

TECHNICAL NOTE**CRIMINALISTICS**

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Vapor-phase Staining of Cyanoacrylate-Fumed Latent Fingerprints Using *p*-Dimethylaminobenzaldehyde

ABSTRACT: Contrasting or enhancing of cyanoacrylate ester-fumed latent fingerprints deposited on solvent-sensitive materials such as oil marker writings and rough surface materials such as unglazed earthenware is not easy by conventional dye solutions dipping or dye powder dusting. In this study, a new vapor-phase staining method using *p*-dimethylaminobenzaldehyde (DMAB) is proposed for staining such materials. DMAB has high volatility and selective absorbability to cyanoacrylate-fumed fingerprints, so that cyanoacrylate-treated samples can be easily stained by leaving them simply in a closed container along with DMAB crystals for 48–96 h at room temperature or in conjunction with the use of mild heating. The stained fingerprint could be excited by UV irradiation (365 nm), and the fluorescent fingerprint was photographed through a UV cut-off filter (420 nm). The new method achieved minimally destructive fluorescent staining for the solvent-sensitive samples and the rough surfaced samples.

KEYWORDS: forensic science, latent fingerprint, *p*-dimethylaminobenzaldehyde, vapor-phase staining, cyanoacrylate fuming

A fingerprint left behind at a crime scene by a suspect is a most important item of evidence for criminal investigation. That explains why attempts to develop new methods for the visualization of latent fingerprints have been continued throughout the forensic community.

Cyanoacrylate ester (super glue) fuming was originally developed by the Japanese National Police Agency and has been widely used as a routine method for fingerprint detection on smooth surfaces such as glasses, plastics, and metals (1,2). Vaporized cyanoacrylate monomer reacts with moisture or the other components in latent fingerprint deposits to form a white polymeric layer on the fingerprint ridges. Thus, the latent fingerprint can be developed as a whitish figure on the blackish surfaces of samples. In the fuming process, fingerprint details are not intrinsically altered because no solution or powder is used.

However, in subsequent staining processes required to better contrast it from whitish background surfaces and/or to enhance a weakly developed fingerprint, dipping in a fluorescent dye solution or dusting with a fluorescent dye powder has sometimes destroyed the ridge detail (3–7). In dye solution staining, methanol or ethanol has universally been used as a mild organic solvent, because they generally do not dissolve the cyanoacrylate polymer on fingerprint ridges. The most suitable combination of dyes and solvents has to be chosen according to the characteristics of the sample. Sometimes, nonpolar organic solvents have been added to methanol or ethanol to keep destruction of the samples to be minimum. In our experience, however, some kinds of material such as oil marker writings are sensitive even to the mild organic solvents and tend to deteriorate. The deterioration of the sample

likely affects fingerprints on the sample and sometimes washes them away from the sample entirely. Dye powders usually adhere everywhere with little selectivity to the fingerprints on rough surfaced samples such as unglazed earthenware and at times interfere with the observation because of the lack of contrast. Particles condensed from the hot subliming dye vapor method have been previously studied (8). However, it is not true vapor-phase staining and did not solve the nonselectivity of dye powders. The choice of the best staining method is actually more difficult if the target sample consists of multiple materials. Thus, vapor-phase staining has been desired for such samples in view of its minimally destructive characteristic in comparison with dye solution staining and dye powder dusting.

This study describes a new vapor-phase staining method for contrasting and enhancing cyanoacrylate-fumed fingerprints by utilizing *p*-dimethylaminobenzaldehyde (DMAB), the chemical structure of which is shown in Fig. 1. DMAB is known to be used as a color test reagent, Ehrlich's reagent, for detecting pyrrole and its derivatives (9). This bluish white crystal conveniently has two major advantages, high volatility and UV fluorescence. In this study, first, absorbability of DMAB to cyanoacrylate-treated fingerprints was examined by comparing with smooth plates made of various kinds of material. Second, this method was tested by applying to several samples. Incidentally, *p*-dimethylaminocinnamaldehyde (DMAC) (10), which is a DMAB analog, was also examined, but its volatility was found not to be sufficiently high enough for vapor staining at room temperature or under mild heating.

