

# An examination of Some Commonly Utilized Techniques for Perception of Secret Writing

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## Abstract

Secret writing is the art of covered or hidden writing. The art of secret writing is meant to create a message unreadable by a third party however doesn't hide the existence of the secret communication. This paper is meant as a technical introduction to secret writing for those unacquainted with the field. Invisible inks are generally used for secret writing. These are fluids used to write hidden messages that do not appear unless exposed by a revealing process. Invisible inks can be classified into three main categories: those that are revealed by heat, those revealed by chemical reactions and those that are visible under ultraviolet light. Some common household invisible inks are diluted fruit juices, vinegar and laundry detergent, all which can be applied by a paintbrush, special invisible ink pen or even a toothpick, Historically, used in times of war by governments and insurgents alike. The chemical processes of invisible inks are well known, so a variety of detection methods exist. The simplest invisible ink experiment consists of dipping a brush in vegetable juice, biological fluids and different chemicals and writing on a piece of blank varieties of paper. When the "ink" dries, it will be invisible to the naked eye, but if the paper is held up to a moderate heat source such as a light bulb, a radiator or an iron using UV lamp to deciphering invisible writing. Many other mild chemicals also used for restoration of secret writing.

**Keywords** – Secret Writing, Invisible inks, decipherment, physical, chemical methods

## Introduction

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. Invisible inks can be classified into three main categories: those that are revealed by heat, those revealed by chemical reactions and those that are visible under ultraviolet light. Some common household invisible inks are diluted fruit juices, vinegar and laundry detergent, all which can be applied by a paintbrush, special invisible ink pen or even a toothpick, Historically, used in times of war by governments and insurgents alike. The chemical processes of invisible inks are well known, so a variety

of detection methods exist.<sup>1</sup> The simplest invisible ink experiment consists of dipping a brush in vegetable juice, biological fluids and different chemicals and writing on a piece of blank white paper. When the "ink" dries, it will be invisible to the naked eye, but if the paper is held up to a moderate heat source such as a light bulb, a radiator or an iron using UV lamp to deciphering invisible writing. Many other mild chemicals also used for restoration of secret writing.<sup>1-3</sup>

## Invisible Inks

Broadly, invisible inks can be categorized as: organic fluids and sympathetic inks. The former consists of the "natural" methods many of us tried our hand at as kids: lemon juice, vinegar, milk, sweats saliva, onion juice, and even urine and diluted blood, to name a few. These organic invisible inks can be developed through heat, such as with fire, irons, or light bulbs, and some can be seen when placed under ultraviolet light. The organic fluids alter the fibers of the paper so that

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the secret writing has a lower burn temperature and turns brown faster than the surrounding paper when exposed to heat. Sympathetic inks are more complicated chemical concoctions. Sympathetic inks contain one or more chemicals and require the application of a specific "reagent" to be developed, such as another chemical or a mixture of chemicals.<sup>3-6</sup>

An acidic citrus juice, of which lemon juice is most often the preferred choice because it dries without leaving any evidence it has been applied. The juice takes the place of ink, and is applied by swabbing with cotton. After the juice dries, the acid remains on the paper, which it weakens, and therefore the message is readily exposed when heat is applied to the paper. Other liquids for invisible ink include milk, which is mildly acidic, as well as white wine, vinegar, or apple juice. In the past, prisoners of war have used their own sweat, saliva, or even urine, all of which contain acidic secretions that adhere to the paper, weakening it, even after the water in those bodily fluids has evaporated.<sup>7</sup>

A slight variation on this technique is the use of a baking soda and water mixture as the invisible ink, and, after drying, applying grape juice concentrate with a paint brush. The acid in the grape juice reacts with the baking soda (a base or alkali in chemical terms), exposing the message.<sup>8</sup>

### Types of Invisible inks

Heat-Activated Invisible Inks: Iron the paper, set it on a radiator, place it in an oven (set lower than 450° F), or hold it up to a hot light bulb.

1. Any Acidic Fruit Juice (E.G., Lemon, Apple, Or Orange Juice)
2. Onion Juice,
3. Baking Soda (Sodium Bicarbonate)
4. Vinegar
5. White Wine
6. Dilute Cola
7. Diluted Honey
8. Milk
9. Soapy Water
10. Sucrose (Table Sugar) Solution

### 11. Urine

#### Inks Developed by Chemical Reactions:

These inks are sneakier, because you have to know how to reveal them. Most of them work using pH indicators, so when it doubts, paint or spray a suspected message with a base (like sodium carbonate solution) or an acid (like lemon juice). Some of these inks will reveal their message when heated with vinegar.

