

ORIGINAL ARTICLE

Scrutiny of SECRET Writings Executed with Different Fluid Media Across a Spectrum of Paper Supports

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ABSTRACT

Background: Secret writing, or invisible writing, involves concealing messages so they remain unseen until revealed by specific techniques. It has been practiced since ancient times using both physical and chemical methods to ensure message confidentiality. Over time, secret communication evolved from early cipher tools such as the Spartan scytale to modern chemical-based invisible inks.

Aim: The study aims to examine and compare forensic methods used to detect and decipher secret writings made with biological fluids, chemical substances, and fruit or vegetable juices on different types of paper substrates.

Materials and Methods: A total of 180 samples were prepared using various invisible inks on three types of paper: bond paper, drawing paper, and A4 sheets. Each sample was developed using three principal visualization techniques heat exposure, ultraviolet (UV) illumination, and iodine fuming to reveal and compare the visibility of the concealed writings.

Results: The experimental results showed that heat exposure and iodine fuming were more effective and sensitive than UV illumination in visualizing invisible inks, particularly those prepared from fruit juices and chemical reagents. The clarity and longevity of the developed writings varied with the type of ink, paper, and developing method used.

Conclusion: Traditional development techniques like heat and iodine fuming remain highly reliable for detecting invisible writings when compared with UV illumination. Combining these conventional approaches with modern forensic techniques can significantly improve the accuracy and efficiency of detecting concealed messages.

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Key Message: The integration of classical and modern forensic methods provides a robust approach for the detection and interpretation of secret writings across various ink types and substrates.

KEYWORDS

• Secret Writing • Heat • Iodine Fuming • Identification • UV

INTRODUCTION

Secret writing is a skill of concealed writing. The art of secret writing is projected to make the written text unreadable by other person who is exposed or deciphered by different revealing process to make the messages readable.¹ Invisible inks are used for secret writing. These are fluids used to write hidden messages that do not appear unless exposed by a revealing process.

In 500 B.C., the Spartans developed a device called the scytale to send and receive secret messages. The device consisted of a cylindrical rod around which a narrow strip of parchment was tightly wound. The message was written lengthwise along the wrapped parchment. When unwound, the message appeared scrambled and unreadable. The original text could only be restored when the strip was rewound around a rod of the identical diameter, causing the letters to realign and reveal the intended message. This device used a transposition cipher, a cryptographic method that changes the order of characters without altering the characters themselves.

Julius Caesar's substitution cipher, used around 2,000 years ago, marks one of the earliest recorded military applications of cryptography. In this technique, each letter in the original message is systematically replaced by another letter a fixed number of positions down the alphabet. Only individuals who know the exact substitution pattern can decode the concealed message. This method of encryption ensured that sensitive information remained secure during transmission, with the key to deciphering the message lying in the knowledge of the letter shifts applied.²

Invisible inks are fluids used for secret writing that remain hidden until revealed through a special process. Common household invisible inks include diluted fruit juices, vinegar, biological fluids, laundry detergents etc. These can be applied using various tools. Such as a paintbrush, an invisible ink pen, or even a

toothpick. **Secret writing** encompasses any form of written communication in which the actual text is deliberately hidden, regardless of whether it is encrypted or encoded. Although codes and ciphers are often grouped under the term "secret writing," this is only accurate in its broadest sense, referring to any writing that is concealed in some manner. Unlike codes and ciphers, which obscure the meaning of a message, secret writing conceals the existence of the message itself. Invisible inks can be classified into two primary categories: organic fluids and sympathetic ink.^{3,4,5}

- a) **Organic fluids:** This category includes natural substances that many people have experimented with in childhood, such as lemon juice, vinegar, milk, sweat, saliva, onion juice, diluted blood, and even urine. These organic invisible inks become visible when exposed to heat sources like fire, irons, or light bulbs. Some organic inks can also be detected under ultraviolet light. When heated, these fluids alter the paper fibers, lowering the paper's burn temperature and causing the written areas to brown faster than the surrounding paper.^{6,7}
- b) **Sympathetic Inks:** Sympathetic inks are more complex chemical mixtures that require a specific "reagent" another chemical or combination of chemicals to reveal the hidden message. These inks depend on chemical reactions for visualization, unlike the heat-based development of organic fluids.^{5,8}

AIM AND OBJECTIVES

Aim:

- To conduct a comprehensive forensic analysis of secret writing across various writing substrates.⁹

Objectives:

- To decipher secret writings on diverse writing surfaces using an array of analytical methods and techniques.¹⁰

- To evaluate the sensitivity and responsiveness of secret writing on different substrate types.¹¹
- To assess how the detectability of secret writing varies over time, accounting for temporal factors affecting its visibility.

