in the crime scene are identified, classified and compared with other fingerprints. This is referred by the term "Dactyloscopy". In ancient age, the fingerprints are seen only as a normal impression and they weren't used for identification as these days then.
At first, the ancient Babylonians used their fingerprints as the records for business transactions by pressing

the impressions on the clay. As days go by, the importance of fingerprints was established in various fields, mainly in forensic science to identify an individual who have possibly involved in a crime. The impressions formed by the friction ridges on the fingerprints. The fingerprints have creases and valleys which forms the shapes of the ridges. The unique characteristics of the fingerprints makes it the valuable evidence in the Crime scene. If a fingerprint found in the crime scene is partial, the forensic scientist recovers the fingerprint by forensic methodologies.

Latent fingerprints are commonly found in any surfaces. As we all know that these prints are invisible in nature as they are left by clean hands of a person. The latent fingerprints can be possibly present anywhere in the crime scene. This makes the collection and preservation of latent fingerprints important when dealing with analysis.

1.1 Fingerprint

The impression left by the friction ridges of a human finger is known as fingerprint. The skin is made up of three layers.

- Epidermis
- Dermis
- Hypodermis

Epidermis

- The epidermis is a layer of the Skin which consists of raised portions known as friction ridge. These ridges are commonly referred as “Epidermal Ridges”. The epidermal ridges are formed between the dermal papillae of the dermis and inter papillae of the epidermis.
- The ledge-Like formation are is developed in the foetus during 13th week of pregnancy, at the bottom of the epidermis adjacent to dermis. Around 15th week of foetal development, unique features of friction ridges are formed, which is unalterable until decomposition.
- The epidermis consists of cells named as Keratinocytes, Melanocytes, Langerhans’ cells and Merkel’ cells. Each cell is significant according to their anatomical and physiological. The epidermis has five Sub-layers, which are named as:
- Stratum Basale
- Stratum Spinosum
- Stratum Granulosum
- Stratum lucidum
- Stratum Corneum

Dermis

The layer of skin between the epidermis and subcutaneous tissues is known as dermis. The dermis is classified into papillary region and reticular dermis. The papillary regions have loose areolar connective tissue, which are finger like projections called papillae or dermal papillae. It is composed of collagen elastic fibres and extra fibrillar matrix. It also contains hair follicles, sweat glands, sebaceous gland, apocrine glands, lymphatic vessels, nerves and blood vessels The dermis has three types of cells such as fibroblasts, macrophages and mast cells.

Hypodermis

The lowermost layer of the skin is called as hypodermis which are commonly known as subcutaneous tissue. This consists of large blood vessels, nerves, loose connective tissue and fats. The cells found hypodermis layers are fibroblasts, Adipose cells and macrophages.

1.2 Composition of Fingerprints

The fingerprints are mostly made up of 95%-99% of water contents with organic and inorganic constituents. The organic components includes proteins, amino acids, lactase, glucose, urea, pyruvate, fatty acids and sterols. The inorganics are chloride, sodium, potassium and iron.

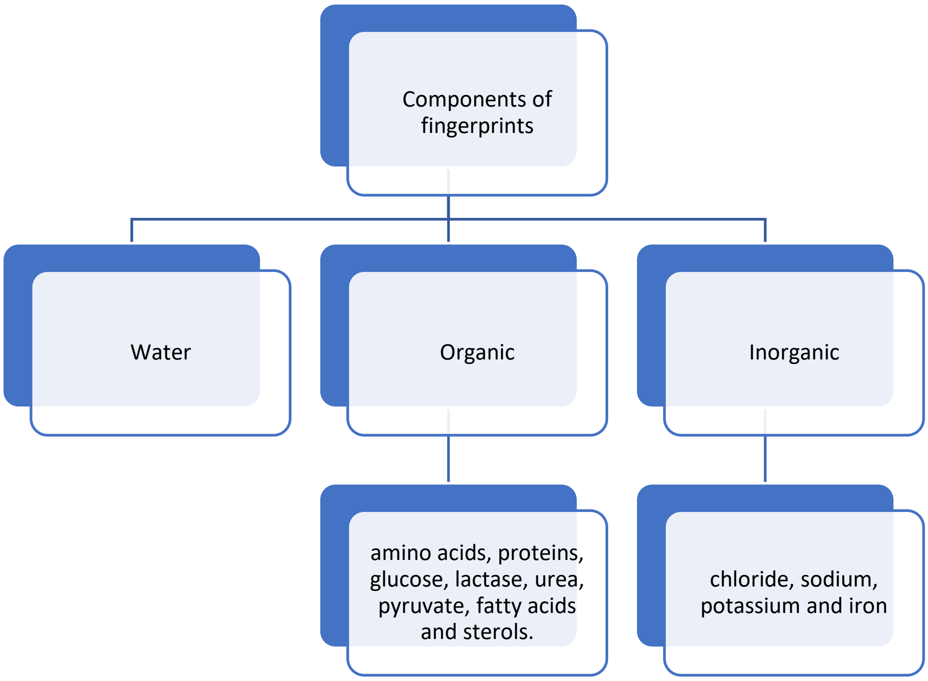

Figure. 1 Composition of fingerprints

1.3 Importance of Fingerprints

The fingerprints are well known for their unique characteristics and features which specifies them for security reasons. In these days, the fingerprints are utilized for both civil and criminal which includes biometric, identity purposes, identification in the involvement in a criminal activity. In general, the fingerprints acts as vital evidence in crime scene mainly because of their importance.