1. Phenolphthalein (Ph Indicator), Developed by Ammonia Fumes or Sodium Carbonate (Or Another Base),
2. Thymolphthalein, Developed by Ammonia Fumes or Sodium Carbonate (Or Another Base),
3. Vinegar or Dilute Acetic Acid, Developed by Red Cabbage Water,
4. Ammonia, Developed by Red Cabbage Water,
5. Sodium Bicarbonate (Baking Soda), Developed by Grape Juice,
6. Sodium Chloride (Table Salt), Developed by Silver Nitrate,
7. Copper Sulfate, Developed by Sodium Iodide, Sodium Carbonate, Potassium Ferricyanide, Or Ammonium Hydroxide,
8. Lead (II) Nitrate, Developed by Sodium Iodide,
9. Iron Sulfate, Developed by Sodium Carbonate, Sodium Sulfide, Or Potassium Ferricyanide,
10. Cobalt Chloride, Developed by Potassium Ferricyanide,
11. Starch (E.G., Corn Starch or Potato Starch), Developed by Iodine Solution,
12. Lemon juice, developed by iodine solution.

**Inks Developed by Ultraviolet Light:** Most of the invisible writing visible under UV light gives characteristic fluorescence.

1. Dilute laundry detergent (the bluing agent glows),
2. Body fluids,
3. Tonic water (quinine glows),

4. Vitamin B-12 dissolved in vinegar.<sup>9</sup>

**Materials & Method**

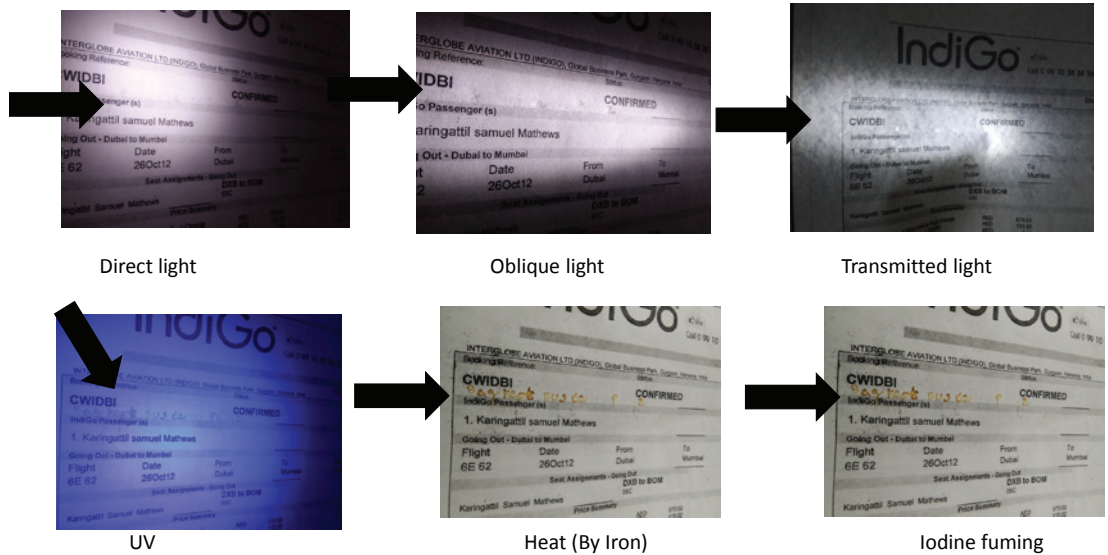
**MATERIAL USED:** Organic fluids mainly Fruit juices (lemon juice, onion juice), Biological fluids (saliva, urine) and three types of paper mainly copier, bond paper and cheque of different GSM.

**METHOD:** The paint brush was dipped in the required invisible ink and messages were written over the papers. The papers with secret messages were marked at the top, with date of sample preparation, name of the invisible ink and the respective day on it is examined. Extra samples of secret messages were also prepared in the same manner. The papers containing written messages were kept under a running fan, so that the inks dry up.

