JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# Deciphering Secret Writing: Utilizing UV and Heat Treatment Techniques

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## Abstract:-

Secret writing is any writing which is not visible to the naked eye. It can only deciphered under an appropriate light source or equipment's like UV chamber or VSC (Video Spectral Comparator) or by heating or by suitable treatment with a chemical. Secret writings are used mostly by Prisoners, Criminals, Terrorists, International spies, Intelligence agents and Drug dealers. Invisible inks are also known as Sympathetic inks which are colourless in nature and cannot be visible until it is treated with heat, vapour or chemical. Secret writing has been a subject of interest in forensic science, as they play a crucial role in criminal investigations. When a message is intentionally concealed through encryption or other covert means, forensic experts may be called upon to decipher the hidden content and uncover valuable evidence. In this paper we will explore the modern applications of invisible ink, uncovering the impact on historical events and its relevance in today's digital age. This article will examine the fascinating techniques used to create and reveal hidden messages, shedding light on its intriguing role in communication espionage. The study's major goal is to discover secret writings using various solutions and to know which solution is visible under instrument.

Key Words:-

Secret writing, Invisible inks, Sympathetic inks, Forensic science, Criminal investigations, Encryption, Covert communication.

## Introduction:-

Secret writing is a form of written communication that is concealed and invisible to the naked eye; as such it requires minimal development techniques. Making the written material unintelligible to everybody who comes into contact with it is the aim of covert communication.

Secret writings have been a subject of interest in forensic science as it plays a crucial role in criminal investigations.

In forensic science, the analysis of secret writings involves a range of techniques including traditional methods such as visual examination, UV light and chemical reagents to reveal invisible inks. Additionally, advanced technologies such as digital forensics and computer algorithms are used to analyse encrypted digital communications and uncover hidden information.

Invisible inks are used for secret writing. These are fluids used to write hidden messages that do not appear unless exposed by revealing process. Invisible inks can be classified into three categories those which can be revealed by heat; those which are visible under UV light; those which are revealed by chemical reactions. Some common household invisible inks are vinegar and laundry detergent, all which are applied by a paint brush or even a tooth pick.

Secret writing is a written communication whereby a spy conceals the actual text, whether it is encoded or not.

Simplest invisible ink experiment consists of dipping a brush in vegetable juice, biological fluids and writing it on a piece of blank paper. When the ink dries it will become 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 a UV lamp. Many other mild chemicals are also used for restoration of secret writing.

Invisible inks: Invisible inks are broadly classified as organic fluids and sympathetic inks. The former consists of natural solutions like Lemon juice, orange juice, milk, sweat, saliva, onion juice, and urine. These organic invisible inks can be developed through heating, such as using a candle. The Organic fluids alter the fibres of the paper so that the secret writings has a low burn temperature and turns brown faster than the surrounding paper when exposed heat. Secret writings written with saliva are not visible through heat treatment as it contains 95% water and components like amylases and lysozymes which make it look invisible even after heat treatment. Sympathetic inks are most complicated chemical concoctions. Sympathetic inks contain one or more chemicals and require the application of specific reagent for the development, such as another chemical or a mixture of chemicals.

Acidic citrus juices, of which of which lemon juice is often the preferred choice because it dries without leaving any evidence. This juice takes the place of ink, and is applied by using a cotton swab or a toothpick. After the juice gets dried the acid remains on the paper which it weakens and therefore readily exposed when the heat is applied to the paper. Other liquids for invisible inks include milk, which is mildly acidic, as well as the white wine, vinegar, or apple juice. In the past prisoners of war have used their own sweat or saliva or even urine which contains acidic secretions that adhere to the paper weakening it after the water in the bodily fluids has evaporated.

## Aim of the research:-

The aim of the research is the Decipherment of secret writings written with various samples by using UV light and Heat treatment.

## Objectives:-

- These techniques can be used to authenticate historical documents, letters, or artworks by revealing any hidden inscriptions or annotations that can verify their authenticity.
- In criminal investigations deciphering secret writings can provide crucial evidence. For instance, hidden messages might contain information about criminal activities, locations, or identities.
- In intelligence and counterintelligence operations, detecting and deciphering secret communications is critical. It helps in uncovering espionage activities, identifying spies, and understanding covert operations.

## Methodology:-

The basic steps to be followed for decipherment of secret writings are to prepare the sample first and then analyse them, i.e. the Decipherment methods.

## Materials required: -

Cotton swab or tooth pick or blunt screw driver or any pen with empty refill, UV-lamp or UV chamber or video spectral comparator (VSC), and Candle.

## Sample preparation:-

Firstly, there is a need to prepare samples of secret writing. The simplest way to write with the invisible inks is to dip the writing instrument into the liquid invisible inks and write it on the paper. Being non-volatile in nature, the ink dries up and caused disturbances in the fibres of paper, that's why it causes thinning of paper, and it helps in decipherment of writing.

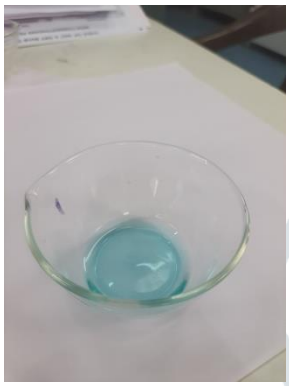


Fig no 1: CuSo4 Sample

Fig no: 2 Oxalic acid sample

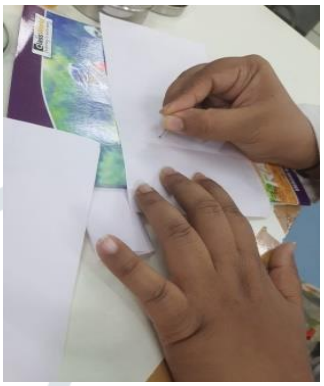


Fig no: 3 writing technique

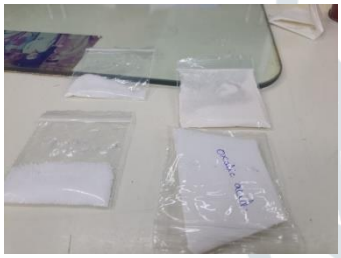


Fig no 4: Chemical samples

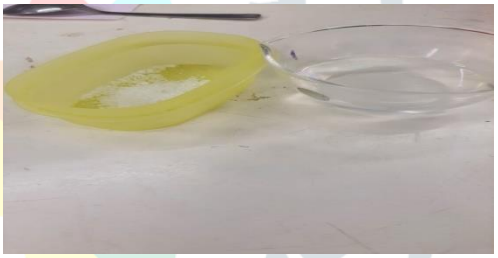


Fig no 5: Sodium bi carbonate.

## Decipherment:-

The decipherment techniques include both physical and chemical revealing methods. Most of these methods are reliable as they give good results but few of them are destructive in nature. The basic concept for the development and revealing of the hidden message is to change the colour contrast between the marked and unmarked area simply means the area of paper which contains written text (by invisible ink) and the area without written text, respectively.

In this paper we have only used Physical methods like UV- light and Heat treatment techniques for decipherment of secret writings.

## Physical method:-

Most of the physical methods which are used for the decipherment of invisible inks are non-destructive in nature while a few of them are destructive as well. Firstly, decipherment by physical methods is preferred, but if those don't work then the chemical methods are preferred.

- Ultra-violet light: - It is also a non-destructive technique. The use of UV lamp or UV chamber or video spectral comparator for the detection of secret ink is also useful as most of the invisible inks

give fluorescence under UV-light when visualized. This fluorescence makes the impressions of writings visible, then these must be photographed.

- Heat treatment: - There are several methods of developing invisible ink by heat: such as: place the paper in oven, hold the paper onto a hot light bulb, hold the paper near the candle flame, and iron the paper. These developing methods help in revealing the message by the changes colour which is due to thinning of the paper.

For physical developing methods, the development by Heat and UV gives better results as compared to all other physical developing methods, even when observed for 30 days continuously. Ink developed by heat mostly gave brown colour over the text or secret message. While inks visualized under UV light gave blue fluorescence.

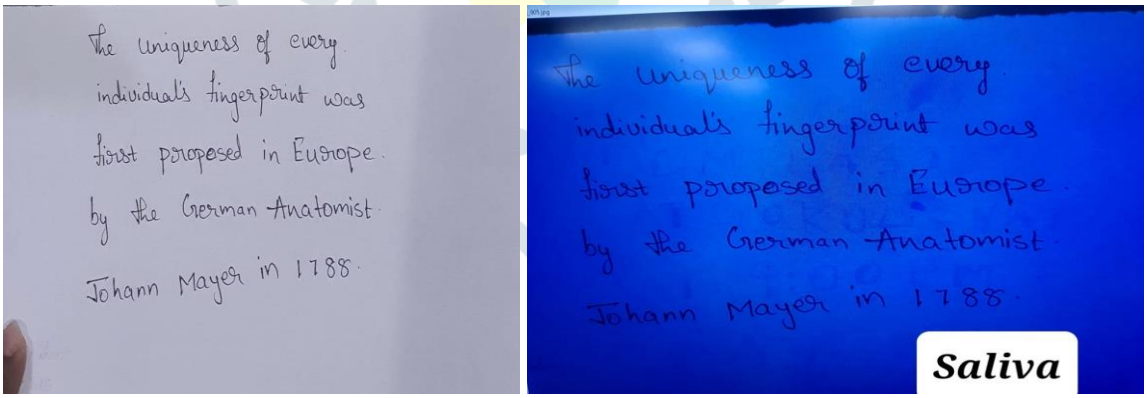
## Samples: -

This research paper comprises of fifty samples which contains hidden messages written with biological samples like (Sweat, Tears, Saliva, blood and Urine), Chemicals like (Vinegar, copper sulphate(cuso4), Sodium chloride(NaCl), Ammonium chloride(NH3Cl), Starch, Sodium Bicarbonate(NaHCo3), Phenolphthalein(C20H14O4), Oxalic acid(C2H2O4)), Fruit and vegetable juices( Lemon juice, Potato juice, orange juice, pineapple juice, Tomato juice, Coconut water, onion juice, Diluted apple juice and Orange peel juice), Plant extract (Aloe Vera gel), Medicines(ENO, Thyroid tablet, B.P tablet(Amlopres), Dolo650,Cofsils, Paracip-500, Acetaminophen, Pain killer gel (bengay gel), Eldoper, Aspirin, Ashwagandha supplements, Sugar tablet(Glimi save), Dettol (C8H9ClO) ) and other samples (Comfort, Ketchup, Cola, Mouthwash, Face wash, Tamarind juice, Rose water, Toothpaste, Shampoo, Ariel liquid detergent, Chalk piece powder, Chilli powder, Conditioner and Sugar solution).