Materials and Methods

Materials

Cyanoacrylate ethyl ester (type 201) offered from Toagosei (Tokyo, Japan) and DMAB (for-synthesis grade) commercially purchased from Merck (Darmstadt, Germany) were used.

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Received 6 Aug. 2010; and in revised form 4 Dec. 2010; accepted 2 Jan. 2011.

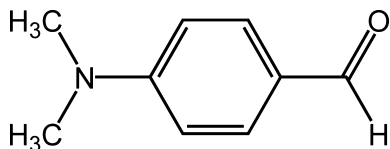


FIG. 1—The structure of *p*-dimethylaminobenzaldehyde.

The plates examined for adsorbability were polyethylene (PE), polypropylene, polyvinylchloride (PVC), polystyrene, polyethylene terephthalate, polycarbonate, acrylonitrile-butadiene-styrene copolymer, polymethylmethacrylate, polycyanoacrylate, aluminum, and stainless steel.

Vapor Staining of Cyanoacrylate-Fumed Sample

Initially, a latent fingerprint deposited normally on a sample had been left for 24 h in a room and then usually fumed with warmed cyanoacrylate ester in a conventional fuming box. The fumed sample was subsequently stained by placing it in a closed glass container (ca. 0.3–2 L volume corresponding to the sample size) with coexistence of about 5–10 g of DMAB crystals and then simply left at room temperature or under gentle heating. In almost all samples, the most consistent fluorescence of fingerprints was achieved by leaving them for >48 h at room temperature. Rough surfaced samples generally needed longer exposure times than the smooth surfaced samples. By naked eye observation, appearance of the sample before and after DMAB staining did not change at all, because DMAB adhering on samples is colorless. Throughout the staining process, generated fluorescence was checked using UV lamp (365 nm), and additional staining was repeated until reasonable fluorescence was obtained. Heating DMAB directly by uncovered Nichrome wire should be avoided for safety considerations, although its flash point (over 100°C) is not seriously low (11). A large or a small container, according to the size of each sample, should be used for effective staining. The appropriately sized container, in which the sample had been placed along with the DMAB crystals, was then sealed and placed in a dark location during development. As a matter of course, this staining method cannot be applied to samples possessing strong inherent UV fluorescence which interferes the observation of fingerprint fluorescence.

The lethal dose value of DMAB is not serious (oral rat LD₅₀: 500 mg/kg; oral rat LD₅₀ > 6400 mg/kg) (11), but DMAB easily transfers from one surface to another of latex gloves, PE bags, and so forth. Throughout this examination, all DMAB operations were carried out with ventilation and with the operator wearing nitrile rubber gloves to take care not to stain the skin.

Observation and Photograph

Stained samples were initially observed using white light and subsequently excited using a conventional UV lamp (365 nm). Photographs were conveniently taken by a system consisting of a digital camera, a high-pass filter (420 nm), and a notebook-type computer to control the camera (12). Any number of commonly available forensic light sources could be substituted as an excitation source, such as the Polilight® (Rofin, Tullamarine, Australia), the Crime Scope® (Horiba Jobin Yvon, Inc., Chilly Mazarin, France), and the LED-based Polilight-Flare® Plus (Rofin), which is a small, light-weight, and battery-powered light source.

