J Forensic Sci, Nov. 2004, Vol. 49, No. 6
Paper ID JFS2003422
Available online at: www.astm.org

TECHNICAL NOTE

Shigeru Sugawara,[1] *M.S.*

Comparison of Near Infrared Light Photography and Middle Infrared Light Photography for Deciphering Obliterated Writings*

ABSTRACT: There are obliterated writings that are undecipherable by conventional visible and near infrared monochromatic light photography. Some of them could be deciphered undestructively by middle infrared light photography. Characters were written on paper with 101 kinds of pens. Middle infrared light photographs and near infrared light photographs of them were taken and compared to recognize what kinds of inks is transparent at examined wavelength regions. Based on the results obtained, the combination of ink for drawing and obliterating (which is not deciphered by visible and near infrared light photography, but expected to be deciphered with middle infrared light photography) is selected. From the examined photographs, it is demonstrated that there exist obliterated writings which are undecipherable by conventional near infrared light photography, but decipherable by middle infrared light photography.

KEYWORDS: forensic science, questioned document, decipherment, obliterated writing, middle infrared light photography, thermography, VSC

Visible and near infrared monochromatic light photography (wavelength: 0.4–1 μm) (1–3), is an outstanding technique to decipher an obliterated writing undestructively and quickly. However, there are obliterated writings undecipherable by this technique. The decipherability is dependent on the combination of inks used for writing and obliteration.

Although the chemical method using solvents (4) and the autoradiography method (5) were proposed as methods to decipher obliterated writings, these methods damage samples.

It is very important in the criminal investigation to develop technique that is undestructive and able to decipher obliterated writings undecipherable by the conventional methods.

The absorption mechanism for ink in the case of the middle infrared light (wavelength: 2.5–13 μm) is very different from that in the case of the visible and near-infrared light (wavelength: 0.4–1μm). The middle infrared light absorption is attributed to the molecular vibration excitation, while the visible and near infrared light absorption is attributed to the electronic excitation from valence band to conduction band. Therefore, obliterated writings undecipherable by the conventional methods are possibly deciphered undestructively by the middle infrared light photography.

[1] Fourth Forensic Department, National Research Institute of Police Science, Kahiwanoha 6-3-1, Kashiwa, Chiba, Japan.

* Presented at the 8th Annual Meeting of the Japanese Association of Science and Technology for Identification, Tokyo, 7–8 Nov. 2002.

Received 21 Dec. 2003; and in revised form 24 Apr. and 3 July 2004; accepted for publication 3 July 2004; published 6 Oct. 2004.

Material and Methods

Middle infrared light photography was performed with the optical system as shown in Fig. 1. An infrared thermography (TVS-8500 type made by Nippon Avionics Co., Ltd.) was used as camera. It was equipped with a InSb semiconductor detector and a band path filter in front of lens. The filter transmitted light of wavelength 3.5–4.1 μm and 4.5–5.1 μm. A tungsten lamp was used as light source. The light source was turned on just before taking a photograph. Because infrared rays warm inks, and warmed inks emit infrared radiation to disturb the photograph. Immediately after light source lighting, infrared emission of ink was weaker than reflected light and absorbed light. However, after several seconds, infrared emission of ink became stronger than reflected light and absorbed light. This was not the case in near infrared light photography. This problem seemed to be more important in longer wavelength light photography.

Visible and near infrared light photography was performed with VSC-2000 (Foster & Freeman Ltd.). Figure 2 shows its optical system. The camera was equipped with a Si semiconductor detector and wavelength variable interference filters in front of lens. A narrow band path filter and a wide band path filter were used. The narrow band path filter has the half-width of 40 nm and central wavelength varying from 0.4 to 1 μm. The wide band path filter transmitted visible light of wavelength 0.4–0.63 μm. A tungsten lamp was used as light source.

One hundred and one kinds of six manufacturers' black pens as shown in Table 1 including 42 kinds of ball-points, 58 kinds of marking pens, and one kind of brush pen were examined. The information about solvents (water, oiliness, or gel) and coloring matters (dye or pigment) of the inks used in these pens were collected from catalogs and manufacturers. All characters were drawn on recycled

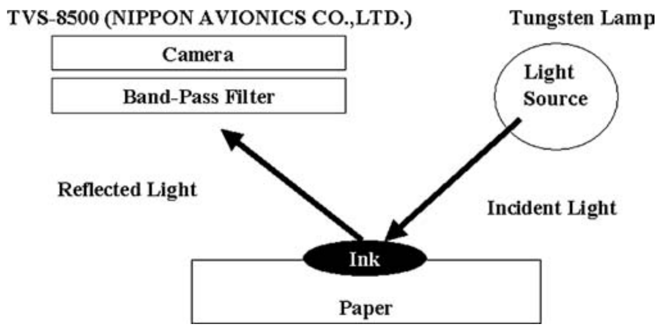

FIG. 1—*Optical system for middle infrared light photography (wavelength 3~5 µm). Incident light is not monochromatic.*