- **Unique:** Every individual has a unique pattern of fingerprints formed by friction ridges. The friction ridges are formed for each person is different even the identical twins does not have similarities in their fingerprints. Thus, this feature helps in identification of a person.
- **Universal:** As we all know that the fingerprints are the medium of identification for all individuals thus making them a universal mode for identification. A fingerprint found in a crime scene can directly lead to the identification of the suspect.
- **Permanent:** The fingerprints are formed during the 15th week of foetus development and are permanent until the decomposition begins. Those friction ridge pattern remains same except when there is an injury, surgery or damage to the layer of the skin which may lead to change in the pattern.
- **Classified:** Classification of fingerprints are carried out easily because of their different patterns of ridge formations, making them unique to all the individuals. The fingerprints are classified into different records.
- **Inimitable:** The forgery of a fingerprint is not a recommended technique so far, as the results received from the forged/imitated fingerprints are not accurate. The fingerprints impression can be imitated but they are not that successful and perfect. Thus, the fingerprints are considered as imitable.

1.4 Types of Fingerprints

There are three major types of fingerprints classified by general characteristics. They are,

- Patent fingerprints
- Latent fingerprints
- Plastic or negative fingerprints

The fingerprints are also further classified into eight more types based on their pattern formations.

1.5 CLASSIFICATION OF FINGERPRINTS PATTERNS

Fingerprint patterns are classified based on their ridge formation which differs in shapes, cut in ridge, turning of the curves, merging of the ridge or joining, bifurcation, trifurcation and so on, thus making an infinite variation of combinations in the ridge formation. In general, the patterns are categorized majorly as Arches, Loops, Whorls, Composite and Accidental. Then these three are further classified into specific patterns. The frequency percentage of the ridge patterns are: Arches- 5-10%; Loops- 60-65% and Whorls- 30-35%.

Arch: The ridges in the arch are formed starting from one end to the other end of the finger with no returning or curving. These arches can be of two types such as;

- Plain Arch
- Tented Arch

Loop: The loops are the type of pattern which starts from one side then recurve, extend, pass and terminate on the same side from where it started.

- Radial loop
- Ulnar loop

Whorl: Whorl or plain whorl is the ridge formation which possess either a circle, oval, spiral etc making a whole complete path.

Composites: Central pocket loop- These contains a recurve of a single whorl which makes a pocket formation with two deltas.

Double loop- As the name suggest, the double is the formation of two different loop structures joined in a fingerprint.

Accidental: Certain patterns that arise very rarely and are present by accident, those are known as accidental patterns. Some of them are; Loop and central pocket, Loop and whorl, Loop and tented arch, Double loop and central pocket loop.

1.6 DEVELOPMENT OF LATENT FINGERPRINTS

Latent fingerprints are not visible to naked eye. In order to visualize these prints need to be developed. They are developed using various methods such as conventional and non-conventional methods. Every method has its own advantages and disadvantages. But conventional methods are one still followed in the cases to develop the latent prints.