Results and Discussion

Selective Absorbability to Fingerprint

To obtain well-contrasted fingerprint images, selective absorbability of DMAB to the fingerprint ridge is required. So we examined DMAB for its absorbability to a cyanoacrylate-treated fingerprint on a PE plate and to 11 kinds of smooth surfaced plates, comparatively. These plates were prepared by cutting commercially available sheets, except for the polycyanoacrylate plate that was prepared by polymerization of liquid ethyl cyanoacrylate. Eleven untreated plates and the fumed fingerprints were set in a closed container filled with DMAB vapor, and the intensity of fluorescence (440 nm) excited by UV irradiation (365 nm) was then measured at 24-h intervals using a Leica MPV SP microscope photometer (Leica Microsystems, Wetzlar, Germany). Figure 2 shows the increase in their fluorescence intensity throughout a 72-h period.

Fluorescence intensity of the fingerprint ridge obviously increased for 48 h and held constant out to 72 h (showed as line a in Fig. 2). On the other hand, intensities on all of the reference plates showed little or practically no increase (lines b and c shown in Fig. 2). Among the 11 plates, the polycyanoacrylate plate and the PE plate (lines b) showed a little larger increase compared to the other nine plates (lines c), but still about 1/20 the intensity as that of the fingerprint ridge (line a). Exposure was continued until 240 h, but each plate intensity did not increase any more. After taking the fingerprint sample out of the container, the fluorescence intensity of the fingerprint has remained constant for more than a month. From this examination, DMAB was found to have selective absorbability to cyanoacrylate-fumed fingerprints.

We estimate that the large fluorescence increase on the fingerprint ridge originates from this fiber-like form, in addition to some interaction between the DMAB molecule and the polycyanoacrylate molecule. The interaction was suggested from the increasing fluorescence on the polycyanoacrylate plate (line b in Fig. 2) compared to that on the other nine plates (line c).

The detailed form of the cyanoacrylate polymer grown on the fingerprint ridge was observed by using an electron microscope and is shown in Fig. 3. The polycyanoacrylate was observed to be

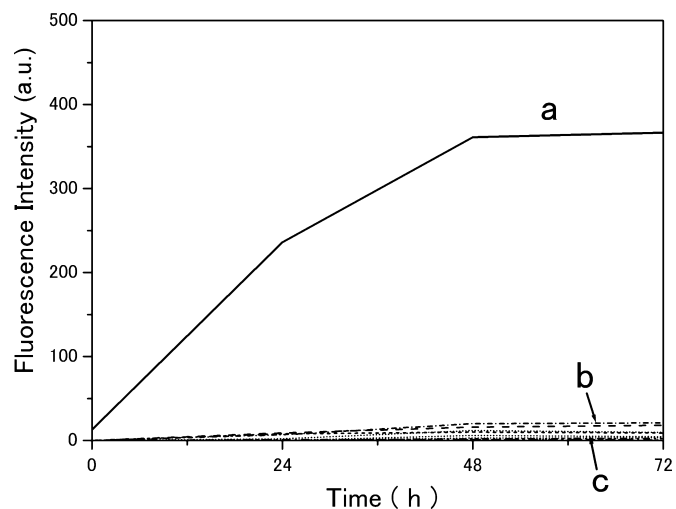


FIG. 2—Increase in fluorescence intensity with *p*-dimethylaminobenzaldehyde exposing time; (a) cyanoacrylate-fumed fingerprint ridge, (b) smooth plates of polycyanoacrylate and polyethylene, (c) smooth plates of polyvinylchloride, polystyrene, polypropylene, polycarbonate, polyethylene terephthalate, acrylonitrile-butadiene-styrene, polymethylmethacrylate, aluminum, and stainless steel.

