

Examination of Invisible Writing Liquid Composition and Their Decoders

Harne Prajakta*, Mishra Munish K.**, Sodhi G.S.***

Authors Affiliation: *Ph.D. Scholar, Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh 211007, India. **Assistant Professor, Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh 211007, India. ***Associate Professor, Forensic Science Unit, Shri Guru Tegh Bahadur Khalsa College, University of Delhi, New Delhi, Delhi 110007, India.

Reprints Requests: Harne Prajakta, Ph.D. Scholar-Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh 211007, India.

E-mail: prajakta.harne@gmail.com

Received on 06.07.2018, Accepted on 17.09.2018

Abstract

From the earlier times of espionage, invisible ink is considered to be an assured and significant device of cryptography. Even though the use of invisible ink has now been almost entirely taken over by technical cryptography or steganography, its history still remains exceptionally fascinating, and today researchers are trying to find out readily available compositions which can inscribe secretly and their respective decoders. The art of secret writing was probably proposed to create any written text indecipherable to a reader who could read the same only after applying certain decoding process to make the writing legible. Though, the methods of secret writing are abundant but this paper principally emphasizes on the application of commonly available items which could act as a secret ink and similarly other commonly available items which could be applied as their respective decoders.

Keywords: Invisible Ink; Questioned Documents; Cryptography.

Introduction

According to the Merriam Webster Dictionary, 'Ink' is a colored and generally a liquid material for writing and printing. Indeed the definition is absolute as it could be perceived, by and large, in its visible appearance unless otherwise. However, the uncertainty lies in the case of Invisible Ink. As the name suggests such an object could create inscriptions obscured to bare eyes and essentially which can only be seen when it is specially treated in a way, more or less, by some chemical treatment. Invisible inks might sound fascinating and rather incredible, but they can be produced to inscribe classified information by simply using ordinarily available organic fluids. As per the available literature, there are two classes of Invisible inks, first could be 'Organic Fluids' such as lemon juice,

vinegar, milk, sweat, saliva, onion juice, biological fluids and even blood and the second class of Invisible inks are known as 'Sympathetic Inks' which are comparatively complex chemical compositions and requires the application of a specific reagents or concoctions in order to be developed [1]. Use of Invisible ink, for producing concealed inscription, is also considered as a method of 'Steganography', i.e. disguising a message. Concealing a message or inscription, precisely called as Secret Writing, is any means of inscribed message whereby the writer conceals the actual written script. Codes and ciphers are every so often erroneously placed under the heading of secret writing, nevertheless this is accurate only if that expression is taken in its overall implication, as writings that are concealed anyhow. While, codes and ciphers obscure the meaning of a message, secret writing conceals the actual message. Methods of producing secret

writing include the use of invisible ink and carbon copies. Extensively applied from ancient times until the early twentieth century, secret writing has been virtually exclusively taken over by modern ways and means of concealing messages [2, 3].

This research involves the application of milk, lemon juice, Eno® (an OTC antacid), vinegar, sun cream, curd, sweat, as ink to inscribe concealed writing and detect out their respective decoders from common household items. The principle suggests that when the ink (fluids) dries out, it becomes invisible to the vision. From its antiquity, invisible inks were used as a part of communicative machinery by intelligence agencies. Although, the use of secret writing has dropped since the middle of the twentieth century due to advancement in communication technology, but this area of calligraphy still catches the attention of investigating agencies and forensic experts as the invisible inks are still used by naïve criminals for communication. The annexation of encryptions and cryptographs under secret writing brings this field under the category of disputed document examination.

