

# Decipherment of disappearing ink on different documents by chemical and instrumental techniques

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## Abstract

Nowadays, criminals are adopting new modus operandi with the new technology to cheat the individuals. One of the latest techniques applied to commit frauds with bank instruments (cheque or other withdrawal form) or any other paper documents is the use of disappearing ink pen. Disappearing ink is a solution, which when applied on paper, cloth or any material will disappears slowly when comes in contact carbon dioxide present in the air within few minutes to few hours without leaving any visible traces. These inks are not normally visible under visible light, ultra-violet rays or infrared rays. Thymolphthalein and phenolphthalein was used to make the blue and red disappearing ink respectively. The prepared ink was examined on different types of papers to identify its fading time. These inks was decipher when treated chemically with the alkaline solution of NaOH and KOH, and by iodine fuming method. An instrumental examination was carried out to visualize the faded writing by Video Spectral Comparator (VSC), Docucenter NIRVIS, Projectina Docubox and Forensic XP-4010 D. The aim of this study is to develop a simple and rapid technique to solve the financial crimes related to cheque, bills, deeds, contract, etc. committed through these inks.

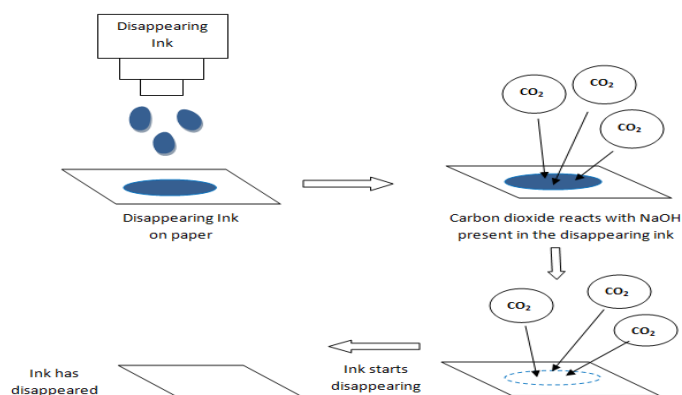
**Keywords:** Disappearing ink, Acid-base indicator, Instrumental analysis.

## Introduction

There are continuous research and development in the field of science which led to advances in both directions i.e. positive and negative. In the field of forensic science, scientists in the laboratories are continuously dealing with new type of frauds. One such new type of fraud which has been committed is with the use of disappearing ink. When any document is written with such inks, it become very difficult to detect writing as there is no sign of any physical, chemical, mechanical erasures on the document. Hence, it becomes very difficult to identify any alteration or addition to the document<sup>1</sup>. There are two techniques used for analysis of ink, namely Destructive and Non-destructive and to identify disappearing ink, chemical, fuming and the instrumental examination has been performed.

Thymolphthalein and phenolphthalein are the indicators used to make the blue and red disappearing ink respectively<sup>2</sup>. These two indicators are belongs to the group of dye known as phtalein dye. These are colorless solutions but when it reacts with the base, it immediately turns to colored solution<sup>1-2</sup>. Both indicators were used to make two colorinks, the original color was purple which slowly fades to pink and then it becomes colorless<sup>3</sup>. When the inks were used on any document, the water present in the ink react with the carbon dioxide to form the carbonic acid which are weakly acidic in nature:  $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ . The carbonic acid reacts with the base (NaOH) and forms the sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) by the neutralization reaction<sup>1</sup>:  $2\text{NaOH} + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{CO}_3$ . The above reaction is known as

neutralization reaction. Due to this, the pH value of ink decreases from 10.5 to 9.5 and this resulted in the color change of the ink, i.e. from blue to colorless solution.



**Figure-1:** Mechanism of Disappearing Ink.

Disappearing inks are used in textile industries and making dressmaking<sup>4</sup> and as teaching materials like answers are written using disappearing ink next to the visible questions and become visible using coloring reagent<sup>5</sup>.

Disappearing ink is also used as paints. For example, it is difficult to determine which part of an existing coat of white paint are not covered by a new paint of similar shade especially under poor lighting; disappearing ink can solve the problem<sup>6-7</sup>.

They are also be used as a marking system for dance lessons, sports training or any other activities that require proper placement of steps (a sole containing marking system)<sup>8</sup>.

