A Study on Concealed Writing Using Daily Commodities and Their Visibility over a Period of Time

Ms. Siri G Bharadwaj [1], Ms. Sonika. R[2] and Mrs. Gloria Christal [3]

Student , Jain (Deemed To Be University)
Student , (Deemed To Be University)
Assistant Professor, (Deemed To Be University)

Abstract

Secret messages were created on paper using four different liquids such as body perfume, body lotion, lens cleaner, and washing liquid. A total of 28 samples were prepared, with each liquid tested in two distinct ratios. The current research paper aims to study whether certain personal care products such as body perfume and body lotion, health care products such as lens cleaner, and laundry detergents such as washing liquid have the potential to function as invisible inks and be created for use in practical applications. The durability of the secret messages made using these products was also examined, and only physical techniques were adopted for visualizing hidden messages. The purpose of the study is to determine whether any other fluid, in addition to organic fluids, can also be used.

KEYWORDS *- Perfume, washing liquid, lens cleaner, body lotion, heat, visibility, durability.*

Introduction

The examination of questioned documents stands as a critical investigative tool in the field of forensic science to unravel mysteries concealed within the written word. Among the various obstacles confronted by document examiners, the presence of secret writing adds an intriguing dimension to the investigation. The term "secret writing" refers to any form of writing that is not visible or readable to other people. Deciphering it requires either the use of a suitable light source or equipment, the application of heat, or the application of a chemical treatment that is designed for the purpose. Inks that remain unseen until exposed through a specific process, known as invisible inks, serve the purpose of secret writing. These liquids are used to write hidden messages, which only become visible when exposed to a certain way of revealing. These inks are used for the purpose of hidden writing. Invisible inks have a long history of being exploited during times of war by both governmental authorities and insurgents. After a short amount of time, the ink that is generated will no longer be visible to the human eye. On the other hand, this concealed message can be uncovered by subjecting it to an appropriate amount of heat that is administered precisely to the characters being discussed. **(1)**

The use of these liquids allows for the writing of concealed messages, which are visible only after being exposed to a particular method of exposure. There are three primary categories of invisible inks: (i) Revealed by heat - you can use a spirit lamp or lighter, iron the paper. After some time, you can see the character appear. (ii) Revealed by chemical interactions - These inks are not visible because you must know how to reveal them. Most of them work using pH indicators. We can decipher them by using certain chemicals that react with them to make them visible in an acidic condition (ex., lemon juice). (iii) Revealed by UV light - Certain invisible inks can be developed to fluoresce, or emit light, in response to radiation wavelengths, therefore becoming visible. Certain compounds may undergo chemical reactions when exposed to radiation, changing the ink's color or visibility. Radiation may be detected by the invisible ink if it absorbs it and subsequently emits it at a different wavelength.

Secret writing is the process of writing a message on paper with various liquids and then letting it dry. The resulting ink soon loses its ability to be seen with the naked eye. However, by applying a

moderate amount of heat on the characters individually, this hidden message can be made visible. According to the literature review, invisible inks have been classified as sympathetic and organic fluids, indicating that this classification is feasible. Furthermore, this classification is feasible, according to the review. Organic fluids, which come from natural sources (such as salivs, milk, vinegar, and lemon juice), are often thought to be simple. For example, citrus juice, such as lemon juice, frequently leaves no visible residue when dried. Writing created using organic invisible inks may become visible when heated, heated with an iron, exposed to ultraviolet light, or undergoes other chemical reactions. Conversely, sympathetic inks can be identified from other kinds of inks by their complicated chemical makeup. To reveal the contents of these inks, which could consist of one or more compounds, reagents must be used. Synthetic invisible inks are frequently activated by subjecting them to particular radiation types, including UV light, which causes them to glow or alter their optical characteristics. Our study intends to determine whether certain commonly used fluids, such as those included in laundry, personal care, and pharmaceutical products, have the capacity to operate as invisible inks and be created for use in real-world applications. The study suggests that the fluorescence of the invisible ink is comparable to that of detergents. Fluorescent chemicals in some detergent formulas increase the visibility of stains on clothing when exposed to UV light. Similar to this,under specific circumstances, the invisible ink exhibits a distinctive light that indicates its existence. The samples utilized in this study are Body Perfume, Body Lotion, Lens Cleaner and Cloth Washing Liquid.

Methodology

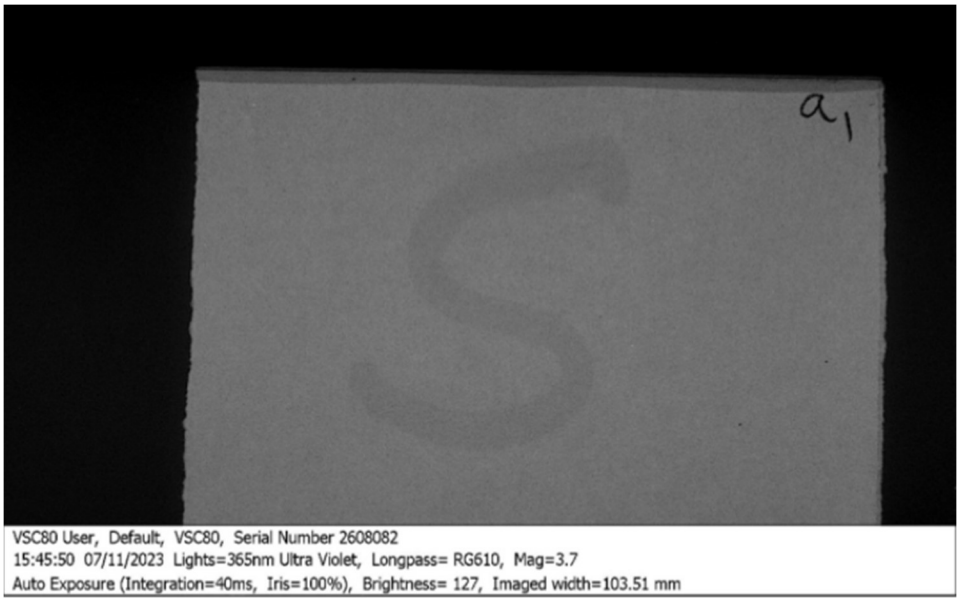
Materials required: - Body perfume, Body lotion, Washing liquid, Lens cleaner, paper, cotton swab, candle. The samples were prepared in two ratios. A cotton swab was taken, and it was dipped in the 1:10 ratio solution of the sample and a single character was written on a small sheet of paper, the character chosen was that of letter “S”. The same procedure was followed for the 1:20 ratio solution of the sample as well. The character written on the paper was allowed to air dry in room conditions and no other source was used for the same. 14 samples of each ratio were made of each of the liquids that is for perfume, washing liquid, body lotion and lens cleaner. The samples of ratio 1:10 were marked in uppercase letters **(Andharmule et al., 2013)** that is A for perfume, B for washing liquid, C for body lotion and D for lens cleaner. The samples of 1:20 ratio was marked in lowercase letters **(Ss & Sahu M, 2017)** that are from a –d. The secret writings were deciphered using physical methods only such as UV and HEAT for a period of 13 days using video spectral comparator. **(Rohatgi et al., n.d.)** The analysis was done from the day of preparation of the samples which was considered as day 0 and the analysis was continued to be done until day 13. **(Sri Shreya & Pooja Yadav, 2023)**