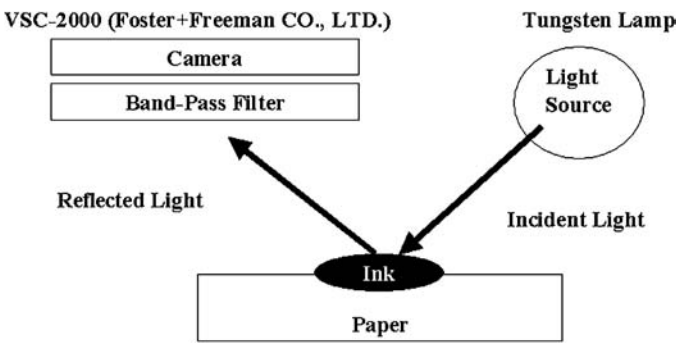

FIG. 2—*Optical system for visible and near infrared light photography (0.4□1 µ□). Incident light is not monochromatic.*

TABLE 1—*Pens used in the study.*

		Solvent		Coloring Matter	
Ballpoint pen	42	water-soluble	17	dye	5
				pigment	4
				unknown	8
		oil-soluble	15	dye	0
				pigment	0
				unknown	15
		gel	10	dye	0
				pigment	5
				unknown	5
Marking pen	58	water-soluble	26	dye	6
				pigment	15
				unknown	5
		oil-soluble	31	dye	19
				pigment	5
				unknown	7
		gel	1	dye	0
				pigment	0
				unknown	1
Brushing pen	1	water-soluble	1	pigment	1

papers for copying machines made by NBS Ricoh Co., Ltd. "my recycling paper 100W (A4T)."

Procedure of Experiment 1 (Examination of Inks to Select Pens Used in the Experiment 2)

The characters, the lines, the points, etc. (all of them are henceforth called as characters) were drawn with different pens on five sheets of papers with grid (Sample 1). These characters were not obliterated. One sheet of Sample 1 is shown in Fig. 1. Visible, near-infrared and middle infrared light photographs of Sample 1 were taken and compared to select pens used in the Experiment 2.

Procedure of Experiment 2 (Comparison of Near Infrared Light Photographs and Middle Infrared Light Photographs of Obliterated Writings)

To demonstrate that there exist obliterated writings that are undecipherable by the conventional near infrared light photography, but decipherable by middle infrared photography, samples of obliterated writing were made (Sample 2). The pens used to make Sample 2 were selected based on the results of the Experiment 1. The Japanese characters "不明文字" were written by a pen that contains carbon black (WBMAR-M-B, PILOT CORPORATION), and they were obliterated by a pen which contains nigrosine dye (Sakura Pen Touch Black: Sakura COLOR PRODUCTS CORPORATION). Since an experimental result can depend on the thickness of obliterating ink, the dependence of the results on the thickness was also examined. The samples were prepared with different thickness where thickness of obliteration was controlled by the number of repetition of obliteration. In order to obliterate effectively the direction of the obliteration is changed alternately and the sample was dried for 1min with incandescent light from a 150 W tungsten lamp each after obliteration. The backs of the samples were also obliterated as the fronts of the samples were done.

Results and Discussion

Results of Experiment 1

When observing through the narrow band path filter, some characters drawn on Sample 1 were transparent. When setting the central wavelength of the filter to between 0.4 µm and 0.63 µm, no characters were transparent. However, when setting the central wavelength to longer than 0.63 µm, some characters were transparent. When setting the central wavelength to 1 µm, the largest number of characters were transparent. As the central wavelength was moved to the longer, the number of characters that were transparent increased.

When observing through the wide band path filter, no characters drawn on Sample 1 were transparent. Figure 4 shows examples of near infrared light photographs taken with the narrow band path filter that central wavelength was set to 1 µm (henceforth called as near infrared light photographs). Figure 4 also shows examples of visible light photographs taken with the wide band path filter (henceforth called as visible light photographs).

On near infrared light photographs only characters drawn by pens that contain nigrosine and pigment were not transparent, while all characters drawn by pens that contain other dye were transparent (Table 2).