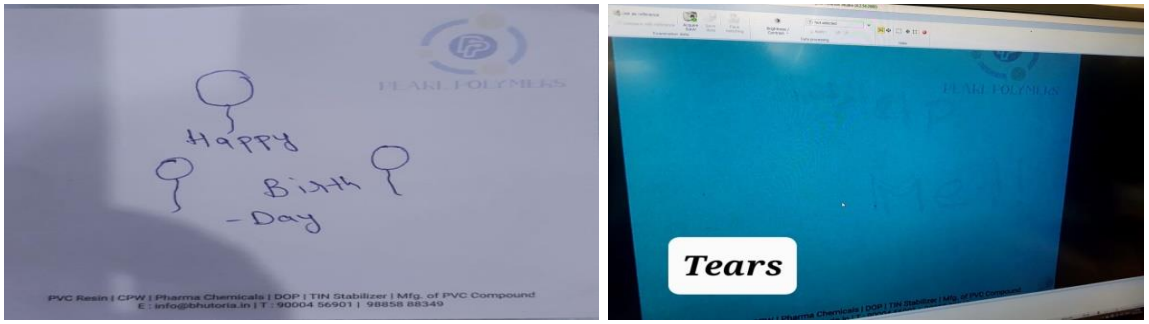
## Result and Discussion:-

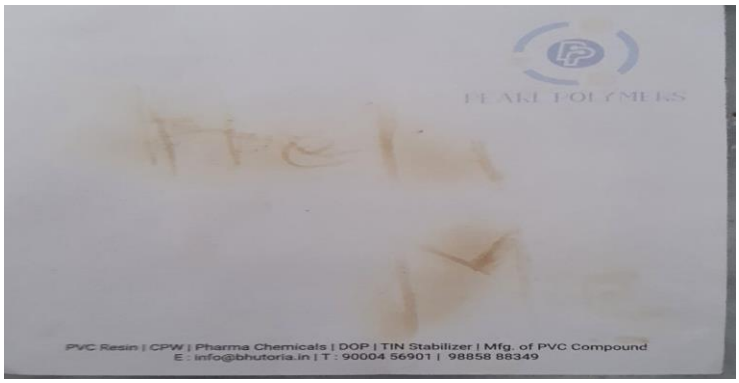
The Following observations show the visibility of writings by using Physical methods like UV and Heat treatment.

### Biological Fluids:-

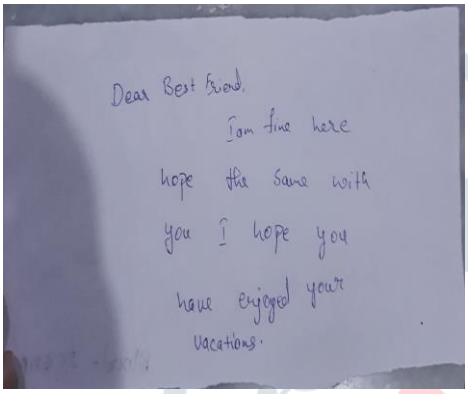



Saliva sample is visible under UV wavelength of 313nm and heat treatment.

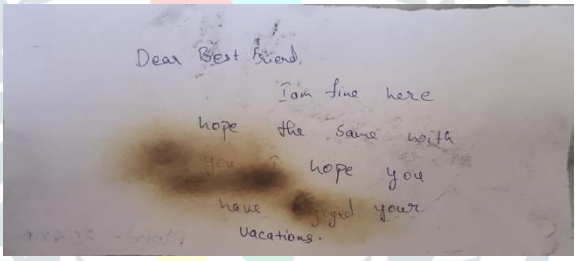




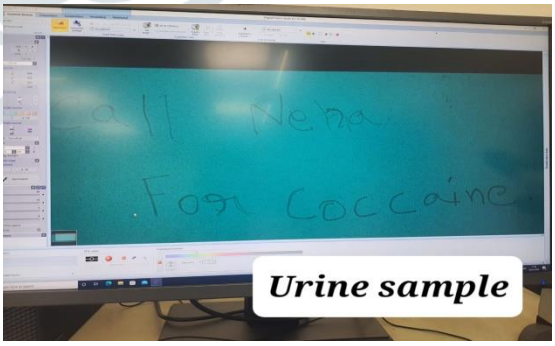

Tears sample is visible under UV wavelength of 254nm and Heat treatment.



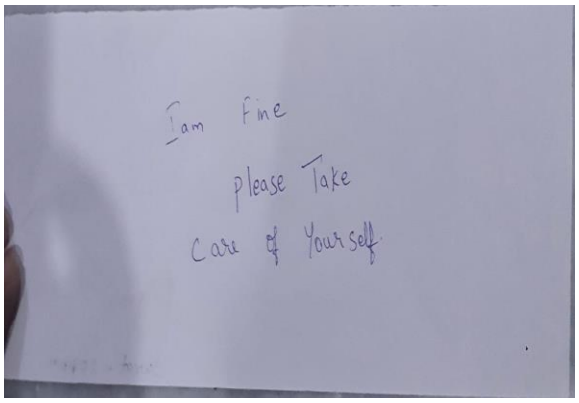




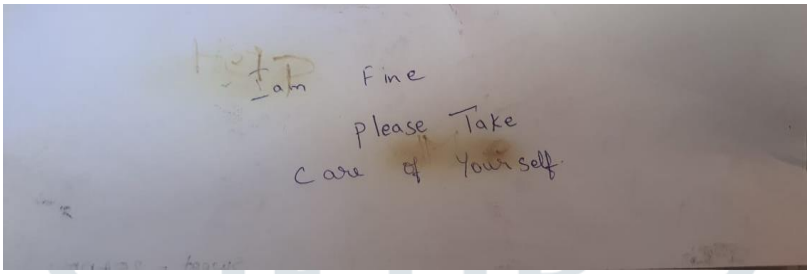

Blood sample is visible under UV wavelength of 254nm and Heat treatment.




Urine sample is visible under UV wavelength of 313nm and Heat treatment.





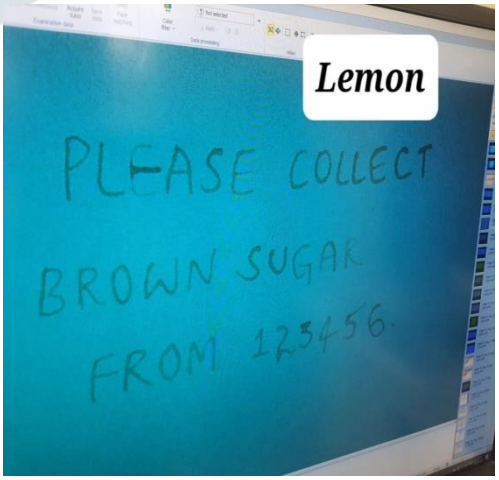


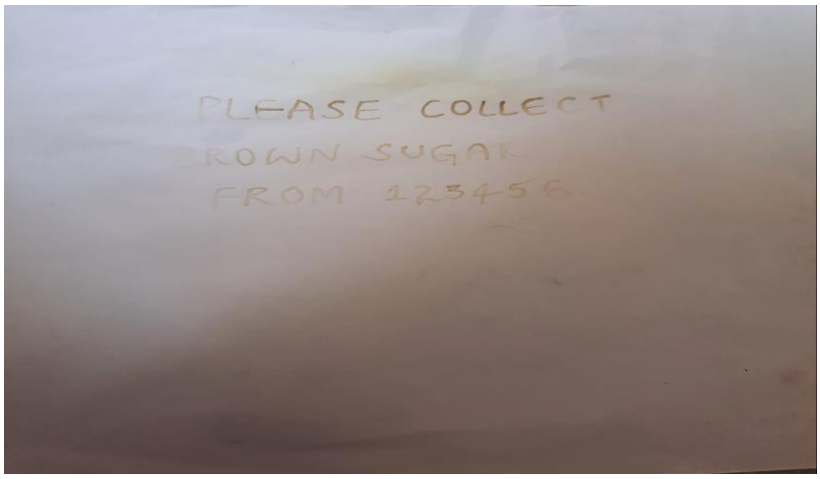

Sweat sample is visible under UV wavelength of 254nm and Heat treatment.

| S.no | Sample | Wavelength | | | | Heat treatment |
|---|---|---|---|---|---|---|
| | | 400nm | 365nm | 313nm | 254nm | |
| 1. | Saliva | × | × | ✓ | × | × |
| 2. | Tears | × | × | × | ✓ | ✓ |
| 3. | Blood | × | × | × | ✓ | ✓ |
| 4. | Urine | × | × | ✓ | × | ✓ |
| 5. | Sweat | × | × | × | ✓ | ✓ |

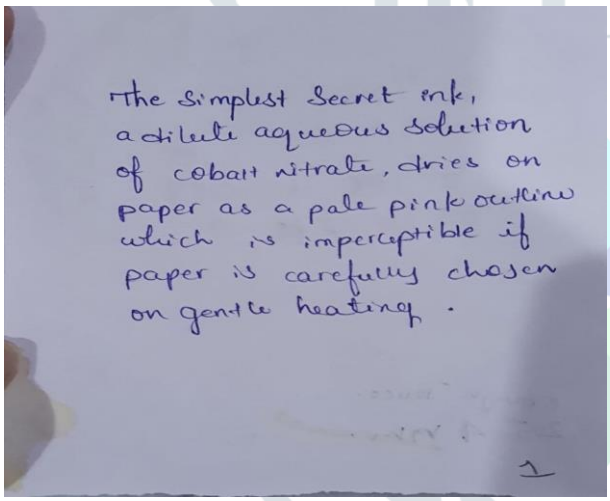
Table 1 representing the wavelengths of Biological fluids.

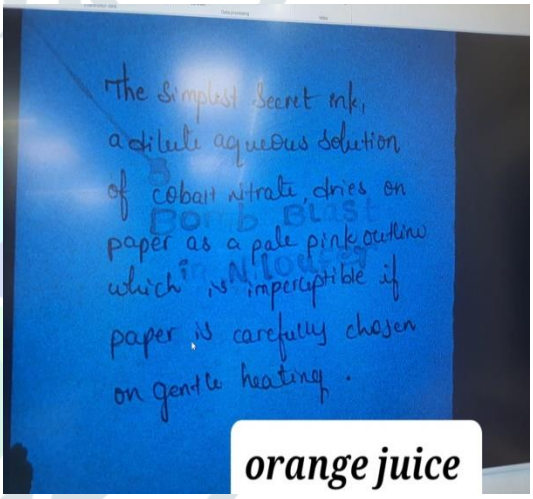
## Fruit and Vegetable juices:-

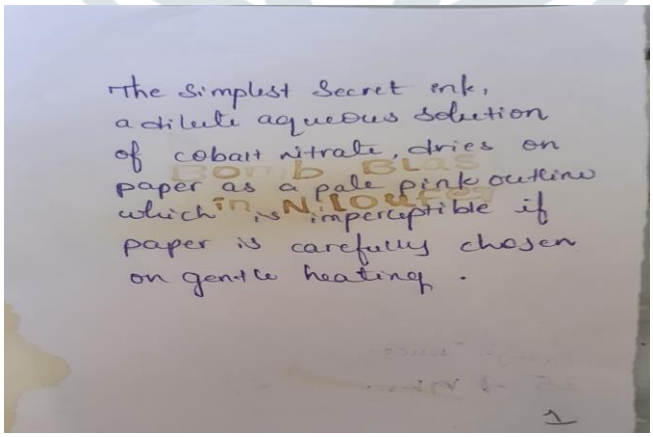





Lemon juice sample is visible under UV wavelength of 313nm and Heat treatment.