The history of invisible ink dates about 2,000 years back and was employed by the ancient Greeks and romans. The first evidence of it comes from *Pliny the Elder* in the first century A.D, who cited the milk of *tithymalus* (euphorbia) plant as a form of an invisible ink in his book *Natural History*. Invisible ink sustained to be applied throughout the *Renaissance*; Statesmen used it in their literatures; & *Ovid* mentions the practice in his *Art of love*. An Italian polymath, *Giovanni Battista Della Porta*, formed a preparation for invisible ink that involved of an ounce of alum and a pint of vinegar, once coated on the casing of a hard-boiled egg, it would exude through and transfer the letter onto the white of egg. The writing could only be decrypted once the egg was unpeeled. During the revolutionary war, both the British and the Americans employed invisible ink as a method of clandestine transmission of messages. The British applied both organic fluids and common sympathetic ink. The agent of chief British intelligence officer, Major John Andre, delivered a letter as a means of their communication to report to the addressee that by which method the concealed the secret message can be developed but George Washington required more advance ink that could only be discovered by a distinctive specifically prepared reagent [4,5]. During World War- I chemical inks were engaged but basics like lemon juice and milk were still being applied. While Americans were subsiding back on old

methods, the Germans were at the prominent edge of generating substantial formulations. At the beginning of the war, the Germans employed ink prepared from laxatives and medicines of headache and fever and these were easily accessible being common medicines. When the allies caught on, they were forced to formulate inks other from those based on common household items. They employed inks from sulphates of iron and copper or cobalt salts or reagent of sodium carbonate or ammonium fumes and potassium ferrocyanide. During examination it was revealed that iodine vapour turns all invisible ink brown. Both methods come up with complex means to conceal their inks.

Methodology

The present study was carried out to examine the common deciphering approaches for secret writing written with invisible inks and to know the sensitivity of these approaches over a period of time. Milk, lemon juice, Eno®, vinegar, sun cream, curd and human sweat were employed as invisible ink. Standard size blank papers were used for arranging secret writing samples and ear bud is used as a writing instrument for executing the writing. The tip of ear bud was dipped in the respective invisible ink and messages were inscribed on the blank paper. The samples with secret messages were designated at the top, with date of sample preparation bearing name of the invisible ink and the corresponding day on which it required to be examined. Additional samples of secret messages were also arranged in the same way. The papers comprising written messages were let air dry transforming the inscription invisible. These samples were left at normal room temperature and conditions. They were then examined at even interval of five days for one month by means of crude methods including chemically by the acid-base reaction and also physically by applying magnetic powder. Following categories of decoders were applied for the given purpose:

Decoders-

- **D1 = Mustard Oil**

Mustard oil is common edible oil available in every household grocery containing 99% fat. These fats are liquid because it consists of fats which are chiefly unsaturated.

- **D2 = Crystal Violet**

Crystal Violet stain is prepared by mixing two pre-prepared solutions of which first is prepared by dissolving 2g of crystal violet dye in 20 ml of 95% ethyl alcohol and second dissolving 0.8 g ammonium oxalate monohydrate in 80 ml deionized water.

- **D3 = Sodium Chloride + Phase Transfer Catalyst (PTC)**

While Sodium Chloride is known as Common Salt the PTC is a catalyst that enables the passage of a reactant through one phase to other phase where reaction takes place. Phase-transfer catalysis is a distinctive formula of heterogeneous catalysis. Ionic reactants are generally soluble in an aqueous phase but insoluble in an organic phase in the absence of the phase-transfer catalyst. The catalyst functions like a detergent for solubilizing the salts into the organic phase [6].

- **D4 = Tamarind**

Tamarind is a regular sour food item.

- **D5 = Tamarind + Sodium Chloride**

Tamarind is regular food item. Similarly, sodium chloride is the common salt.

- **D6 = Crystal Violet + Sodium Chloride**

- **D7 = Whisky + Sodium Chloride**

Whisky is a purified alcoholic drink prepared from fermented grain pulp. Several grains are applied for diverse ranges, comprising barley, maize, rye,

and wheat. And Sodium chloride has been applied to taste and preserve foods for several of years. Sodium chloride has other applications beyond flavour and antibacterial protection to foods.