RESULTS

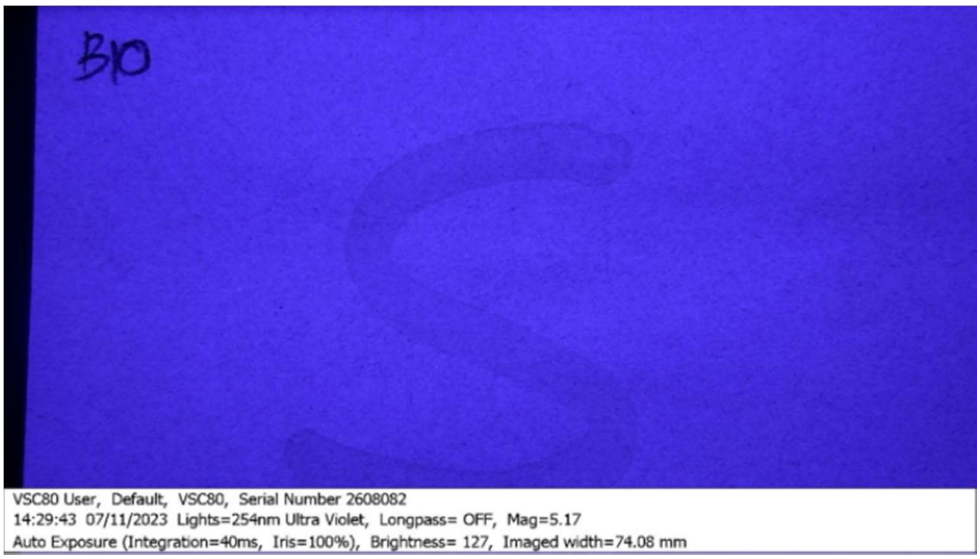
The tables below use the following notations to indicate character visibility: C – Clear, PC –
Partially Clear, 50 Below – Visibility below 50%, and NV – Not Visible, indicating that the character was not distinct enough to assess accurately.