## Materials and methods

**Materials:** The study was carried out at Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The faded handwriting samples were then also identified by different instruments like Video Spectral Comparator (FSL, Ram nagar, Varanasi), Docucenter NIRVIS (FSL, Delhi), Forensic XP-4010 D and Projectina Docubox (both from FSL, Dharamshala). Disappearing ink was prepared in laboratory and ballpoint disappearing ink pen (blue color) is collected from the online market. Ink were applied on different papers (notebook papers, A4 printing papers, Butter Papers, Photo Papers, Stamp Papers, Cheque Papers of different Banks and Bank Withdrawal Forms) to prepare the samples.

**Methods:** Preparation of Disappearing Ink: 1gm of thymolphthalein was dissolved in 10ml of ethyl alcohol and the solution was shaken until the complete solubility was obtained. Then 5 ml glycerol was added to the solution and shaken again. Finally, 85 ml of distilled water was added until the volume reached to the 100ml, the solution will be milky white. After that 5ml of different calculated concentration of sodium hydroxide (1N and 2N NaOH), the solution was immediately turns to blue color. The disappearing time of the prepared ink was examined by applying it on the different types of papers. The ink is used for handwriting by filling a dry fountain pen and the test samples have been prepared on different documents. Substitute phenolphthalein was used to make the red disappearing ink and to make the two color ink, both the indicators were used and the same procedure was applied and the purple color ink was prepared which first turns to pink and after that it became colorless<sup>9</sup>.



Figure-2: Disappearing Ink.

The samples were prepared on different types of papers and kept at normal room temperature. They analyzed using different physical (application of heat, iodine crystals fuming and under

UV lamp), chemical (NaOH and KOH) and instrumental (Video Spectral Comparator, Docucenter NIRVIS, Forensic XP- 4010 D and Projectina Docubox) methods.

## Results and discussion

The fading time (time from writing until disappearance of the colour) of disappearing inks is varied according to the writing surfaces<sup>2</sup>. The Table-1 shows the different fading times on the different paper samples. It was also observed that the temperature also plays a major role in the stability of the ink or its fading time. High temperature decreases the quality of the ink while in low temperature its quality and stability is better.

The fading time (writing stability) on the different types of papers follows this order: Printing Paper > Notebook Paper > Cheque Paper > Withdrawal Form > Stamp Paper > Butter Paper > Photo Paper.

Table-1: Showing the fading time on different types of paper exhibits.

Types of Paper	Fading Time
Notebook Paper	15 hours
Printing Paper	16-18 hours
Butter Paper	5:40 hours
Photo Paper	Immediately
Stamp Paper	4-5 hours
Cheque Paper	13-14 hours
Withdrawal Form	11-12 hours

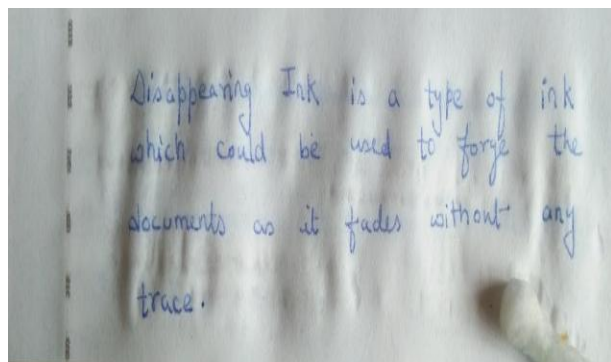
**Chemical Examination:** On application of the weak alkaline solution such as NaOH and KOH, the faded writing becomes visible for a small period of time. Printing paper, notebook paper, stamp paper, cheque paper and withdrawal form shows the better stability than the butter and photo paper on the treatment with the alkaline solutions. Figures-3a are the photograph of sample exhibit treated with NaOH and Figure-3b shows the photograph of sample exhibit treated with KOH.

**Fuming Examination:** The faded writing was visible when treated with the iodine crystals fumes. The mechanism behind visualization of the faded writing is that when the samples were written, ink disturbs the surface fibers of the paper so when the iodine fuming is done, the iodine sticks preferentially to the altered areas of the paper<sup>10</sup> and developed as a brown writing.