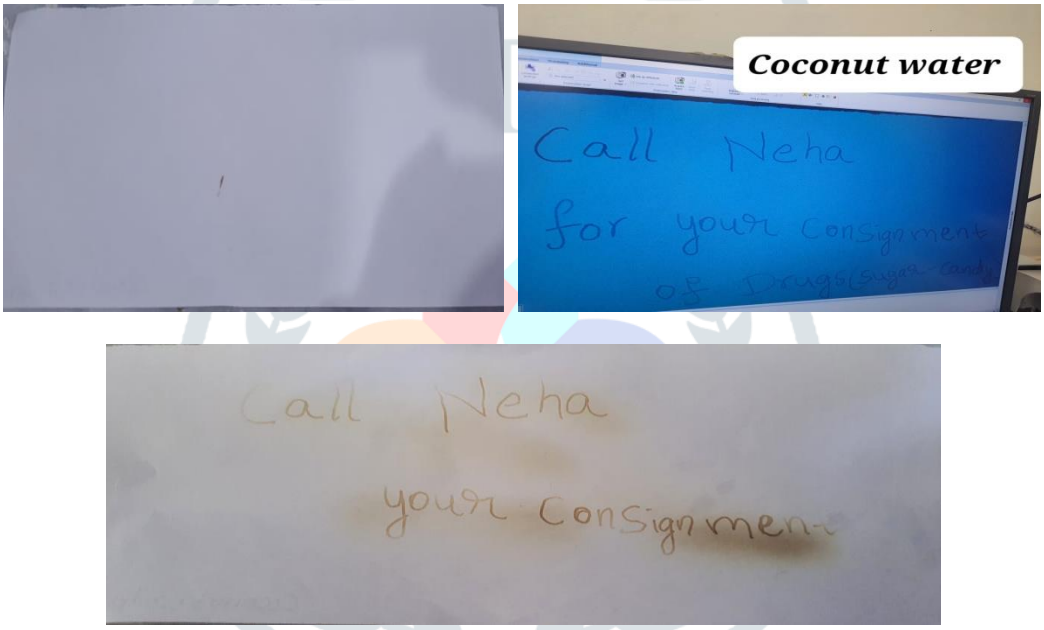


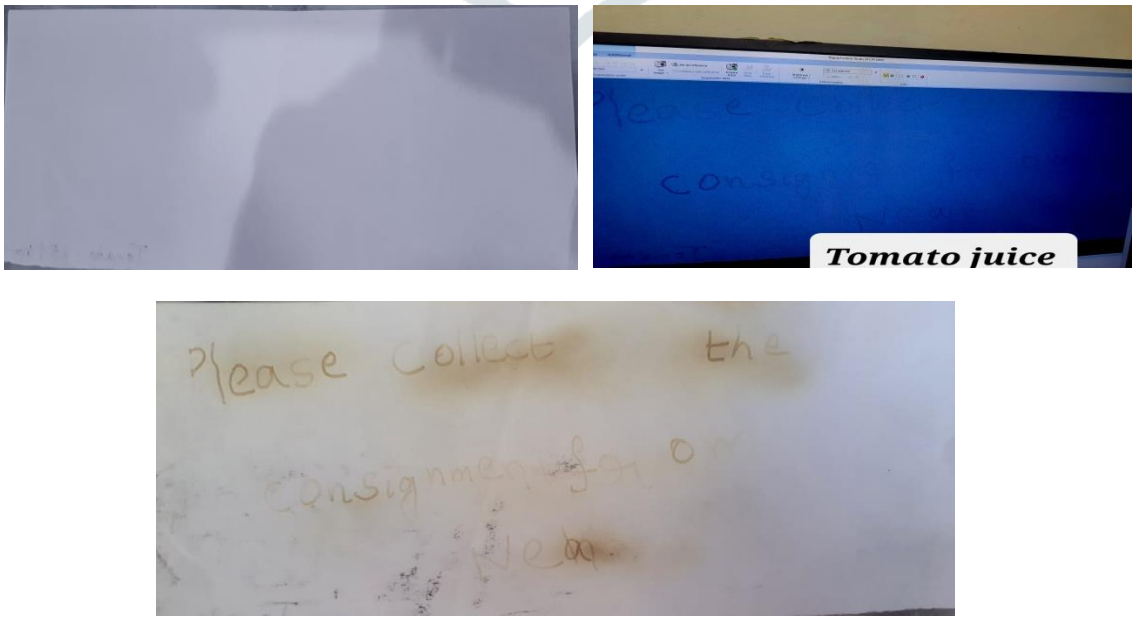




Orange juice sample is visible in UV wavele ngth of 254nm and Heat treatment.

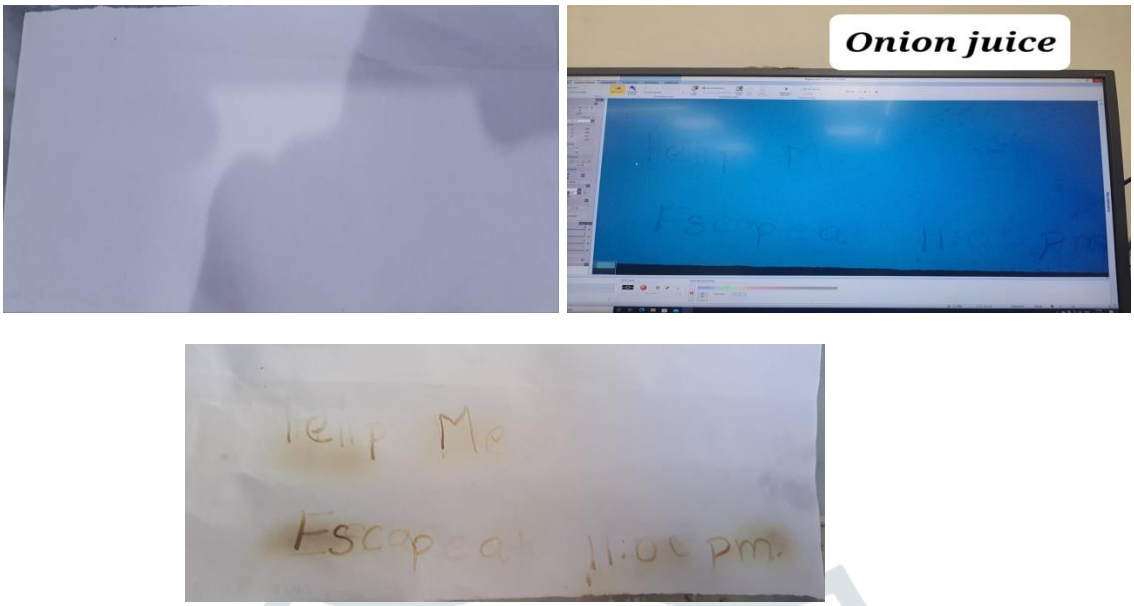

Diluted Apple juice is visible under UV wavelength of 254nm and Heat treatment.



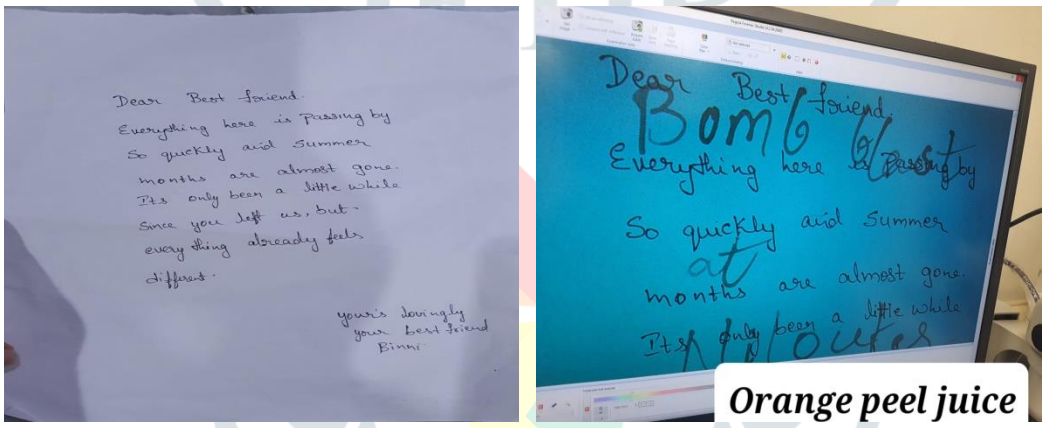

Coconut water sample is visible under UV wavelength of 254nm and Heat treatment.



Tomato juice sample is visible under UV wavelength of 254nm and Heat treatment.