(i) Images of sample of 1:10 ratio

SAMPLE A – UV

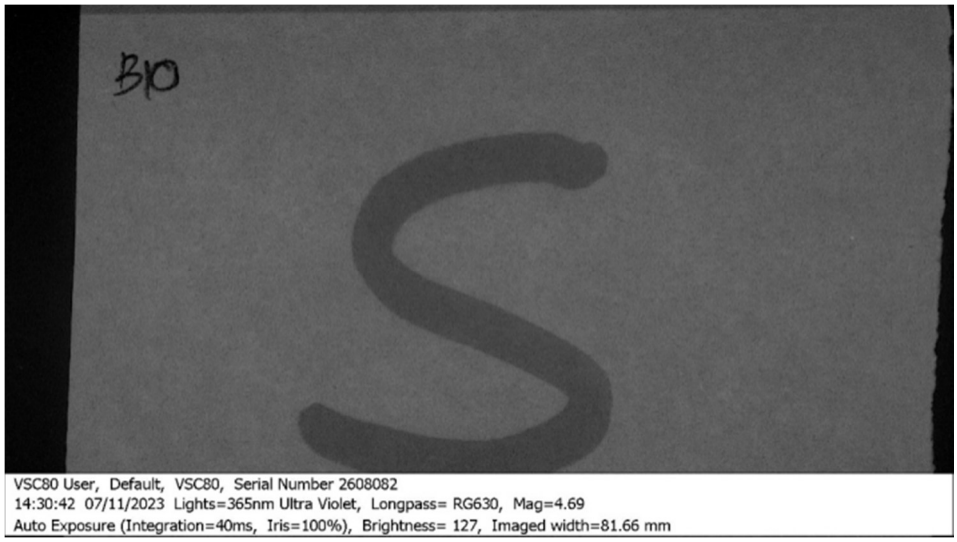


SAMPLE A- UV+IR

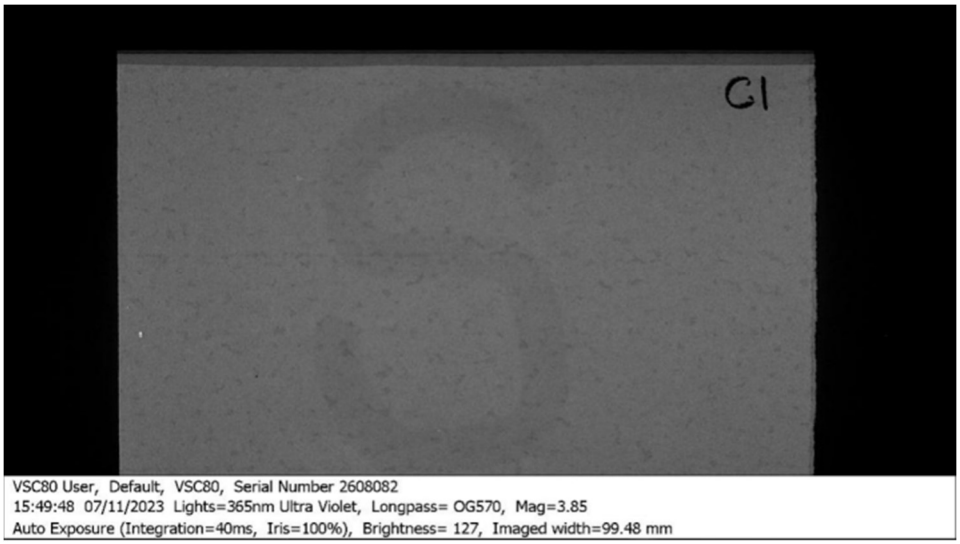


SAMPLE B – UV

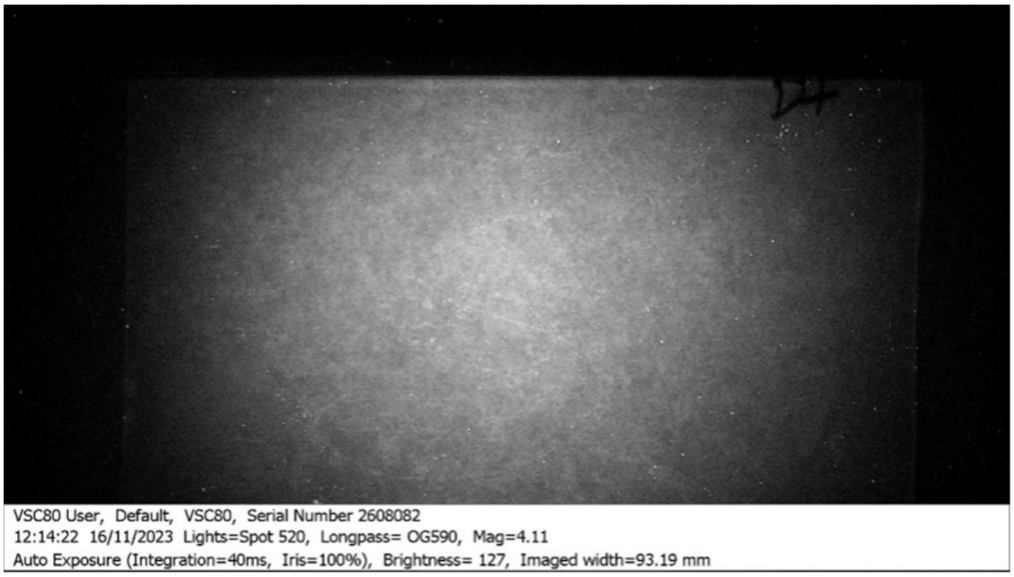
SAMPLE B – IR



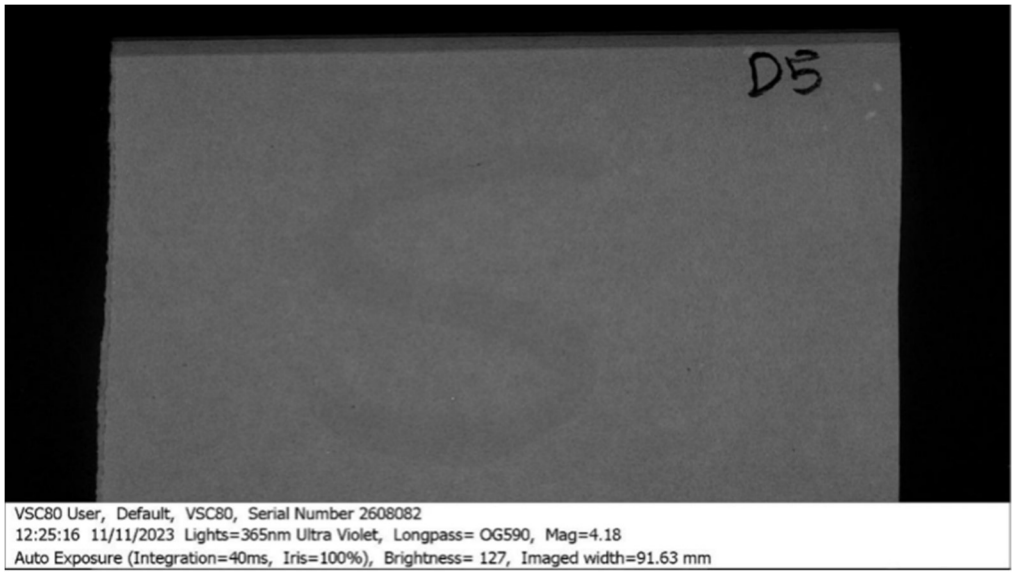
SAMPLE B - UV+IR



SAMPLE C - UV+IR



SAMPLE D – IR



SAMPLE D - UV+IR

TABLE 1- The results of the secret writing made using perfume in 1:10 ratio are as follows:

RATIO 1:10	PERFUME (A1 -A14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	PC	-	-	50 BELOW - RG645	PC (312nm+ OG 570) & (365nm+O G 570)	PC
DAY 1	50 BELOW	-	-	50 BELOW- RG 630	PC (365nm+O G 590)	C

DAY 2	PC	-	-	50 BELOW (RG 630)	PC (365nm+RG 610)	PC
DAY 3	50 BELOW	-	-	50 BELOW (RG 610)	PC (365nm+OG 570)	PC
DAY 4	PC	-	-	50 BELOW (RG 645)	PC (365nm+ OG 570), 50 BELOW (312nm +OG 570)	NV
DAY 5	50 BELOW	-	-	-	PC (365nm+ RG 610_	PC
DAY 6	C	-	-	-	PC (365nm+OG 570)	NV
DAY 7	PC	-	-	-	PC (365nm+OG 570)	C
DAY 8	PC	-	-	50 BELOW (RG 610)	PC (365nm+OG 590)	NV

DAY 9	PC	-	-	-	PC (365nm+OG 590)	C
DAY 10	-	PC	-	-	PC (365nm+OG 590)	C
DAY 11	-	50 BELOW	-	-	PC (365nm+OG 590)	C
DAY 12	50 BELOW	-	-	-	PC (365nm+OG 590)	C
DAY 13	-	PC	-	-	PC (365nm+OG 570)	C

TABLE 2- Visualization of secret writing made using washing liquid in 1:10 ratio by physical methods.