**Instrumental Examination:** The test samples were examined under these four instruments at different wavelength of lights with different filters and intensity. When the ink interacts with

the light at any observable events resulted in the decipherment of disappearing ink because of its optical phenomenon. The lights of different wavelength were used but the decipherment of the ink can only be occurred in UV region. Disappearing ink

when react with the carbon dioxide it leaves a white residue, which was invisible to the naked eyes but when examined under the instruments it gives fluorescence<sup>1</sup>.

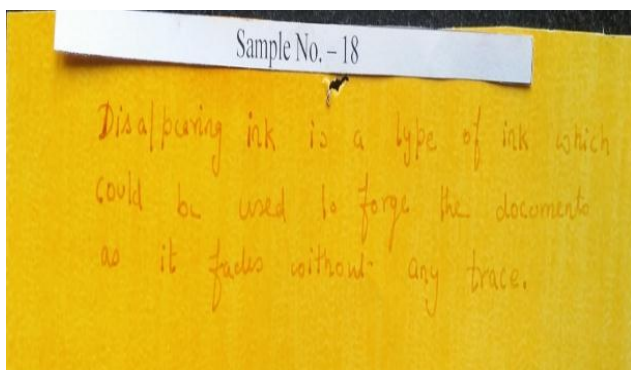


(a)

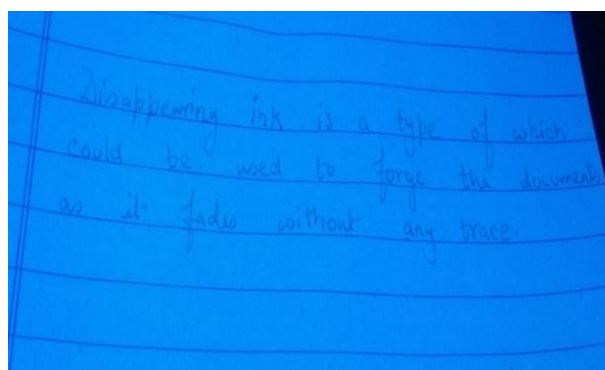


(b)

**Figure-3:** (a) Photograph of secret writing revealed when the sample (prepared ink) was treated with the 1N NaOH solution which resulted in the decipherment of the ink on stamp paper. (b) Photograph of secret writing revealed when the sample (standard ink) was treated with the 1N KOH solution, resulted in the decipherment of the ink on cheque paper.

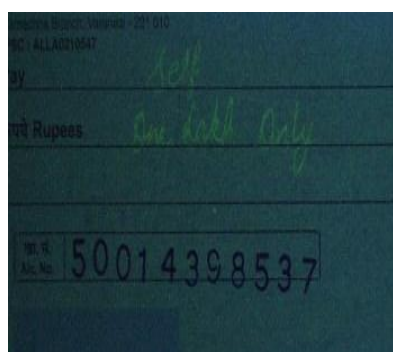


(a)

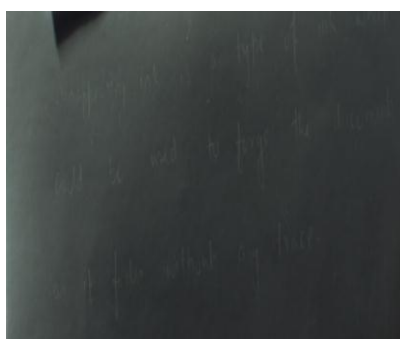


(b)

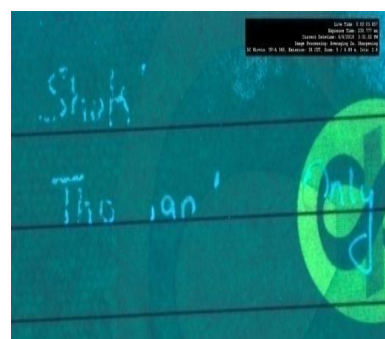
**Figure-4:** (a) Photograph of secret writing revealed when the samples (prepared ink) was treated with the iodine crystal fuming, resulted in the decipherment of the ink on photo paper. (b) Photograph (under UV light) of secret writing revealed when the samples (standard ink) was treated with the iodine crystal fuming, resulted in the decipherment of the ink on notebook paper.