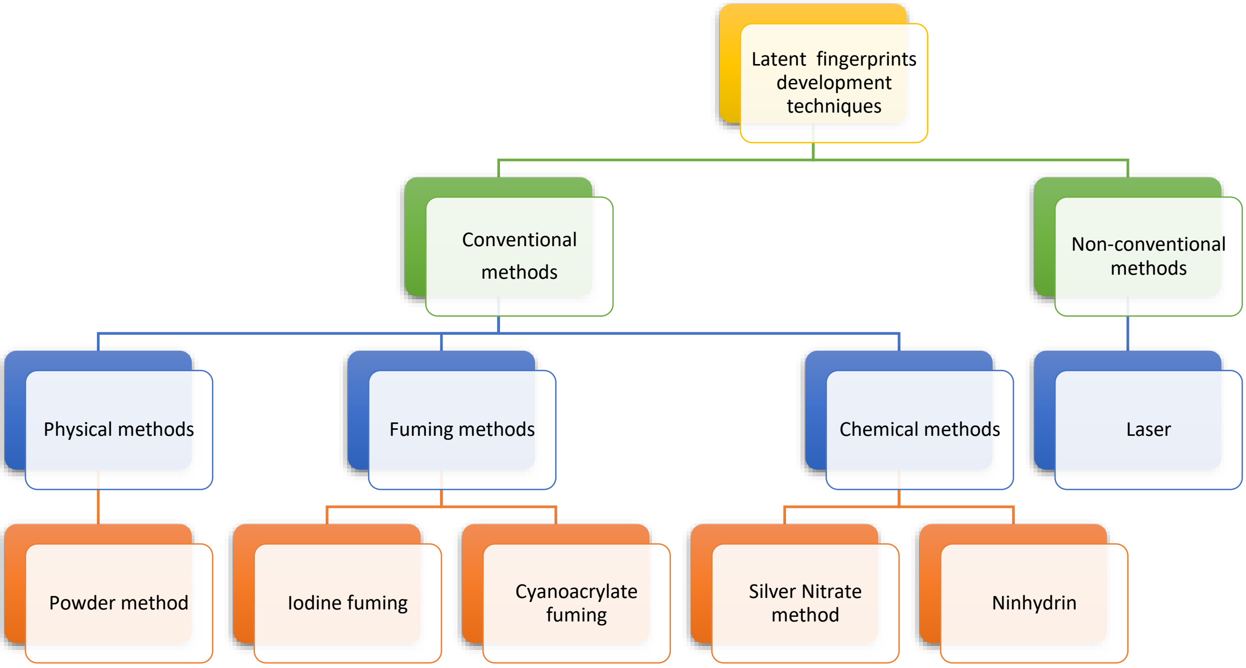

Figure 2 Methods of Developing Latent Fingerprints

1.7 IODINE FUMING

Iodine fuming is the oldest technique used to develop a latent print. As it is well known for the easy development process and its effectives. They are easy to develop and also are considered to be effective. This technique is low cost and non-destructive. Iodine is a toxic compound and it is strongly corrosive. They are irritating, so wearing gloves and other precautions like goggle, protective clothing is a must.

The iodine fuming is done by setting up the fuming chamber and iodine crystals. Then the iodine crystal is kept on a plate so that the iodine crystals start to sublime. The transformation of solid to gas is known as sublimation. As the fumes are started the sample is suspended into the chamber using a forceps and closed. After few seconds, the prints are developed. Then the sample is taken out and examined.

The iodine fuming developed prints were produced with yellowish brown colour prints. The iodine fuming is absorbed by the fat and oil deposits of the latent prints. The drawback in iodine fuming is that the developed prints are not permanent.

1.8 NINHYDRIN

Ninhydrin (2,2-dihydroxyindane-1,3-dione) is a chemical compound that has long been used in forensic science for the detection of latent fingerprints on various surfaces. This reaction forms the basis of ninhydrin's utility in fingerprint analysis. The compound has been a cornerstone in fingerprint analysis since its first use in the mid-20th century, and its effectiveness has been well-documented in various

studies. When applied to a surface, ninhydrin reacts with the amino acids present in the sweat residue left by fingers, producing a purple or blue-coloured compound called Ruhemann's purple.
Chemical Mechanism of Ninhydrin Reaction:
Ninhydrin reacts with the amines (especially amino acids) in sweat deposited by fingers on surfaces such as paper, fabrics, and some other porous materials. The reaction typically involves the following steps:
Dehydration: Ninhydrin interacts with the amino acids or peptides to form an intermediate compound.
Cyclization: This intermediate undergoes cyclization to form a coloured product, Ruhemann's purple, which is a highly stable compound.
The colour change occurs because ninhydrin oxidizes the amino acids, releasing a free amino group that interacts with ninhydrin to form the purple-coloured product. This reaction is highly sensitive and can detect latent fingerprints even when they are faint.

α-amino acid + 2 ninhydrin → CO_2 + 3 H_2O + aldehyde + final complex (Deep Purple)

Ninhydrin is used as developing reagent by spraying it on the surface of the sample from about 6 inches distance. After few minutes, the prints start to develop in purple colour. While using ninhydrin in an experiment, a few parameters should be maintained. Chemical parameters like concentration of ninhydrin, nature of the solvent and the acidity of the formulation. Physical parameters such as the mode of application, heating temperatures and relative humidity.

1.9 BRUCINE

Brucine is weal indole alkaloid compound, which is extracted from the tree Strychnos nux-vomica. Even though the brucine compound has its own pharmacological and therapeutic properties, the toxic nature of brucine inhibits its utility. The potential chemical compounds like brucine are prohibited in many aspects because of their toxicity and side effects. The use of brucine in fingerprint development is less common than other reagents like ninhydrin or silver nitrate, but it has been explored in forensic literature for its ability to react with the amino acids present in sweat left by fingers on various surfaces.
In fingerprint detection, brucine is used to reveal latent prints, especially on porous surfaces such as paper and cardboard, where the amino acids in the fingerprint residue can undergo a chemical reaction with the brucine solution.
Mechanism of Brucine in Fingerprint Detection:
Brucine reacts with amino acids in latent fingerprints, forming a coloured product similar to the reaction seen with other reagents like ninhydrin. The mechanism involves the oxidation of amino acids in the fingerprint residue, which leads to the formation of a coloured complex. While the exact nature of the complex can vary, the product typically has a distinctive colour (often yellow or brown) depending on the specific amino acids present in the fingerprint. This reaction highlights the print and makes it visible for further analysis.