RATIO 1:10	WASHING LIQUID (B1-B14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT

DAY 0	C	-	-	C (OG 590)	NV	C
DAY 1	C	-	-	C (OG 590)	C (254nm+RG 630)	C
DAY 2	C	-	-	C (OG 590)	PC (312nm +OG 590), C (365nm+RG 645)	C
DAY 3	C	-	-	C (OG 590)	C (312nm +OG 590)	C
DAY 4	C	-	-	C (RG 630)	PC (312nm +OG 590), C (365nm+RG 630)	C
DAY 5	C	-	-	C (OG 590)	PC (312nm+RG 610), C (365 nm +RG 630)	C
DAY 6	C	-	-	C (OG 590)	PC (312nm+	C

					OG 570), C (365nm+R G 630)	
DAY 7	C	-	-	C (OG 590)	C (312nm +OG 570), C (365nm+R G 645)	C
DAY 8	C	-	-	C (RG 610)	PC (312nm +OG 570), C (365nm+R G 645)	C
DAY 9	C	-	-	C (RG 630)	PC (312nm+ OG 570), C (365nm+R G 630)	C
DAY 10	C	-	-	C (RG 610)	PC (312nm+ OG 570), C	C

					(365nm+RG 630)	
DAY 11	C	-	-	C (OG 590)	PC (312nm +OG 570), C (365nm+RG 645)	C
DAY 12	C	-	-	C (RG 610)	PC (312nm+ OG 570), C (365nm+RG 630)	C
DAY13	C	-	-	C (RG 630)	PC (312nm+ OG 570), C (365nm+RG 630)	C

TABLE 3- Visualization of secret writing made using body lotion in 1:10 ratio by physical methods.

RATIO 1:10	BODY LOTION (C1- C14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	-	-	-	-	PC (365nm+OG 570)	PC
DAY 1	-	-	-	-	PC (365nm+OG 590)	PC
DAY 2	-	-	-	-	PC (365nm+RG 610)	PC
DAY 3	-	-	-	-	50 BELOW (365nm+OG 590)	NV
DAY 4	-	-	-	-	PC (365nm+RG 610)	PC
DAY 5	-	-	-	-	PC (365nm+OG 590)	PC

DAY 6	-	-	-	-	PC (365nm+OG 590)	PC
DAY 7	-	-	-	-	PC (365nm+OG 590)	PC
DAY 8	-	-	-	-	PC (365nm+RG 610)	PC
DAY 9	-	-	-	-	PC (365nm+OG 590)	C
DAY 10	-	-	-	-	PC (365nm+OG 590)	PC
DAY 11	-	-	-	-	PC (365nm+OG 590)	PC
DAY 12	-	-	-	-	PC (365nm+RG 610)	PC
DAY13	-	-	-	-	PC (365nm+OG 590)	PC

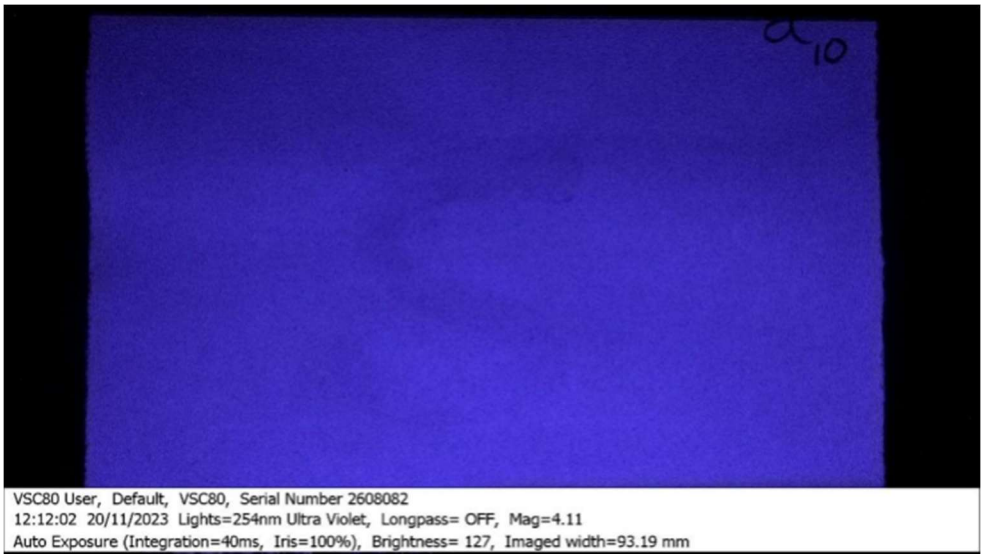
TABLE 4 - Visualization of secret writing made using lens cleaner in 1:10 ratio by physical methods.

RATIO 1:10	LENS CLEANER (D1-D14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	-	-	-	-	50 BELOW (365nm+ OG 570)	C
DAY 1	-	-	-	-	PC (365nm+ OG 590)	C
DAY 2	-	-	-	-	PC (365nm+ OG 590)	C
DAY 3	-	-	-	-	50 BELOW	C

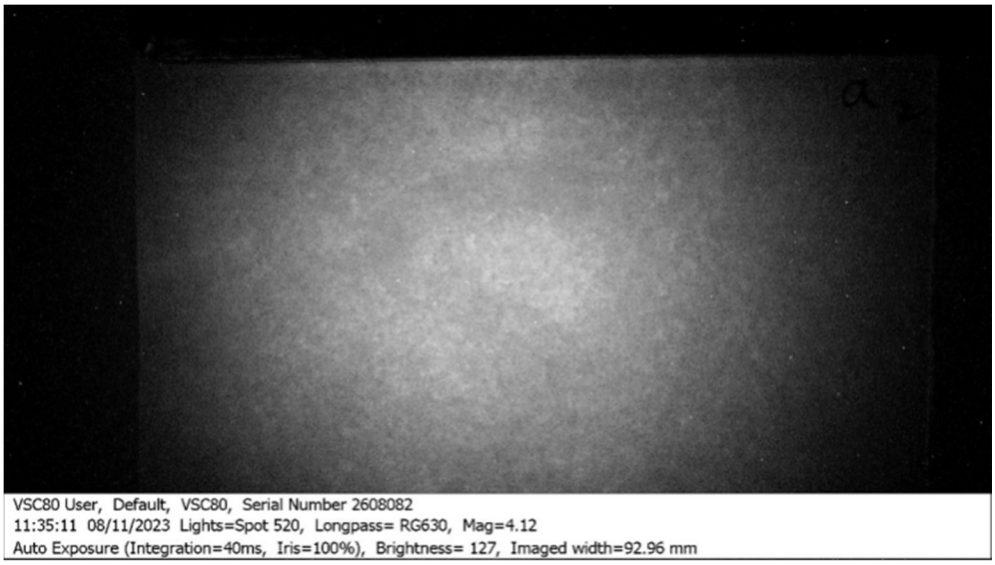
					(365nm+RG 610)	
DAY 4	-	-	-	-	PC (365nm+ OG 590)	C
DAY 5	-	-	-	50 BELOW (OG 590)	PC (365nm+ OG 610)	C
DAY 6	-	-	-	PC (OG 590)	PC (365nm+RG 610)	C
DAY 7	-	-	-	50 BELOW (OG 590)	PC (365nm+RG 610)	C
DAY 8	-	-	-	-	PC (365nm+RG 610)	C