- **D8 = Magnetic Powder**

Magnetic powder enhances an extensive variety of flexibility to one's resources of developing prints such as fingerprint or palm print. In general, magnetic powder is applied on non-magnetic planes, and regular powder on iron-based planes.

Results and Discussion

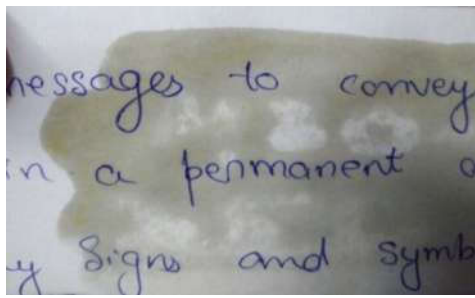
When applied with the appropriate, aforementioned, decoders the fluids used as invisible ink showed distinctive results (Table 1 Fig. 1).

The fluids which are used are commonly encountered in daily routine and most of them have basic compositions. The decoders which are used in the present study are also available in general household items. The experiments showed that the decoders are giving significant results to visualize the invisible fluids used as an instrument of secret writing. As the objective of the study was to identify the suitable and most appropriate decoders to visualize the fluids, it was observed that chemical decoders are however more likely to give better results. In the present case the combination of Sodium Chloride and Phase Transfer Catalyst produced good results (Fig. 2). Similarly, to an extent the physical decoder used in the study, i.e., the magnetic powder, also gave satisfactory results. However, its limitation can be exempted due to the reason of its coarse property

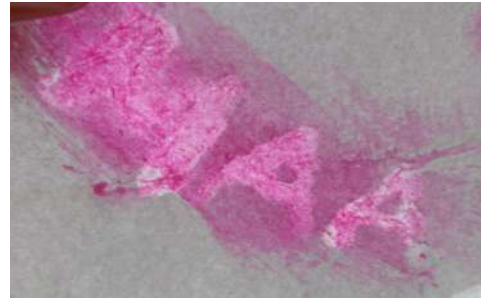
Table 1: Results of decoders upon the fluids

Fluids	Decoders							
	D1	D2	D3	D4	D5	D6	D7	D8
Milk	+	-	-	-	-	-	-	-
Lemon	-	-	+++	-	-	-	-	-
Eno®	-	-	-	-	+++	-	++	-
Vinegar	-	-	+++	-	-	+++	-	-
Suncream	+++	-	-	-	-	-	-	-
Curd	+	-	-	-	-	-	-	-
Sweat	-	++	-	-	-	-	-	++

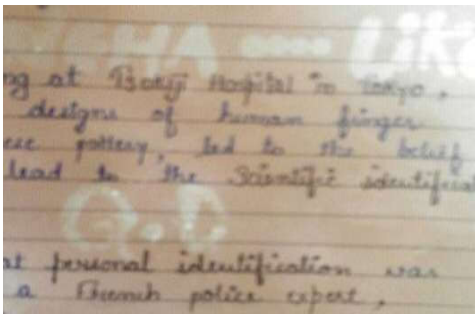
+ (Partial clear); ++ (Clear); +++ (Very clear); - (No result)



