



## An Evaluation of Some commonly used Methods for Visualization of Secret Writing

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Available online at: [www.isca.in](http://www.isca.in)

Received 8<sup>th</sup> March 2013, revised 17<sup>th</sup> April 2013, accepted 25<sup>th</sup> April 2013

### Abstract

*Secret writing is the art of covered or hidden writing. The art of secret writing is intended to make a message unreadable by at Third party but does not hide the existence of the secret communication. This paper is intended as a technical introduction to secret writing for those unfamiliar with the field. The current research paper comprises of twenty seven samples which contained hidden messages written using some biological fluids (milk, saliva, and urine), chemical fluids (vinegar, saline and baking soda) and vegetable fluids (lemon, orange and onion juice). They were then visualized using physical method (UV lamp), by heat treatment, and by chemical method in a specific interval of time, examine from 1<sup>st</sup> day to 30<sup>th</sup> day after regular interval of five days.*

**Keywords:** Secret writing, hidden messages, invisible ink.

### 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>.

Secret writing is any means of written communication whereby a spy conceals the actual written text, whether it is enciphered or encoded or not. Codes and ciphers are sometimes mistakenly placed under the heading of "secret writing," but this is accurate only if that expression is taken in its most general sense, as writings that are concealed in any way. Whereas codes and ciphers conceal the meaning of a message, secret writing conceals the actual message. Techniques of secret writing include the use of invisible ink and carbon copies. Widely applied from ancient times until the early twentieth century, secret writing has been almost entirely eclipsed by more modern methods of concealing messages, such as microdots<sup>2,3,4</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</sup>.

**Invisible Inks: Basics:** 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 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>5</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.

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.

**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. i. Any Acidic Fruit Juice (E.G., Lemon, Apple, Or Orange Juice), ii. Onion Juice, iii. Baking Soda (Sodium Bicarbonate), iv. Vinegar, v. White Wine, vi. Dilute Cola, vii. Diluted Honey, viii. Milk, ix. Soapy Water, x. Sucrose (Table Sugar) Solution, xi. 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 doubt, 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. i. Phenolphthalein (Ph Indicator), Developed By Ammonia Fumes Or Sodium Carbonate (Or Another Base), ii. Thymolphthalein, Developed By Ammonia Fumes Or Sodium Carbonate (Or Another Base), iii. Vinegar Or Dilute Acetic Acid, Developed By Red Cabbage Water, iv. Ammonia, Developed By Red Cabbage Water, v. Sodium Bicarbonate (Baking Soda), Developed By Grape Juice, vi. Sodium Chloride (Table Salt), Developed By Silver Nitrate, vii. Copper Sulfate, Developed By Sodium Iodide, Sodium Carbonate, Potassium Ferricyanide, Or Ammonium Hydroxide, viii. Lead(II) Nitrate, Developed By Sodium Iodide, ix. Iron Sulfate, Developed By Sodium Carbonate, Sodium Sulfide, Or Potassium Ferricyanide, x. Cobalt Chloride, Developed By Potassium Ferricyanide, xi. Starch (E.G., Corn Starch Or Potato Starch), Developed By Iodine Solution, xii. Lemon juice, developed by iodine solution.

**Inks Developed by Ultraviolet Light:** Most of the invisible writing visible under UV light gives characteristic fluorescence. i. Dilute laundry detergent (the bluing agent glows), ii. Body fluids, iii. Tonic water (quinine glows), iv. Vitamin B-12 dissolved in vinegar.

Any chemical that weakens the structure of paper can be used as an invisible ink.

### Methodology

**Aim:** To evaluate some commonly used methods used for visualizing secret writing and their sensitivity over a period of time.

**Material Required:** Cotton swab, UV lamp, Electric iron or candle, phenolphthalein reagent, iodine and silver nitrate solution, etc.

**Samples:** This research paper comprises of twenty seven samples which contains hidden messages written in biological fluids (milk, saliva, and urine), chemical fluids (vinegar, saline, baking soda) and by vegetable fluids (lemon, orange, onion juice). They were kept at normal room temperature and conditions for one month. They were then deciphered using different physical and chemical methods at regular intervals of five days for one month.