DAY 9	-	-	-	-	PC (365nm+ OG 590)	C
DAY 10	-	-	-	-	PC (365nm+ OG 590)	C
DAY 11	-	-	-	50 BELOW (OG570)	PC (365nm+ OG 590)	C
DAY 12	-	-	-	-	PC (365nm+ OG 590)	C
DAY 13	-	-	-	50 BELOW (OG590)	PC (365nm+ OG 590)	C

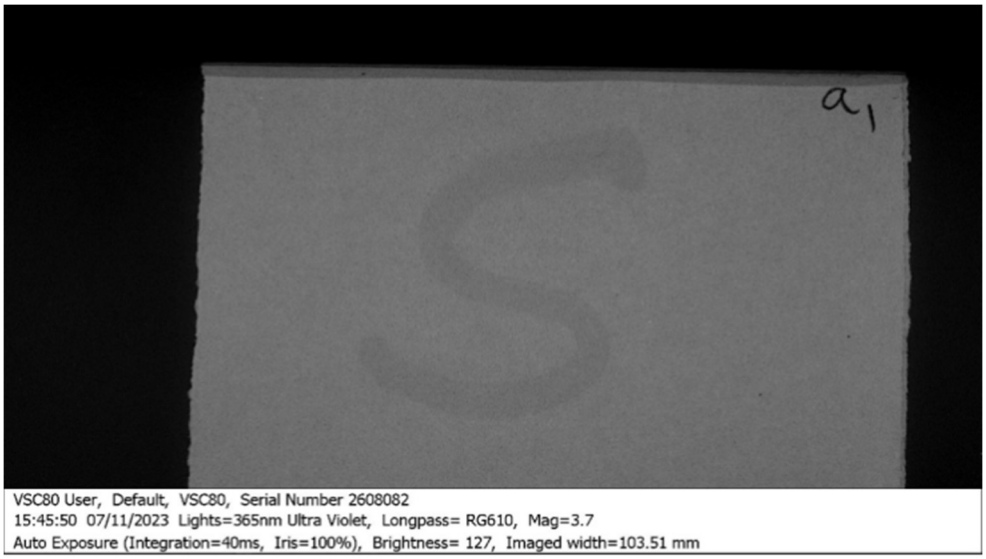
(ii) Images of sample of 1:20 ratio



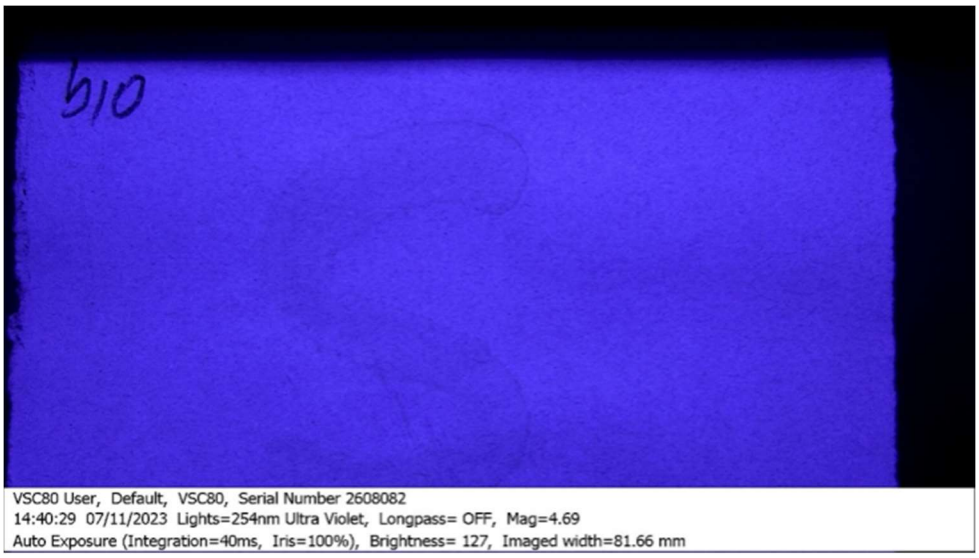
SAMPLE a – UV



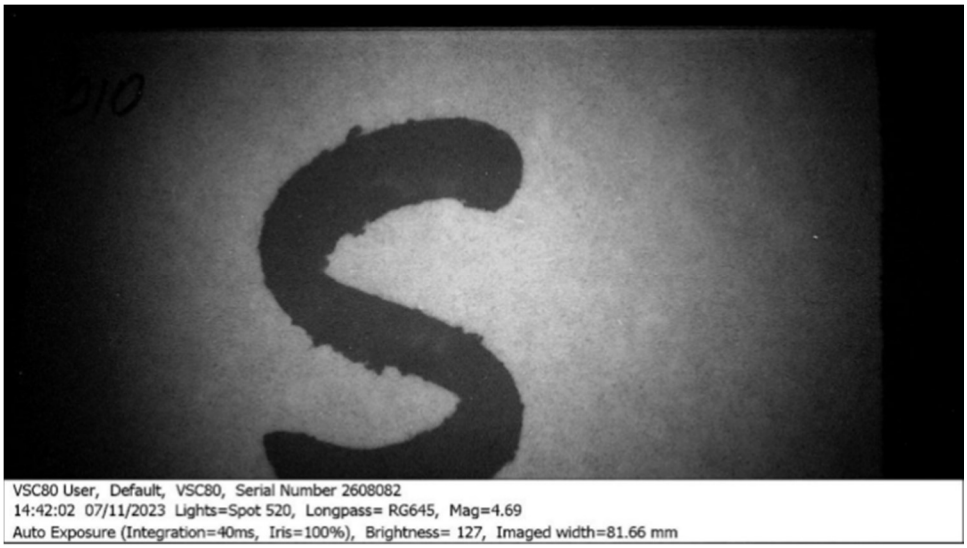
SAMPLE a - IR



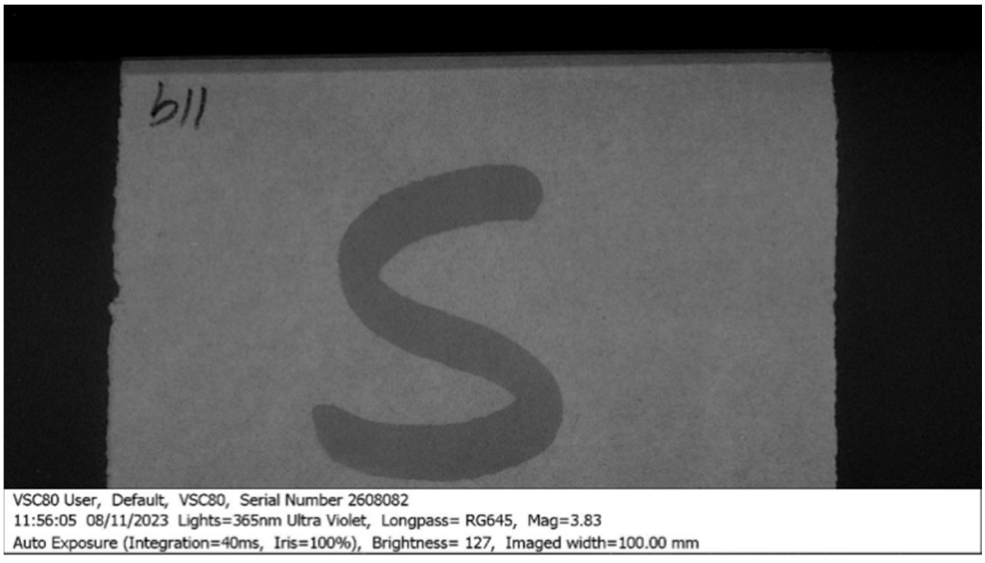
SAMPLE a - UV+IR



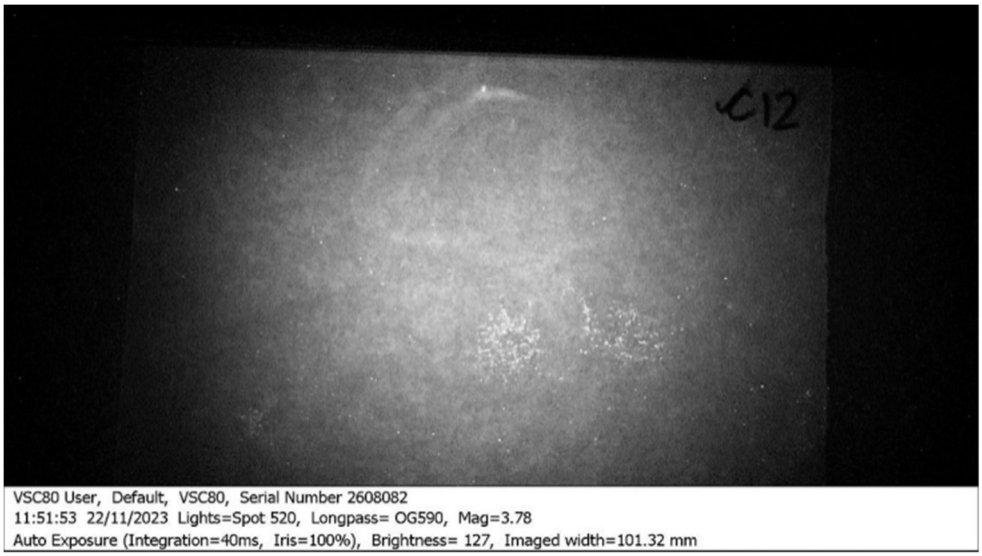
SAMPLE b – UV



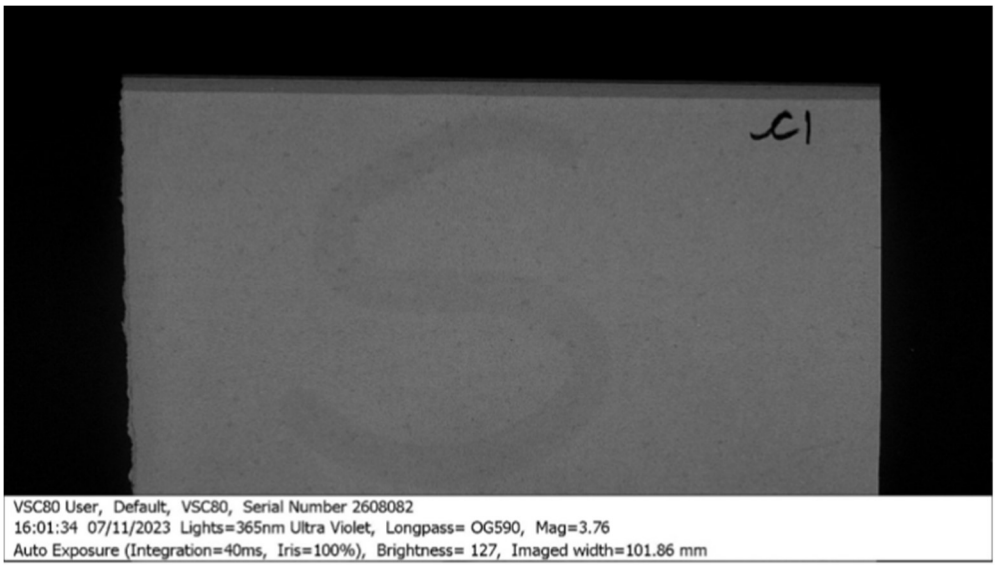
SAMPLE b – IR



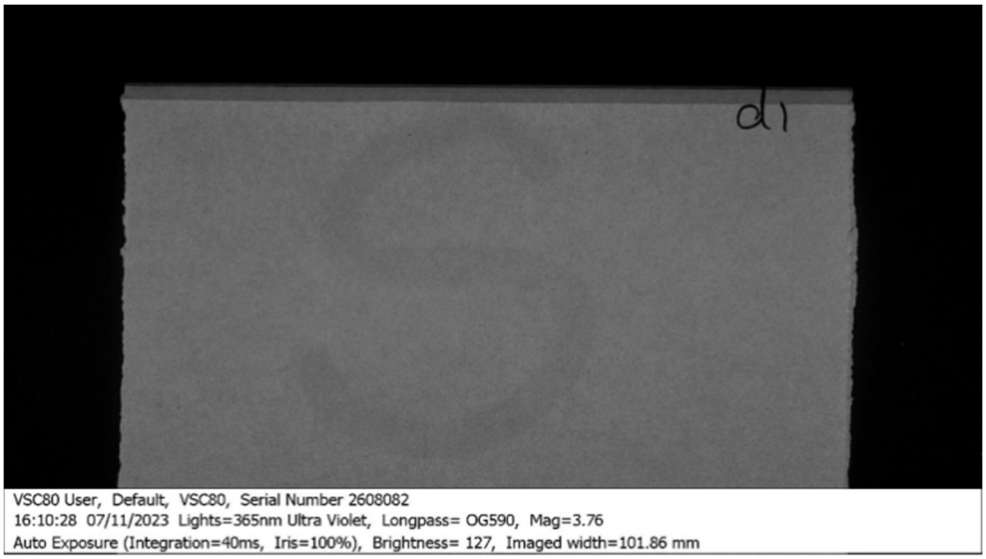
SAMPLE b – UV+IR



SAMPLE c - IR



SAMPLE c - UV+IR



SAMPLE d - UV+IR

TABLE 5- Visualization of secret writing made using perfume in 1:20 ratio by physical methods.

RATIO 1:20	PERFUME (a1- a14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT

DAY 0	PC	-	-	50 BELOW-RG 630	50 BELOW (312nm+OG 570), C(365nm+RG610)	C
DAY 1	50 BELOW	-	-	50 BELOW-RG 630	50 BELOW (312nm+OG 570), PC (365nm+OG 590)	PC
DAY 2	50 BELOW	-	-	-	PC (365nm+OG 590)	C
DAY 3	50 BELOW	-	-	-	50 BELOW (365nm+OG 570)	PC
DAY 4	50 BELOW	-	-	-	50 BELOW (365nm+OG 590)	NV

DAY 5	50 BELOW	-	-	-	PC (365nm+RG 610)	PC
DAY 6	50 BELOW	-	-	50 BELOW - OG 590	PC (365nm+OG 590)	C
DAY 7	50 BELOW	-	-	-	PC (365nm+OG 590)	C
DAY 8	50 BELOW	-	-	-	PC (365nm+RG 610)	C