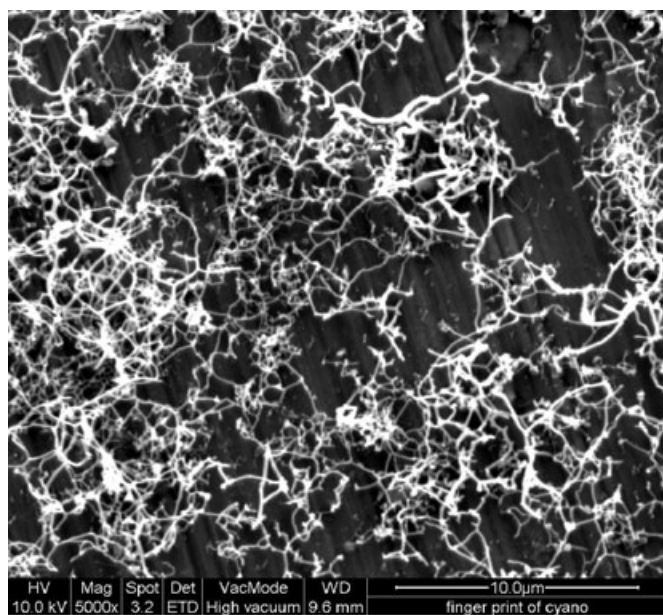


FIG. 3—Minute polycyanoacrylate fiber observed on fingerprint ridge; the EPMA picture shows c. 28×28 micrometers area.

minute fibers linking with each other, as reported by Morimoto et al. (8). As generally known, the minute fiber form of polymers has a larger surface area than the bulky form. This must result in a greater quantity of DMAB adhering to the fiber. Furthermore, excitation UV irradiation and resulting fluorescence can be enhanced effectively by reflection on the minute fiber surface.

Actually, a latent fingerprint deposited on a smooth polycyanoacrylate plate could be detected by cyanoacrylate fuming followed by DMAB vapor staining, as shown in Fig. 4. The result in Fig. 4 shows the positive effect of the fiber form on staining the ridge.

Applications

Oil markers as organic solvent-sensitive samples and unglazed flower pot, old Japanese roof tile, and rusty cutter knife as rough



FIG. 4—Latent fingerprint partially visualized by cyanoacrylate fuming, *p*-dimethylaminobenzaldehyde vapor staining, and UV irradiation (365 nm); the fingerprint had been deposited on a smooth surface of polycyanoacrylate plate in advance.

surfaced samples were examined. Fingerprint detection on these samples via conventional staining methods is known to be problematic. Figure 5 shows white PVC insulating tape (not the adhesive side) partially written on with a red oil marker. The fingerprints had been deposited on the sample 24 h before cyanoacrylate fuming. After the fuming, the sample was developed with DMAB vapor in a small closed container at room temperature for 48 h. Initially, the sample was observed under white light (Fig. 5a) and subsequently under UV irradiation (Fig. 5b). Under white light, only the fragmented prints on the red markings could be observed (Fig. 5a). With UV irradiation, the whole fluorescent fingerprint could be observed clearly without ridge detail being damaged on the marker (Fig. 5b).

If a methanol solution of dye was applied to the solvent-sensitive markers, the solution could dissolve the markings to a greater or lesser degree and subsequently obliterate the fingerprint on it as well. Figure 6 shows white PE sheet partially written on with a black oil marker. The fingerprints had been deposited on the sample 24 h before cyanoacrylate fuming. After the fuming, the sample was divided into two parts. The left half was exposed with DMAB vapor in a small closed container at room temperature for 48 h,