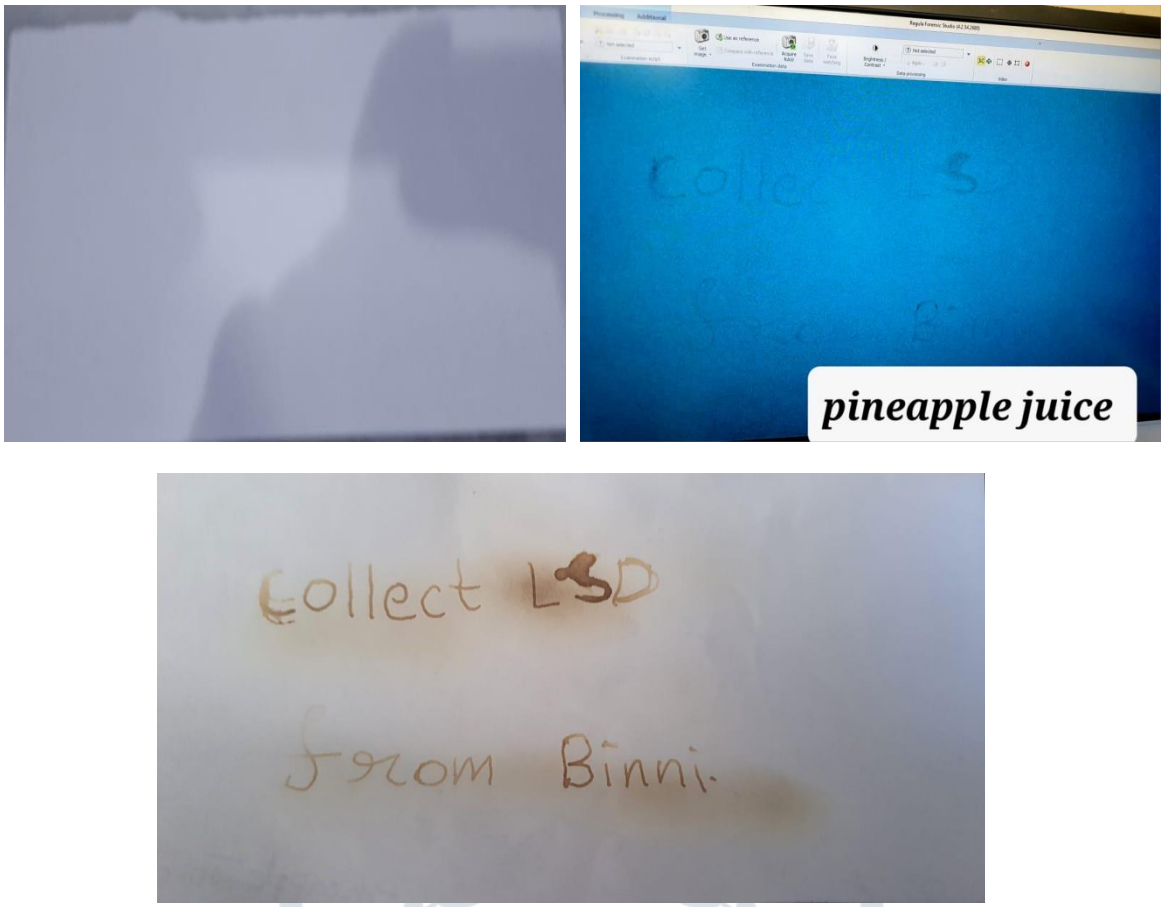



Onion juice sample is visible under UV wavelength of 254nm and Heat treatment.




Orange peel juice sample is visible under wavelength of 254nm.


Potato starch sample is visible under wavelength of 254nm.



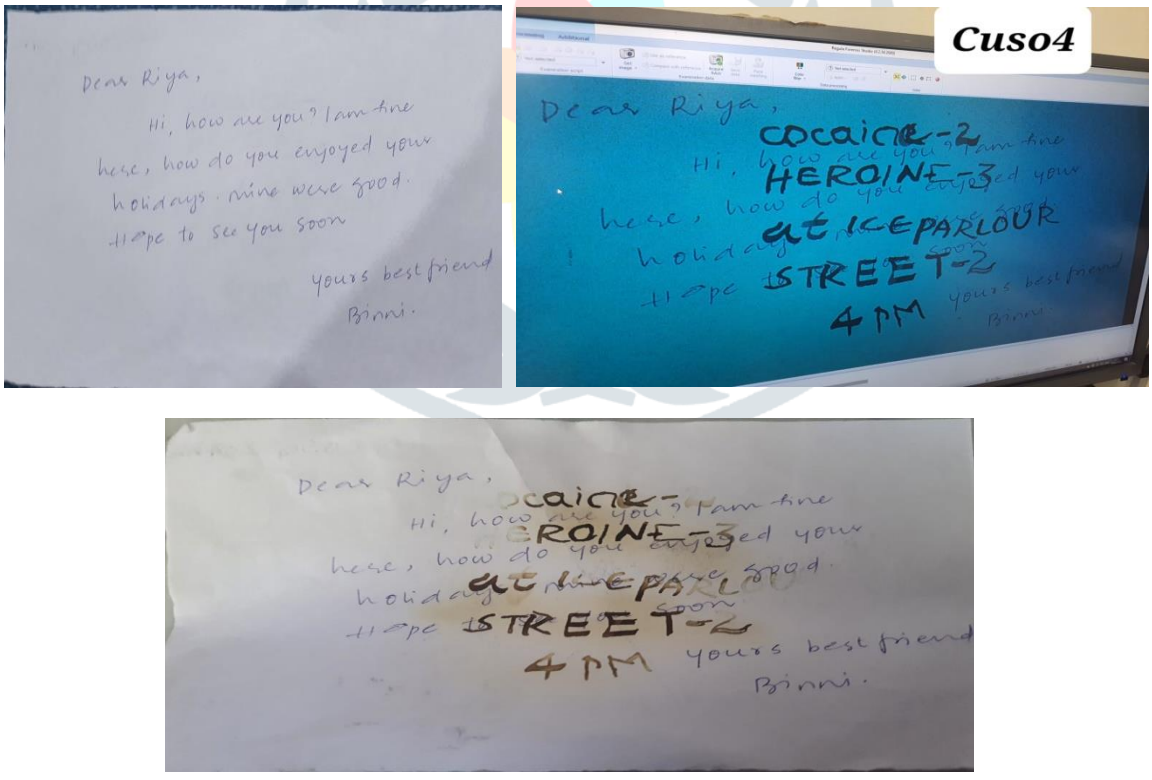

Pineapple juice sample is visible under the wavelength of 254nm and Heat treatment.

| S.no. | Sample | Wavelength | | | | Heat Treatment |
|---|---|---|---|---|---|---|
| | | 400nm | 365nm | 313nm | 254nm | |
| 1. | Lemon juice. | × | × | ✓ | × | ✓ |
| 2. | Orange juice. | × | × | × | ✓ | ✓ |
| 3. | Diluted Apple juice. | × | × | × | ✓ | ✓ |
| 4. | Coconut water. | × | × | × | ✓ | ✓ |
| 5. | Tomato juice. | × | × | × | ✓ | ✓ |
| 6. | Onion juice. | × | × | × | ✓ | ✓ |
| 7. | Orange peel juice. | × | × | × | ✓ | × |
| 8. | Potato starch. | × | × | × | ✓ | Slightly visible |
| 9. | Pineapple juice. | × | × | × | ✓ | ✓ |

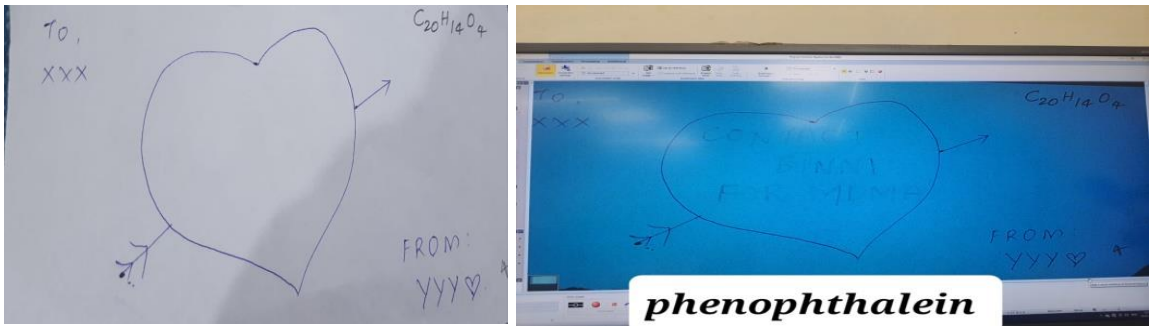
Table no 2. Representing the visible wavelength of fruit and vegetable sample and heat treatment.

## Chemical samples:-


Oxalic acid sample is visible under UV wavelength of 254nm and Heat treatment.

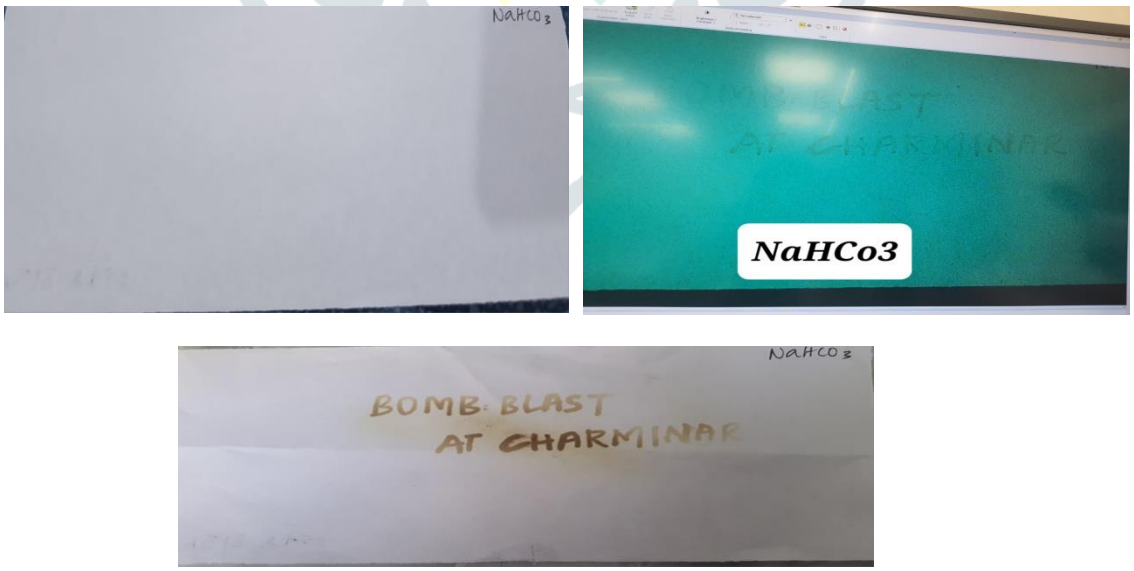



Copper sulphate (CuSo4) sample is visible under UV wavelength of 254nm and Heat treatment.




Phenolphthalein (C20H14O4) sample is under UV wavelength of 254nm.

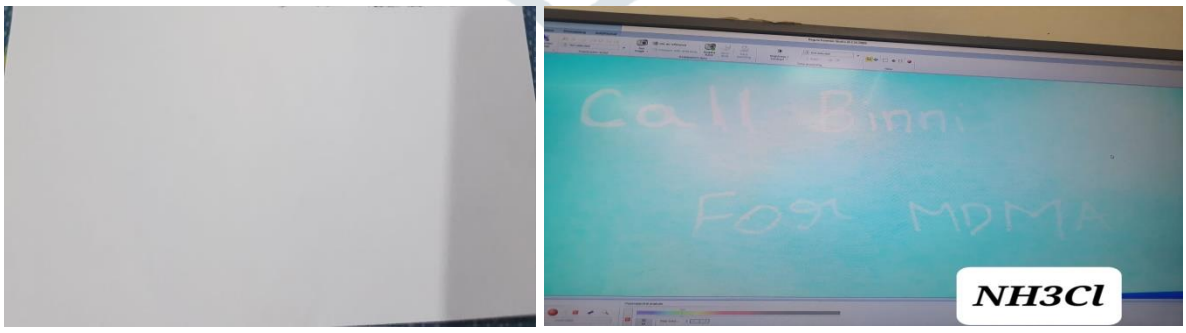

Vinegar sample is visible under UV wavelength of 254nm and Heat treatment.