DAY 9	PC	-	-	-	PC (365nm+OG 590)	C
DAY 10	-	PC	-	-	PC (365nm+RG 610)	C

DAY 11	-	50 BELOW	-	-	PC (365nm+OG 590)	C
DAY 12	-	50 BELOW	-	-	PC (365nm+OG 590)	C
DAY 13	-	-	-	-	PC (365nm+OG 590)	C

TABLE 6 - Visualization of secret writing made using washing liquid in 1:20 ratio by physical methods.

RATIO 1:20	WASHING LIQUID (b1 -b 14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	C	-	-	C - OG 590	C (365nm+RG 645)	C

DAY 1	PC	-	-	C - OG 590	C (365nm+RG 645)	C
DAY 2	PC	-	-	C - OG 590	PC (312nm+OG 590), C (365nm+RG 610)	C
DAY 3		-	-	C - OG 590	PC (312nm+OG 570), C (365nm+RG 630)	C
DAY 4	50 BELOW	-	-	C - RG 630	PC (312nm+OG 590), C (365nm+RG 630)	C
DAY 5	PC	-	-	C - RG 610	PC (312nm+OG 590), C (365nm+RG 630)	C
DAY 6	PC	-	-	C - OG 590	PC (312nm+OG 570), C	C

					(365nm+RG 630)	
DAY 7	50 BELOW	-	-	C - OG 590	C (312nm+OG 590), C (365nm+RG665)	C
DAY 8	PC	-	-	C - RG 610	PC (312nm+OG 590), C (365nm+RG 645)	C
DAY 9	PC	-	-	C - RG 645	50 BELOW (312nm+OG 570), C (365nm+RG 645)	C
DAY 10	50 BELOW	-	-	C - OG 590	PC (312nm+OG 590), C (365nm+RG 645)	C

DAY 11	PC	-	-	C - OG 590	PC (312nm+RG 610), C (365nm+RG 645)	C
DAY 12	50 BELOW	-	-	C - OG 590	PC (312nm+OG 590), C (365nm+RG 645)	C
DAY 13	50 BELOW	-	-	C - OG 590	PC (312nm+OG 590), C (365nm+RG 645)	C

TABLE 7 - Visualization of secret writing made using body lotion in 1:20 ratio by physical methods.