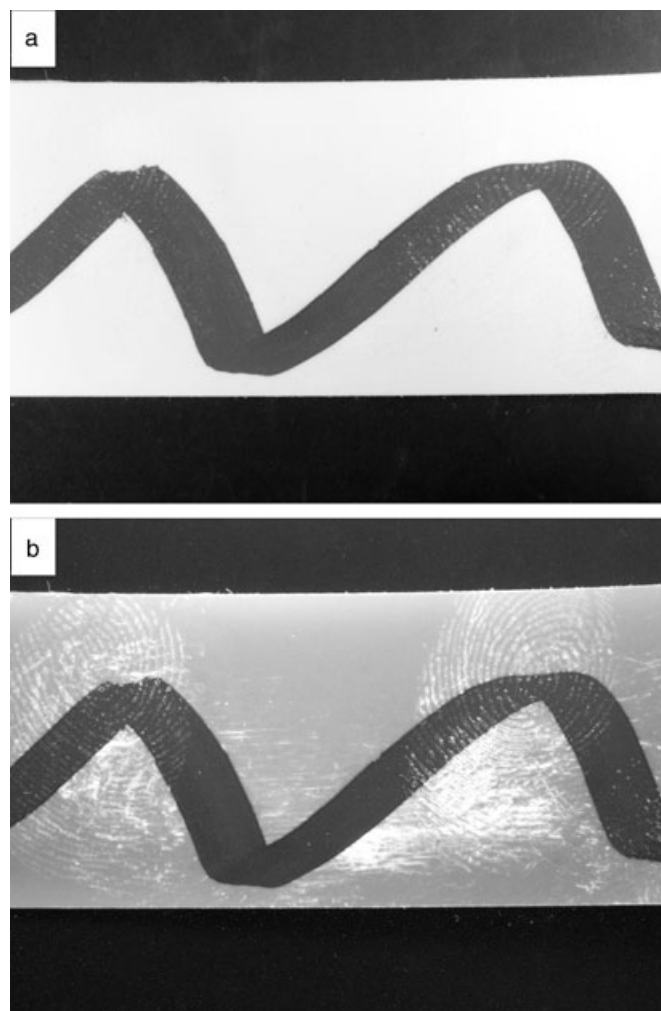


FIG. 5—Latent fingerprint developed by cyanoacrylate fuming and subsequent *p*-dimethylaminobenzaldehyde vapor staining for 48 h at room temperature from a white polyvinylchloride tape written with red oil marker; (a) visible observation under white light, (b) fluorescence observation under UV irradiation (365 nm).

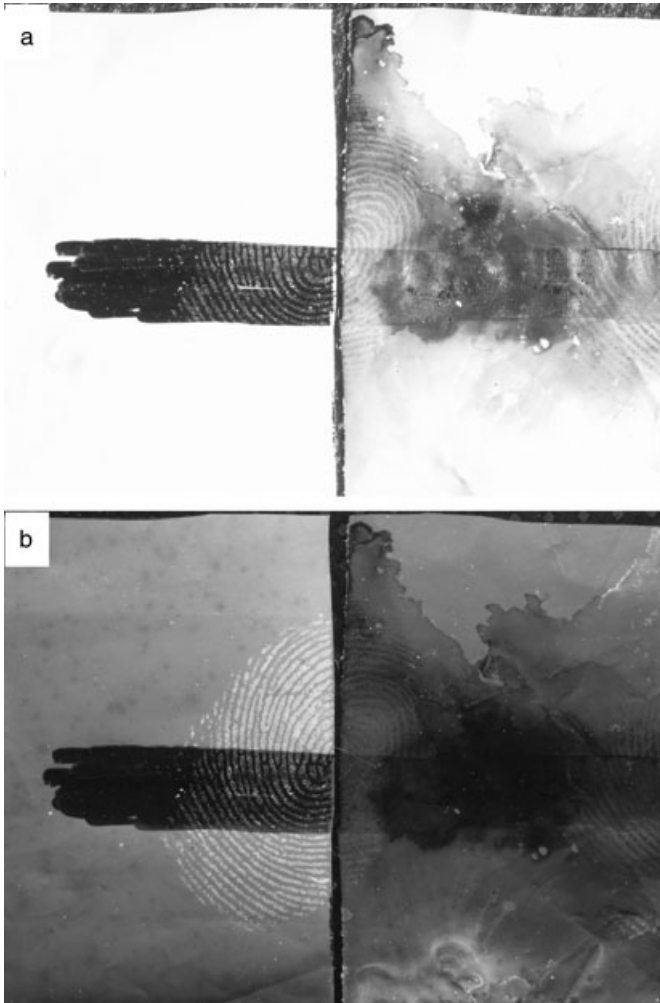


FIG. 6—Latent fingerprint treated by cyanoacrylate fuming and subsequent two kinds of staining method, *p*-dimethylaminobenzaldehyde vapor staining for 48 h at room temperature (left half) and dropping a few drops of methanol solution of Basic yellow 40 (right half), from a white polyethylene sheet written with black oil marker; (a) visible observation under white light, (b) fluorescence observation under UV irradiation (365 nm).