2. Literature Review

2.1 Iodine fuming

In this research paper of Jasuja et al. (2009), they conducted the testing on developing latent fingerprinting on thermal papers by using iodine fuming method. The degree of permanency and colour production depends on the different types of thermal papers. The intensity of sebaceous and eccrine fingerprints was also observed. In fresh prints the decrease in intensity of eccrine glands is noted and even after further observation for 7days, the sebaceous prints have more intensive results than eccrine. Similarly, the study of Kelly et al. (2011), paper was performed for the enhancement of faded text on the thermal papers by using Iodine fuming method. The thermal papers are widely used in the various places as receipts etc. The fading of the text in thermal paper can be natural or deliberately done. Iodine vapours produce brown colour on paper and enhances the latent prints contrastingly. This method can also be used on other papers also in order to develop the latent prints.

The study by Kaur et al. (2019) provides an in-depth examination of the powder method, one of the most widely used techniques for developing latent fingerprints at crime scenes. The review discusses the various types of powders, their composition, and how they interact with different surfaces to reveal clear fingerprint impressions. The authors highlight the advantages of this method, such as its simplicity, cost-effectiveness, and versatility, while also addressing its limitations, including the potential for powder contamination and challenges with certain surfaces. Overall, the article emphasizes the continued relevance of the powder method in forensic science and calls for further research to refine and optimize its application.

2.2 Latent fingerprint development techniques

The study by Dhaneshwar et al. (2021) provides a comprehensive analysis of latent fingerprint detection methods, highlighting their effectiveness, challenges, and practical applications. It underscores the significance of tailoring techniques to specific surface types and environmental conditions to maximize accuracy and reliability. The study concludes that continuous advancements in fingerprinting methods are essential for improving forensic investigations and ensuring robust evidence collection in criminal cases. The article by Kaur et al. (2015) provides a comprehensive analysis of the physical developer (PD) technique, which uses a redox reaction to deposit metallic silver on fingerprint residues, making them visible on porous surfaces, especially those exposed to moisture. It highlights the method's effectiveness on various materials such as paper, adhesive tapes, and clay-based items, particularly in cases where other methods like ninhydrin fail. The review compares PD with other fingerprint development techniques, noting its advantages, such as sensitivity to older or degraded prints, but also its limitations, such as being time-consuming and potentially damaging certain materials. The authors suggest further research into improving the efficiency and safety of the method, making it a valuable resource for forensic professionals.

2.3 Ninhydrin

The article by Chen et al. (2015) investigates the effectiveness of two chemical reagents, ninhydrin and 1,2-indanedione, for developing latent fingerprints on thermal paper, a challenging surface due to its unique composition. The study compares the performance of these reagents in revealing clear fingerprint impressions and assesses their advantages and limitations in forensic applications. The authors find that 1,2-indanedione offers superior results in certain conditions, providing better contrast and stability compared to traditional ninhydrin. The article emphasizes the importance of selecting the right chemical method based on the specific surface and environmental factors, offering valuable insights for forensic experts dealing with thermal paper evidence in criminal investigations. The study by Yang et al. (2014) explores the application of a solid-medium ninhydrin method for developing latent fingerprints, aiming to improve the traditional liquid-based ninhydrin technique. The study investigates the use of solid mediums, such as paper or other substrates, to apply ninhydrin more effectively and uniformly on fingerprint impressions. The authors discuss the method's advantages, including ease of use, reduced handling time, and improved stability of results, while also addressing potential challenges such as the variability of surface conditions and the need for careful control of temperature and humidity. Overall, the article presents solid-medium ninhydrin as a promising advancement in latent fingerprint detection, offering a practical and efficient alternative for forensic applications.

2.4 Brucine solution

In a study by Jasuja et al. (2012), the use of brucine solutions for fixing fingerprints on porous and non-porous surfaces following iodine fuming was investigated. Two types of brucine solutions, reagent A (dipping method) and reagent B, were employed, with reagent B (vapour method) (vapour method) demonstrating superior effectiveness. The results indicated that the vapor method yielded better outcomes for fingerprints on porous surfaces, while the dipping method was more effective for non-porous surfaces. However, when reagent B-treated fingerprints were subjected to ninhydrin, the marks were completely erased. Additionally, it was noted that brucine solutions with a pH of 7 exhibited an extended shelf life of up to two months, further highlighting their practicality in forensic applications.