RATIO 1;20	BODY LOTION (c1- c14)					
DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 1	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 2	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 3	-	-	-	-	PC (365nm+ OG 590)	PC

DAY 4	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 5	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 6	-	-	-	-	PC (365nm+ OG 590)	C
DAY 7	-	-	-	-	PC (365nm+ OG 590)	C
DAY 8	-	-	-	-	PC (365nm+ OG 590)	NV
DAY 9	-	-	-	-	PC (365nm+ OG 590)	C

DAY 10	-	-	-	-	PC (365nm+ OG 590)	C
DAY 11	-	-	-	50 BELOW - OG 590	PC (365nm+R G 610)	C
DAY 12	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 13	-	-	-	50 BELOW - OG 590	PC (365nm+R G 610)	C

TABLE 8 - Visualization of secret writing made using lens cleaner in 1:20 ratio by physical methods.

RATIO 1:20	LENS CLEANER (d1-d14)

DAY	UV SHORT	UV MEDIUM	UV LONG	IR	UV +IR	HEAT
DAY 0	-	-	-	-	PC (365nm+ OG 590)	C
DAY 1	-	-	-	-	PC (365nm+R G 610)	C
DAY 2	-	-	-	-	PC (365nm+ OG 590)	C
DAY 3	-	-	-	-	PC (365nm+R G 610)	PC
DAY 4	-	-	-	-	PC (365nm+ OG 590)	C

DAY 5	-	-	-	-	PC (365nm+ OG 590)	C
DAY 6	-	-	-	-	PC (365nm+R G 610)	PC
DAY 7	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 8	-	-	-	-	PC (365nm+ OG 590)	PC
DAY 9	-	-	-	-	PC (365nm+ OG 590)	NV
DAY 10	-	-	-	-	PC (365nm+R G 610)	PC