and the right half was treated by dropping a few drops of methanol solution of Basic yellow 40. Under white light, remarkable flowing of the marker was observed (right half of Fig. 6a), and the fingerprint fluorescence became weaker by the loss of ridge and interference of the flowing marker (right half of Fig. 6b). In the meantime, DMAB staining gave clear ridge detail even on the marker without the ridge destruction (left half of Fig. 6a,b).

In general, detection of latent fingerprints on rough surfaced samples such as unglazed earthenware is difficult, except on papers for which ninhydrin development is effective. In staining such samples, the rough surfaces trap dusting powder or dye solution residue, resulting in background noise. As compared to dye solution or dye powder, DMAB vapor can selectively stain cyanoacrylate polymer on the bumpy portions with minimum contamination of the background surface. Figure 7 shows an unglazed flower pot, on which a fingerprint was deposited 24 h before cyanoacrylate fuming. After the fuming, the sample was divided into two parts. The left half was treated with DMAB vapor in a small closed container at room temperature for 96 h, while the right half was dusted with sepia powder (containing resin-treated manganese dioxide). The

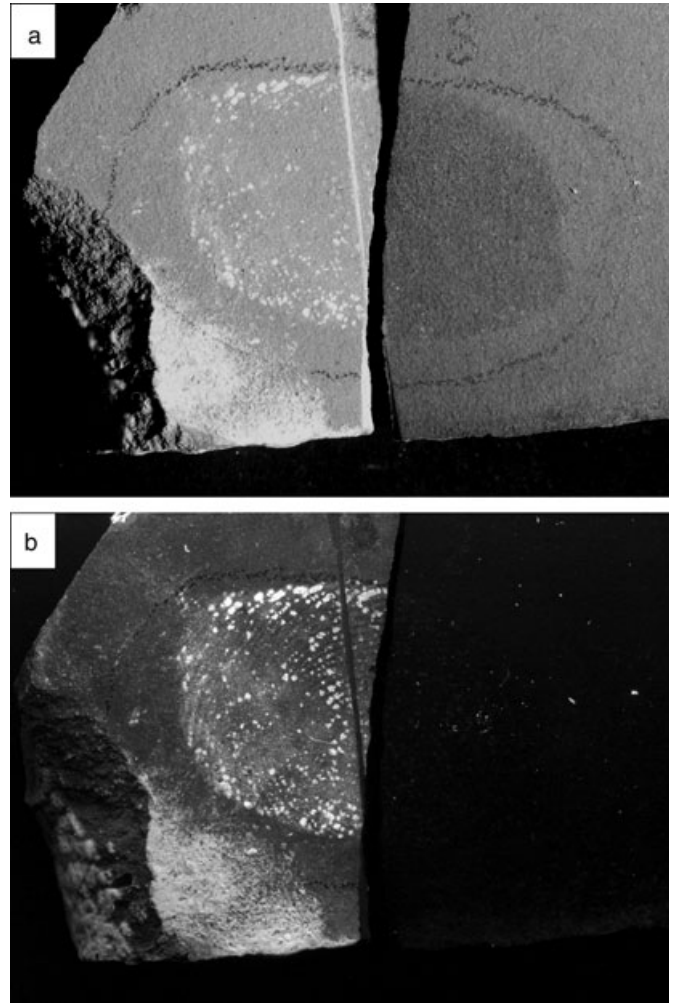


FIG. 7—Latent fingerprint treated by cyanoacrylate fuming and subsequent two kinds of staining method, *p*-dimethylaminobenzaldehyde vapor staining for 96 h at room temperature (left half) and dusting with sepia powder (right half), from a unglazed earthenware flower pot; (a) visible observation under white light, (b) fluorescence observation under UV irradiation (365 nm).