**Results**

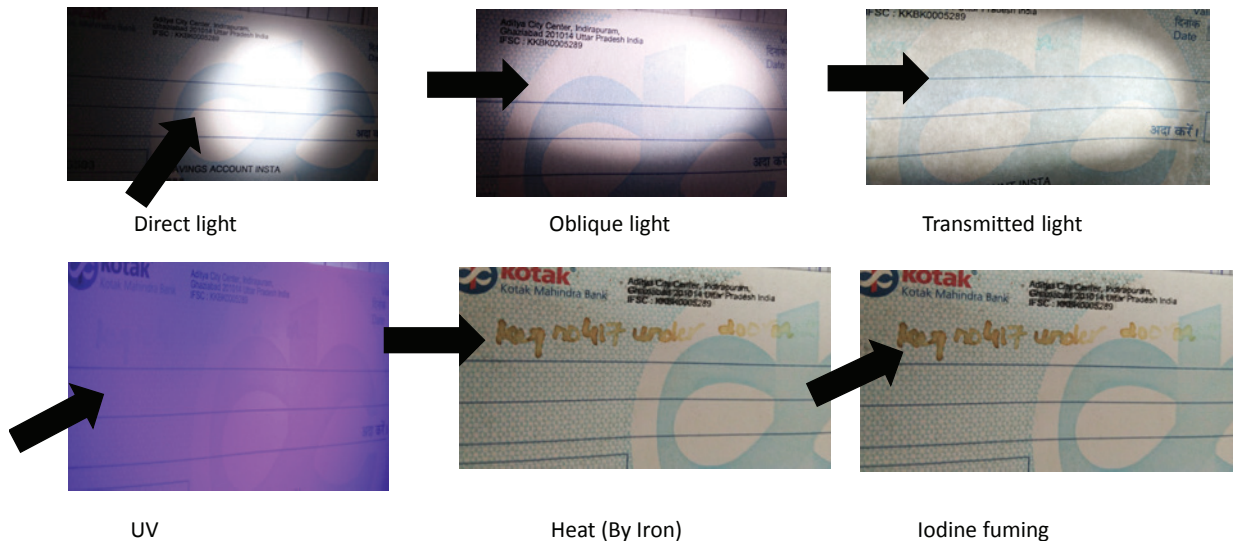
**Visibility of Organic Fluids on Bond Paper (A4 Sheets) 74 GSM**

**Lemon Juice (S2)- Visibility with the use of Physical and chemical methods**



**Visibility of Organic Fluids on Cheque 95 GSM**

**Lemon Juice (S4)- Visibility with the use of Physical and chemical methods**



**Table 1. Visibility of Organic Fluids on Bond Paper (A4 Sheets) 74 GSM**

Organic fluid	Sample No.	Direct light	Oblique light	Transmitted light	UV	Heat (By iron)	Silver Nitrate	Iodine fuming	Phenolphthalein
Lemon juice	1	+	+	-	++	+++	-	+++	-
	2	-	+	-	+++	++	-	+++	-
	3	-	+	-	++	+++	-	+++	-
	4	-	+	-	+++	++	-	+++	-
	5	-	-	-	+++	++	-	+++	-
Onion juice	1	-	-	-	+++	-	-	+++	-
	2	+	-	-	+++	++	-	+++	-
	3	-	-	-	+++	-	-	+++	-
	4	+	-	-	+++	++	-	+++	-
	5	-	-	-	+++	-	-	+++	-
Saliva	1	+	-	-	+++	++	-	+++	-
	2	+	-	-	++	+++	-	+++	-
	3	+	-	-	++	+++	-	+++	-
	4	-	+	-	++	+++	-	+++	-
	5	+	-	-	++	+++	-	+++	-
Urine	1	-	-	-	++	-	-	+++	-
	2	-	-	-	++	-	-	+++	-
	3	-	-	-	++	-	-	+++	-
	4	-	-	-	++	-	-	+++	-
	5	-	-	-	++	-	-	+++	-



**Table 3: Visibility of Organic Fluids on Cheque 95 GSM**

Organic fluid	Sample No.	Direct light	Oblique light	Transmitted light	UV	Heat (By iron)	Silver Nitrate	Iodine fuming	Phenolphthalein
Lemon juice	1	++	+	+	-	+++	-	+++	-
	2	+	-	-	++	+++	-	+++	-
	3	+	-	-	++	+++	-	+++	-
	4	+	-	-	+	+++	-	+++	-
	5	+	-	-	+	+++	-	+++	-
Onion juice	1	+	+	-	++	+++	-	+++	-
	2	+	+	-	++	+++	-	+++	-
	3	+	+	-	++	+++	-	+++	-
	4	+	+	-	++	+++	-	+++	-
	5	+	+	-	++	+++	-	+++	-
Saliva	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-
Urine	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	+	+	-	+	++	-	+++	-
	4	-	-	-	-	++	-	+++	-
	5	-	-	-	+	+	-	+++	-