(a)

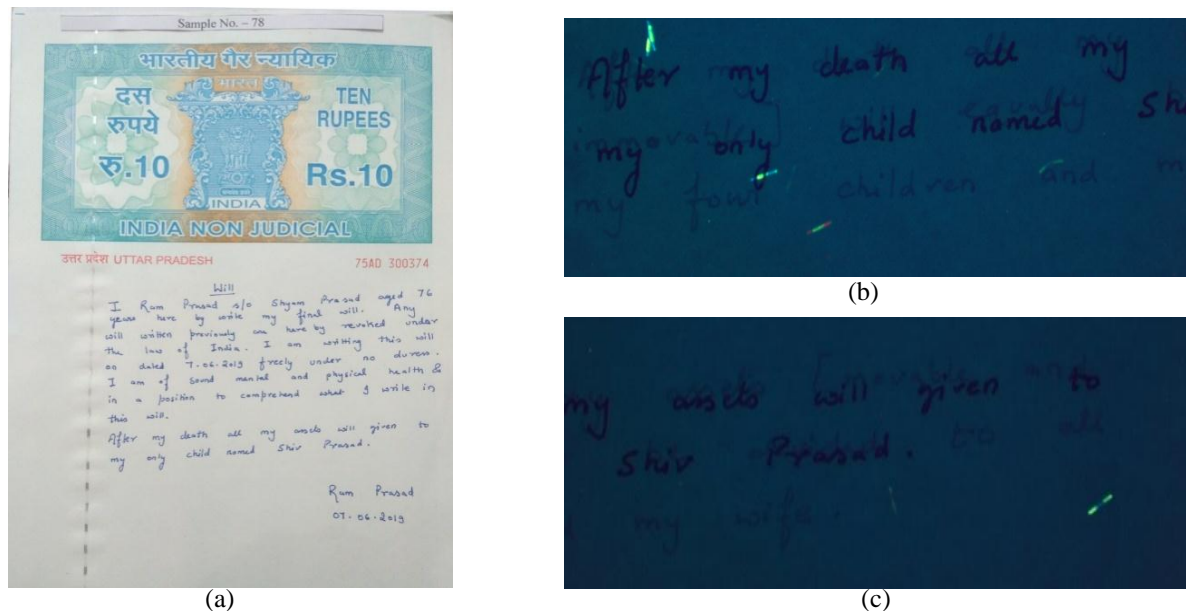


(b)

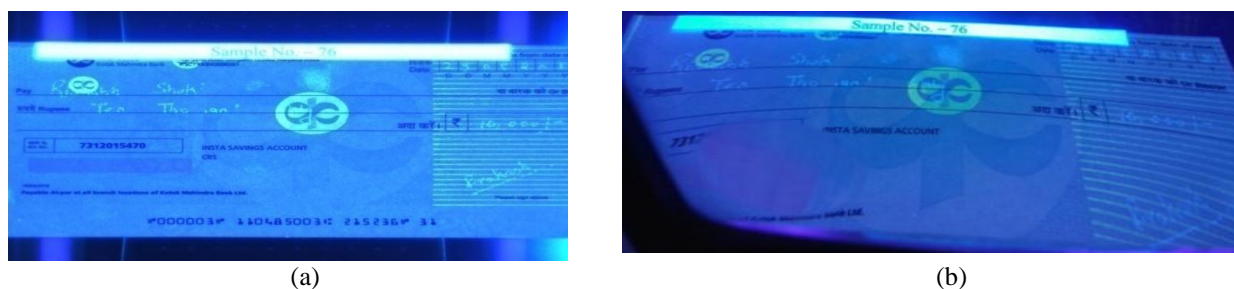


(c)

**Figure-5:** (a) Photographs of secret writing (prepared ink) revealed when the disappearing ink exposed under the UV light at 313 nm, resulted in the decipherment of ink because of its optical phenomenon on cheque paper by the instrument Video Spectral Comparator. (b) Showing the vanishing ink under the oblique light. (c) Photograph of showing the secret writing (standard ink) revealed when the ink exposed under the UV-A 365 nm resulted in the decipherment of ink because of its optical phenomenon by the instrument Docucenter NIRVIS.



**Figure-6:** (a) Photograph showing a sample exhibit prepared using disappearing ink (standard ink) on stamp paper. (b) and (c) Photographs are showing the secret writing revealed when the ink exposed under the UV- C 254 nm resulted in the decipherment of ink because of its optical phenomenon by the instrument Docucenter NIRVIS.