The article by Hiruntad et al. (2016) provides a comprehensive pharmacognostic evaluation and quantitative analysis of Strychnos nux-vomica seeds, focusing on the toxic alkaloid’s strychnine and brucine. It establishes detailed pharmacognostic specifications, including macroscopic and microscopic characteristics, to aid in seed identification and authentication. Using High-Performance Liquid Chromatography (HPLC), the study accurately quantifies the alkaloids, contributing to the standardization and safety of herbal preparations. The findings highlight the seeds' therapeutic potential while addressing toxicity concerns, offering insights into their controlled medicinal use. This work significantly advances quality control and safe application of Strychnos nux-vomica in traditional medicine. The study by Liu et al. (2012) focuses on the forensic determination of poisoning caused by Strychnos nux-vomica. Presented at the 2012 International Conference on Biomedical Engineering and Biotechnology, the research explores analytical methods for detecting strychnine and brucine in biological samples. Utilizing techniques such as High-Performance Liquid Chromatography (HPLC), the study provides a reliable and accurate approach to identifying these toxic alkaloids, aiding in forensic investigations of poisoning cases. The work contributes significantly to the field by improving the detection and understanding of Strychnos nux-vomica toxication in forensic science.

2.5 non-porous surfaces and other reagents

Longchar et al. (2019), executed research on Fingerprints to determine the stability of the fingerprints on the aluminium and plastic surfaces at low temperature, test was carried out by development of the prints on 80 samples using Black powder, Red and Green magnetic fluorescence powder, Iodine fuming method, Ninhydrin method, Cyanoacrylate method, silver nitrate method and small particle reagent method. In these, Iodine fuming method, Cyanoacrylate method, silver nitrate method, SPR method gave positive results for aluminium surfaces and for plastic surfaces black powder method and SPR method gave better results.

The study of Flynn et al. (2004) makes a comparison between spray reagents like Iodine benzoflavone and RTX (Ruthenium tetroxide) and Conventional powder methods. The testing was done by comparison of powdering after spray versus powdering only and spray after powdering versus powdering only. The results determines that every surface requires different developing techniques. In this, the spray methods shown impressive results on bricks, walls and raw wood rather than the powdering method. But the powdering technique showed better results after 3-4 days. Also, the conventional powdering methods will be cost efficient compared to the reagents used in spray techniques.

3. Materials and Methodology

3.1 Aim

The aim of this study is to investigate the effectiveness of Brucine Solution as a fixing agent for chemically developed latent fingerprints.

3.2 Objectives

- To assess the durability and longevity of latent fingerprints fixed with Brucine Solution.
- To explore the potential applications of Brucine Solution in forensic fingerprint analysis.
- To investigate the effectiveness of Brucine Solution as a fixing agent for chemically developed latent fingerprints.

3.3 Need and Significance

As we discussed in the prior chapters, the fingerprints are the most vital source of evidence in identifying a suspect and linking any individual to the crime scene. The fingerprints are unique to every individual, for example, even the identical twins have different ridge patterns. Thus, this feature makes it significant in the field of criminology and forensic science for analysing the fingerprints and identifying the suspect. In forensic science the fingerprints are collected, preserved and analysed in order to explore the information. In this the latent fingerprints need more development processes as they are invisible to the naked eyes. There are various general techniques to develop latent prints such as powder method, chemical methods, physical methods etc. But every method has a drawback, for example, the print developed by iodine fuming, ninhydrin and other are not permanent. To make them sustain for longer period various secondary fixative agents are used. One such upcoming agent utilized in this study is known as brucine. The brucine solution is being tested for its effectives on different materials which are most commonly encountered in the crime scene.

3.4 Variables

3.4.1 Independent variables

- Brucine solution
- Iodine
- Ninhydrin

3.4.2 DEPENDENT VARIABLES

- Ordinary paper
- Bond paper
- Thermal paper
- Cigarette
- Chocolate wrapper

3.5 Laboratory

The experiment of this study was conducted in the Laboratory of Centre of Excellence in Digital forensics (CoEDF) institution located at Perungudi, Chennai.

3.6 Samples

The samples employed in this experiment were chosen as which are all most familiarly encountered in the crime scene. The day-to-day life materials commonly used by the public can be the evidence in many of the cases.

Table 1 Samples list

S.no	Sample	Sample size
1	Cigarette	4 samples + 1 control sample
2	Ordinary paper	4 samples + 1 control sample
3	Thermal paper	4 samples + 1 control sample
4	Bond paper	4 samples + 1 control sample
5	Chocolate wrapper	4 samples + 1 control sample

3.7 REAGENTS:

The study deals with development of latent prints using important and most commonly used techniques in forensic science such as fuming and chemical methods.

Table 2 Reagents list

S.no	Reagents
1	Iodine
2	Ninhydrin
3	Brucine

3.8 MATERIALS REQUIRED

- Iodine crystals
- Fuming chamber with lid
- Forceps
- Ninhydrin
- Acetone
- Spray bottle
- Brucine
- Potassium persulfate
- Sodium chloride
- Distilled water

3.9 REAGENT PREPARATION

3.9.1 IODINE FUMING

0.5-1 gram of iodine crystals are kept inside the fuming chamber which is placed on the hotplate. The chamber is closed so the iodine crystals are sublimed to fumes in order to be used for fuming the fingers.