**Table 4: The above table shows deciphering secret writing using various physical and chemical methods.**

Organic fluids	Writing surface	Result (Physical method)	Chemical Method
	Bond paper	Heat > UV > Oblique > Direct	Iodine Fuming
Lemon Juice	Copier paper	UV > Heat > Direct > Oblique	Iodine Fuming
	Cheque	Heat > UV > Direct	Iodine Fuming
	Bond paper	UV > Heat > Direct	Iodine Fuming
Onion Juice	Copier paper	Heat > UV	Iodine Fuming
	Cheque	Heat > UV > Direct / Oblique	Iodine Fuming
	Bond paper	Heat > UV > Direct	Iodine Fuming
Saliva	Copier paper	Heat > UV > Direct	Iodine Fuming
	Cheque	Nil	Nil
	Bond paper	UV	Iodine Fuming
Urine	Copier paper	Nil	Nil
	Cheque	Heat in very few	In some cases Iodine Fuming

Secret writing written with samples it turns into Brown in color when heated. This is because these samples are either mildly acidic or alkaline in nature and such as an acid or base weakens the paper. When the paper is then held near a heat source these acidic parts of the paper burn or turn brown faster before the rest of the paper revealing the message. These samples were visible under UV light because of their fluorescence or the differentiation of absorbance or reflection of UV rays of them. The reason that lemon juice shows slightly brown fluorescence in most of the cases may due to more concentration of juice.

Iodine fuming of samples revealed secret message in white paper contain starch and when iodine fumes come in contact with the paper they react with starch and produce purple color.

Secret writing written by different organic fluids by using silver nitrate gives brown color and with phenolphthalein gives pink (Colorless) results but in all types of paper the results were negative.

## Discussion

Secret writing samples written with different biological fluids and vegetable juices were deciphered by physical and chemical methods. Secret writings written with biological fluids and vegetable juices turned brown in color when heated. This is because these fluids are either mildly acidic or alkaline in nature and such an acid or base weakens the paper. The acid or base from these fluids remains in the paper after the water has evaporated and the paper has dried. These fluids were visible under UV light because of their fluorescence or the differential absorption and reflection of UV rays by them.

The reason that lemon juice showed slightly brown fluorescence in most cases, may be due to more concentration of the juice. Iodine fuming of fruit juices revealed secret messages in white color with purple-brown background because the paper contains starch and when iodine fumes come in contact with the paper, they react with starch and produce purple color while the fruit juices do not react with the fumes and remain colorless. Iodine fuming of chemical and biological fluids revealed

the writing in brown color. Some of the invisible inks appeared transparent when treated with phenolphthalein solution. This may be due to the fact that these fluids are mildly acidic in nature and phenolphthalein is colorless in acidic condition.

The appearance of brown color in case of apple juice, when treated with silver nitrate solution, may be due to some chemical reaction between silver nitrate and certain salt present in the juice. As we know that, certain salts react with silver nitrate and produce a silver salt that decomposes to silver metal on exposure to light and this metallic silver gives brown color. The visibility of the invisible inks used in this project, differed over a period of one month. Although, some of the inks showed neither decrease nor increase in their visibility for the whole month. The visibility of some of the inks, as expected, decreased with time. The constant visibility exhibited by some of the inks may be because they require longer than one month for their fading.

### Conclusions

From the results obtained in this study, it could be concluded that the secret writings written with different vegetable juices and biological fluids can be deciphered by physical and chemical methods. Among physical methods, heating is the best for deciphering these fluids as it does not take much time and the document is also not affected if it is heated carefully. Visualization under UV light also doesn't ruin the document, but all the invisible inks cannot be visualized easily under it, so it becomes time consuming and will require effort for the visibility of messages. Among chemical methods, iodine fuming is the best because it does not spoil the documents extensively, like the phenolphthalein and silver nitrate solution does, for further testing. The purple color of iodine fades away after a few minutes. However, it requires a little more time than heat treatment to develop the secret messages. Both of these methods give good results up to one month. Further studies considering a larger sample size and considering more factors will help gain a better understanding of the visualization methods most suitable for developing secret writing.

**Ethical Clearance** – Taken from the departmental research committee of Amity University, Noida

**Source of funding**- Self funding

**Conflict of interest** – The authors declare no conflict on interest

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