Sodium bicarbonate (NaHCo3) is visible under UV wavelengths of 313 & 254nm and Heat treatment.


Starch sample is visible under UV wavelength of 254nm and Heat treatment.


Sodium chloride (NaCl) is visible UV wavelength of 400nm and Heat treatment.

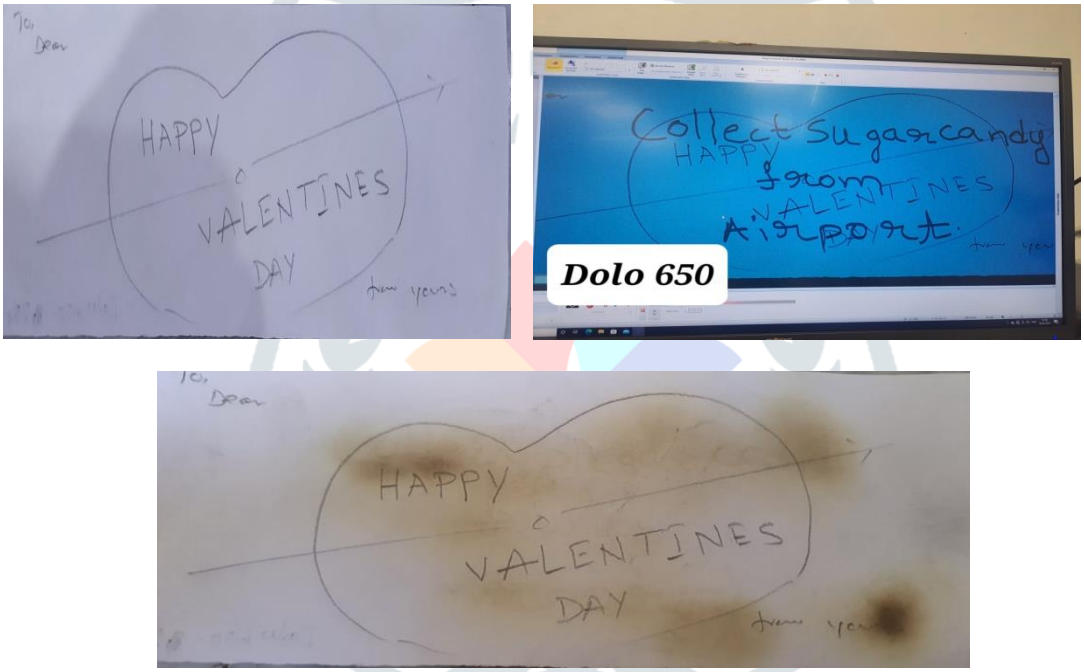



Ammonium chloride (NH3Cl) is visible under UV wavelength of 400nm.

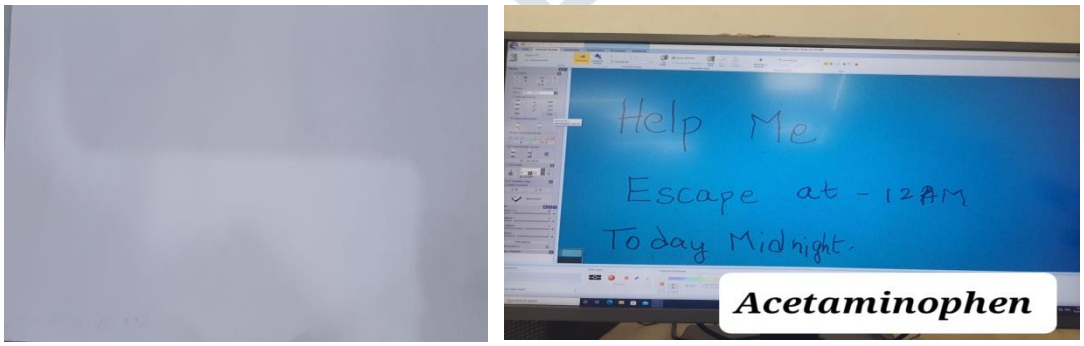
| S.no | Sample | Wavelength | | | | Heat treatment |
|---|---|---|---|---|---|---|
| | | 400nm | 365nm | 313nm | 254nm | |
| 1. | Oxalic acid | × | × | × | ✓ | ✓ |
| 2. | Copper sulphate | × | × | × | ✓ | ✓ |
| 3. | Phenolphthalein | × | × | × | ✓ | × |
| 4. | Vinegar | × | × | × | ✓ | ✓ |
| 5. | Sodium bicarbonate | × | × | ✓ | ✓ | ✓ |
| 6. | Starch | × | × | × | ✓ | ✓ |
| 7. | Sodium Chloride | ✓ | × | × | × | ✓ |
| 8. | Ammonium Chloride | ✓ | × | × | × | × |

Table no.3 representing the wavelengths of Chemical samples.

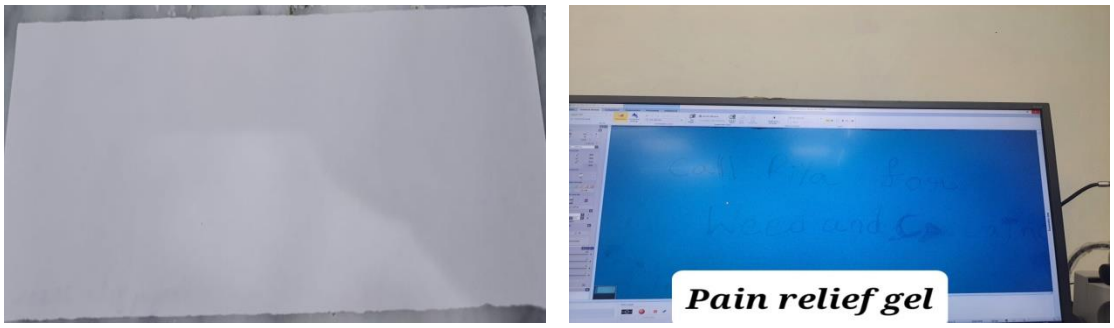
## Medicine samples and Plant extract (Aloe Vera gel): -




Dolo-650 sample is visible under UV wavelength of 254nm and Heat treatment.

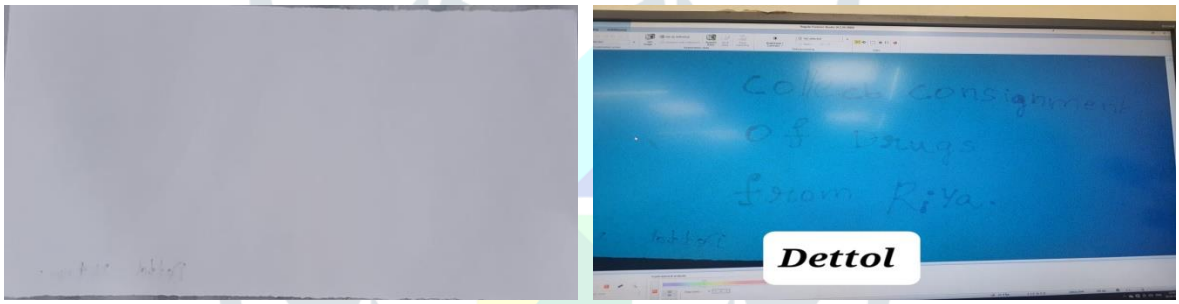



Acetaminophen sample is visible under UV wavelength of 254nm.



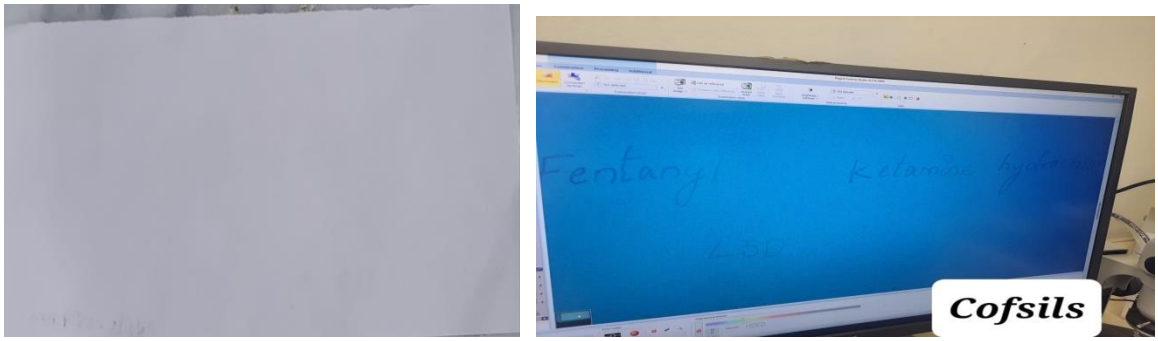

Pain killer gel sample is visible under UV wavelength of 254nm.

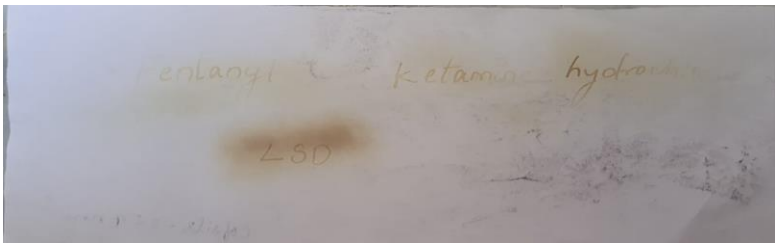

Paracip-500 sample is visible under UV wavelength of 254nm.



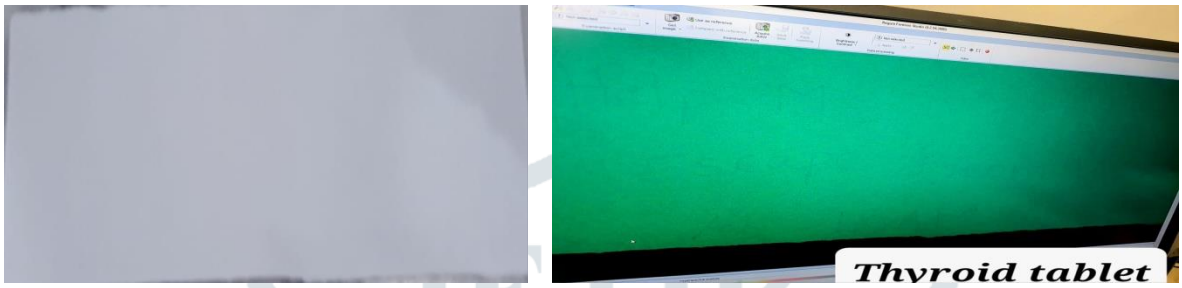

Dettol sample is visible under UV wavelength of 254nm.


B.P tablet (Amlopres) sample is visible under UV wavelength of 254nm.