3.9.2 NINHYDRIN

To prepare ninhydrin solution, 0.20 g of ninhydrin is dissolved in about 25ml of acetone. The solution is given a slight gentle mix to dissolve the contents. The reagent is transferred to a spray bottle for the purpose of the experiment.

3.9.3 BRUCINE

In this study, the brucine solution is applied in two forms of reagent so that the difference in the effectiveness can be addressed. The following is the method used in preparing the reagent.

Reagent A (dipping method)– 1% of aqueous solution of brucine was prepared by adding 0.250g of brucine to 25ml of distilled water. Then dissolve them thoroughly using stirrer for 15mins. Note the pH of the reagent.

Reagent B (vapour method)– 1% of aqueous solution of brucine was prepared by adding 0.250g of brucine to 25ml of distilled water. Then add 0.25g of potassium persulfate and 0.25g of sodium chloride were added. The solution is heated for 5mins. The colour changes from milky white to red is observed. Note the pH of the reagent.

3.10 PROCEDURE

Step 1: Initial Treatment of Samples with Iodine Fuming and Ninhydrin Spraying

- Two samples of each material (i.e. for example, if the first sample material is cigarette, then two cigarette samples are used) were selected and treated using iodine fuming.
- The iodine fuming method involves exposing the material to iodine vapors, which temporarily react with the oils and sweat residues in fingerprints, making them visible.
- The fuming process was carried out by placing iodine crystals in a closed chamber and allowing vapors to develop, which were then absorbed by the fingerprint residue on the material.
- Another two samples of each material were treated with ninhydrin reagent.
- Ninhydrin is commonly used to detect latent fingerprints on porous surfaces such as paper.
- The reagent was directly sprayed onto the material, allowing it to react with amino acids present in the fingerprint residue, leading to the development of a purple-colored print (Ruhemann's purple) over time.

Step 2: Post-Treatment of Iodine-Fumed Prints with Reagent A (dipping method) and Reagent B (vapour method)

- After iodine fuming, one of the samples was submerged in Reagent A for 20–40 seconds.
- The purpose of this treatment was to enhance the visibility and contrast of the developed fingerprint. The chemical composition of Reagent A contains brucine and distilled water and applied onto the material by dipping.
- The second iodine-fumed sample was subjected to double fuming using Reagent B, which was generated from a Brucine, Distilled water, Potassium persulfate, Sodium chloride.
- Brucine, a chemical similar to strychnine, produces vapors that may interact with the iodine residue or fingerprint components, potentially enhancing the clarity of the print.
- The sample was exposed to these vapors in a controlled fuming chamber to allow for a chemical reaction with the existing iodine-treated fingerprint.

Step 3: Repeating the Procedure for All Iodine-Fumed Prints

- The same post-treatment steps (dipping in Reagent A and double fuming with Reagent B) were carried out for all iodine-fumed fingerprint samples across different materials such as Cigarette, Ordinary paper, Thermal paper, Bond paper, Chocolate wrapper.
- This ensured consistency in the experiment and allowed for comparative analysis across multiple materials and treatment combinations.

Step 4: Post-Treatment of Ninhydrin-Developed Prints with Reagent A (dipping method) and Reagent B

- Similar to the iodine-fumed samples, the ninhydrin-treated fingerprints were also subjected to additional chemical treatments.
- One of the ninhydrin-treated samples was dipped in Reagent A (dipping method) for 20–40 seconds to observe any potential enhancement or alteration in color and contrast.
- The second ninhydrin-treated sample was fumed with Reagent B (vapour method) using brucine vapors, similar to the iodine-fumed samples.
- The aim was to investigate whether the brucine vapors further enhanced or changed the ninhydrin-developed prints in any way.

Step 5: Repeating the Procedure for All Ninhydrin-Developed Prints

- The same post-treatment steps (dipping in Reagent A and double fuming with Reagent B) were carried out for all ninhydrin-developed fingerprint samples across different materials.
- This ensured that results could be compared systematically to determine the effectiveness of each chemical treatment method.

Step 6: Observation and Documentation of Results

- Once all treatments were completed, the developed fingerprints on each material were carefully examine. The documentation of the experiment was recorded with photographical evidence which demonstrates the visible changes and enhances in the prints. The results are observed in the presence of normal lightning.
- The following factors were noted for each treatment combination:
- Clarity and contrast of the developed fingerprints.
- Any color changes or enhancements observed.
- Effectiveness of each reagent in improving the visibility of prints.

4. Results and Discussion

4.1 Results

The latent prints developed with iodine fuming and ninhydrin gave positive results on all the materials. But the reactions to the brucine reagents were different. Some materials gave positive reaction but some faded away with the exposure of brucine solutions. Thus, the results are noted as (+) for persistence and (-) for faded away of the prints.