DAY 11	-	-	-	-	PC (365nm+ OG 590)	NV
DAY 12	-	-	-	-	50 BELOW (365nm+ OG 590)	C
DAY 13	-	-	-	-	PC (365nm+ OG 590)	NV

Discussion

The samples were analyzed using physical methods only such as UV and heat with the help of the instrument VSC-8000. **(Vivekkumar Mangilal Chayal et al., 2019)** Three different ranges of UV were used to analyze the samples such as UV-SHORT that is 254nm, UV- MEDIUM that is 312nm, and UV-LONG that is 365nm. Various IR filters were also used to analyze the samples. **(Malik et al., n.d.)** UV and several IR filters together were used to analyze the samples, as few of the samples were not visible in both UV and IR respectively such as body lotion and lens cleaner. The samples were also subjected to heat for the decipherment of the secret writing. The secret writing samples marked as A1 –A14 **(table 1)** were analyzed in three different UV wavelengths. The visibility of the character mostly ranged from being partially clear to 50% below from day 0 to day 13 in the UV SHORT range, but the character's visibility varied for each day, but only on day 6 the character was found to be clear. The character was only visible in

UV SHORT wavelength on the days marked as 0,1,2,3,4,5,6,7,8,9 and 12. The character was visible on UV MEDIUM wavelength on day 10, day 11 and day 13 only. The character was not visible in the UV LONG range. The visibility of the character was only found to be 50 % below in the IR range. The character was found to be partially clear only on most of the days in the UV +IR range, but on day 4 it showed a variation of being partially clear in one of the UV+IR range and 50 %below in another UV +IR range. The samples were subjected to heat, and the results varied for each day as shown in the table. The character visibility ranged from being partially clear to clear, but on day 4, day 6 and day 8 the character was not visible when subjected to heat. The secret writing samples marked as B1 –B14 **(table 2)** were also analyzed in three different UV wavelengths. The character was clearly visible in UV SHORT wavelength on all the days showing no variation in the results. The character was not visible in the UV MEDIUM and UV LONG range. The character was clearly visible on all the days in the IR range, showing no variation in the results. The character was not visible in the UV +IR range on day 0 but it was found to be visible from day 1. The results varied for each day from being partially clear and clear on one day to being only clear on the next day. The samples were subjected to heat, and the results were constant as shown in the table. On analyzing the samples marked as C1 –C14 **(table 3),** it was found out that the character written was not visible in any of the UV ranges. The character was also not visible in the IR range. The character was only visible in the UV+IR range, and the character was mostly found to be partially clear. But on day 3 only, the visibility of the character was found to be 50% below, showing a variation in the visibility of the character. The samples were subjected to heat, and the visibility of the character seemed to vary, that is from day 0 to day 2 the character was partially clear, whereas on day 4 the character was not visible. The character was again found to be partially clear from day 5 to day 8 and day 10 to day 13, but it showed a slight variation on day 9 only, where the character was clearly visible. On analyzing the samples marked as D1–D14 **(table 4)**, it was found out that the character written was not visible in any of the UV ranges. The character was initially not visible in the IR range, but the character was seen 50% below on days 5, day 7, day 11 and day 13 and was partially clear on day 6. The character was again not visible from day 8 to day 10 and also on day 12. The character showed a visibility of 50% below and partially clear from day 0 to day 13 in the UV+IR range, but it did not show constant results initially. On day 0 and day 3, the character was visible in 50% below range, whereas it was partially clear on day 1, day 2 and the other days. The samples were subjected to heat, and the character was clearly visible from day 0 to day 13, showing no variation in the visibility of the character. Heat proves to be one of the most reliable methods for the decipherment of secret writing in this study **(Malik et al., n.d.)** because the character written using the sample D that is lens cleaner was not visible in any of the ranges of UV, it was also not found to be visible in any of the IR filters, even though the character was visible in UV+IR ranges it was found to be more visible through heat only. **(Shivanjali S. Ramugade & Manjushree S. Bagul, 2024).**

On analyzing the samples marked as a1–a14 **(table 5),** the visibility of the character was mostly found to be 50% below in UV SHORT range and the character was partially clear on day 0 and day9 only. The character was not visible from day 10 to day 13. The character visibility varied from 50% below and partially clear in the UV MEDIUM range. The character was not visible in the UV LONG range. The character was visible at 50%below in the IR range on day 0, day 1 and day 6, not showing any results on the other days. The character was clearly visible on day 0 in one of the ranges of UV and IR, whereas it showed 50% below visibility in another range. The variation between 50% below and partially visible was seen from day 0 to day 4. The visibility of

the characters did not show a variation from day 5 to day 13, they were only found to be partially clear. The samples were subjected to heat, and the character was clearly visible on day 0 and day 2, and from day 6 to day 13, showing a variation in the visibility of being partially clear on the other days and not visible on day 4.On analyzing the samples marked as b1–b14 **(table 6)**, it was observed that the character written was not visible in UV MEDIUM and UV LONG. The visibility of the character varied between partially clear and 50% below in the UV SHORT range. The character was clearly visible on all the days in the IR range. The character was visible on day 0, day 1 and day 7 in the UV and IR range, and from day 2 to day 13, the character was found to be both clear and partially visible.The samples were subjected to heat, and the character was clearly visible on all the days.

On analyzing the samples marked as c1–c14 **(table 7),** it was observed that the character written was not visible in any of the UV ranges. The character was initially not visible in the IR range, but it showed a visibility of 50% below on days 11 and 13. The character was partially visible on all days in the UV+IR range. The samples were subjected to heat, and the character was partially visible from day 0 to day 5, but it was observed from day 6 to day 13 that the character showed a variation between being clearly visible and partially visible. On analyzing the samples marked as d1 and d14 (**table 8)**, it was observed that the character was not visible in any of the UV range, and the character was partially visible on most of the days in the UV+IR range except on day 12, which showed 50 below. The samples were subjected to heat, and there were variations seen in the results from being visible, partially visible, and not visible.

Conclusion

Based on the results obtained in this study, it was found out that products such as perfume, washing liquid, body lotion and lens cleaner could also be utilized to make secret writings. The character was observable throughout the 13 days of the study conducted. Deciphering the secret writing through heat was found to be the most reliable method, because in the sample lens cleaner of 1:10 ratio, the character was not found to be visible in any of the UV range and IR range. Irrespective of the character being visible in UV+IR range, the visibility of the character was found to be more prominent comparatively in heating method.

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