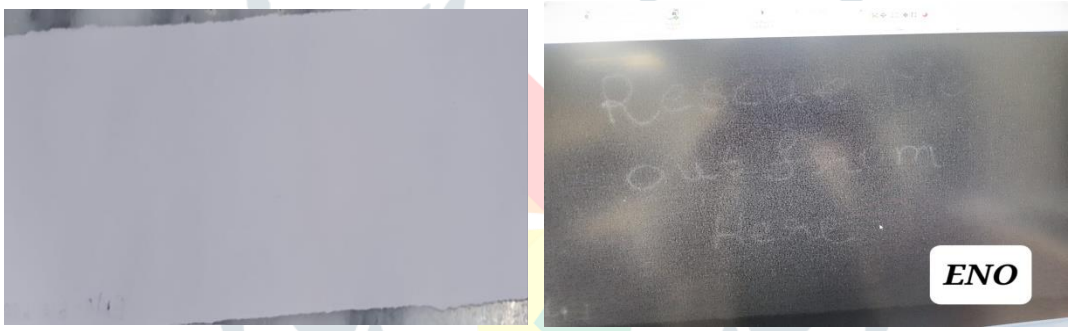


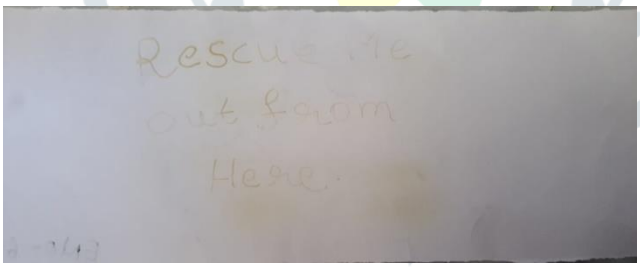



Cofsils sample is visible under UVV wavelength of 254nm and Heat treatment.

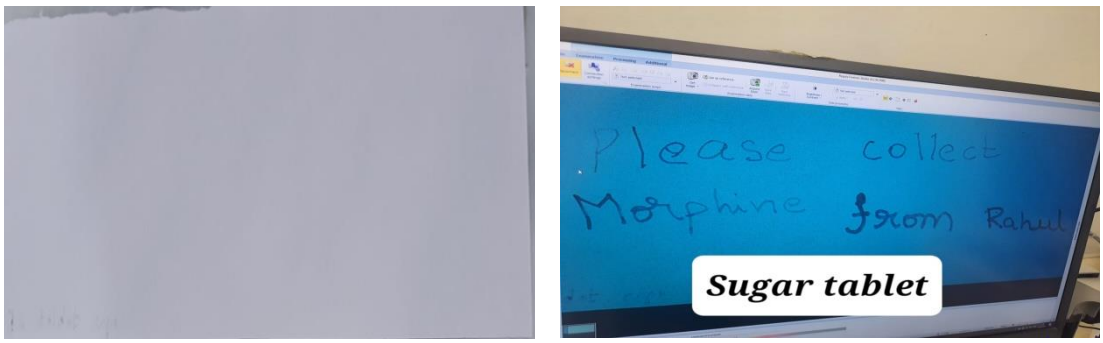


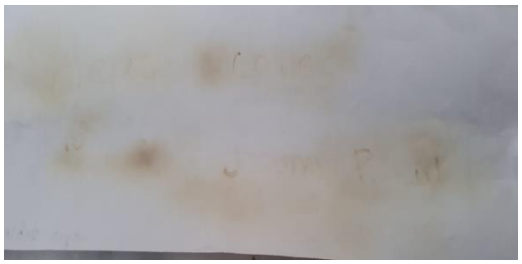

Thyroid tablet sample is visible under UV wavelength of 254nm.



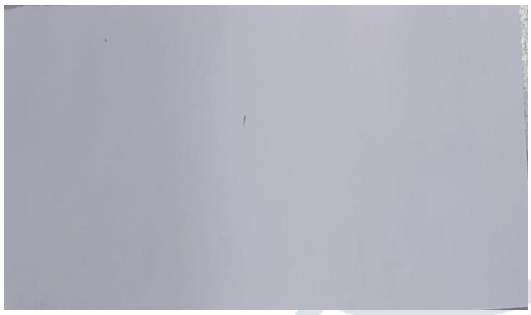
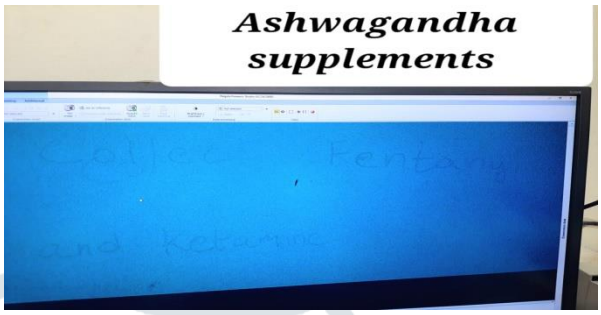



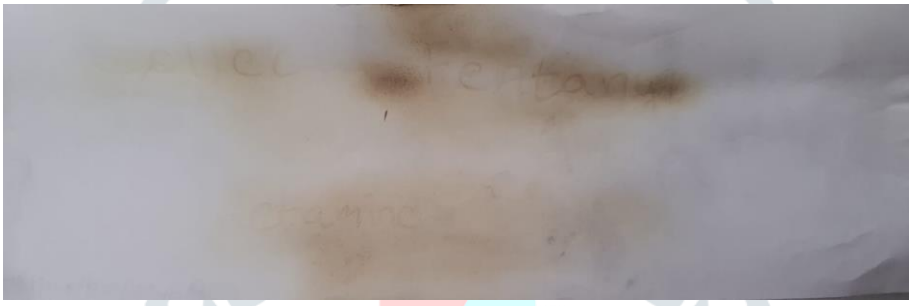

ENO sample is visible under UV wavelength of 625-655nm and Heat treatment.





Sugar tablet (Glimi save) is visible under UV wavelength of 254nm and Heat treatment.

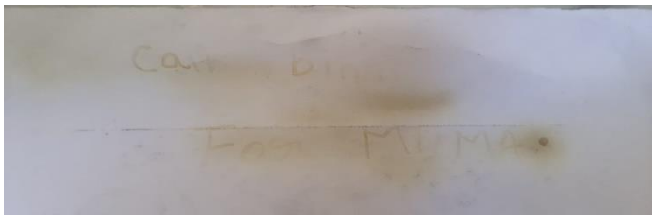





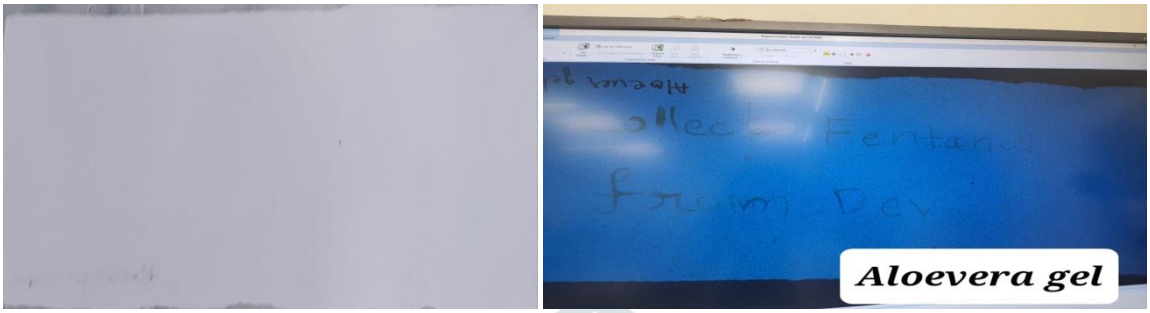
Ashwagandha supplements sample is visible under UV wavelength of 254nm and Heat treatment.



Aspirin sample is visible under UV wavelength of 254nm.

Eldoper sample is visible under UV wavelength of 254nm and Heat treatment.

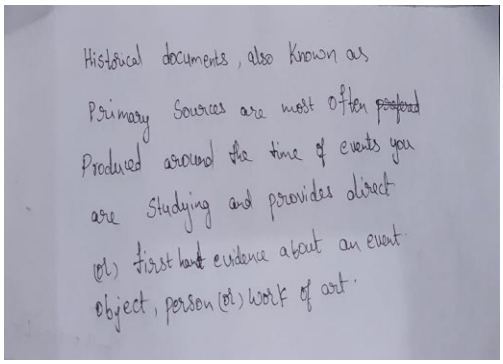


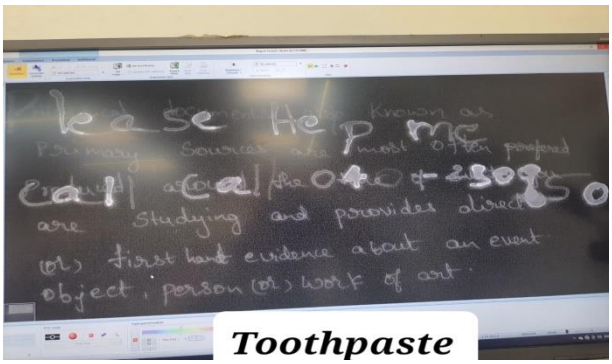

Aloe Vera gel sample is visible under UV wavelength of 254nm.

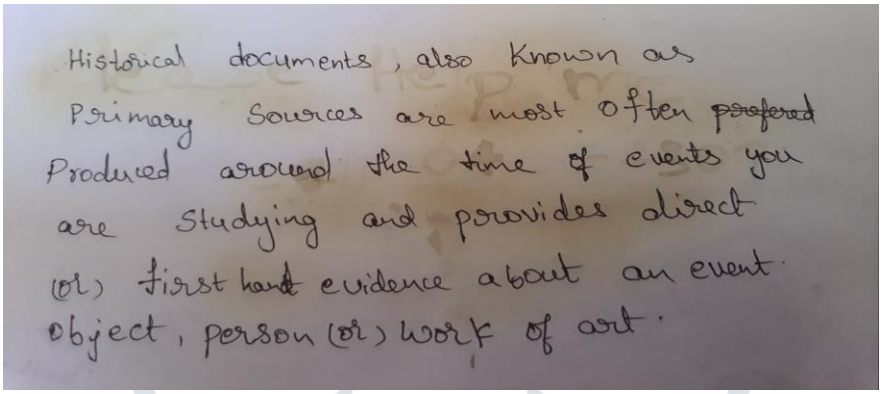
| S.no. | Sample | Wavelength | | | | | Heat Treatment |
|---|---|---|---|---|---|---|---|
| | | 400nm | 365nm | 313nm | 254nm | 625-655nm | |
| 1. | Dolo-650. | × | × | × | ✓ | × | Slightly visible |
| 2. | Acetaminophen. | × | × | × | ✓ | × | × |
| 3. | Painkiller gel. | × | × | × | ✓ | × | × |
| 4. | Paracip-500. | × | × | × | ✓ | × | Slightly visible |
| 5. | Dettol. | × | × | × | ✓ | × | ✓ |
| 6. | B.P tablet (Amlopres) | × | × | × | ✓ | × | × |
| 7. | Cofsils | × | × | × | ✓ | × | ✓ |
| 8. | Thyroid tablet | × | × | × | ✓ | × | × |
| 9. | ENO | × | × | × | × | ✓ | ✓ |
| 10. | Sugar tablet (Glimi save) | × | × | × | ✓ | × | ✓ |
| 11. | Ashwagandha supplements | × | × | × | ✓ | × | ✓ |
| 12. | Aspirin | × | × | × | ✓ | × | × |
| 13. | Eldoper | × | × | × | ✓ | × | ✓ |
| 14. | Aloe Vera gel | × | × | × | ✓ | × | ✓ |

Table no.4 representing the wavelengths of Medicine and plant extract (Aloe Vera gel) samples.