4.1.1 Dipping Test using Reagent A (Dipping Method)

The results obtained from the dipping method using reagent A gave positive outcome in ordinary paper for iodine fuming whereas it led to fading of prints in ninhydrin. In thermal paper the results were vice versa because the iodine fumed prints showed negative result but ninhydrin was positive. The cigarette sample gave negative results for both iodine fumed and ninhydrin prints. Other than that, both bond paper and chocolate wrapper gave similar negative outcome on both iodine fumed and ninhydrin.

4.1.2 Fuming Test using Reagent B

The results obtained from the fuming method by using reagent B gave positive outcome in ordinary paper and thermal paper for both iodine fuming and ninhydrin. The cigarette, bond paper and chocolate wrapper showed fading to no sign of fingerprint which indicated the negative outcome for both iodine fumed and ninhydrin.

Table 3 Dipping Method by using Reagent A

S.no	Materials	Iodine Fumed (IA)	Ninhydrin (NA)
1	Cigarette	_	_
2	Bond Paper	_	_
3	Ordinary Paper	+	_
4	Chocolate Wrapper	_	_
5	Thermal paper	_	+

Table 4 Fuming Method by using Reagent B

S.no	Materials	Iodine Fumed (IB)	Ninhydrin (NB)
1	Cigarette	_	_
2	Bond paper	_	_
3	Ordinary paper	+	+
4	Chocolate Wrapper	_	_
5	Thermal paper	+	+

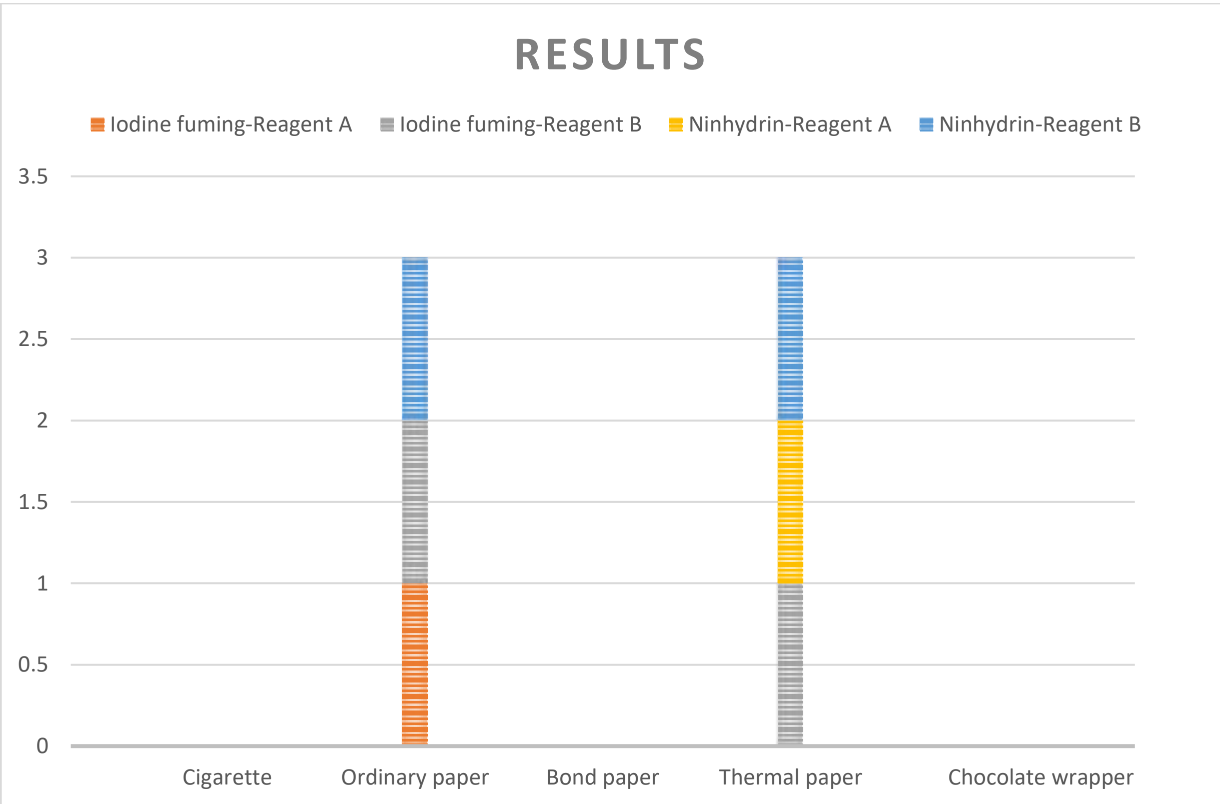

Figure 3 Results graph of the experiment

4.2 Discussion

4.2.1 Impacts by the Type of Sample Materials

The sample materials used for these experiments are relevant and are practically possible to be found as evidence in a scene of crime. Thus, the samples are particularly chosen from day-to-day based items and most common things to have fingerprint impressions on. These types of materials are also the ones used in similar previous studies. Thus, for more understanding purpose, the same types of sample materials were picked. This helps us to experiment different techniques on the sample to yield various outcomes.