### Secret Fluids

Vegetable Fluids	Biological Fluids	Chemical Fluids
Lemon juice	Milk	Vinegar
Orange juice	Saliva	Saline
Onion juice	Urine	Baking soda

### Results and Discussion

The following observation shows variation in visibility time of invisible writing by using physical and chemical method

#### Vegetable Fluids

Table-1

##### Visibility under UV light

Day	Lemon Juice	Orange Juice	Onion Juice
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	++	++	++
20	++	++	++
25	++	++	++
30	++	++	++

Table-2

##### Visibility with the application of heat

Day	Lemon Juice	Orange Juice	Onion Juice
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	++	++	++
20	++	++	++
25	++	++	++
30	++	++	+

Table-3

##### Visibility with the use of chemical methods

Day	Lemon juice	Orange Juice	Onion Juice
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	++	++	++
20	++	++	++
25	++	++	++
30	++	++	+

#### Biological Fluids

Table-4

##### Visibility under UV light

Day	Milk	Saliva	Urine
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	+++	+++	+++
30	++	+++	+++

**Table-5**  
**Visibility with the application of heat**

Day	Milk	Saliva	Urine
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	+++	+++	+++
30	+	++	++

**Table-8**  
**Visibility with the application of heat**

Day	Vinegar	Saline	Baking soda
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	+	++	++
30	+	++	++

**Table-6**  
**Visibility with the use of chemical methods**

Day	Milk	Saliva	Urine
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	++	++	++
30	+	++	++

**Table-9**  
**Visibility with the use of chemical methods**

Day	Vinegar	Saline	Baking Soda
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	++	++	++
30	+	++	++

+++:- Visualized Easily, Required less time, Clearly Legible. ++:- Visualized with slight effort, required time, Legible. +:- Visualized with difficulty, required longer duration, slightly legible.

**Chemical Fluids**

**Table-7**  
**Visibility under UV light**

Day	Vinegar	Saline	Baking soda
1	+++	+++	+++
5	+++	+++	+++
10	+++	+++	+++
15	+++	+++	+++
20	+++	+++	+++
25	++	++	++
30	++	++	++

**Vegetable Fluids:** Secret writing written with vegetable fluids visualized by heat was visible in brown color. Secret writing written with vegetable fluid when placed under U.V. lamp was visible as blue colour fluorescence.

When Iodine fumes was passed on the sample, writing deciphered in white coloured message with purple background. Because Vegetable fluids when react with Iodine; the paper contains starch, which turns purple when it reacts with Iodine , There is a color change of the Iodine from the initial red to purple. This is indicative of the presence of the starch in the paper. Vegetable fluids stop the color change so the areas where the message has been written remain white and written sample seen.

**Table-10**  
**Vegetable fluids visualized by physical and chemical method**

Sr. No.	Fluids	Sample	Physical Method	Result Y/N	Chemical Method	Result Y/N	
1	Vegetable Fluids	Lemon juice	Heat	Y	Phenolphthalein	N	
			UV	Y		Silver nitrate	N
			IR	N		Iodine	Y
2		Orange juice	Heat	Y	Phenolphthalein	N	
			UV	Y		Silver nitrate	N
			IR	N		Iodine	Y
3		Onion juice	Heat	Y	Phenolphthalein	N	
			UV	Y		Silver nitrate	N
			IR	N		Iodine	Y

**Table-11**  
**Biological fluids visualized by physical and chemical method**

S. No.	Fluids	Sample	Physical Method	Result Y/N	Chemical Method	Result Y/N
1	BIOLOGICAL FLUIDS	Milk	Heat	Y	Phenolphthalein	N
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y
2		Saliva	Heat	Y	Phenolphthalein	N
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y
3		Urine	Heat	Y	Phenolphthalein	N
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y

**Table-12**  
**Chemical fluids deciphered by physical and chemical method**

S.NO	Fluids	Sample	Physical Method	Result Y/N	Chemical Method	Result Y/N
1	CHEMICAL FLUIDS	Vinegar	Heat	Y	Phenolphthalein	N
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y
2		Baking soda	Heat	Y	Phenolphthalein	Y
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y
3		Salt, water	Heat	Y	Phenolphthalein	N
			UV	Y	Silver nitrate	N
			IR	N	Iodine	Y

**Biological Fluids:** Biological fluids include milk, urine and saliva, when heated, the invisible message appears in brown color. Biological fluids under U.V. lamp were visible as blue colour fluorescence. Biological fluids when react with iodine gives brown colour.

**Chemical Fluids:** Secret writing written with chemical fluids turn into brown in colour when heated. Secret writing experiment works because substances such as vinegar or baking soda are either mildly acidic or alkaline in nature, and such an acid or base weakens paper. The base form the baking soda remains in the paper after the water has evaporated and the paper has dried. When the paper is then held near a heat source such as a light bulb or candle flame the alkaline parts of the paper burn or turn brown before the rest of the paper does, revealing the message written on the paper. Chemical fluids under U.V. lamp were visible as blue colour fluorescence. Vinegar, Baking soda reacts with Iodine solution and show brown color and saline react with Iodine solution and show black colour. Baking soda reacts with phenolphthalein and show pink color and invisible message is visible in pink color.

**Conclusion**

Secret writing written with different biological, vegetable and chemical fluids and samples decipher by physical and chemical methods. Best method for deciphering secret message with biological, vegetable and chemical fluid is by heat treatment and iodine fuming. Iodine Fuming gives better result upto one month. Further studies considering a larger sample size and considering more factors will help gain a better understanding

of the visualisation method(s) most suitable for developing secret writing.

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