dusted powder adhered not only to fingerprint ridge but also to the valley between ridges, resulting to give the obscure print (right half of Fig. 7a). The pot surface is rough and has a whitish orange color, so the treated fingerprint is partially invisible and hard to identify under white light (left half of Fig. 7a). Under UV irradiation, the fluorescent fingerprint could be observed even on the invisible part because of enhancement by DMAB staining, which had highly selective attachment to the invisible polymer on the ridge (left half of Fig. 7b).

Figure 8 shows visualization on an old Japanese roof tile, which was made from clay and also has a rough surface. Its surface color is blackish gray, but a cyanoacrylate-fumed fingerprint was virtually invisible under white light (Fig. 8a). DMAB preferentially attached to the invisible polycyanoacrylate layer, allowing the fluorescent fingerprint to be faintly visualized (Fig. 8b).

Rust also has a rough surface. Detection of latent fingerprints on fresh rust is generally difficult because cyanoacrylate tends to polymerize on contact with it. A rusty cutter knife was examined, and the result is shown in Fig. 9. The examined knife had been used for a long time, so the rust was not fresh and the color was

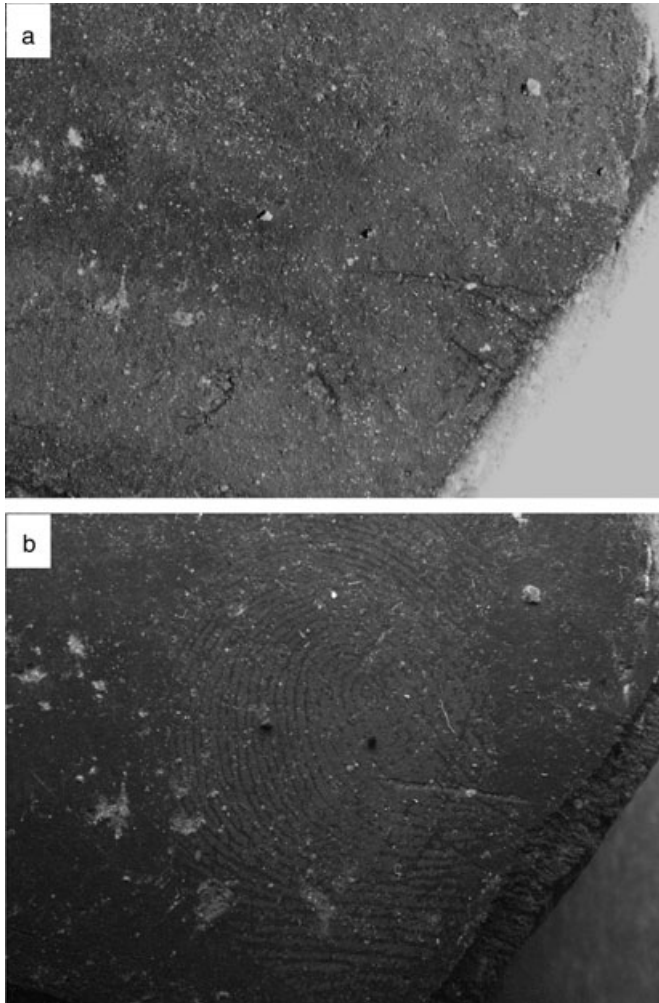


FIG. 8—Latent fingerprint developed by cyanoacrylate fuming and subsequent *p*-dimethylaminobenzaldehyde vapor staining for 96 h at room temperature from an old Japanese roof tile; (a) visible observation under white light, (b) fluorescence observation under UV irradiation (365 nm).