**Figure-7:** (a) Photograph of bank instrument showing the disappearing ink when exposed under the UV light at 313 nm resulted in the decipherment of ink because of its optical phenomenon by the instrument Forensic XP-4010D. (b) Photograph of bank instrument showing the disappearing ink when exposed under the UV light at 365 nm resulted in the decipherment of ink because of its optical phenomenon by the instrument Projectina Docubox.

**Discussion:** The sample exhibits prepared using disappearing ink, when examined by chemicals such as NaOH and KOH, the decipherment of the faded writing has been occurred due to fact that when the ink was used on any paper, the water in the ink reacts with the carbon dioxide and form the carbonic acid. The carbonic acid is weakly acidic and it reacts with the NaOH present in the ink and neutralizes the reaction, resulted the pH value of the ink decreases and causes the fading of ink<sup>1</sup>. Addition of weak base again turns the ink to the blue color. Iodine fuming of the samples revealed the writing as brown color. This is because, these inks disturb the surface fibers of the paper so when the iodine fuming is done, the iodine sticks preferentially to the altered areas of the paper and developed as a brown writing<sup>10</sup>. The faded writing was examined under the different wavelength of light, intensities and filters by the all four instruments, which revealed the original disappearing ink. The disappearing ink leaves a colorless residue of sodium

carbonate, which are not visible to naked eye but when viewed under the UV light, it gives the fluorescence.

Sample exhibit prepared on bank cheque of Punjab National Bank and Bank of Baroda does not gave the decipherment with Projectina Docubox and Forensic XP 4010-D while the check of Kotak Bank gave the decipherment of faded writing.

There are multiple previous studies which confirmed that there is a fixed relationship between disappearing ink and types of paper used<sup>3-11</sup>. The stability of ink was attributable to the physical properties of the papers used for examination. The cheque sample showed the high-absorption of the ink with subsequent accelerated reduction in the pH value. The plain A4 paper surface fibers are coated with polymer and this coating increases the pH due to which the ink are much stable on printing paper than other paper documents<sup>2</sup>. The results were

negative on butter paper because of its smooth surface due to that the ink does not properly absorb and evaporated.

Disappearing ink is used to commit the frauds as ink became invisible with the passage of time, so the forger are able to re-write over the main body of the cheque with the normal ink pen, thus manipulating the bank system and cheating the innocent person<sup>11</sup>.

## Conclusion

The study concludes that disappearing ink can be recovered using both chemical and instrumental techniques. However, the instrumental techniques are much preferred as being non-destructive, and among the four instruments used for the study Docucenter NIRVIS is the most suitable instrument as it gave the better results in comparison to others.

## References

1. Vaid, B. A., Kumar, S., Rana, R. S. and Kumar, N. (2012). Visualisation of disappearing ink writing. *Problems of Forensic Science*, 92, 311-318.
2. Abd-ElZaher, M. (2013). Different types of inks having certain medicolegal importance: Deciphering the faded and physically erased handwriting. *Egyptian Journal of Forensic Science*, 4(2), 39-44.
3. El-Molla, M. M., Shama, S. A. and Saeed, S. S. (2013). Preparation of disappearing ink and studying the fading time on different paper surfaces. *Journal of forensic sciences*, 58(1), 188-194.
4. Ronald D. Kurp (2003). U.S. Patent. US 6531528B1.
5. Kiyoharu Kawashima (1993). U.S. Patent. US 5196243 A.
6. Fassno and Maple Glen (1992). European Patent Application. EP 549145A1.
7. Bramley, Christopher Sinjin Tyne (2003). European Patent Application. EP 1400574 A1.
8. Bartolome, Burguera and Richard, K. Stanzak (1996). U.S. patent. US 5586501.
9. Shama S. A., El-Molla M. M., Basalah R. F. and Saeed S. E. (2008). Fading Time Study on Prepared Thymolphthalein, Phenolphthalein and their Mixture Disappearing Ink. *Research Journal of Textile and Apparel*, 12(1), 18.
10. Hussain, S. S. and Sahu, M. (2017). A Study on Common Visualization Methods for Secret Writing done by Invisible Inks and their Sensitivity Over a Period of Time. *Austine Journal of Forensic Science and Criminology*, 4(2), 2380-0801.
11. Throckmorton, G. (1990). Disappearing Ink: Its Use, Abuse and Detection. *Journal of Forensic Science*, 35(1).