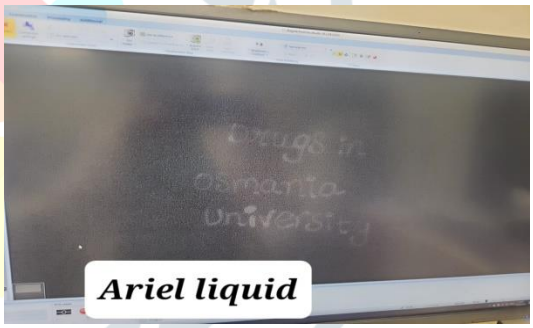
## Other samples:-



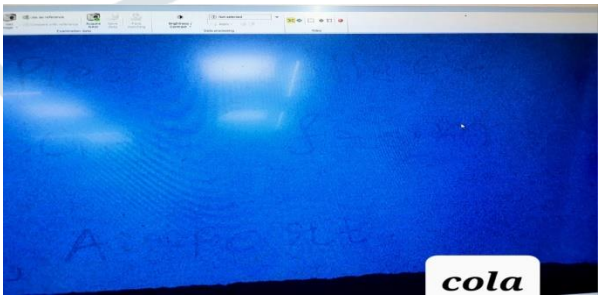



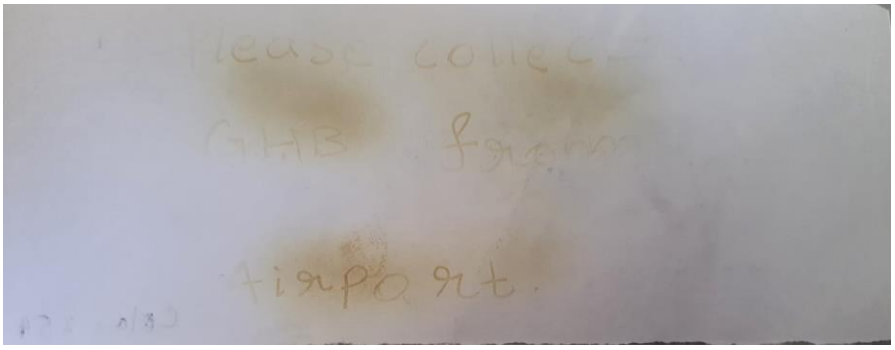




Toothpaste sample is visible under UV wavelength of 625-655nm and Heat treatment.

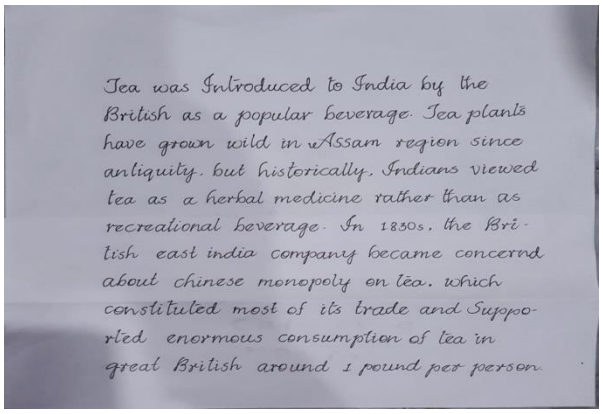


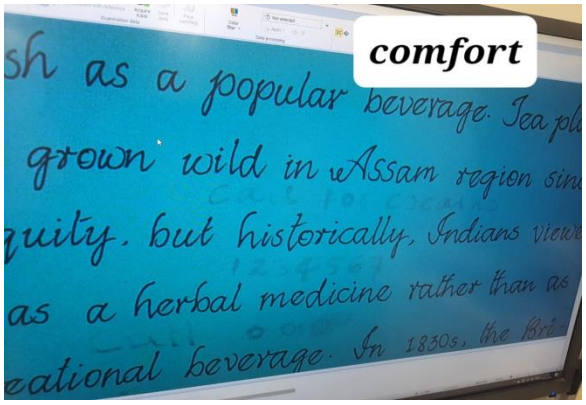

Ariel liquid sample is visible under UV wavelength of 625-655nm.

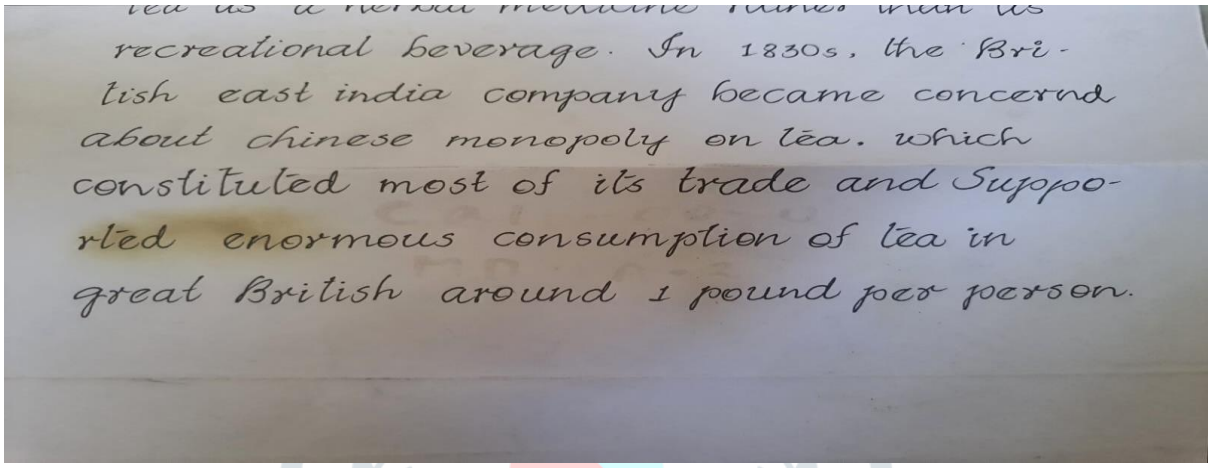


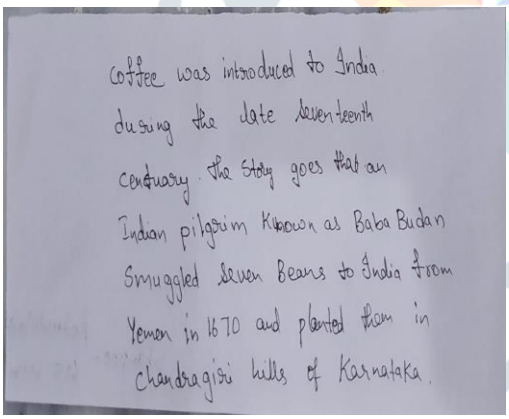
Cola sample is visible under UV wavelength of 254nm and Heat treatment.

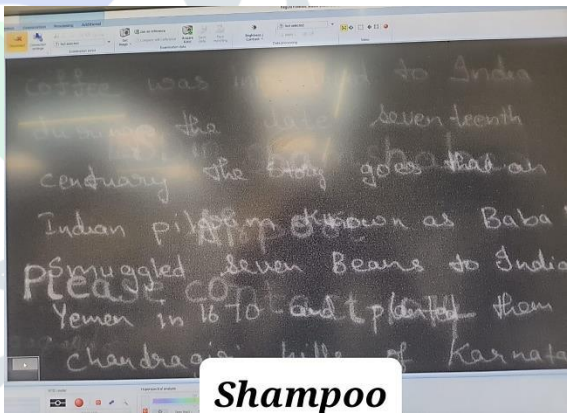


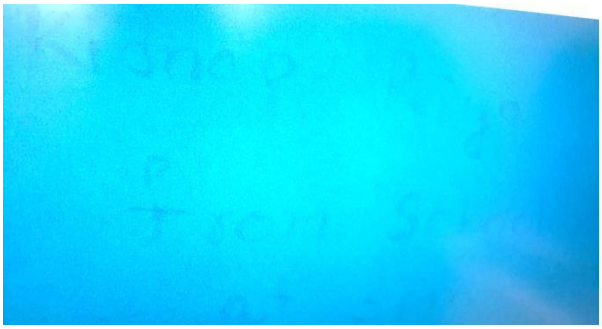




Comfort sample is visible under UV wavelength of 254nm and Heat treatment.

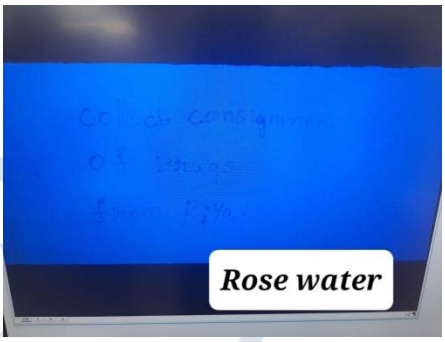


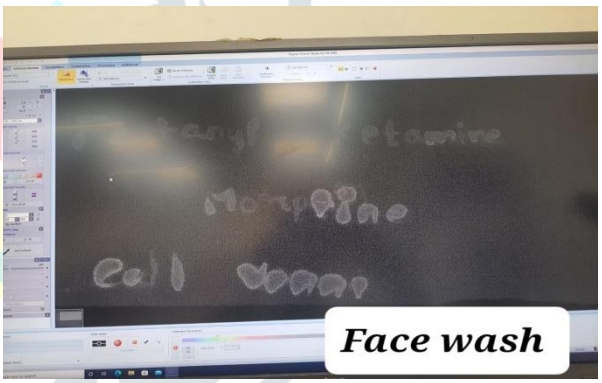

Shampoo sample is visible under UV wavelength of 625-655nm.



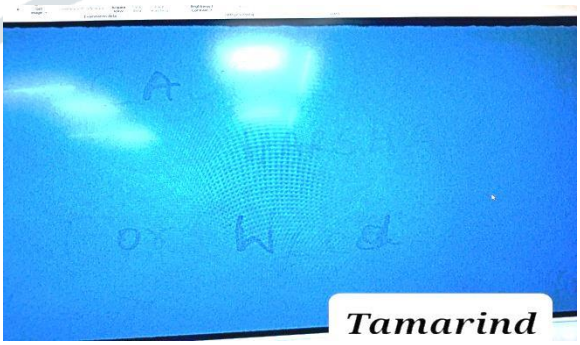
Conditioner sample is visible under UV wavelength of 254nm and Heat treatment.