RESEARCH METHODOLOGY

The research methodology involved the examination of a total of 180 samples prepared on three distinct types of paper substrates: bond paper, drawing paper, and A4 sheets. Each of these papers was treated with a variety of fluids, categorized into biological fluids (such as milk, saliva, blood, urine, sweat), chemical solutions (including detergent, sugar solution, vinegar), and vegetable or fruit juices (like lemon, apple, grapes). For the visualization of secret writings created with these fluids, three principal development techniques were employed.

Development by UV light: The first method utilized ultraviolet (UV) light, wherein samples were exposed individually in a UV chamber to induce fluorescence, making some of the invisible inks temporarily visible. However, this method yielded limited success compared to others.¹²

Development by Heat: The second technique relied on heat development. Samples were placed on a hotplate at controlled temperatures, causing the invisible inks to oxidize and turn brown, providing a clear and lasting revelation of the hidden message. This method was found to be both highly sensitive and cost-effective.

Development by Iodine Fuming: The third approach was iodine fuming. Iodine crystals were heated to produce fumes in a sealed jar containing the samples, which reacted chemically with the inks to induce color changes, rendering the secret writing visible. Despite its effectiveness, the developed markings were transient, necessitating prompt photographic documentation for preservation.¹³

RESULT AND DISCUSSION

The results of the study on common visualization methods (physical and chemical), for decipherment of secret writings done using different invisible inks, and on three different types of paper Bond paper, A4,

and drawing paper varied as shown in the Tables 1-3. To find out the sensitivity of the visualization methods over a period of time. Positive sign shows the visibility of secret writing it goes from one to five one for least visibility and five for maximum. in table where as negative sign shows non visibility.¹⁴ The study on visualization methods for secret writing revealed that heat treatment was the most effective and sensitive technique for deciphering messages written with different biological, chemical, and fruit-based fluids. Heat development produced clear and long-lasting brown-colored impressions because of oxidation and charring due to acidic or alkaline components in the inks. Iodine¹⁵ fuming proved to be the second-best method, showing high contrast visibility, especially for samples containing starch, sugars, or oils such as fruit juices and bodily fluids. However, the developed impressions gradually faded over time due to the volatile nature of iodine.

Under ultraviolet (UV) light, only a few samples, particularly those containing fluorescent compounds like detergent and vinegar, showed visible results, though the sensitivity was lower compared to heat or iodine fuming. Among all tested surfaces, bond paper provided the best results, followed by drawing sheets, while A4 sheets showed comparatively less clarity and contrast. Fruit juices such as lemon, pomegranate, onion, and ginger produced consistent results across all visualization methods due to their inherent acidity and organic content.¹⁶

Biological fluids like sweat and saliva responded well to iodine fumes because of their protein and oil content, while chemical fluids such as sodium bicarbonate and saline gave variable outcomes depending on concentration and paper absorption.^{17,18} Over a one-month observation period, some inks maintained constant visibility, while others faded or showed irregular results due to environmental exposure or ink composition. Overall, the study concludes that heat treatment remains the most efficient, inexpensive, and non-destructive method for deciphering invisible writings in forensic examinations, whereas iodine fuming provides an excellent chemical alternative where precision contrast is needed.

The observation is shown below:

Table 1: Showing the result of different taken samples on Bond paper with visualization methods such as heat, Iodine fuming, and observation under UV light chamber

Sample	Methods of Development		
	Heat	Iodine Fuming	UV
Appy	+++	+	-
Coke	++++	+++	++
Sting	+++++	+	+++++
Frooti	+++++	-	-
Sweat	++++	+++	-
Saliva	+	+++	-
Sanitizer	-	++++	-
Shampoo	-	+++++	-

Sample	Methods of Development		
	Heat	Iodine Fuming	UV
Detergent	+	++++	-
Milk	++	++++	++
Lemon	+++++	++	++
Vinegar	+++++	+++	+++++
Onion	+++++	++++	+++++
Aloe Vera	+	+	+++
Pomegranate	+++++	++++	+++++
Tomato	+++++	++	+++
Ginger	+++++	+++	+++++
Sodium Bicarbonate	+++++	++++	-
Saline Solution (NaCl)	++++	+++++	+++
Sugar Solution	++++	++	-