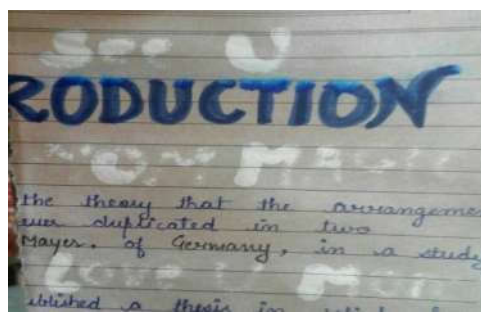
Ink = Milk Decoder = D1



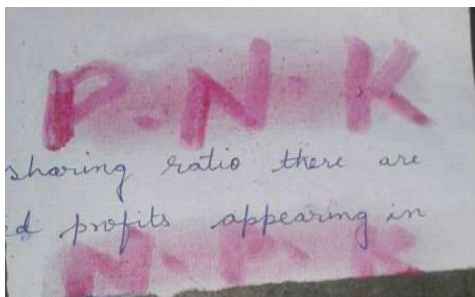
Ink = Lemon Juice Decoder = D3



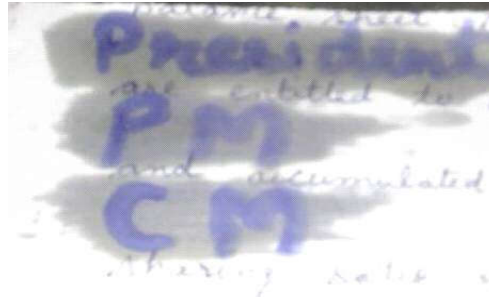
Ink = Eno Decoder = D5



Ink = Eno Decoder = D7



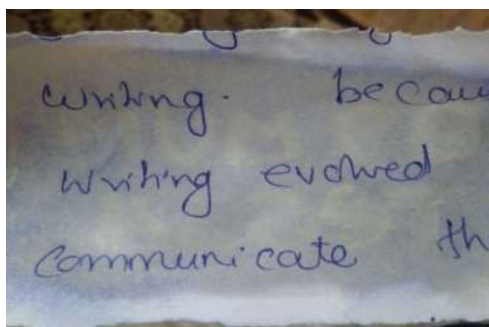
Ink = Vinegar Decoder = D3



Ink = Vinegar Decoder = D6



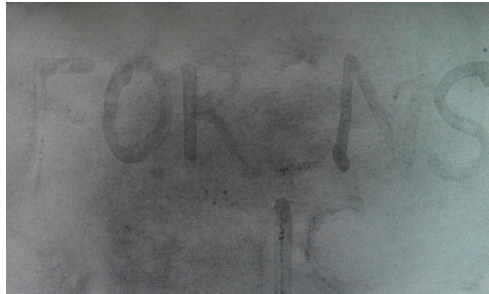
Ink = Sun Screen Decoder = D1



Ink = Curd Decoder = D1



Ink = Human Sweat Decoder = D2



Ink = Human Sweat Decoder = D8

Fig. 1: Images of decoded secret writing

and large particle size. Most interestingly, it was observed that mustard oil, i.e., commonly used edible item, can be used as a good decoder as it showed adequate results.

Conclusion

The progress in the field of questioned document examination, by the development of new techniques, are invented or adapted from elsewhere in science [7].

In recent years, the use of the laser, visible light spectroscopy, liquid chromatography has been introduced for ink related queries. From the results obtained in this research, it can be concluded that the secret writings executed with different fruit extract, chemical and biological fluids can be decrypted by physical and chemical methods. Further research considering a larger sample size and taking more factors will assist to gain an enhanced understanding of the visualization methods most appropriate for developing secret writing.

References

1. Andharmule D, Kapoor N, Badiye A. An Evaluation of Some commonly used Methods for Visualization of Secret Writing. *Research Journal of Forensic Sciences*. 2013;1:1-4.
2. Gardner, Martin. *Codes, Ciphers, and Secret Writing*. New York: Pocket Books, 1974.
3. Zim, Herbert Spencer. *Codes and Secret Writing*. New York: W. Morrow, 1948.
4. Lardner George, Jr., Panel Proposes Tougher Laws against Espionage, *Washington Post*, (May 24, 1990): A16. (1990).
5. "Secret Writing." *Encyclopedia of Espionage, Intelligence, and Security*. 2004. Retrieved April 17, 2013 from *Encyclopedia.com*: <http://www.encyclopedia.com/doc/1G2-3403300676.html>.
6. Desikan Sridhar and Doraiswamy L K, *Chemical Engineering Science*, 2000;55:6119-6127.
7. Wilson R. Harrison, *Suspect Document*, 2008;3: 494-533.