Figure 5 shows examples of near infrared light photographs and middle infrared light photographs of Sample 1. On middle infrared light photographs the characters drawn by pens that contain pigment

TABLE 2—*Results of the Experiment 1.*

Coloring Matters Used in Pens	Near Infrared Light Photography	Middle Infrared Light Photography
Dye inks other than nigrosine dye inks	Transparent	Transparent
Nigrosine dye inks	Not transparent	Transparent
Pigment inks	Not transparent	Not transparent

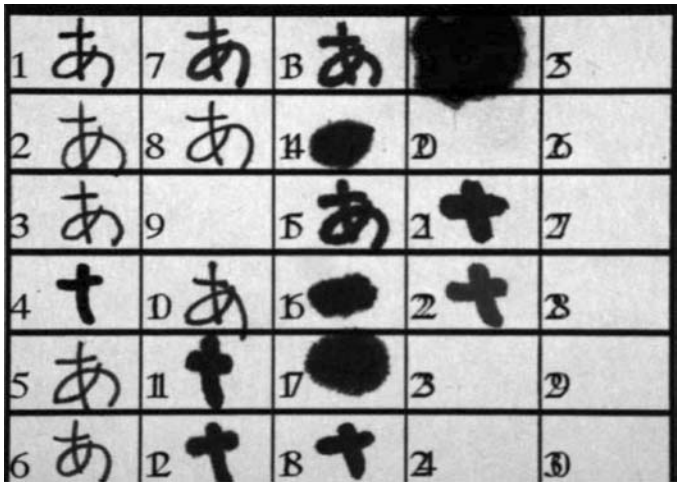

FIG. 3—*Sample for examination of inks to select pens used in the Experiment 2 (Sample 1). The number in each square corresponds to the number labeled on each pen. Nothing is drawn in the squares 9 and 20.*

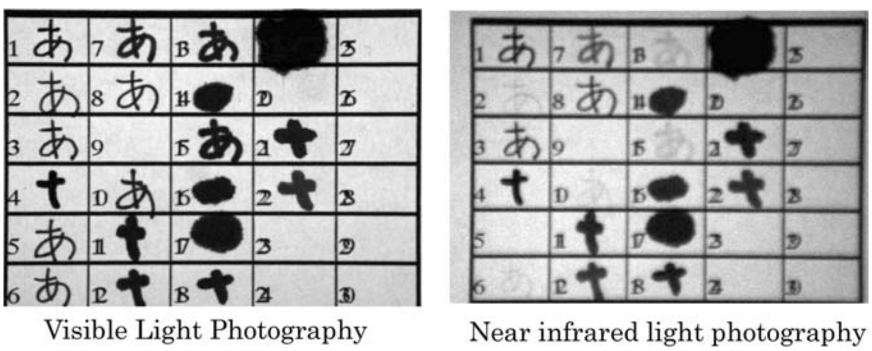

FIG. 4—*Visible light photograph and near infrared light photograph of Sample 1. If ink line is visible (black), the ink absorbs the light. If ink line is invisible and transparent, the ink doesn't absorb the light.*

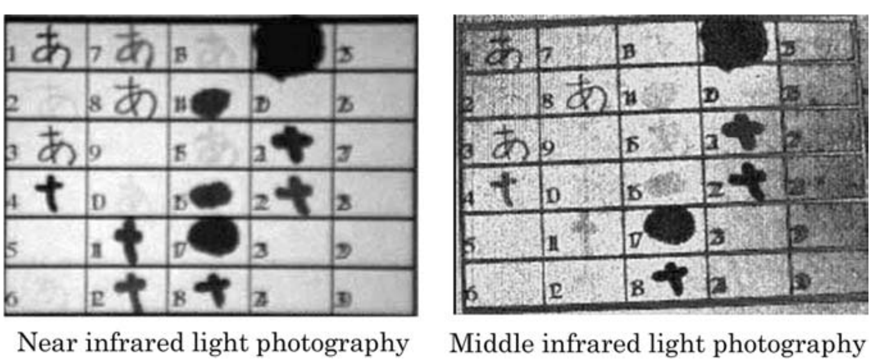

FIG. 5—*Near infrared light photograph and middle infrared light photograph of Sample 1 (Inks in the square 7,11,12,14,16 absorb near infrared light, but don't absorb or little absorb middle infrared light.)*