Some of the following sample images of heat and iodine fuming method for better understanding are given as below:

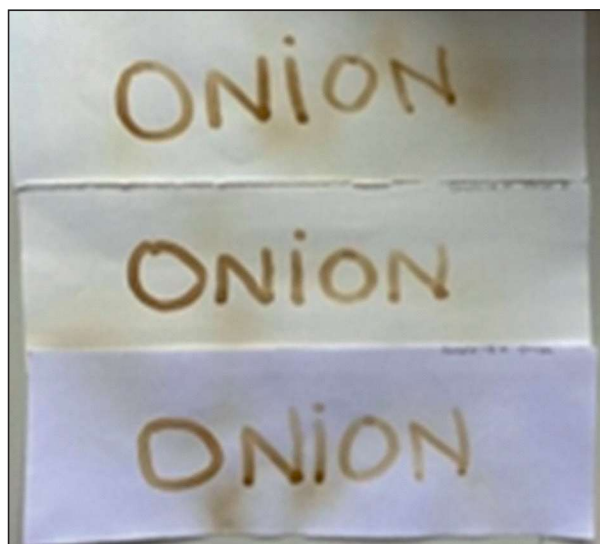


Figure 1:



Figure 2:

Taken a Onion and coke sample on all 3 paper Bond paper, Drawing paper and visualize through Heat method.



Figure 3:



Figure 4:

Taken Milk and Vinegar sample on all 3 paper Bond paper, Drawing paper and visualize through chemical method (Iodine fuming)

Table2 Showing the result of different taken samples on A4 paper with visualisation methods such as heat, Iodine fuming, and observation under UV light chamber.

Sample	Methods of Development		
	Heat	Iodine Fuming	UV
Appy	+++++	+	-
Coke	+++++	+++	++
Sting	+++++	++++	+++++
Frooti	+++++	+	-
Sweat	+++	+++	-
Saliva	+	++++	-
Sanitizer	-	+++++	-
Shampoo	-	+++++	-
Detergent	+	+++++	-
Milk	++	+++++	++
Lemon	+++++	+	++
Vinegar	++++	+++++	+++++
Onion	+++++	+++	+++++
Aloe Vera	+	-	+++++
Pomegranate	++++	++++	+++++
Tomato	++++	+++++	+++
Ginger	++++	+++++	+++++
Sodium Bicarbonate	+++++	++++	-
Saline Solution (Nacl)	++++	+++++	++++
Sugar Solution	++++	+++++	-

Table 3: Showing the result of different taken samples on Drawing paper with visualisation methods such as heat, Iodine fuming, and observation under UV light chamber

Sample	Methods of Development		
	Heat	Iodine Fuming	UV
Appy	+++++	+	-
Coke	+++++	+++	++
Sting	+++++	++++	+++++
Frooti	+++++	+	-
Sweat	+++	+++	-
Saliva	+	++++	-
Sanitizer	-	+++++	-
Shampoo	-	+++++	-
Detergent	+	+++++	-
Milk	++	+++++	++

Sample	Methods of Development		
	Heat	Iodine Fuming	UV
Lemon	+++++	+	++
Vinegar	++++	+++++	++++
Onion	+++++	+++	++++
Aloe Vera	+	-	+++++
Pomegranate	++++	++++	+++++
Tomato	++++	+++++	+++
Ginger	++++	+++++	+++++
Sodium Bicarbonate	+++++	++++	-
Saline Solution (Nacl)	++++	+++++	++++
Sugar Solution	++++	+++++	-

CONCLUSION

From this study, it is evident that for forensic decipherment of invisible writing, heat treatment is superior in terms of sensitivity, efficiency, and document preservation provided proper care is taken during heating. Although iodine fuming offers an alternative with strong contrast, it requires timely documentation as the coloration soon fades. UV light visualization, while non-destructive, was not universally effective, especially with non-fluorescent fluids.¹⁹ The findings suggest that selecting the appropriate visualization technique depends on the ink's chemical nature and the document's intended preservation time. Regular monitoring and selection of visualization method are essential, as environmental exposure and ink type can lead to irregular visibility or fading.²⁰ Further research with expanded samples and advanced analytic techniques could enhance understanding of optimal forensic methods and improve reliability for future casework.

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