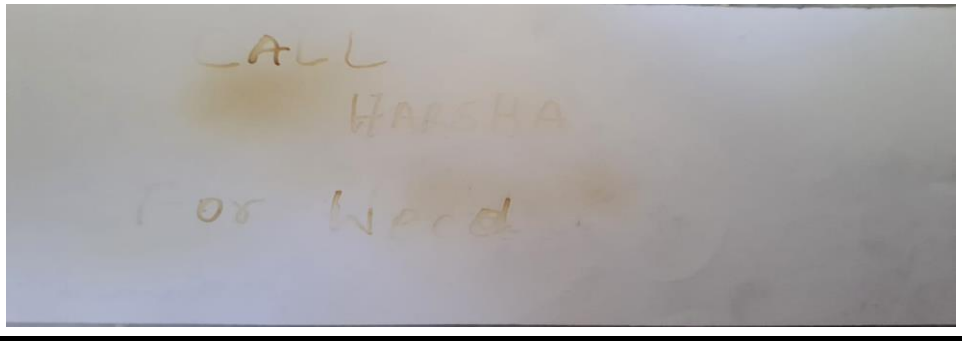



Rose water sample is visible under UV wavelength of 254nm.

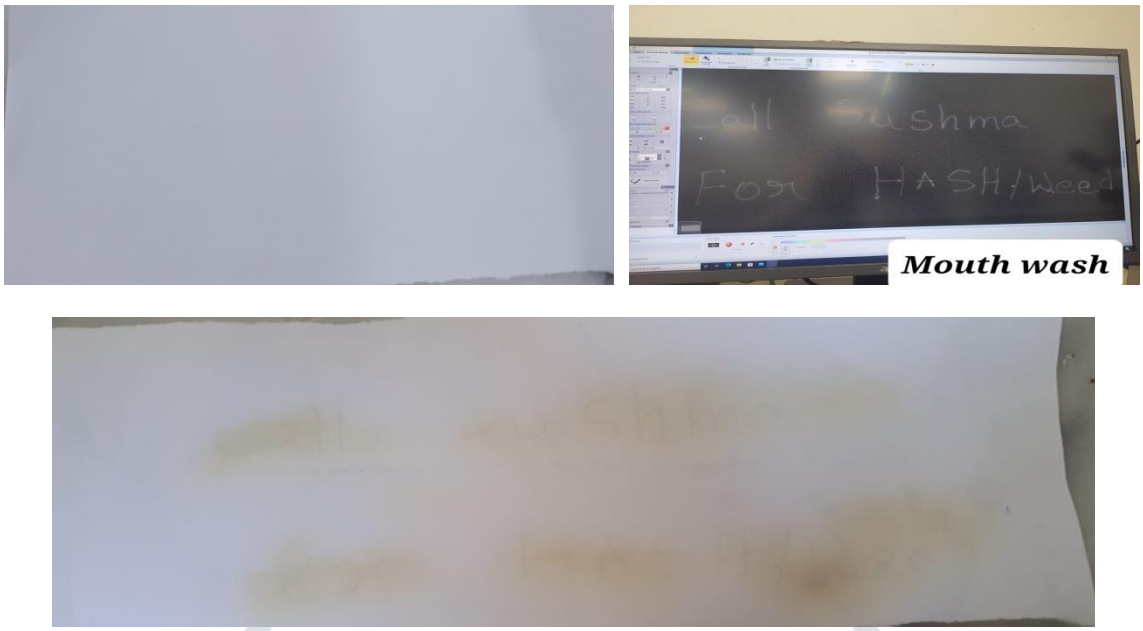



Face wash sample is visible under UV wavelength of 625-655nm.

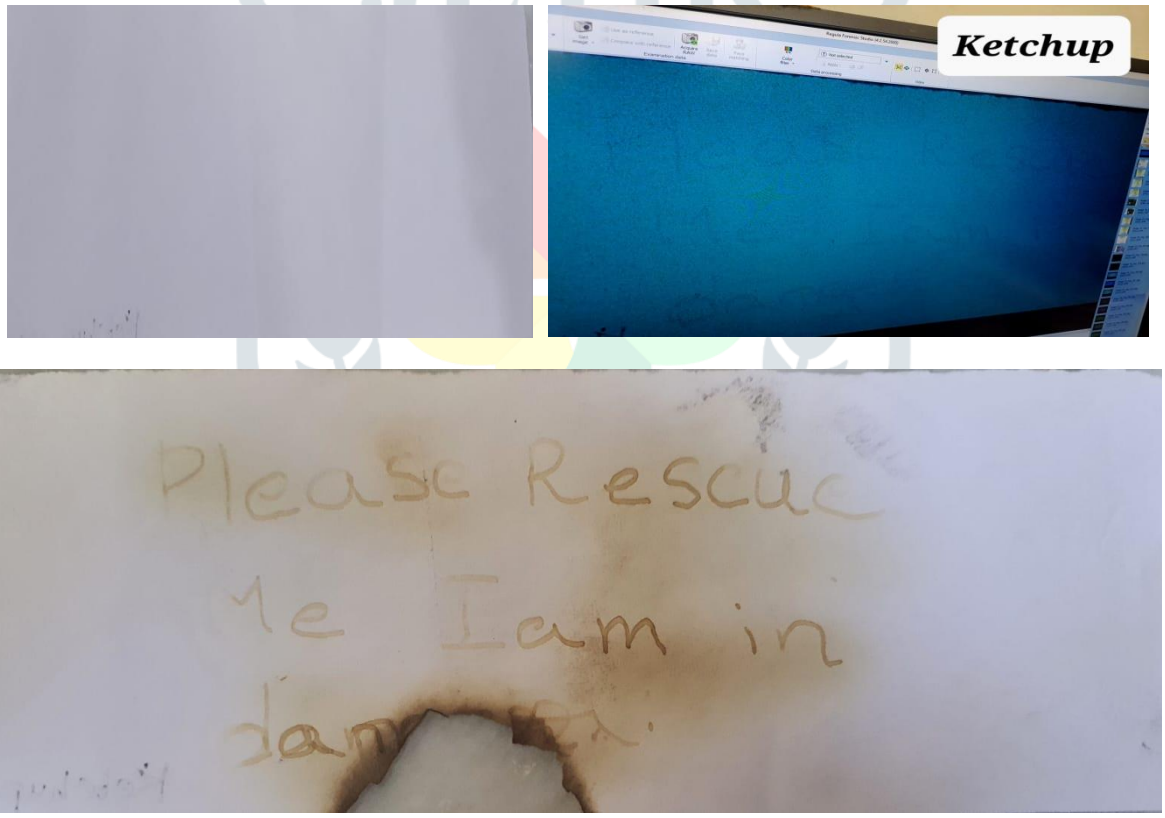


Tamarind sample is visible under UV wavelength of 254nm and Heat treatment.



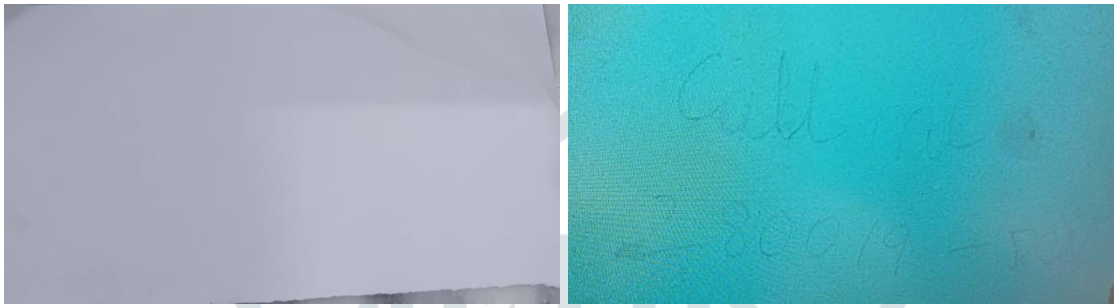

Mouth wash sample is visible under UV wavelength of 625-655nm and Heat treatment.




Ketchup sample is visible under UV wavelength of 254nm and Heat treatment.

Chalk piece powder sample is visible under UV wavelength of 254nm.


Chilli powder sample is visible under UV wavelength of 254nm.



Sugar solution sample is visible under UV wavelength of 254nm.

| S.no. | Sample. | Wavelength. | | | | | Heat Treatment. |
|---|---|---|---|---|---|---|---|
| | | 400nm | 365nm | 313nm | 254nm | 625-655nm | |
| 1. | Toothpaste. | × | × | × | × | ✓ | ✓ |
| 2. | Ariel liquid. | × | × | × | × | ✓ | × |
| 3. | Cola. | × | × | × | ✓ | × | ✓ |
| 4. | Comfort. | × | × | × | ✓ | × | Slightly visible |
| 5. | Shampoo. | × | × | × | × | ✓ | ✓ |
| 6. | Conditioner. | × | × | × | ✓ | × | Slightly visible |
| 7. | Rose water. | × | × | × | ✓ | × | × |
| 8. | Face wash. | × | × | × | × | ✓ | × |
| 9. | Tamarind. | × | × | × | ✓ | × | ✓ |
| 10. | Mouth wash. | × | × | × | × | ✓ | ✓ |
| 11. | Ketchup. | × | × | × | ✓ | × | ✓ |
| 12. | Chalk piece powder. | × | × | × | ✓ | × | × |
| 13. | Chilli powder. | × | × | × | ✓ | × | × |
| 14. | Sugar solution. | × | × | × | ✓ | × | × |

Table no.5 representing the UV wavelengths of Other samples.

## Conclusion:-

The utilization of Ultraviolet light (UV) and heat treatment for deciphering secret writings presents an effective and non-invasive method for revealing hidden texts. UV light can expose writings made with materials that fluorescence under such illumination, often invisible under normal light. Heat treatment, on the other hand, can make writings visible by causing certain substances to undergo chemical changes that alter their colour or opacity. Together, these offer a powerful combination for forensic analysis, historical document examination, and authentication process. By enabling the recovery of hidden information without damaging the original documents, these methods provide significant value in various fields, from criminal investigations to the preservation of cultural heritage.

The combination of UV light and heat treatment offers a non-invasive and non-destructive approach to deciphering secret writings, preserving the integrity of the original documents while unlocking valuable historical information. This method has been employed successfully in various studies and research projects, demonstrating its efficacy in revealing hidden texts and codes.

Overall, the use of UV and heat treatment in deciphering secret writings has advanced the field of cryptanalysis and historical preservation, providing new insights into ancient cultures, languages, and societies. Further research and technological advancements in this area will continue to enhance our ability to uncover and interpret hidden messages in historical documents, contributing to our understanding of the past.

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