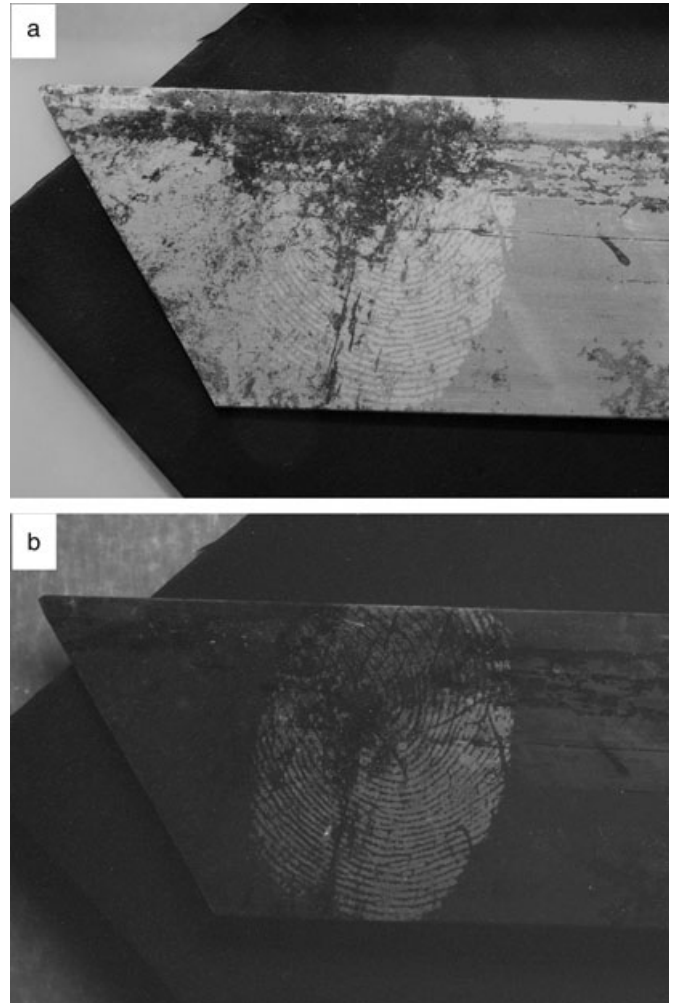


FIG. 9—Latent fingerprint developed by cyanoacrylate fuming and subsequent *p*-dimethylaminobenzaldehyde vapor staining for 96 h at room temperature from a rusty cutter knife; (a) visible observation under white light, (b) fluorescence observation under UV irradiation (365 nm).

blackish when treated. Under white light, ridge detail on the rusted portion was invisible in contrast to clear ridge detail on the smoother portion of the surface (Fig. 9a). Under UV irradiation, some ridge detail on the rust could be identified (Fig. 9b). On rough surfaced samples, longer DMAB exposure time was needed. The fluorescence in Figs 7–9 was achieved by 96-h exposure at room temperature.

From these applications, it was confirmed that DMAB vapor staining is useful for minimally destructive staining on troublesome samples including solvent-sensitive samples, rough surfaced samples, and so on. Fluorescence of these samples was observed even after storage for 4 months in a sealed PE bag at room temperature.

Conclusion

The minimally destructive and simple method for staining cyanoacrylate-fumed latent fingerprints was developed by utilizing vapor from highly volatile and fluorescent DMAB crystals. The new method achieved minimally destructive fluorescent staining of solvent-sensitive materials and rough surfaced materials, both of which were difficult to stain by conventional methods. It should become

easier to detect latent fingerprints from a troublesome sample composed of closed such materials.

Acknowledgments

We are grateful to Dr. Kimberly Bouldin and Mr. Russell Murdock for reading the manuscript. They have been friends with one of us (MT) since the summer of 1999 at Texas Tech University.

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