The ordinary paper, bond paper, cigarette, thermal paper and chocolate wrapper were observed with positive results for the iodine fuming and ninhydrin fingerprint detection. The ordinary paper and thermal paper both gave positive results with reagent B (vapour method) whereas in reagent A (dipping method), the iodine fumed ordinary paper and thermal paper showed positive and negative results respectively. Conversely, the ninhydrin ordinary paper and thermal paper showed negative and positive results respectively. This proves the study of Chen et al. (2015) that thermal paper yields fine prints by ninhydrin. The cigarette, bond paper and chocolate wrapper produced negative outcome for both reagent A (dipping method) and reagent B (vapour method).

4.2.3 Impact by the Brucine Reagent

This study focusses on exploring the effectiveness of the brucine reagent as a secondary fixing agent for iodine fuming and ninhydrin. In order to analyse that, two types of reagents of brucine are prepared which helps in studying the differences in the outcomes. Prepared reagents contains two types of composition so that one can be used for dipping and other for vapour methods.

In reagent A, other than the iodine fumed ordinary paper and ninhydrin thermal paper, rest all were negative outcomes. The iodine fumed ordinary paper and thermal paper produced positive for reagent B (vapour method) and similarly the ninhydrin ordinary paper and thermal paper produced positive for reagent B. Whereas the cigarette, bond paper and chocolate wrapper were showed negative results. This outcome partially confirms the study by Jasuja et al. (2012) that porous surface responds better with reagent B (vapour method).

5. Summary and Conclusion

5.1 Summary

The purpose of this study was to investigate the effectiveness of the brucine solution as a secondary agent for enhancing latent fingerprints. Five different materials are used as fingerprint sample. The samples were first enhanced using the iodine fuming and ninhydrin method. The developed fingerprints are then reacted with two types of brucine reagent- reagent A and reagent B by dipping and fuming method respectively. Except ordinary paper and thermal paper, all other three materials caused barely any effect, and moreover the prints are also faded away. These results establishes that the reagent B is more effective than reagent A, because of its positive result on ordinary paper and thermal paper.

5.2 Conclusion

The final conclusions of the study are

- Both reagent A (dipping method) and reagent B (vapour method) are suitable for fixing the latent prints on iodine fumed ordinary paper. But prints vanished in ninhydrin ordinary paper by reagent A.

- Reagent B (vapour method) is more effective than reagent A (dipping method) on the thermal paper, because except the iodine fumed reagent A, other three results gave positive outcomes.
- Iodine fumed and ninhydrin cigarette is erased by reagent B, and also has a fading effect of prints by reagent A. Thus, providing negative results for all outcomes.
- The ninhydrin bond paper had fading effect on reagent A. Except that all other three prints were completely vanished.
- The chocolate wrapper has zero effects for both reagent A and reagent B. The prints were completely vanished without any traces of remnants.

5.3 Limitations

This study focuses solely on evaluating the effectiveness of brucine solution as a secondary agent for iodine fuming and ninhydrin. The experiment can be conducted using any other latent fingerprint development solution as the primary agent for brucine. Additionally, the materials used in this study are limited to common resources, but a variety of other materials could also be tested, as fingerprints at a crime scene may be found on different surfaces. Furthermore, the study does not determine the time duration or shelf life of fingerprints or the reagent, which could be explored in future research to gain a deeper understanding of brucine's properties. The important limitation of this study is the toxicity of the brucine solution. Due to its toxic properties, it is not used in various fields, even though it has beneficial properties. Handling of the brucine solution must be done with all the precautionary steps.

5.4 Implications

The primary fingerprint development methods used in this study, such as iodine fuming and ninhydrin, are widely accepted techniques. However, using brucine as a secondary reagent may negatively impact the integrity of the evidence, making it unsuitable for crime investigations as it could potentially damage crucial evidence. The study finds that Reagent B has a greater effect on ordinary paper and thermal paper compared to other samples. Additionally, it concludes that the vapor method of Reagent B is more effective than Reagent A. Therefore, for future research, Reagent B could be utilized as a fixing agent to help minimize experimentation time and resource consumption.

5.5 Recommendations

Since this study employed only two types of primary reagents for fingerprint development, further experimentation with a wider range of latent fingerprint developers available on the market is necessary for a more comprehensive understanding. Limited research exists on this aspect of brucine, highlighting the need for further investigation. Additionally, as this analysis was conducted using a few common materials, it can be extended to various other surfaces that may serve as potential fingerprint carriers, given that fingerprints can be found on any material. Due to the toxic nature of the brucine solution, appropriate safety precautions must be taken in the laboratory before handling the reagent. Moreover, the study can be expanded to explore different factors, such as the reaction time on various materials, the shelf life of fingerprints, and the properties, effects, and advantages of brucine solution.

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