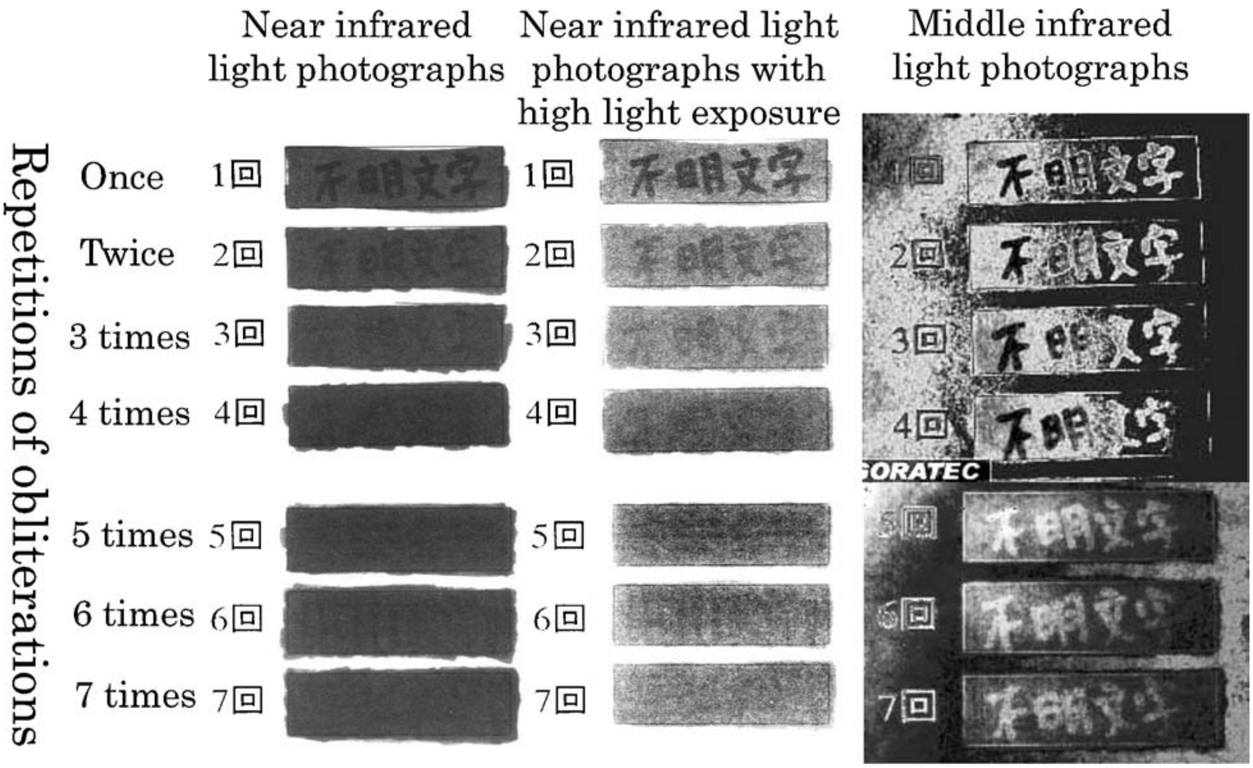

FIG. 6—*Near infrared light photograph, near infrared light photograph with image processing and middle infrared light photograph of Sample 2.*

were not transparent, while all characters drawn by pens that contain dye including nigrosine were transparent (Table 2).

As shown in Table 2, only nigrosine dye inks gave different results for near infrared light photography and middle infrared light photography. Therefore, to make obliterated writings that were undecipherable by near infrared light photography but decipherable by middle infrared light photography, nigrosine dye inks must be used. Then, pens that contain nigrosine dye inks were used to obliterate and pens that contain pigment inks were used to write characters in the Experiment 2.

Results of Experiment 2

From the results of Experiment 1, Sample 2 were thought to be not deciphered by near infrared light photography, but were expected to be deciphered by middle infrared light photography.

This speculation was examined. Figure 6 shows near infrared light and middle infrared light photographs of Sample 2. Thin obliteration writings (the number of repetition of obliteration was 1∼3) were deciphered both on near infrared light photographs and middle infrared light photographs. However, thick obliteration writings (the number of repetition of obliteration was 4∼7) were deciphered only on middle infrared light photographs.

Therefore, it was confirmed there exist obliterated writings that were deciphered only by middle infrared light photography.

Conclusion

There exist obliterated writings that were deciphered only by middle infrared light photography. Obliterated writings that were written by pigment inks, and that were obliterated thickly by nigrosine dye inks were undecipherable by near infrared photography, but decipherable by middle infrared photography.

References

1. Dines JE. Document examiner textbook: Pantex International Ltd., 1998;239:200–1.
2. Hilton O. Scientific examination of questioned documents: Elsevier 1982;117–8.
3. Foster & Freeman Ltd. VSC (Video Spectral Comparator) 2000 operating manual. 1999;9:25–6.
4. Dines JE. Document examiner textbook: Pantex International Ltd., 1998;241.
5. Yoshida K. Application of autoradiography on examination of questioned documents. Reports of the National Research Institute of Police Science Forensic Science Version 1970;23:326–9.

Additional information and reprint requests:
Shigeru Sugawara
Second Information Science Section
Fourth Forensic Science Department
National Research Institute of Police Science
Kahiwanoha 6-3-1, Kashiwa city
Chiba Prefecture, Japan, 277-0882